NBER WORKING PAPER SERIES

THE U.S. TREASURY PREMIUM

Wenxin Du
Joanne Im
Jesse Schreger

Working Paper 23759
http://www.nber.org/papers/w23759

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2017

We thank Carlo Favero, Jeffery Frankel, Pierre-Olivier Gourinchas, Victoria Ivashina, Ruth Judson, Annette Vissing-Jorgenson, Arvind Krishnamurthy, and conference participants at the NBER International Seminar on Macroeconomics (Vilnius, Lithuania) for helpful comments and suggestions. We thank Kimberly Hagan for editorial assistance. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System, any other person associated with the Federal Reserve System, or the National Bureau of Economic Research. All remaining errors are our own.

The U.S. Treasury Premium
Wenxin Du, Joanne Im, and Jesse Schreger
NBER Working Paper No. 23759
August 2017
JEL No. E4,F30,G12,G15

ABSTRACT

We quantify the difference in the convenience yield of U.S. Treasuries and the bonds of near default-free sovereigns by measuring the gap between the FX swap-implied dollar yield paid by foreign governments and the U.S. Treasury dollar yield. We call this wedge the "U.S. Treasury Premium." We find that this premium was approximately 21 basis points for five-year bonds prior to the Global Financial Crisis, increased up to 90 basis points during the crisis, and has disappeared since the crisis with the post-crisis mean at -8 basis points. We show the decline in the premium cannot be explained away by credit risk or FX swap market mispricings. In addition, we present evidence that the relative supply of government bonds in the United States and foreign countries affects the premium.

Wenxin Du
Federal Reserve Board
Division of International Finance
20th Street and Constitution Avenue NW
Washington, DC 20551
wenxin.du@frb.gov

Joanne Im
Federal Reserve Board
joanne.im@frb.gov

Jesse Schreger
Columbia Business School
3022 Broadway
Uris Hall 821
New York, NY 10027
and NBER
jesse.schreger@columbia.edu

1 Introduction

Investors value the liquidity and safety of Treasury securities and are willing to forego the so-called convenience yield to hold them over privately-issued papers (for example, see Krishnamurthy and Vissing-Jorgensen (2012)). In this paper, we quantify the convenience yield differential between U.S. Treasuries and foreign government bonds by taking the difference between the FX swap market implied dollar yield paid by foreign governments and the U.S. Treasury yield. Henceforth, we call this differential the "U.S. Treasury Premium." A positive premium implies the U.S. sovereign is paying less to borrow in real terms. The novelty and advantage of this measure is that it captures how special the U.S. government is as a debt issuer vis-a-vis comparably safe governments, not vis-a-vis large U.S. agencies or corporates.

We measure the U.S. Treasury Premium vis-à-vis government bonds in Australia, Canada, Denmark, Germany, Japan, New Zealand, Norway, Sweden, Switzerland and United Kingdom, referred to as the "G10 countries." Except for Japan, all sample countries have a AAA or near-AAA sovereign credit rating and is perceived as near default-free by global investors.[1] From 2000-2016, we find the average premium on U.S. Treasuries was 10 basis points at the five-year horizon and 25 basis points at the three-month horizon. The premia also differ significantly across countries, with means ranging between -26 and 61 basis points.

Furthermore, we document a steady decline in the U.S. Treasury Premium at medium- and long-term maturities since the Global Financial Crisis (GFC). The average five-year premium is 21 basis points pre-GFC, increases up to 90 basis points during the GFC, and declines to -8 basis points post-GFC. In contrast, the three-month premium averages 20 basis points before the GFC, increases up to 280 basis points during the GFC, but remains at 20

[1]The long-term local currency bonds in seven of 11 countries are AAA-rated throughout the sample (Australia, Canada, Denmark, Germany, Norway, Sweden and Switzerland). The other four countries (Japan, New Zealand, United States and United Kingdom) do not have a perfect credit rating. The United States was downgraded to AA+ in 2011 and New Zealand was downloaded to AA in 2011 and the United Kingdom lost its AAA rating after the Brexit in 2016. Japan was downgraded several times in our sample, currently rated A+, several notches lower than all the other sovereigns and the lowest in our sample.

basis points after the GFC. The decline in the medium- and long-term U.S. Treasury Premia after the GFC is accompanied by a sharp inversion of the term structure of the premia.

To investigate the drivers of the convenience yield differential, we decompose our U.S. Treasury Premium into three components: (1) sovereign credit risk differential between the foreign country and the United States; (2) swap market mispricing given by deviations from covered interest rate parity (CIP) for interbank funding instruments (Du et al. (Forthcoming)); and (3) a residual term, which we attribute to differences in broadly-defined liquidity, which can include market liquidity, collateral value, near-money features of Treasuries, and so forth.

We show that in the pre-GFC period, measured credit spread differentials and CIP deviations were both negligible; thus the positive U.S. Treasury Premium is almost entirely driven by the liquidity component. In the post-GFC period, both the CIP deviations for interbank rates and sovereign CDS spread differentials tend to increase the U.S. Treasury Premium because the U.S. has lower sovereign CDS spreads than the average G10 country and swap market mispricing on average makes the swap-implied dollar yield higher than the direct dollar yield. Therefore, the secular decline in the medium- to long-term U.S. Treasury Premium is mostly driven by the decline in the residual liquidity component.

We then examine the behavior of our U.S. Treasury Premium measure against other measures of the liquidity and safety value of U.S. Treasury yields. At the short horizon, the general collateral (GC) repo-Treasury bill (repo-Tbill) spread is considered a measure of the liquidity premium in Treasury bill yields, as the GC repo is secured by Treasury collateral and has very little credit risk, but is not as liquid as Treasury bills (Nagel (2016)). We find that variations in the average 3-month premium of U.S. Treasury bills are strongly correlated with the U.S. repo-Tbill spread. When the repo-Tbill spread is high, our average 3-month U.S. Treasury Premium is also high. Furthermore, we find that a higher repo-Tbill spread in foreign countries is correlated with a reduction in the U.S. Treasury Premium at the 3-month horizon, which supports the notion that our premium measures the relative liquidity of U.S. Treasury bills vis-a-vis foreign Treasury bills.

However, at medium to long maturities, our U.S. Treasury Premium behaves differently from conventional measures of liquidity and safety that are constructed by taking the yield spread between near risk-free agencies and Treasuries. In the United States, a commonly used long-term liquidity premium measure is the yield difference between Resolution Funding Corporation (Refcorp) coupon strips and Treasury strips (Fleckenstein et al. (2014) and Negro et al. (2017)). Refcorp strips are fully guaranteed by U.S. Treasuries and thus have the same credit risk as Treasuries. We note that contrary to the secular decline of our U.S. Treasury Premium, the Refcorp-Treasury premium increases after the GFC. Our results show that U.S. Treasuries have lost their specialness vis-a-vis other developed sovereigns at the medium-to-long horizon, even as it increases vis-a-vis domestic safe agency debt of the same currency.

Finally, we examine how the relative supply of U.S. Treasuries over foreign government bonds affects the U.S. Treasury Premium. Krishnamurthy and Vissing-Jorgensen (2012) show that the U.S. public debt to GDP ratio is inversely related to the convenience yield on U.S. Treasuries. When the debt to GDP ratio is low, Treasuries are more scarce and therefore commands a higher premium compared to private paper. Consistent with their results, we find that an increase in the supply of foreign government bonds relative to U.S. Treasuries is associated with a higher U.S. Treasury Premium.

Our U.S. Treasury Premium measure is related to a number of papers that examine the convenience yields of U.S. Treasuries, in particular Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016) and Greenwood et al. (2015). Krishnamurthy and Vissing-Jorgensen (2012) examine the effect of the amount of debt outstanding on the liquidity and safety premia of U.S. Treasuries. The authors estimate the premium at 73 basis points, which they identify off of the effect of Treasury issuance on AAA-Treasury spreads. While our benchmark estimates are lower than those in Krishnamurthy and Vissing-Jorgensen (2012), this should not be surprising as we are measuring a different concept. We are considering the U.S. Treasury's liquidity and safety premia relative to other governments rather than relative to safe agencies and corporates. Therefore, one way to interpret our results is to say that the US earns a premium relative to developed sovereigns that is smaller than that earned relative to its own agencies and corporates. Greenwood et al. (2015) estimate the convenience yield of T-bills using the differential between the actual T-bill yield and the fitted yield based on the estimated yield curve, and find a premium of 40 basis points for one-week bills. Nagel (2016) measures the liquidity premium on T-bills as their spread relative to a three-month general collateral repo with the mean premium equal to about 24 basis points.

The question of how much less the U.S. government pays on its debt because of its "specialness" is also related to the question of the "Exorbitant Privilege" and the source of the return differentials between the United States and the rest of the world. This question is examined by Gourinchas and Rey (2007b), Gourinchas and Rey (2007a), Gourinchas et al. (2010), and Curcuru et al. (2008). By converting all foreign government bond yields into U.S. dollars, we contribute to this literature by quantifying the degree to which the U.S. government pays less than foreigners, above and beyond differences in the currency risk premia. By focusing on the specialness of government bonds within a currency, this measure is largely distinct from the question of why the U.S. dollar is the global reserve currency (Maggiori (Forthcoming), Maggiori (Forthcoming)) and attempts to measure premium on U.S. dollar-denominated assets (Maggiori et al. (2013)).

Recently, a number of papers in international finance have examined how changes in the relative convenience yield of government bonds across countries can help resolve a number of exchange rate puzzles. Engel (2016) and Valchev (2016) argue that time variation in bond convenience yields can explain the term structure of violations of uncovered interest rate parity. Itskhoki and Mukhin (2017) looks at how a similar shock can generate exchange rate disconnect. Our measure U.S. Treasury Premium provides an empirical counterpart to the shocks in these papers.

In terms of the construction of the U.S. Treasury Premium measure itself, this paper build on the earlier work of Du and Schreger (2016a) and Du and Schreger (2016b). Du and Schreger (2016a) construct the "local currency credit spread" in an identical way as the measure used in this paper and argue that it largely captures sovereign default risk on nominal debt in emerging markets.[2] The "U.S. Treasury Premium" is constructed in the same way as the "local currency credit spread" in these earlier papers but is given a very different interpretation. This is because sovereign default risk is very low in G10 countries, and therefore, it is likely that the factors such as the liquidity premium differential and financial market frictions play more important roles than default risk in explaining the U.S. Treasury Premium vis-à-vis G10 government bonds. We discuss the difference in the behavior of this measure between emerging and developed countries in Section 3.2. The measure in this paper is closely related to the analysis of "Relative Swap Spreads" in Codogno et al. (2003). Codogno et al. (2003) decompose yield spreads in euro area countries into international risk factors, default, and liquidity, while accounting for the fact that bonds are in different currencies by using interest rate swaps. Our measure differs from the measure in that paper by including the cross-currency basis swap, but would be the same if this basis was close to zero as was generally the case prior to the GFC. Our analysis is also related to Feldhütter and Lando (2008) and Jermann (2016) which analyze the sources of variations in U.S. asset swap spreads. Our paper could be recast as analyzing the difference between the U.S. asset swap spread and foreign swap spreads, net the cross currency basis swap. Finally, as our measure is defined as the size of the failure of CIP between government bond yields, it also relates to the recent literature studying CIP deviations in context of the behavior of banks and corporate issuers (such as Ivashina et al. (2015), Liao (2016), Du et al. (Forthcoming), and Avdjiev et al. (2016)).

The paper is organized as follows. In Section 2, we discuss the methodology behind calculating the premium and our data sources. In Section 3, we present the main results

[2] Hofmann et al. (2016) studies this same measure in connection to currency appreciation.

on the behavior of the U.S. Treasury Premium across time, currency, and maturity. In Section 4, we compare this premium to existing measures of the safety and liquidity of U.S. Treasuries. In Section 5, we examine the relationship between the relative bond supply and the premium. Section 6 concludes.

2 Methodology and Data

2.1 Definition of the U.S. Treasury Premium

In this section, we present the methodology for comparing yields in different currencies. We follow Du and Schreger (2016a) and use cross-currency swap rates to swap sovereign yields in different currencies into synthetic dollar yields. Then the U.S. Treasury Premium is defined as the difference between the synthetic dollar yields paid by foreign governments and the yield on U.S. Treasuries. A positive U.S. Treasury Premium suggests that the U.S. government is paying less in real terms than foreign governments. We keep the discussion of currency hedging brief here, but more details and discussions can be found in Du and Schreger (2016a).

We illustrate the construction of our synthetic dollar yields by taking the Japanese yen (JPY) as an example. The fixed-for-fixed cross-currency swap, or the market-implied forward premium, can be constructed in the following way. First, an investor pays the yen interest rate swap rate, irs_t^{JPY}, to swap the fixed yen cash flow into floating yen Libor, and then the investor pays the cross-currency basis swap, $bs_t^{USD/JPY}$ to swap yen Libor into dollar Libor, and finally the investor receives the dollar interest rate swap, irs_t^{USD}, to swap the floating dollar Libor into fixed dollar cash flows. Therefore, the fixed-for-fixed cross-currency swap rate from JPY to USD is equal to

$$\rho_{nt}^{JPY/USD} = irs_{nt}^{JPY} + bs_{nt}^{JPY/USD} - irs_{nt}^{USD}, \tag{1}$$

where t denotes time, and n denotes tenor. Given the nominal yield on the Japanese government bond, y_{nt}^{JPY}, the synthetic dollar yield is equal to

$$y_{nt}^{JPY,\$} = y_{nt}^{JPY} - \rho_{nt}^{JPY/USD}.$$

We refer to $y_{nt}^{JPY,\$}$ as the synthetic dollar yield on a Japanese government bond because it is equal to the dollar yield that an investor would receive by purchasing a yen bond and swapping all promised yen cash flow into dollars, conditional on the Japanese government not defaulting. Subtracting the U.S. Treasury yield y_{nt}^{USD} from both sides, we can decompose the nominal yield differential between Japan and the US into two components:

$$y_{nt}^{JPY} - y_{nt}^{USD} = \rho_{nt}^{JPY/USD} - (y_{nt}^{JPY,\$} - y_{nt}^{USD}) \equiv \rho_{nt}^{JPY/USD} + \Phi_{it}^{JPY/USD}. \tag{2}$$

The first component $\rho_{nt}^{JPY/USD}$ reflects the currency risk between JPY and USD. The second component $\Phi_{it}^{JPY/USD}$ measures the synthetic dollar yield differential between Japan and the US. We refer to $\Phi_{it}^{JPY/USD}$ as the "U.S. Treasury Premium" vis-à-vis Japan, or

$$\Phi_{it}^{JPY} \equiv y_{nt}^{JPY} - y_{nt}^{USD} - \rho_{nt}^{JPY/USD}.$$

More generally, the U.S. Treasury Premium vis-à-vis country i is defined as

$$\Phi_{it}^{i} \equiv y_{nt}^{i} - y_{nt}^{USD} - \rho_{nt}^{i/USD}, \tag{3}$$

where y_{nt}^{i} is the n-year government bond yield in country i and $\rho_{nt}^{i/USD}$ is the n-year forward premium (or the fixed-for-fixed cross-currency swap rate) for currency i against the dollar. In order to further decompose this premium, we need to begin by outlining the factors than can affect the prices of U.S. Treasuries and foreign government bonds.

2.2 Decomposition of the U.S. Treasury Premium

In this subsection, we provide a simple theoretical decomposition of the U.S. Treasury Premium defined in Equation 3 to three components: credit risk, swap market mispricing, and liquidity. The underlying assumption is that government bond markets and FX markets are integrated and priced by a global investor, which is a reasonable assumption for G10 countries. In this framework, the U.S. Treasury premium can exist for three reasons. First, the government bond yield can be higher than the hypothetical risk-free rate if the government bond is not default-free, so the U.S. Treasury premium can be affected by the safety differential between the foreign country and the United States. Second, swap market frictions introduce a wedge between the observed swap rate and the difference in hypothetical risk-free rates, and this wedge directly enters into the U.S. Treasury premium calculation as the observed swap rate is the price of hedging currency risk. Third, since the government bond yield can be lower than the hypothetical risk-free rate if there are positive liquidity benefits to holding the government bond, the U.S. Treasury Premium is also affected by the liquidity premium differential between government bonds in the foreign country and the United States.

2.2.1 Price of a U.S. Treasury Bond

Given a U.S. Treasury bond, let L^*_{t+1} denote the default loss and Λ^*_{t+1} , the liquidity benefit at time $t+1$, where the star denotes that these are U.S. variables. $\mathbb{E}^*_t$ denotes the risk-neutral expectation at time t using the U.S. dollar numeraire. Then the price of a one-period U.S. Treasury bond is given by

$$P^*_t = \exp(-\tilde{y}^*_t)\mathbb{E}^*_t[(1 - L^*_{t+1})(1 + \Lambda^*_{t+1})],$$

and the yield on the U.S. Treasury is

$$
\begin{aligned}
y_t^* &= \tilde{y}_t^* - \ln \mathbb{E}_t^*[(1 - L_{t+1}^*)(1 + \Lambda_{t+1}^*)] \\
&= \tilde{y}_t^* - \ln[\mathbb{E}_t^*(1 - L_{t+1}^*)\mathbb{E}_t^*(1 + \Lambda_{t+1}^*) + Cov_t^*(1 - L_{t+1}^*, 1 + \Lambda_{t+1}^*)] \\
&= \tilde{y}_t^* - \ln \mathbb{E}_t^*(1 - L_{t+1}^*) - \ln \mathbb{E}_t^*(1 + \Lambda_{t+1}^*) - \ln \left[1 + \frac{Cov_t^*(1 - L_{t+1}^*, 1 + \Lambda_{t+1}^*)}{\mathbb{E}_t^*(1 - L_{t+1}^*)\mathbb{E}_t^*(1 + \Lambda_{t+1}^*)}\right] \\
&= \tilde{y}_t^* + l_t^* - \lambda_t^* - \xi_t^*, \qquad (4)
\end{aligned}
$$

where $\tilde{y}_t^*$ is the hypothetical dollar risk-free rate, l_t^* is the default premium, λ_t^* is the liquidity premium, and ξ_t is the covariance between liquidity and default risk.

If the U.S. Treasury bond is default-free, we have $l_t^* = 0$ and $\xi_t^* = 0$, and then $y_t^* = \tilde{y}_t^* - \lambda_t^*$. In other words, the Treasury yield can be lower than the hypothetical dollar risk-free rate if it has liquidity benefits over the risk-free rate.

2.2.2 Price of a Foreign Government Bond

Now we price a one-period foreign government bond in an analogous way. Let $L_{i,t+1}$ denote the default loss at $t+1$ on a government bond of country i, and $\Lambda_{i,t+1}$ be the liquidity benefit at $t+1$ for holding the bond. Let $\tilde{y}_{it}$ be the hypothetical risk-free rate for currency i.

$$
P_{it} = \exp(-\tilde{y}_{it})\mathbb{E}_t[(1 - L_{i,t+1})(1 + \Lambda_{i,t+1})]
$$

Based on the derivation for the U.S. Treasury yield, we have

$$
y_{it} = \tilde{y}_{i,t} + l_{it} - \lambda_{it} - \xi_{it}.
$$

The hypothetical risk-free rate in currency i, $\tilde{y}_{it}$, is connected to the hypothetical U.S. risk-free rate as follows

$$
\tilde{y}_{it} = \tilde{y}_t^* + \tilde{\rho}_{it}, \qquad (5)
$$

where $\tilde{\rho}_{it}$ is the hypothetical forward premium in a frictionless market given by the CIP relationship for the risk-free rates $\tilde{y}_{it}$ and $\tilde{y}^*_{it}$.

Therefore, we can write the foreign bond yield as

$$y_{it} = \tilde{y}^*_t + \tilde{\rho}_{it} + l_{it} - \lambda_{it} - \xi_{it}. \tag{6}$$

Once again, if the foreign government bond is default-free, we have $l_{it} = 0$ and $\xi_{it} = 0$, so $y_{it} = \tilde{y}^*_t + \tilde{\rho}_{it} - \lambda_{it}$. The foreign yield can differ from the dollar risk-free rate due to currency risk and the liquidity benefit.

2.2.3 Swap Market Frictions

In practice, the hypothetical frictionless forward premium, $\tilde{\rho}_{it}$, is not observed. As shown in Equation 1, the observed forward premium is a combination of interest rate swaps and the cross-currency basis swap,

$$\rho_{it} = irs^i_t + bs^{i/\$}_t - irs^{\$}_t, \tag{7}$$

where irs^i_t and $irs^{\$}_t$ stand for the fixed-for-floating interest rate swaps in currency i and the U.S. dollar, respectively, and $bs^{i/\$}_t$ stands for the cross-currency basis swap exchanging the floating rate in currency i for the U.S. floating rate (U.S. dollar Libor). Frictions in these swap rates can potentially create a wedge between the observed forward premium and the hypothetical forward premium.

We let the hypothetical forward premium in a frictionless market $\tilde{\rho}_{it}$ be the sum of the observed ρ_{it} and a wedge due to swap market frictions, τ_t:

$$\tilde{\rho}_{it} = \rho_{it} + \tau_{it}. \tag{8}$$

By Equation 5, we note that

$$\tau_{it} = \tilde{\rho}_{it} - \rho_{it} = (\tilde{y}_t - \tilde{y}^*_t) - \rho_{it}$$

so τ_{it} is equal to the deviation from the CIP condition.

In lieu of the unobserved hypothetical risk-free rates, $\tilde{y}_t$ and $\tilde{y}_t^*$, interbank rates have long been used as benchmark interest rates to test the CIP condition. Before the GFC, the CIP relationship held very closely for benchmark interbank rates, the swap rate implied by interbank rate differentials were equal to the observed forward premium. However, as documented in Du et al. (Forthcoming), large CIP deviations emerged during the GFC and persisted after the GFC for benchmark interbank rates. Du et al. (Forthcoming) argue the CIP deviations exist due to constraints on the balance sheet capacity of financial intermediaries, and CIP deviations can be viewed as an intermediation fee that financial intermediaries are earning to justify the marginal cost of balance sheet capacity while providing currency hedging. Furthermore, characteristics of CIP deviations remain if we use other interest rate instruments, such as repo rates and overnight index swap rates. In the rest of the paper, we use CIP deviations based on interbank rates to measure τ_{it}, which is equal to the cross-currency basis swap rate bs_{it}. In terms of the directions of the CIP deviations, as shown in Du et al. (Forthcoming), $\tau_{it} > 0$ for the most G10 currencies, except the Australian and New Zealand dollar. Therefore, swap market frictions implied by CIP deviations suggest that the observed forward premium is generally lower than the hypothetical forward premium ($\rho_{it} < \tilde{\rho}_{it}$).

We note that in addition to the CIP deviations, the "negative swap spread" is another fixed-income anomaly that emerged after the GFC (for example, Jermann (2016)). The swap spread is defined as the difference between the the U.S. interest rate swap yield and Treasury yield. The swap spread turned negative at the 30-year tenor during the GFC and has since remained negative. The 5-year and 10-year U.S. swap spread also turned negative in 2015. A negative swap spread implies an arbitrage opportunity,[3] which suggests that the observed U.S. interest rate swap market is higher than the hypothetical swap rate. As can be seen in Equation 7, this mispricing alone tends to push the observed forward premium ρ higher than the hypothetical forward premium $\tilde{\rho}$, which works in the opposite direction of the overall bias in the forward premium implied by CIP deviations. Since the overall bias in the forward premium is what matters for our U.S. Treasury Premium calculation, we do not separately identify mispricing in U.S. interest rate swap markets.

2.2.4 Decomposition

By substituting Equation 8 into Equation 6, we can write the foreign government bond yield as[4]

$$y_{it} = \tilde{y}_t^* + (\rho_{it} + \tau_t) + l_{it} - \lambda_{it} - \xi_{it}.$$

The U.S. Treasury Premium, denoted by Φ, can be decomposed as follows:

$$\begin{aligned}
\Phi_{it} &= y_{it} - \rho_{it} - y_{it}^* \\
&= [\tilde{y}_t^* + (\rho_{it} + \tau_t) + l_{it} - \lambda_{it} - \xi_{it}] - \rho_{it} - (\tilde{y}_t^* + l_t^* - \lambda_t^* - \xi_t^*) \\
&= \tau_t - \hat{l}_{it} + \hat{\lambda}_{it} + \hat{\xi}_{it} \\
&\approx \tau_t - \hat{l}_{it} + \hat{\lambda}_{it},
\end{aligned} \tag{9}$$

where $\hat{x} \equiv x^* - x$. We assume that the difference in the covariances between currency and liquidity risk is negligible, i.e., $\hat{\xi} = 0$. Therefore, the U.S. Treasury Premium can be

[3] To see this, the arbitrageur can purchase a 30-year Treasury bond and finance the purchase by rolling over a three-month repo with the Treasury bond being the collateral. Meanwhile, the arbitrageur can pay the fixed 30-year interest rate swap rate, and receive the floating three-month U.S. Libor. The net cash flow of the arbitrageur is to receive the three-month Libor and to pay the three-month repo rate backed by Treasuries. Since the three-month Libor-repo spread is always positive, the trade involves zero upfront investment and has positive carry throughout the trading horizon, which is a violation of the no-arbitrage condition.

[4] Our theoretical decomposition focuses on the pricing of one-period bonds. We assume the intermediate spread τ_t is known ex ante and do not consider the covariance between the τ_t and λ_{it} entering the spread. However, once we extend to multi-period bond, the covariance between τ_t and λ_{it} could matter for bond pricing.

decomposed into (1) an intermediation spread arising from frictions in the swap market, (2) difference in default risk, and (3) difference in liquidity premium.

To illustrate the effects of each component on the unadjusted premium given by Equation 9, we present two adjusted versions of the U.S. Treasury Premium,

$$\bar{\Phi}_{it} \equiv \Phi_{it} - \tau_t = -\hat{l}_{it} + \hat{\lambda}_{it} \tag{10}$$

$$\tilde{\Phi}_{it} \equiv \Phi_{it} - \tau_t + \hat{l}_{it} = \hat{\lambda}_{it}, \tag{11}$$

where $\bar{\Phi}_{it}$ is the premium adjusted for swap market frictions, and $\tilde{\Phi}_{it}$ is the premium adjusted for both swap market frictions and the credit quality differential between foreign and U.S. Treasuries.

In the absence of CIP deviations ($\tau_t = 0$) or differences in default risk $\left(\hat{l}_{it} = 0\right)$, the unadjusted premium Φ_{it} in Equation 9 caputres the liquidity premium differential $\hat{\lambda}_{it}$. If we aim to capture $\hat{\lambda}_{it}$ but we are concerned about time variation in frictions in the swap market ($\tau_t > 0$), but assume that sovereign bonds in all developed countries are free from default risk $\left(\hat{l}_{it} = 0\right)$, then $\bar{\Phi}_{it}$ in Equation 10 will specifically capture the liquidity component of the U.S. Treasury premium. To measure τ_t, we use CIP deviations based on interbank rates as in in Du et al. (Forthcoming). Finally, if we adjust for time variation in the swap market *and* differences in default risk $\left(\hat{l}_{it} \neq 0\right)$ as measured by CDS spreads,[5] then $\tilde{\Phi}_{it}$ in Equation 11 captures the liquidity premium differential $\hat{\lambda}_{it}$.

2.3 Data Sources

We briefly discuss our data sources. We use Bloomberg BFV curves for government bond yields in the United States and G10 countries; BFV curves are fitted par yield curves based

[5]There is the question of what exactly sovereign CDS spreads capture. G10 Sovereign CDS markets for are not very liquid and Klingler and Lando (2016) show that CDS premium for safe sovereigns are primarily driven by regulatory demand. One alternative assumption is to assume that all sovereigns in the sample are risk-free and therefore, $\hat{l}_t = 0$.

on secondary market bond prices estimated by Bloomberg. We also use Bloomberg data for yields on interest rate swaps and cross-currency basis swaps.

Credit default swap spreads data are from Mark.it and are on senior unsecured credit-default swap contracts denominated in U.S. dollars. They were obtained for the six-month, and one to 10-year contracts. Because data on the 3-month contract is unavailable, we used the six-month contract for the three-month contract instead.

We use two measures of the scarcity of government paper. The first is the ratio of nominal federal debt outstanding to nominal GDP, and the second is the ratio of nominal debt outstanding, net central bank purchases, to nominal GDP. Data on federal debt outstanding and seasonally adjusted nominal GDP are from Haver Analytics. Data on central bank holdings of domestic sovereign debt were hand collected from individual country websites.

We obtain data on policy rates and the CBOE VIX Index from Bloomberg, which we used as regression controls when studying bond supply effects. Finally, we obtain GC repo rates from Thomson Reuters Eikon and BFV curves of government agency bonds from Bloomberg to reconstruct well known convenience yield proxies. Bloomberg and Eikon tickers used in the paper can be found in the Appendix B.

3 The U.S. Treasury Premium: 2000-2016

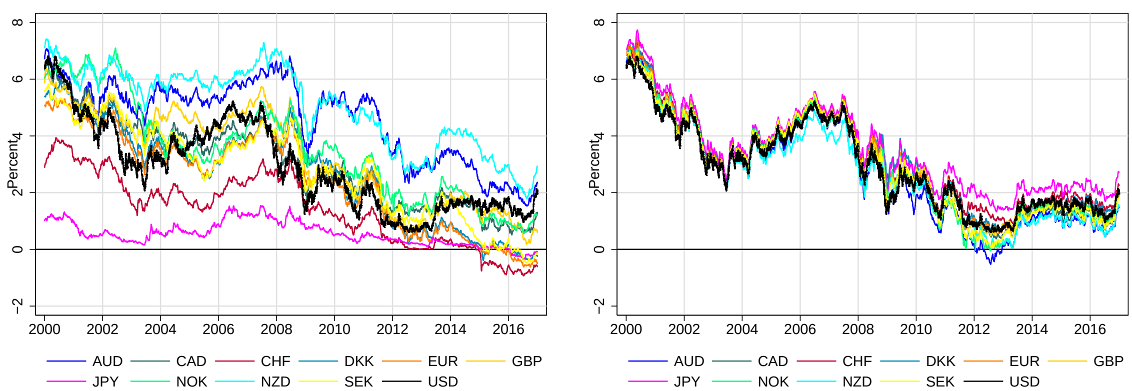
3.1 Main Results

In this section, we present summary statistics and a few stylized facts about the U.S. Treasury Premium.

In Figure 1a, we plot currency-specific nominal yields of our ten country sample at the 5-year horizon. The variation across country is wide. In Figure 1b, we report the swap-implied dollar yields for each country $y_{nt}^{i,\$} = y_{nt}^{i} - \rho_{nt}^{i/USD}$ from combining the five-year bond of country i in its own currency with a fixed-for-fixed cross currency swap to hedge the promised cash-flows from currency i into USD. It is immediately clear that these swap-implied dollar yields track the yield on U.S. treasuries very closely, with significantly less dispersion than currency-specific yields. Our unadjusted U.S. Treasury Premium can be visualized as the spread between these swap-implied dollar yields and the U.S. Treasury yield.

Figure 1: Nominal and Synthetic Dollar Yields

(a) Nominal Yields (b) Synthetic Dollar Yields

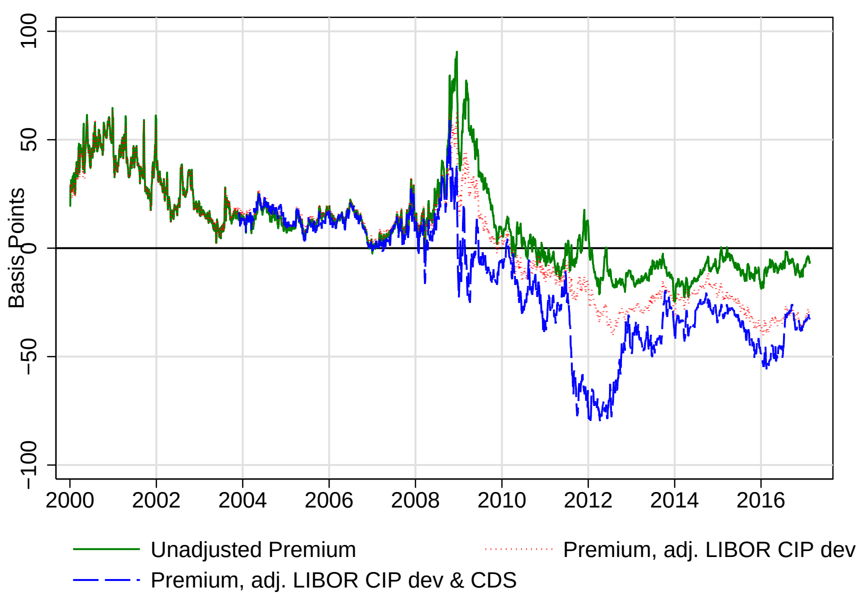


Notes: Figure 1a plots currency-specific yield on five-year government bonds in G10 countries and the United States. Figure 1b plots the five-year synthetic dollar yields on these government bonds after hedging foreign currency risk. Series are seven-day moving averages. EUR refers to Germany.

Figure 2 plots the cross-country mean of the five-year unadjusted premium and two versions of the adjusted premium, as defined in Equations 9-11, respectively. It is easiest to interpret the measures from 2000-2006. During that time, CIP held for interbank rates and sovereign CDS spreads between U.S. and foreign countries were approximately zero. Therefore, the unadjusted and adjusted premia were all equal with the cross-country averages of about 21 basis points. During the GFC (2007-2009), the U.S. Treasury premia generally widened. The unadjusted premium widened most significantly. This, however, is the period in which CIP for interbank rates broke down, and U.S. and foreign sovereign CDS spreads diverged. The two adjusted premia also widened during the GFC, but by significantly less than the unadjusted premium.

In the post-GFC sample (2010-2016), we document a steady decline in the U.S. Treasury Premium. The unadjusted premium trended down to the negative territory in 2010 with the cross-country average at -8 basis points for the 2010-2016 period. The adjusted premium is more negative over that period once we adjust for CIP deviations for interbank rates with an average equal -22 basis points. In other words, if the swap rate was such that the CIP condition for interbank rates held, the U.S. Treasury Premium would be lower. In addition, since the U.S. sovereign CDS spread is lower than the average G10 sovereign CDS spread, the CDS differential adjustment brings down the premium even further to an average -38 basis points in the post-GFC period. Therefore, the decline in the average unadjusted U.S. Treasury Premium post-GFC cannot be attributed to swap market frictions nor to perceived credit quality differentials between the U.S. and foreign sovereigns. Instead, the decline in the premium is driven by a sharp decline in the relative liquidity premium of U.S. Treasuries vis-a-vis foreign Treasuries.

Figure 2: 5-Year Average U.S. Treasury Premium



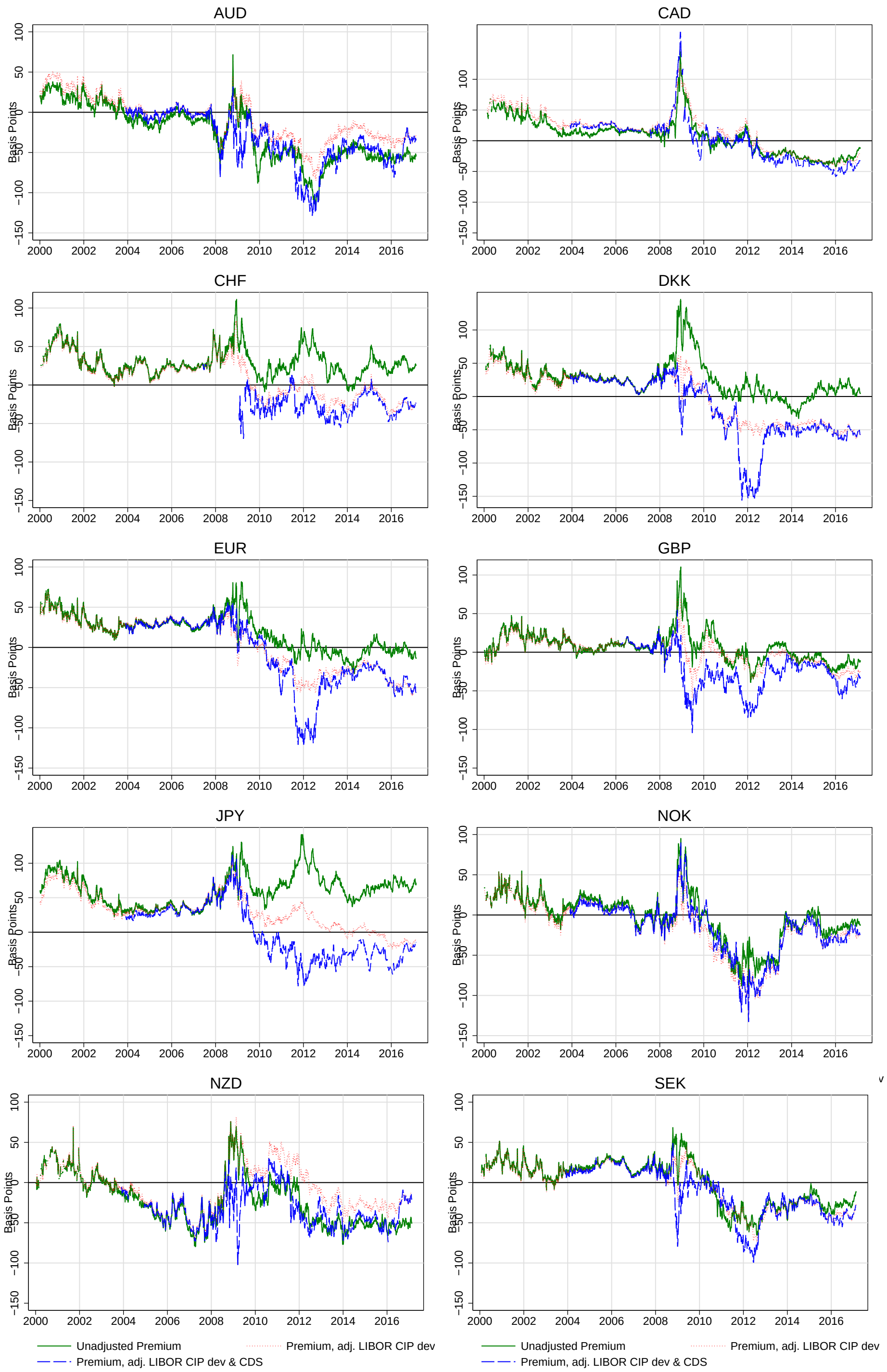
Notes: This figure plots the 5-year U.S. Treasury Premium, averaged across countries. The unadjusted premium (in solid green), the premium adjusted for CIP deviations (in dotted red), and the premium adjusted for CIP deviations and CDS differentials (in dashed blue) are shown from 2000-2016. Series are seven-day moving averages.

Figure 3 shows the three measures by country and Table 1 reports the mean and standard deviations of the unadjusted U.S. Treasury Premium by country.[6] As shown in Table 1, cross-country heterogeneity is large: the U.S. Treasury Premium is highest for Japan with the average equal to 61 basis points and lowest for Australia and New Zealand at about -25 basis points. It also increases in the post-GFC period with the mean increasing to 70 basis points for Japan and -58 basis points for Australia.

In terms of the time variations by country, pre-GFC, the unadjusted premium and adjusted premia are nearly identical for all countries. Broadly, this remains true for Australia, Canada, Norway, Sweden, and New Zealand during and after the GFC, suggesting that for this subset of countries, variations to the unadjusted premia are largely independent of swap market frictions, or credit spread differentials. For Switzerland, Denmark, Europe, and Great Britain, outside the GFC and the European Debt Crisis, the unadjusted premia are generally higher than premia adjusted for CIP deviations. With the adjustment, the premia vis-a-vis this subset of countries falls more precipitously in the post-GFC period, more so when adjusting for both CIP deviations and the CDS spreads. Notably, outside crises, the two adjusted series are very similar; this is unsurprising as CDS spreads are narrow in tranquil periods.

[6] Summary statistics by country of the adjusted premia can be found in Appendix Tables A1 and A2.

Figure 3: 5-Year Average U.S. Treasury Premium by Country



Notes: This figure plots the 5-year U.S. Treasury Premium by country. The unadjusted premium (in solid green), the premium adjusted for CIP deviations (in dotted red), and the premium adjusted for CIP deviations and CDS differentials (in dashed blue) are shown from 2000-2016. Series are seven-day moving averages. EUR refers to Germany.

Table 1: Summary Statistics of 5-Year Unadjusted U.S. Treasury Premium

		Full Sample	2000-2006	2007-2009	2010-2016
AUD	Mean	-24.9***	5.1*	-15.9***	-58.3***
	Std. Error	(4.0)	(2.7)	(6.0)	(2.7)
	N	4406	1797	783	1826
CAD	Mean	7.0**	24.2***	29.4***	-17.8***
	Std. Error	(3.4)	(2.6)	(7.7)	(2.7)
	N	4215	1609	782	1824
CHF	Mean	29.0***	28.6***	40.2***	24.6***
	Std. Error	(2.0)	(2.9)	(4.8)	(2.8)
	N	4186	1603	770	1813
DKK	Mean	25.4***	31.7***	56.5***	6.6***
	Std. Error	(3.2)	(2.1)	(9.8)	(2.4)
	N	4201	1599	776	1826
EUR	Mean	18.6***	32.0***	38.4***	-2.2
	Std. Error	(2.5)	(1.7)	(3.5)	(1.8)
	N	4287	1692	770	1825
GBP	Mean	7.1***	13.1***	21.9***	-4.8*
	Std. Error	(2.2)	(1.6)	(6.3)	(2.6)
	N	4220	1665	775	1780
JPY	Mean	61.1***	50.5***	64.7***	70.0***
	Std. Error	(2.7)	(4.0)	(6.6)	(3.3)
	N	4397	1787	784	1826
NOK	Mean	-4.7	15.1***	12.1*	-28.9***
	Std. Error	(3.5)	(1.9)	(6.6)	(4.1)
	N	4110	1545	772	1793
NZD	Mean	-26.4***	-15.1***	-15.8	-39.1***
	Std. Error	(3.5)	(4.3)	(11.0)	(3.8)
	N	3912	1307	780	1825
SEK	Mean	-0.3	19.6***	24.8***	-28.7***
	Std.Dev.	(3.3)	(1.5)	(3.2)	(2.6)
	N	4235	1630	779	1826
Total	Mean	9.6***	21.3***	25.6***	-7.8***
	Std. Error	(1.4)	(1.3)	(3.2)	(2.2)
	N	42169	16234	7771	18164

Notes: This figure table reports the mean, standard error of the mean based on Newey-West standard errors with a 91-day lag, and number of observations of the 5-year U.S. Treasury Premium by country, and period (pre-GFC (2000-2006), GFC (2007-2009), post-GFC (2010-2016)). Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

Finally, we examine the explanatory power of credit differentials, swap market frictions, and the residual liquidity factor in explaining the total variation in the unadjusted premium.

Table 2 shows panel regression results of changes in the unadjusted premium on changes in swap market frictions and changes in the CDS differential at the daily, weekly, and monthly frequency. The coefficient on the swap market friction, as measured by CIP deviations for the interbank rates, is very close to 1. However, the coefficient on the CDS differential is small and slightly negative, which suggests CDS differentials have a limited role in driving the unadjusted premium. The R^2 of the regressions with both CIP deviations and the CDS spread is 5% at the daily frequency and 25% at the monthly frequency. This implies a large fraction of total variations in the unadjusted premium can be attributed to the residual liquidity factor. To take into account dynamic interactions among these factors, we present results from individual country vector autoregressions (VAR) in the Appendix C.

Table 2: Panel Regression of Changes in the 5-Year Unadjusted U.S. Treasury Premium (Varying Frequencies, 2000-2016)

	(1) $\Delta\Phi_{5Y}$	(2) $\Delta\Phi_{5Y}$	(3) $\Delta\Phi_{5Y}$
$\Delta\tau$	0.983***	1.185***	1.170***
	(0.0581)	(0.0708)	(0.109)
$\Delta\hat{l_i}$	-0.0501***	0.00319	-0.105*
	(0.0191)	(0.0288)	(0.0601)
Constant	-0.00729	-0.0964	-0.502*
	(0.0113)	(0.0636)	(0.282)
Observations	29,004	4,459	1,037
R-squared	0.039	0.188	0.247
Frequency	Daily	Weekly	Monthly

Notes: The table reports results from panel regressions of changes in the 5-year unadjusted treasury premium on changes in the LIBOR CIP deviation, defined as the difference between the swapped foreign interbank rate and the U.S. Libor rate and the CDS differential at the daily, weekly, and monthly frequency. Heteroskedasticity autocorrelation spatial correlation robust standard errors were used with 65 lags at the daily frequency, 13 lags at the weekly frequency, and 3 lags at the monthly frequency. The variable $\Delta\tau$ is changes in LIBOR CIP deviations; and the variable $\Delta\hat{l_i}$ is changes in the CDS differential, defined as the foreign sovereign's CDS spread on a 5-year senior, unsecured contract. Data range from 2005-2016. The unadjusted treasury premium is from the authors' calculations using data from Bloomberg. Data on CIP deviations are from Bloomberg; data on CDS differentials are from Mark.it. Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

3.2 G10 vs. EM Comparison

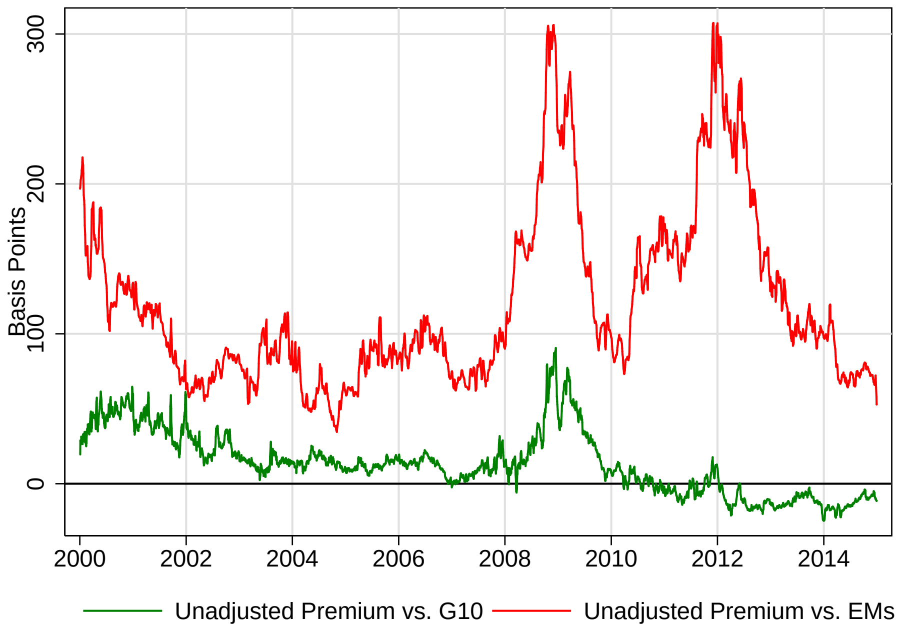
To better understand drivers of the U.S. Treasury Premium, we now compare the measure averaged across G10 currencies to the measure averaged across a set of 13 emerging markets (EMs). Figure 4 plots the U.S. Treasury Premium vis-à-vis G10 countries and the U.S. Treasury Premium vis-a-vis EMs. Unsurprisingly, the average U.S. Treasury Premium vis-à-vis G10 countries is significantly lower than the U.S. Treasury Premium vis-à-vis EMs.[7]

Du and Schreger (2016a) call the U.S. Treasury Premium the "Local Currency Credit Spread" because they argue that it constitutes a credit spread on local currency sovereign debt, and measures the risk that governments explicitly default on debt denominated in their own currency. In the context of G10 currencies, however, we argue that the measure is more akin to a convenience yield. The reason for this significantly different interpretation can be seen in Figure 5. The left panel plots the (unadjusted) mean U.S. Treasury Premium and CDS differential for G10 countries. Other than at the peak of the GFC, we see limited correlation between the measures.[8] Pre-GFC, the CDS differential is approximately zero for G10 countries, but the the U.S. Treasury Premium is positive and sizable. Post-GFC, the average CDS differential between G10 countries and the United States is positive, but the U.S. Treasury Premium is negative. By contrast, in the right panel, we make the same figure for a sample of emerging markets and see very strong co-movement between the unadjusted U.S. Treasury Premium and the CDS Differential, indicating that the premium is capturing fluctuations in default risk.

[7] The included countries are Brazil, Colombia, Hungary, Indonesia, Israel, Mexico, Malaysia, Peru, Poland, Thailand, Turkey South Africa, and South Korea.

[8] Japan is an interesting exception, as can be seen in Appendix Figure A1. The pattern of the strong comovement between the premium and the CDS differential is quite similar to the pattern documented for individual emerging markets in Du and Schreger (2016a). Notably, the credit rating of Japan is the lowest in our sample of sovereigns.

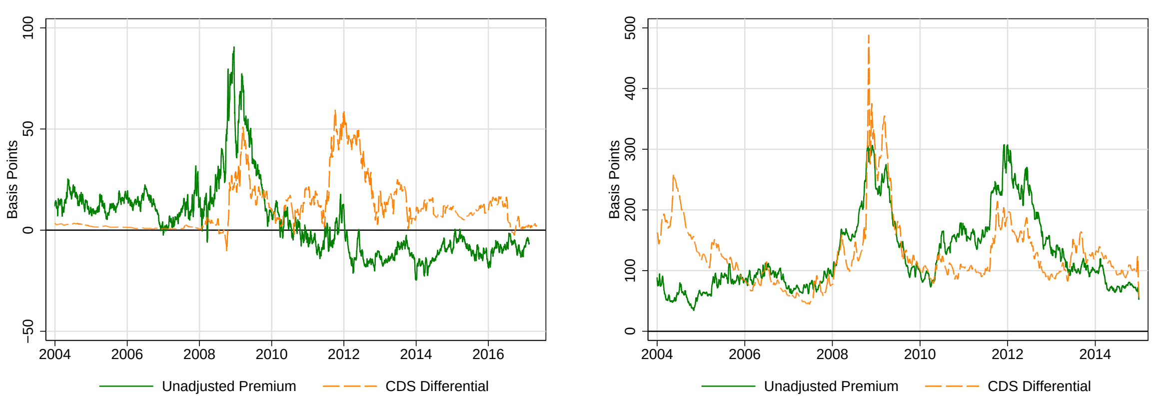
Figure 4: U.S. Treasury Premium vs. EM and G10 countries



Notes: This figure plots seven-day moving averages of cross-sectional mean premium for 13 emerging markets (Brazil, Colombia, Hungary, Indonesia, Israel, Mexico, Malaysia, Peru, Poland, Thailand, Turkey, South Africa, and South Korea) and mean premium for G10 countries.

Figure 5: Components of the 5-Year Unadjusted Treasury Premium

(a) G10 (b) EM



Notes: This figure plots the unadjusted treasury premium (in green), the CDS differential (in orange) for G10s and EMs.

3.3 Term Structure of the U.S. Treasury Premium

Next, we turn our attention to the term structure of the U.S. Treasury Premium. Table 3 presents summary statistics of the unadjusted and adjusted U.S. Treasury Premium by tenors and subsamples. Figure 6 plots the unadjusted premium by maturity. As we can see from Table 3 and Figure 6, before the GFC, the term structure of the U.S. Treasury Premium is upward sloping and the premia are positive across all maturities.

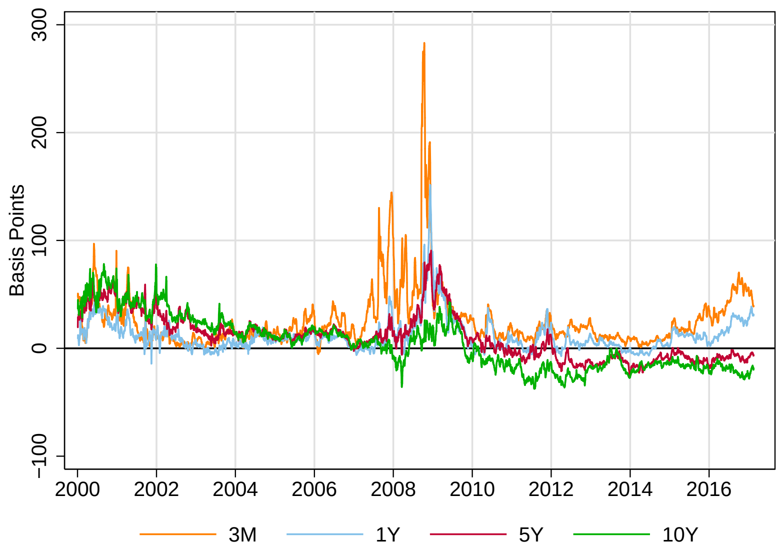
During times of financial stress, such as the Global Financial Crisis, we would expect to see the "flight to safety" phenomenon increase the U.S. Treasury Premium across maturities, with the increase concentrated at shorter maturities as these instruments are seen as closer to cash than long-dated instruments. This is what we observe. During the GFC, the premia increases for all maturities, with the largest increases at short maturities. The cross-country average for the 3-month premium peaks close to 300 basis points during the height of the crisis. The increase in the 10-year premium during the GFC is much more subdued with the highest level only around 50 basis points.

After the GFC, the term structure remains inverted and the 3-month, 1-year, 5-year, and 10-year premia are no longer strongly correlated, nor of the same sign. Post-GFC, the 3-month and 1-year premia are positive and have been trending up; meanwhile, the 5-year and 10-year premia have been negative and approximately flat. Strikingly, the 3-month and 1-year premia begin their upward trend in 2014, rising from nearly 0 basis points to 70 basis points.

The inversion of the term structure of the U.S. Treasury Premium also holds for the premia adjusted for swap market frictions and credit spread differentials. Figure 7 plots the term spread of the U.S. Treasury Premium, which we define as the 10-year premium minus the 1-year premium, for the unadjusted premium and the adjusted premia. The term spread becomes negative for all three premium measures post-GFC.

Therefore, we find that even though medium- to-long-term U.S. Treasuries have lost their specialness relative to other near-default-free government bonds since the GFC, shortdated U.S. Treasury bills still command a sizable premium. The liquidity premium of U.S. Treasuries has shifted from long to short maturities. This "liquidity shift" is consistent with the increased demand for high-quality liquid assets particularly in U.S. dollars, following the GFC.

Figure 6: The Unadjusted U.S. Treasury Premium, by Maturity



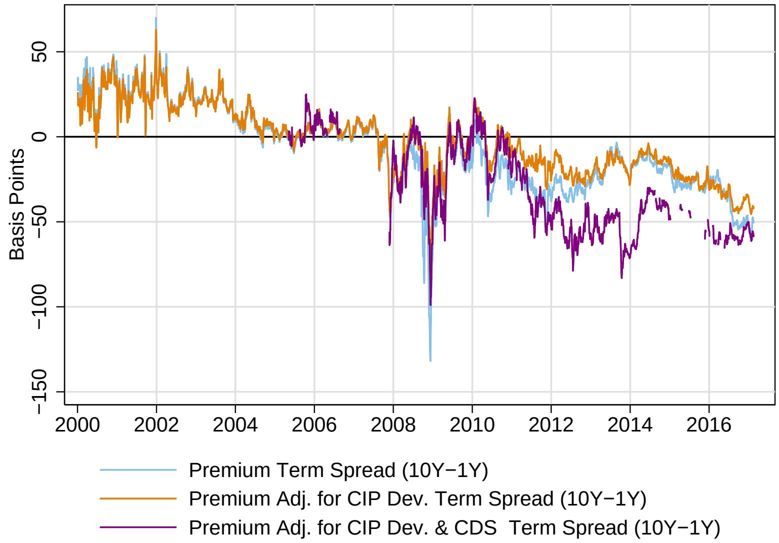
Notes: This figure plots the unadjusted U.S. Treasury Premium at the 3-month horizon (in orange), the 1-year horizon (in blue), the 5-year horizon (in red), and the 10-year horizon (in green) from 2000-2016.

Table 3: Average U.S. Treasury Premium by Tenor and Period

		Unadjusted Premium				Premium Adj. CIP Deviations				Premium Adj. for CIP Dev. and CDS Diff.			
		Full	00-06	07-09	10-16	Full	00-06	07-09	10-16	Full	00-06	07-09	10-16
3M	Mean	25.9***	18.5***	58.8***	19.3***	12.2***	15.9***	37.4***	-2.2	3.0	12.6	21.2***	-2.0
	SE	(1.2)	(1.1)	(4.2)	(1.6)	(1.1)	(1.0)	(3.7)	(1.3)	(2.2)	(8.1)	(6.8)	(2.1)
	N	42,314	17,425	7,433	17,456	42,314	17,425	7,433	17,456	14,569	615	2,752	11,202
1Y	Mean	11.4***	9.7***	24.5***	7.3***	0.5	9.9***	9.7***	-11.3***	-8.9***	7.479	-0.776	-13.4***
	SE	(1.1)	(1.1)	(3.5)	(1.6)	(1.0)	(1.0)	(3.0)	(1.3)	(1.7)	(4.8)	(4.2)	(1.8)
	N	40,717	15,064	7,684	17,969	40,717	15,064	7,684	17,969	18,135	1,303	4,314	12,518
5Y	Mean	9.6***	21.3***	25.6***	-7.8***	2.0*	22.0***	17.4***	-22.4***	-18.2***	13.1***	5.0	-38.1***
	SE	(1.4)	(1.3)	(3.2)	(2.2)	(1.2)	(1.2)	(2.5)	(1.4)	(1.6)	(1.9)	(3.1)	(1.5)
	N	42,169	16,234	7,771	18,164	42,169	16,234	7,771	18,164	30,490	5,928	7,005	17,557
10Y	Mean	3.5**	24.8***	6.4**	-18.1***	-2.1	24.9***	0.3	-29.0***	-35.1***	12.2***	-13.2***	-55.2***
	Std. Error	(1.6)	(1.6)	(2.7)	(2.6)	(1.3)	(1.4)	(2.4)	(1.5)	(1.9)	(2.5)	(3.2)	(1.7)
	N	41,082	16,264	7,746	17,072	41,082	16,264	7,746	17,072	26,496	4,057	6,162	16,277

Notes: This table reports the mean, standard error of the mean based on Newey-West standard errors with a 90-day lag, and number of observations of the unadjusted premium (rows 1-3), premium adjusted for CIP deviations (rows 4-6), and the premium adjusted for CIP deviations and CDS differentials (rows 7-9) across the following tenors: 3-month, 1-year, 5-year, and 10-year, and the following periods: full sample (2000-2016), pre-GFC (2000-2006), GFC (2007-2009), and post-GFC (2010-2016). Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

Figure 7: Term spread of the Unadjusted U.S. Treasury Premium



Notes: This figure plots the spread between the 10-year and 1-year premium for the unadjusted U.S. Treasury Premium (in blue), for the U.S. Treasury Premium adjusted for CIP deviations (in orange), for the U.S. Treasury Premium adjusted for CIP deviations and CDS differentials (in purple).

4 Relationship with Other Convenience Yield Measures

In this section, we examine the relationship between U.S. Treasury Premium and existing measures of the safety and liquidity component of the convenience yield.

4.1 Short-term premium comparison

A measure of convenience in the 3-month market for Treasuries is the General Collateral (GC) Repo-Treasury Bill spread, defined as the spread between the 3-month Treasury GC Repo rate and a 3-month T-Bill yield. Like a Treasury security, a Treasury GC repo is free of credit risk as it is secured by Treasuries. However, repos are not as liquid as Treasury bills because the money is always lent for term (Nagel (2016)); thus, the GC Repo-Treasury Bill spread mainly captures the liquidity premium of Treasury bills.

Since our unadjusted U.S. Treasury Premium is vis-a-vis another country, if it is being driven by a liquidity component, that component should be a relative measure of the U.S.

Treasury market vis-a-vis the Treasury market of a foreign sovereign. The closest approximation of this is the difference in the 3-month GC Repo rate-TBill spread for the United States Treasuries, and the foreign country's Treasuries.

This motivates the following set of regressions to estimate the liquidity component of the 3-month Treasury premium:[9]

$$\underline{\Phi}_{3M,t} = \alpha + \beta \cdot RT_{USD,3M,t} + \epsilon_t$$
$$\Phi_{i,3M,t} = \alpha + \beta \cdot RT_{USD,3M,t} + \gamma \cdot RT_{i,3M,t} + \epsilon_t, \; i \in \{EUR, JPY\},$$

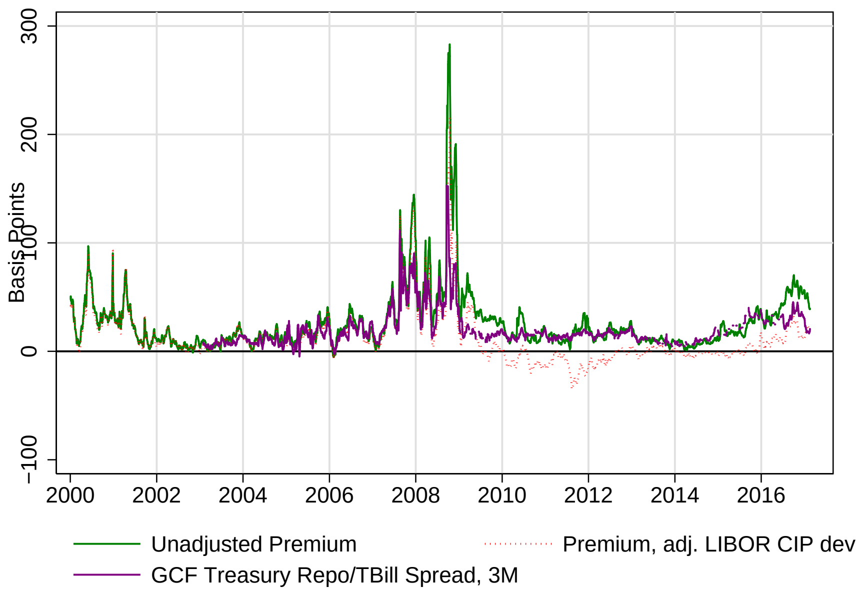
where $\underline{\Phi}_{3M,t}$ denotes the cross-country average of the 3-month unadjusted U.S. Treasury Premium; $RT_{USD,3M}$ is the 3-month GC repo-TBill spread for the United States; $RT_{EUR,3M}$ is the 3-month GC repo-TBill spread for Germany ; $RT_{JPY,3M}$ is the 3-month GC repo-TBill spread for Japan. We run these regressions in levels and changes at the weekly frequency in Table 4 with changes denoted as Δ . This exercise is restricted to Germany andJapan because of lack of good data on GC repo rates in other countries in our sample.

Regression results in levels are reported in the first three columns of Table 4 whereas regression results in differences are reported in the next three columns. In the first regression in levels, $RT_{USD,3M}$ enters with a highly significant coefficient of 1.726 and with the constant, explains 75% of the variation in the Treasury Premium. In the second and third regressions in levels, $RT_{USD,3M}$ enters with a highly significant coefficient of 1.635 and 2.362, respectively. This supports our hypothesis that when the liquidity of the U.S. Treasuries market is high, so is the U.S. Treasury Premium. The country-specific liquidity variables enter in as negative and insignificant in the levels regression for Japan and Germany. The regressions in first differences are broadly consistent with the regressions in levels, and supports the notion that our U.S. Treasury Premium is, at the 3-month horizon, a relative measure of the liquidity of U.S. Treasury bills vis-a-vis foreign Treasury bills. When estimated in first differences,

[9] Throughout the paper, we follow Driscoll and Kraay (1998) and to calculate heteroskedasticity autocorrelation spatial correlation robust standard errors.

however, increases the EUR and JPY GC-Repo are associated with statistically significant declines in the bilateral U.S Treasury Premium. Figure 6 plots the average U.S. Treasury Premium and the GC-repo-Tbill spread at the three-month maturity to make clear just how closely the two measures co-move.

Figure 8: Three-month Average Unadjusted U.S. Treasury Premium vs. Repo-Tbill Spread



Notes: This figure plots the average three-month Treasury premium (unadjusted and adjusted for CIP deviations) and the three-month U.S. GCF Treasury repo and T-bill spread.

Table 4: The 3-month Unadjusted Treasury Premium and the GC repo-Tbill spread (Weekly Frequency, 2000-2016)

	(1)	(2)	(3)	(4)	(5)	(6)
	$\underline{\Phi}_{3M}$	$\Phi_{EUR,3M}$	$\Phi_{JPY,3M}$	$\Delta\underline{\Phi}_{3M}$	$\Delta\Phi_{EUR,3M}$	$\Delta\Phi_{JPY,3M}$
$RT_{USD,3M}$	1.726***	1.635***	2.362***			
	(0.229)	(0.156)	(0.249)			
$RT_{EUR,3M}$		-0.00290				
		(0.0835)				
$RT_{JPY,3M}$			-0.840			
			(0.523)			
$\Delta RT_{USD,3M}$				0.822***	0.916***	1.215***
				(0.238)	(0.295)	(0.219)
$\Delta RT_{EUR,3M}$					-0.198*	
					(0.117)	
$\Delta RT_{JPY,3M}$						-1.393**
						(0.551)
Constant	3.184	-6.201	7.573*	0.0121	-0.0805	0.0986
	(3.534)	(4.318)	(4.511)	(0.338)	(0.387)	(0.675)
Observations	631	444	384	582	395	335
R-squared	0.745	0.803	0.723	0.368	0.428	0.350

Notes: This table reports the regression results of the level of the 3-month unadjusted treasury premium on liquidity measures of the country's and United States' 3-month treasury bills. Standard errors are heteroskedasticity autocorrelation spatial correlation robust with a 13 week lag. The first column reports on the regression of the 3-month, unadjusted treasury premium averaged across countries, $\underline{\Phi}$, on our measure of U.S. treasury liquidity at the 3-month horizon $RT^{Repo/Tbill}_{USD,3M}$, which is the spread between a 3-month Treasury repo and the 3-month U.S. T- bill. The same regression in differences is reported in the fourth column. The second column reports on the regression of the 3-month, unadjusted treasury premium vis-a-vis Germany $\Phi_{EUR,3M}$ on the measure of U.S. treasury liquidity at the 3-month horizon $RT^{Repo/Tbill}_{USD,3M}$ and German treasury liquidity at the 3-month horizon $RT^{Repo/Tbill}_{EUR,3M}$, which is the spread between the 3-month repo rate on German treasuries and the rate on a German T-bill. The same regression in differences is reported in the fifth column. The third column reports on the regression of the 3-month, unadjusted treasury premium vis-a-vis Japan $\Phi_{JPY,3M}$ on the measure of U.S. treasury liquidity at the 3-month horizon and Japanese treasury liquidity at the 3-month horizon $RT^{Repo/Tbill}_{JPY,3M}$, which is the spread between the 3-month repo rate on Japanese treasuries and the rate on a Japanese T-Bill. The same regression in differences is reported in the sixth column. All data are at the weekly frequency and span 2000-2016. The unadjusted treasury premium is from the authors' calculations using data from Bloomberg. The liquidity measures $RT^{Repo/Tbill}_{USD,3M}$, $RT^{Repo/Tbill}_{EUR,3M}$, $RT^{Repo/Tbill}_{JPY,3M}$ were computed by the authors. Three-month GCF rates are from Thomson Reuters Eikon. Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

4.2 Long-term Premium

At medium to long maturities, a conventional measure of convenience for U.S. Treasuries is the spread between yields on near risk-free agency debt and Treasuries from the same country. For the United States, this is the spread between yields on Refcorp coupon strips and Treasury strips, which are both guaranteed by the U.S. government and subject to the same taxation (Negro et al., 2017; Fleckenstein et al., 2014). The time series behavior of the Refcorp-Treasury spread differs substantially from the cross-country average U.S. Treasury Premium as can be seen in Figure 9. Most strikingly, during and after the GFC, the two measures have opposite signs. This difference highlights how our measure is different from those in the literature. Our measure is an *inter*-sovereign measure that measures the specialness of U.S. Treasuries relative to other sovereigns whereas the Refco-Treasury spread is an *intra*-sovereign measure that measures the Treasury spread relative to government-guaranteed debt.[10]

We conduct an exercise similar to the Repo-Tbill regressions at the 3-month tenor, but -for long-term bonds. In addition to looking at the Refcorp-Treasury spread, we look at the comparable analogues for European and Japan with their agency-sovereign spread. We run the following set of regressions:

$$
\begin{aligned}
\underline{\Phi}_{5Y,t} &= \alpha + \beta \cdot AT_{USD,5Y,t} + \epsilon_t \\
\Phi_{i,5Y,t} &= \alpha + \beta \cdot AT_{USD,5Y,t} + \gamma \cdot AT_{i,5M,t} + \epsilon_t, \; i \in \{EUR, JPY\},
\end{aligned}
$$

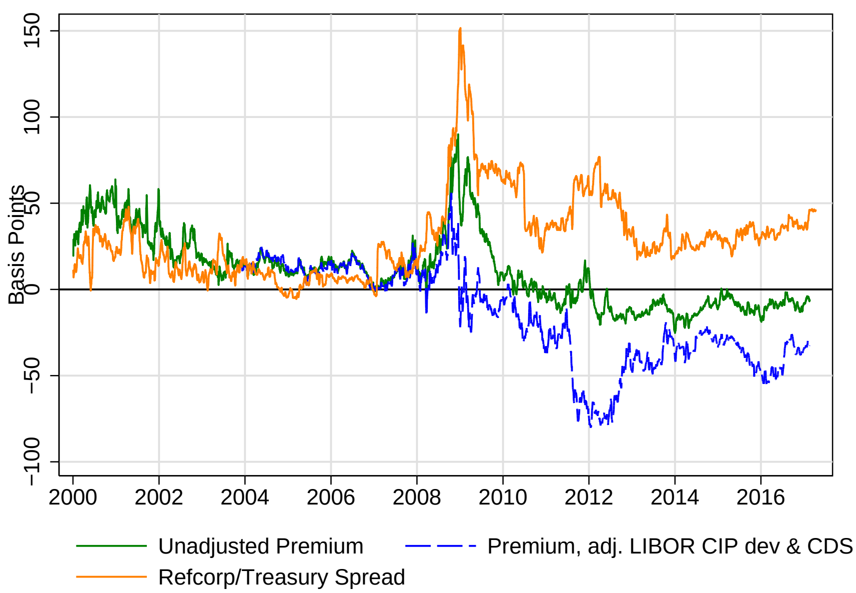
where $\underline{\Phi}_{5Y,t}$ denotes the cross-country average of the 5-year unadjusted premium and $AT_{i,5Y,t}$ denotes the 5-year agency-Treasury spread for country i.

We run the specifications in both levels and first differences, using Δ to indicate weekly changes. Table 5 presents the results. The regression in levels suggests thats higher Agency-

[10] Treasury premia measures used by Krishnamurthy and Vissing-Jorgensen (2012) and Negro et al. (2017) are similarly intra-sovereign measures. The former uses the spread between Aaa-rated corporate bonds and U.S. Treasuries of similar maturity; the latter, a transform of the first principal component of 18 different financial market spreads between U.S. assets).

Treasury spreads in the US are associated with a higher average U.S. Treasury Premium and a higher bilateral premium with Japan. However, the country-specific Agency-Treasury spreads enter insignificantly. In first differences, changes in the US Agency-Treasury spread always enters insignificantly, although increases in the EUR Agency-Treasury spread is associated with a reduction in the bilateral U.S. Treasury Premium with respect to EUR. Another important takeaway from these regressions is the much lower R^2 in these latter 3 regressions relative to those at the 3-month horizon in Table 4. Whereas changes in the US and country-specific repo spreads explained 32% of the change in the average premium and 1% and 45% of the Euro and Japanese Yen premia respectively, in this case the R^2 fall to 0.4%, 5.1% and 0.1%. In other words, while standard Treasury convenience yield measures appear to capture a large fraction of the U.S. Treasury Premium at short tenors, similar measures explain very little of the variation in the long-term premia.

Figure 9: Five-Year Average Unadjusted U.S. Treasury Premium vs. Refcorp-Treasury spread



Notes: This figure plots the unadjusted 5-year Treasury premium averaged across currencies (in solid green), the 5-year treasury premium adjusted for CIP deviations and CDS differentials (in dashed blue), and the spread between a 5-year Refcorp strip and a 5-year U.S. Treasury strip (in solid orange) from 2000-2016.

Table 5: Regressions of the 5-year Unadjusted Treasury Premium on the Agency-Sovereign Spread (Weekly Frequency, 2000-2016)

	(1) $\underline{\Phi}_{5Y,t}$	(2) $\Phi_{EUR,5Y}$	(3) $\Phi_{JPY,5Y}$	(4) $\Delta\bar{\Phi}_{5YR}$	(5) $\Delta\Phi_{EUR,5Y}$	(6) $\Delta\Phi_{JPY,5Y}$
$AT_{USD,5Y}$	0.338***	0.107	0.611***			
	(0.0625)	(0.148)	(0.111)			
$AT_{EUR,5Y}$		-0.0447				
		(0.0663)				
$AT_{JPY,5Y}$			-0.0587			
			(0.327)			
$\Delta AT_{USD,5Y}$				0.0741	0.103	0.0285
				(0.0780)	(0.0906)	(0.0585)
$\Delta AT_{EUR,5Y}$					-0.312**	
					(0.126)	
$\Delta AT_{JPY,5Y}$						-0.106
						(0.149)
Constant	26.24***	12.69***	40.66***	-0.00333	-0.0592	0.0573
	(2.014)	(4.467)	(4.082)	(0.144)	(0.156)	(0.172)
Observations	676	676	676	675	675	675
R-squared	0.324	0.010	0.450	0.004	0.051	0.001

Notes: This table reports regression results of the level of 5-year unadjusted treasury premium $\Phi_{i,5Y}$ on liquidity measures of the country's and United States' 5-year treasuries. Standard errors are heteroskedasticity autocorrelation spatial correlation robust with a 13 week lag. The first column reports on the regression of the 5-year, unadjusted treasury premium averaged across countries $\underline{\Phi}_{5Y,t}$ on our measure of U.S. treasury liquidity at the 5-year horizon $AT_{USD,5Y}$, which is the spread between a 5-year Refcorp strip and a 5-year U.S. Treasury strip. The same regression in differences is reported in the fourth column. The second column reports on the regression of the 5-year, unadjusted treasury premium vis-a-vis Germany $\Phi_{EUR,5Y}$ on the measure of U.S. treasury liquidity at the 5-year horizon $AT_{USD,5Y}$ and German treasury liquidity at the 5-year horizon $AT_{EUR,5Y}$, which is the spread between rates on a German government agency obligation, and a 5-year German treasury. The same regression in differences is reported in the fifth column. The third column reports on the regression of the 5-year, unadjusted treasury premium vis-a-vis Japan $\Phi_{JPY,5Y}$ on the measure of U.S. treasury liquidity $AT_{USD,5Y}$ and Japanese treasury liquidity at the 5-year horizon $AT_{JPY,5Y}$, which is the spread between rates on a 5-year Japan government agency obligation and a 5-year Japanese treasury. The same regression in differences is reported in the sixth column. All data are at the weekly frequency and span 2000-2016. The unadjusted treasury premium is from the authors' calculations using data from Bloomberg; $AT_{USD,5Y}$, $AT_{EUR,5Y}$, $AT_{JPY,5Y}$, are from the authors' calculations using Bloomberg's BFV curves. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

5 Bond Supply and the U.S. Treasury Premium

In this section, we test for a relationship between our measure of the U.S. Treasury Premium and the relative scarcity of sovereign debt in the U.S. vis-a-vis the countries in our sample. We proxy for the scarcity of sovereign debt by taking the ratio of the quantity of outstanding federal debt excluding central bank holdings to seasonally-adjusted nominal GDP.[11] This analysis builds on the work of Krishnamurthy and Vissing-Jorgensen (2012) that finds that the U.S. public debt to GDP ratio is inversely related to the convenience yield on U.S. Treasuries. Because our measure is intended to capture the premium of U.S. Treasuries relative to other safe sovereign debt, we will look at the supply of debt for both the U.S. and other countries.

Our general regression framework is given by:

$$\Phi_{it} = \alpha + \beta \cdot \log \left(\frac{debt}{GDP} \right)_t^{US} + \gamma \cdot \log \left(\frac{debt}{GDP} \right)_{it} + \zeta \cdot X_{it} + \epsilon_{it}, \tag{12}$$

where $\log \left(\frac{debt}{GDP} \right)_t^{US}$ is the log of the U.S. debt to GDP ratio at time t, $\log \left(\frac{debt}{GDP} \right)_{it}$ is the log of country i's debt to GDP ratio at time t, and X_{it} is a set of additional covariates motivated by Nagel (2016). In particular, X_{it} includes the U.S. Policy Rate (the Federal Funds rate), the country i policy rate, and the VIX, which is the CBOE Volatility Index and measures the market expectation of 30-day volatility in the S&P 500. In columns 1-4, we estimate the regressions in levels, and in columns 5-8 we estimate the regressions in changes at the quarterly freuqency. In the even numbered columns, we include country fixed effects and in the odd number columns we omit these fixed effects.

In column 1 of Table 6, we omit country fixed effects and any controls and include only the debt variables. We find that a 1 log point increase in the U.S. debt to GDP ratio is associated with a 0.72 basis point fall in the U.S. Treasury Premium. By contrast, a 1 log point increase in the foreign country debt-to-GDP ratio is associated with a 0.29 basis point

[11] We conduct the same analysis without netting out central bank holdings in Appendix Table A3 and find similar results.

higher U.S. Treasury Premium. Therefore, the initial specification is consistent with the idea that the relative supply of government debt affects the U.S. Treasury Premium. In column 2, we include country fixed effects and the effect of the individual country debt/GDP ratio disappears. In other words, the coefficient in column 1 is driven by differences in between country means. In columns 3 and 4, we rerun the regressions in columns 1 and 2 but include the additional covariates. The U.S. policy rate and VIX enter statistically significantly–the latter result being consistent with "flight to safety" to U.S. Treasuries during times of high global risk aversion. The coefficient on the U.S. debt-to-GDP ratio is quantitatively similar across specifications. In columns 5-8, we estimate the same regressions in first differences and examine whether changes in the debt GDP levels are associated with changes in the U.S. Treasury Premium. One potential concern with these regressions is that quarterly changes in debt ratios can be quite noisy. Indeed, the results of these regression are qualitatively similar to columns 1-4, but the standard errors are much larger and many of the coefficients lose statistical significance.

Taken together, these regressions show that the U.S. Treasury Premium co-moves with the relative supply of government debt, which suggests downward sloping demand functions for these debt securities. When the supply of U.S. Treasuries becomes higher or the supply of foreign government bonds becomes lower, the value that investors assign to the liquidity and safety premia of U.S. Treasuries relative to foreign bonds decreases.[12]

[12]However, our results should be cautiously interpreted. Our debt-to-gdp ratio is of total outstanding federal debt to nominal debt, and is not maturity specific. However, our convenience yield measure is. We do not find a significant effect of relative bond supply on the 3-month Treasury Premium.

Table 6: Effects of Government Bond Supply on the U.S. Treasury Premium, Net Central Bank QE Purchases (Quarterly Frequency, 2000-2016)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Φ_{5Y}	Φ_{5Y}	Φ_{5Y}	Φ_{5Y}	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$
$\log\left(\frac{debt}{GDP}\right)^{US}$	-71.76***	-64.28***	-75.18***	-51.15***				
	(8.966)	(9.458)	(13.17)	(12.11)				
$\log\left(\frac{debt}{GDP}\right)_i$	29.06***	1.735	17.51***	2.616				
	(2.905)	(6.549)	(3.043)	(4.820)				
Policy Rate			-0.0801***	-0.0160				
			(0.0120)	(0.0164)				
U.S. Policy Rate			0.0465***	0.0238*				
			(0.00947)	(0.0123)				
VIX			0.0139***	0.0117***				
			(0.00315)	(0.00312)				
$\Delta\log\left(\frac{debt}{GDP}\right)^{US}$					-64.00	-64.20	-104.6*	-104.9*
					(62.92)	(62.94)	(54.74)	(54.82)
$\Delta\log\left(\frac{debt}{GDP}\right)_i$					18.02**	18.28**	11.10	11.17
					(7.867)	(8.140)	(8.215)	(8.528)
Δ Policy Rate							-0.0544***	-0.0547***
							(0.0120)	(0.0121)
Δ U.S. Policy Rate							-4.38e-05	4.37e-05
							(0.0169)	(0.0168)
Δ VIX							0.00490***	0.00491***
							(0.00173)	(0.00173)
Constant	19.21***	-41.70***	-11.75*	-57.50***	-0.193	-0.908	-0.101	-0.763
	(3.865)	(11.99)	(6.640)	(11.59)	(0.735)	(1.071)	(0.773)	(1.045)
Observations	670	670	670	670	660	660	660	660
R-squared	0.383	0.633	0.552	0.690	0.008	0.009	0.075	0.075
Country FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports panel regression results of the level and differences of the 5-year unadjusted treasury premium on country level and U.S. variables that proxy for the scarcity of government bonds. Heteroskedasticity autocorrelation spatial correlation robust standard errors were used with a 8 quarter lag. The variable $\log\left(\frac{debt}{GDP}\right)_i$ is the ratio of the country's federal debt, net central bank holdings, to nominal GDP and the variable $\log\left(\frac{debt}{GDP}\right)^{US}$ is the ratio of the United States' federal debt, net central bank holdings, to nominal GDP. The variable Policy Rate is the country-specific policy rate, the variable U.S. Policy Rate is the U.S. policy rate–the Federal Funds rate, and the VIX is the CBOE Volatility Index. All data are at the quarterly frequency and span 2000-2016. The unadjusted treasury premium is from the authors' calculations using data from Bloomberg. Data on federal debt and nominal GDP are from Haver Analytics; data on central bank holdings of domestic debt are from national websites; data on policy rates and the VIX are from Bloomberg. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

6 Conclusion

We construct a new measure of the the convenience yield of U.S. Treasuries relative to other near default-free foreign government bonds. We find that prior to the Global Financial Crisis, U.S. Treasuries were quite special and earned a 21 basis point premium at the five-year horizon. Following the crisis, medium and long-term U.S. Treasuries have lost their specialness relative to the government bonds of sovereigns of comparable credit. This change has occurred even as U.S. Treasuries have become more special relative to safe U.S. corporates and agencies, as measured by the widening of spreads like the U.S. Agency-Treasury spread. In contrast, short-term U.S. Treasury bills have retained their specialness after the Great Financial Crisis.

References

Avdjiev, S., W. Du, C. Koch, and H. S. Shin (2016): "The dollar, bank leverage and the deviation from covered interest parity," .

Codogno, L., C. Favero, A. Missale, R. Portes, and M. Thum (2003): "Yield Spreads on EMU Government Bonds," *Economic Policy*, 18, 503–532.

Curcuru, S. E., T. Dvorak, and F. E. Warnock (2008): "Cross-Border Returns Differentials," *Quarterly Journal of Economics*, 123, 1495–1530.

Driscoll, J. C. and A. C. Kraay (1998): "Consistent covariance matrix estimation with spatially dependent panel data," *Review of economics and statistics*, 80, 549–560.

Du, W. and J. Schreger (2016a): "Local Currency Sovereign Risk," *Journal of Finance*, 71, 1027–1070.

——— (2016b): "Sovereign risk, currency risk, and corporate balance sheets," *HBS Working Paper No. 17-024*.

Du, W., A. Tepper, and A. Verdelhan (Forthcoming): "Deviations from Covered Interest Rate Parity," *Journal of Finance*.

Engel, C. (2016): "Exchange rates, interest rates, and the risk premium," *The American Economic Review*, 106, 436–474.

Feldhütter, P. and D. Lando (2008): "Decomposing swap spreads," *Journal of Financial Economics*, 88, 375–405.

Fleckenstein, M., F. A. Longstaff, and H. Lustig (2014): "The TIPS-Treasury Bond Puzzle," *Journal of Finance*, 69, 2151–2197.

Gourinchas, P.-O. and H. Rey (2007a): "From world banker to world venture capitalist: US external adjustment and the exorbitant privilege," in *G7 Current Account Imbalances: Sustainability and Adjustment*, University of Chicago Press, 11–66.

——— (2007b): "International Financial Adjustment," *Journal of Political Economy*, 115, 665–703.

Gourinchas, P.-O., H. Rey, N. Govillot, et al. (2010): "Exorbitant privilege and exorbitant duty," Tech. rep., Institute for Monetary and Economic Studies, Bank of Japan.

Greenwood, R., S. G. Hanson, and J. C. Stein (2015): "A Comparative-Advantage Approach to Government Debt Maturity," *The Journal of Finance*, 70, 1683–1722.

Hofmann, B., I. Shim, and H. S. Shin (2016): "Sovereign yields and the risk-taking channel of currency appreciation," *No. 538, BIS Working Papers, Bank for International Settlements.*

Itskhoki, O. and D. Mukhin (2017): "Exchange rate disconnect in general equilibrium," *National Bureau of Economic Research Working Paper.*

Ivashina, V., D. S. Scharfstein, and J. C. Stein. (2015): "Dollar Funding and the Lending Behavior of Global Banks," *Quarterly Journal of Economics*, 130, 1241–1281.

Jermann, U. J. (2016): "Negative Swap Spreads and Limited Arbitrage," *Available at SSRN.*

Klingler, S. and D. Lando (2016): "Safe-Haven CDS Premiums," *Working Paper, Copenhagen Business School.*

Krishnamurthy, A. and A. Vissing-Jorgensen (2012): "The Aggregate Demand for Treasury Debt," *Journal of Political Economy*, 120, 233–267.

Liao, G. Y. (2016): "Credit Migration and Covered Interest Rate Parity," *Working Paper, Harvard Business School.*

Maggiori, M. (Forthcoming): "Financial intermediation, International Risk Sharing, and Reserve Currencies," *American Economic Review*.

Maggiori, M. et al. (2013): "The US dollar safety premium," *Unpublished working paper. Harvard University*.

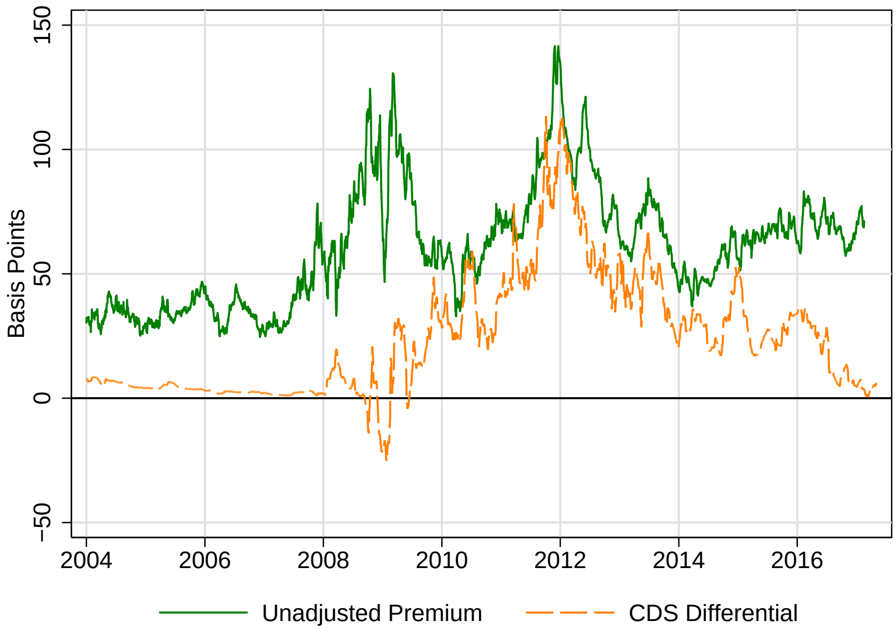
Nagel, S. (2016): "The Liquidity Premium of Near-Money Assets," *Quarterly Journal of Economics*, 131, 1927–1971.

Negro, M. D., G. Eggertsson, A. Ferrero, and N. Kiyotaki (2017): "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities," *American Economic Review*, 107, 824–857.

Valchev, R. (2016): "Bond Convenience Yields and Exchange Rate Dynamics," *Sloan Foundation Economics Research Paper Forthcoming*.

A Appendix Tables and Figures

Figure A1: Japan: U.S. Treasury Premium vs. CDS Differential



Notes: This figure plots 7-day moving averages of the unadjusted U.S. Treasury Premium against Japan and the Japan-US sovereign CDS Differential.

Table A1: Summary Statistics of the 5-year U.S. Treasury Premium Adjusted for CIP Deviations in LIBOR

		Full Sample	2000-2006	2007-2009	2010-2016
AUD	Mean	-9.2***	14.6***	-6.6	-33.8***
	Std. Error	(3.2)	(2.9)	(5.0)	(2.5)
	N	4406	1797	783	1826
CAD	Mean	14.8***	34.9***	40.3***	-13.9***
	Std. Error	(3.9)	(2.7)	(7.9)	(3.7)
	N	4215	1609	782	1824
CHF	Mean	8.4***	26.4***	27.5***	-15.6***
	Std. Error	(3.1)	(2.8)	(5.1)	(2.1)
	N	4186	1603	770	1813
DKK	Mean	-1.8	29.1***	26.3***	-40.8***
	Std. Error	(4.3)	(1.9)	(2.8)	(2.2)
	N	4201	1599	776	1826
EUR	Mean	3.5	32.0***	23.4***	-31.4***
	Std. Error	(3.9)	(1.5)	(3.4)	(2.4)
	N	4287	1692	770	1825
GBP	Mean	0.8	12.2***	4.7	-11.7***
	Std. Error	(1.9)	(1.4)	(5.0)	(2.2)
	N	4220	1665	775	1780
JPY	Mean	30.6***	45.2***	51.3***	7.3**
	Std. Error	(3.1)	(3.5)	(5.1)	(2.9)
	N	4397	1787	784	1826
NOK	Mean	-15.7***	10.3***	-2.6	-43.8***
	Std. Error	(3.9)	(2.1)	(3.9)	(5.1)
	N	4110	1545	772	1793
NZD	Mean	-9.2***	-11.4***	-7.9	-8.1*
	Std. Error	(3.4)	(4.0)	(11.1)	(4.7)
	N	3912	1307	780	1825
SEK	Mean	-3.7	17.8***	17.6***	-31.9***
	Std.Dev.	(3.3)	(1.6)	(2.1)	(2.8)
	N	4235	1630	779	1826
Total	Mean	2.0*	22.0***	17.4***	-22.4***
	Std. Error	(1.2)	(1.2)	(2.5)	(1.4)
	N	42169	16234	7771	18164

Notes: This figure table reports the mean, standard error of the mean based on Newey-West standard errors with a 91-day lag, and number of observations of the 5-year U.S. Treasury Premium adjusted for CIP deviations by LIBOR by country, and period (pre-GFC (2000-2006), GFC (2007-2009), post-GFC (2010-2016)). EUR denotes Germany. Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

Table A2: Summary Statistics of the 5-Year U.S. Treasury Premium Adjusted for CIP Deviations in LIBOR and CDS Differentials

		Full Sample	2000-2006	2007-2009	2010-2016
AUD	Mean	-34.5***	-1.2	-21.2***	-55.3***
	Std. Error	(4.1)	(1.2)	(4.9)	(4.4)
	N	3345	790	782	1773
CAD	Mean	-2.3	22.6***	32.3***	-23.8***
	Std. Error	(4.7)	(1.1)	(12.4)	(3.5)
	N	2944	711	541	1692
CHF	Mean	-25.4***		-19.9***	-26.2***
	Std. Error	(2.1)		(7.2)	(2.2)
	N	2013		253	1760
DKK	Mean	-21.5***	23.8***	17.2***	-57.4***
	Std. Error	(6.4)	(1.3)	(4.1)	(6.4)
	N	3288	740	776	1772
EUR	Mean	-10.1*	29.1***	26.6***	-43.6***
	Std. Error	(5.7)	(1.)	(3.1)	(5.2)
	N	3341	798	770	1773
GBP	Mean	-24.2***	11.5***	-13	-32.4***
	Std. Error	(-3.7)	(2.0)	(8.4)	(3.2)
	N	2657	153	775	1729
JPY	Mean	-0.5	28.5***	44***	-33.0***
	Std. Error	(5.2)	(1.4)	(6.9)	(2.4)
	N	3342	785	784	1773
NOK	Mean	-18.3***	7.7***	4.1	-39.9***
	Std. Error	(4.5)	(-1.8)	(5.9)	(-5.4)
	N	3290	778	772	1740
NZD	Mean	-33.2***	-32.6***	-33.1***	-33.5***
	Std. Error	(2.9)	(3.2)	(5.5)	(4.3)
	N	3114	569	773	1772
SEK	Mean	-15.1***	16.9***	4.6	-34.7***
	Std.Dev.	(4.)	(1.5)	(4.5)	(-4.1)
	N	3156	604	779	1773
Total	Mean	-18.2***	13.1***	5.0	-38.0***
	Std. Error	(1.6)	(1.9)	(3.1)	(1.5)
	N	30490	5928	7005	17557

Notes: This figure table reports the mean, standard error of the mean based on Newey-West standard errors with a 91-day lag, and number of observations of the 5-year U.S. Treasury Premium adjusted for CIP deviations in LIBOR and CDS differentials by country, and period (pre-GFC (2000-2006), GFC (2007-2009), post-GFC (2010-2016)). Statistics are not reported for Switzerland (CHF) for 2000-2006 because of lack of data on CDS spreads. EUR denotes Germany. Significance levels: * $p<0.10$ ** $p<0.05$ *** $p<0.01$.

Table A3: Effects of Government Bond Supply on the U.S. Treasury Premium (Quarterly Frequency, 2000-2016)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Φ_{5Y}	Φ_{5Y}	Φ_{5Y}	Φ_{5Y}	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$	$\Delta\Phi_{5Y}$
$\log\left(\frac{debt}{GDP}\right)_t^{US}$	-67.94***	-60.28***	-70.52***	-48.00***				
	(7.844)	(8.365)	(11.73)	(10.98)				
$\log\left(\frac{debt}{GDP}\right)_{it}$	27.74***	4.302	16.80***	5.268				
	(2.601)	(5.705)	(2.566)	(4.123)				
Policy Rate$_t$			-0.0807***	-0.0153				
			(0.0123)	(0.0162)				
U.S. Policy Rate$_t$			0.0462***	0.0234*				
			(0.00962)	(0.0124)				
VIX$_t$			0.0136***	0.0115***				
			(0.00300)	(0.00303)				
$\Delta\log\left(\frac{debt}{GDP}\right)_t^{US}$					-67.68	-67.81	-113.2*	-113.4*
					(72.78)	(72.81)	(64.55)	(64.66)
$\Delta\log\left(\frac{debt}{GDP}\right)_{it}$					15.45*	15.61*	9.165	9.079
					(8.576)	(8.912)	(9.003)	(9.375)
Δ Policy Rate$_t$							-0.0559***	-0.0563***
							(0.0128)	(0.0129)
Δ U.S. Policy Rate$_t$							-0.000237	-0.000141
							(0.0171)	(0.0170)
Δ VIX$_t$							0.00492***	0.00493***
							(0.00172)	(0.00172)
Constant	19.71***	-35.27***	-9.324	-51.23***	-0.125	-0.797	0.0430	-0.590
	(3.243)	(10.82)	(6.244)	(10.26)	(0.761)	(1.133)	(0.849)	(1.132)
Observations	670	670	670	670	660	660	660	660
R-squared	0.387	0.638	0.555	0.693	0.007	0.008	0.075	0.075
Country FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports panel regression results of the level and differences of the 5-year unadjusted treasury premium on country level and U.S. variables that proxy for the scarcity of government bonds. Heteroskedasticity autocorrelation spatial correlation robust standard errors were used with a 8 quarter lag. The variable $\log\left(\frac{debt}{GDP}\right)_{it}$ is the ratio of the country's federal debt to nominal GDP and the variable $\log\left(\frac{debt}{GDP}\right)_t^{US}$ is the ratio of the United States' federal debt to nominal GDP. The debt/GDP measures include central bank purchases. The variable Policy Rate is the country-specific policy rate, the variable Policy Rate$_{USD}$ is the U.S. policy rate, and the VIX is the CBOE Volatility Index. All data are at the quarterly frequency and span 2000-2016. The unadjusted treasury premium is from the authors' calculations using data from Bloomberg. Data on federal debt and nominal GDP are from Haver Analytics. Significance levels: * p<0.10 ** p<0.05 *** p<0.01.

B Bloomberg and Thomson Reuters Tickers

Table A4: Bloomberg Tickers: IRS, Basis Swaps, Government Yields, Policy Rates

	Series			
Currency	IRS	Basis Swaps	Government Yields	Policy Rates
USD	USSW## Curncy		C082##Y Index	FEDL01 Index
EUR	EUSW##V3, EUSA## Curncy	EUBS## Curncy	C910##Y Index	EUORMARG Index
GBP	BPSW##V3, BPSW## Curncy	BPBS## Curncy	C110##Y Index	UKBRBASE Index
CHF	SFSW##V3, SFSW## Curncy	SFBS## Curncy	C256##Y Index	SZLTTR Index
JPY	JYSW## Curncy, JYBC## Curncy	JYBS## Curncy	C105##Y Index	MUTKCALM Index
AUD	ADSWAP## Curncy	ADBS## Curncy	C127##Y Index	RBACOR Index
CAD	CDSW## Curncy	CDBS## Curncy	C101##Y Index	CABROVER Index
NZD	NDSWAP## Curncy	NDBS## Curncy	C250##Y Index	NZOCR Index
NOK	NKSW## Curncy, NKBFV## Curncy	NKBS## Curncy	C266##Y Index	NOBRDEP Index
SEK	SKSW## Curncy	SKBS## Curncy	C259##Y Index	SWBRDEP Index
DKK	DKSW## Curncy	DKBS## Curncy	C267##Y Index	DEBRDISC Index

Notes: This table lists the Bloomberg tickers used to construct the unadjusted U.S. Treasury Premium for each country. The ## denotes the maturity of the contract. EUR denotes Germany.

Table A5: Bloomberg and Thomson Reuters Eikon Tickers For Convenience Yield Measures

	Series		
	GC Repo Rate	BFV Agency Yield	Government Yields
USD	US3MRP=	C0915Y Index	C0795Y Index
EUR	EUR3MRP=	C9325Y Index	C9105Y Index
JPY	JPY3MRP=	C2215Y Index	C1055Y Index

Notes: This table lists the Bloomberg and Thomson Reuters Eikon tickers for the repo rate, agency yields, and government yields. Column 1 lists the Thomson Reuters Eikon Tickers for 3-month Treasury GC repo rates in their respective countries. Columns 2-3 list the Bloomberg Tickers for 5-year BFV Agency and Government par yields in their respective countries. EUR denotes Germany.

C Vector Autoregression

For each country in our sample, we estimate a dynamic system based on quarterly time series for three variables: the CDS differential, CIP deviations, and the unadjusted premium, in that order.

$$\begin{bmatrix} \hat{l}_{i,t-l} \\ \tau_{i,t-l} \\ \Phi_{5Y,i,t-l} \end{bmatrix} = A_1(L) \begin{bmatrix} \hat{l}_{i,t-1} \\ \tau_{i,t-1} \\ \Phi_{5Y,i,t-1} \end{bmatrix} + A_2(L) \begin{bmatrix} \hat{l}_{i,t-2} \\ \tau_{i,t-2} \\ \Phi_{5Y,i,t-2} \end{bmatrix} + A_3(L) \begin{bmatrix} \hat{l}_{i,t-3} \\ \tau_{i,t-3} \\ \Phi_{5Y,i,t-3} \end{bmatrix} +$$

$$A_4(L) \begin{bmatrix} \hat{l}_{i,t-4} \\ \tau_{i,t-4} \\ \Phi_{5Y,i,t-4} \end{bmatrix} + B \begin{bmatrix} u_{i,t} \\ \epsilon_{i,t} \\ \xi_{i,t} \end{bmatrix}$$

Formal lag selection procedures (the Akaike information criterion (AIC), the Hannan and Quinn criterion, (HQ) and the Schwarz Criterion (SC)) suggest one to four lags. Given our relatively small sample of quarterly observations (34 to 53 quarters), we used the Edgerton and Shukur test to test the null hypothesis of residual autocorrelation. Across currencies, only a model with four lags rejects the null hypothesis for all currencies. We therefore choose four lags. For model stability, we want eigenvalues to be less than one; a formal test confirms all eigenvalues lie inside a unit circle. We triangularize the shocks using an upper triangular Cholesky decomposition, calling the first shock a CDS shock; the second, a CIP shock; and the third, a residual liquidity shock. We then use the estimated VAR system to analyze the dynamic effect of the shocks via a historical decomposition and variance decomposition.

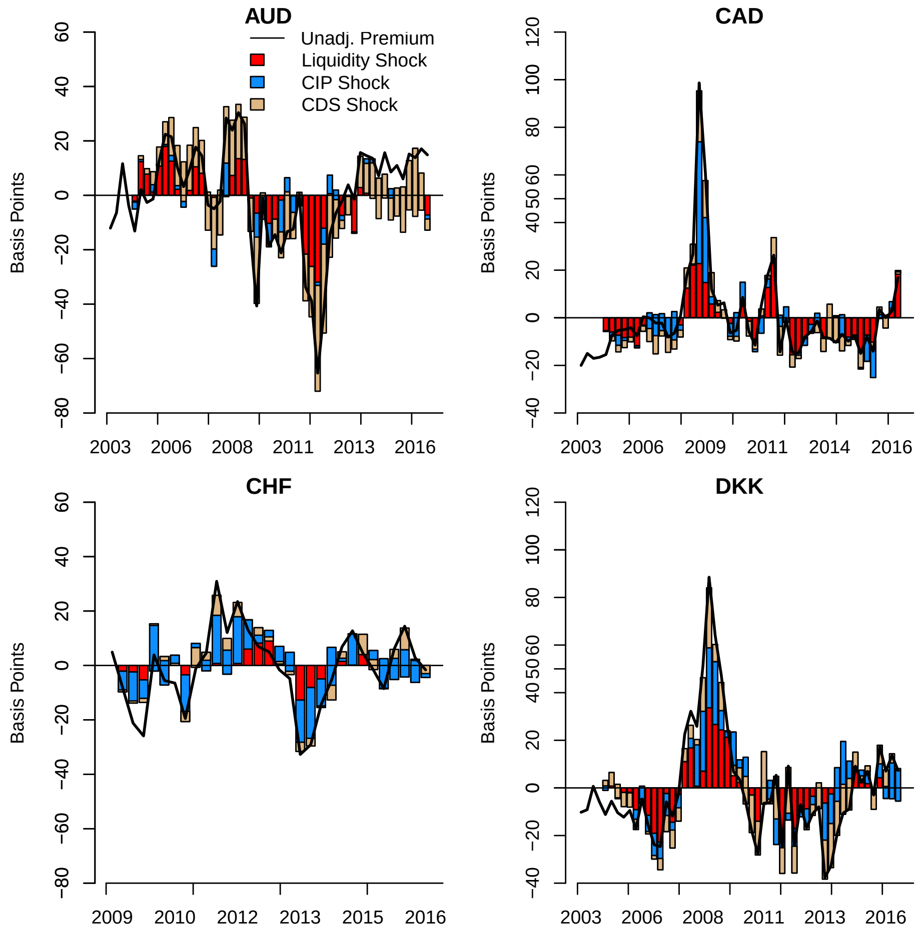
We find the contribution of the liquidity shock to the forecast error to be sizeable across countries despite some variation in the exact percentage. Table A6 shows variance decomposition results based on the 8-quarter forecasting horizon. The average contribution across countries is 20% for the CDS shock, 33% for the CIP shock, and 47% for the residual liquidity shock. The historical decompositions of the five-year unadjusted premium by country are shown in Figure A6. We can see that the residual liquidity shocks (in red) play an important role in all countries, especially in Denmark, Europe, Norway, and Germany.

Table A6: Proportion of Forecast Error 8 Quarters Ahead Produced By Each Innovation: 5-Year Unadjusted Premium (Quarterly Frequency, 2000-2016)

	Triangularized innovation		
	CDS Shock	CIP Shock	Liquidity Shock
AUD	0.58	0.05	0.37
CAD	0.13	0.41	0.47
CHF	0.12	0.66	0.22
DKK	0.21	0.25	0.54
EUR	0.06	0.26	0.68
GBP	0.19	0.37	0.44
JPY	0.39	0.35	0.26
NOK	0.19	0.21	0.59
NZD	0.06	0.02	0.92
SEK	0.07	0.67	0.26
Avg.	0.20	0.33	0.47
Std. Dev.	0.16	0.21	0.21

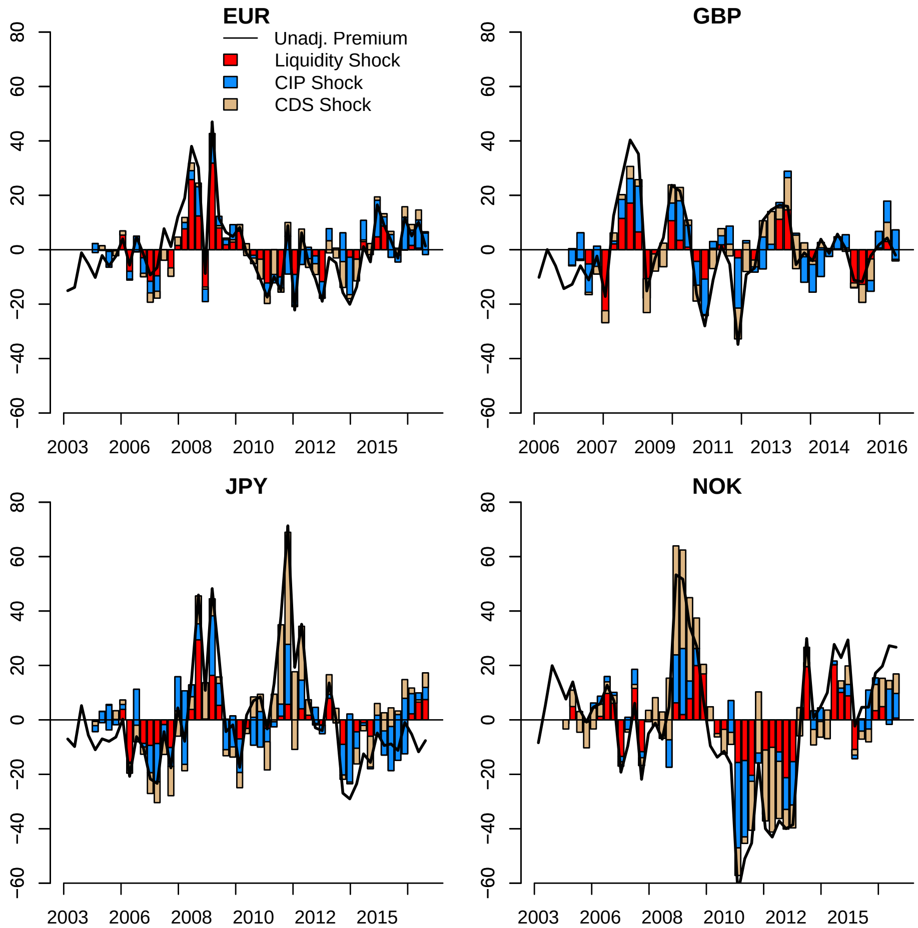
Notes: This table reports the variance decomposition of the 5-year unadjusted premium from a four-lag reduced form VAR of three variables: the CDS differential, CIP deviations, and the 5-year unadjusted premium, in that order. Orthogonalized shocks were obtained by taking the upper triangular Cholesky decomposition of residuals. EUR denotes Germany.

Figure A2: Historical Decomposition of the 5-Year Unadjusted Premium (Quarterly Frequency, 2000-2016)



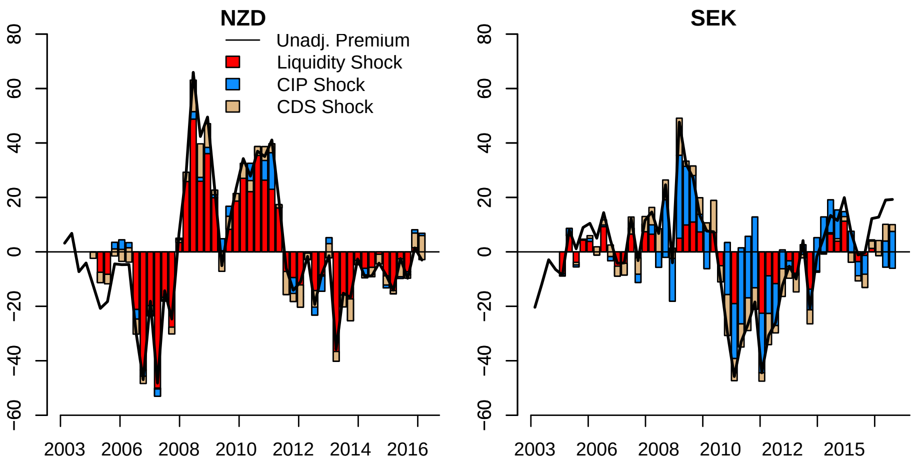
Notes: This figure plots the cumulative contribution of each structural shock to the evolution of the 5-year unadjusted premium over time. Structural shocks were obtained by taking the upper triangular Cholesky decomposition of residuals from a four-lag, reduced form VAR of three variables: the CDS differential, CIP deviations, and the 5-year unadjusted premium, in that order. Bars in red represent the contribution of a liquidity shock; bars in blue, a CIP shock; bars in gold, a CDS shock. The black line is the demeaned, and detrended undjusted premium.

Figure A2: (Continued) Historical Decomposition of the 5-Year Unadjusted Premium (Quarterly Frequency, 2000-2016)



Notes: This figure plots the cumulative contribution of each structural shock to the evolution of the 5-year unadjusted premium (demeaned and detrended) over time. Structural shocks were obtained by taking the upper triangular Cholesky decomposition of residuals from a four-lag, reduced form VAR of three variables: the CDS differential, CIP deviations, and the 5-year unadjusted premium, in that order. Bars in red represent the contribution of a liquidity shock; bars in blue, a CIP shock; bars in gold, a CDS shock. The black line is the demeaned, and detrended undjusted premium. EUR denotes Germany.

Figure A2: (Continued) Historical Decomposition of the 5-Year Unadjusted Premium (Quarterly Frequency, 2000-2016)



Notes: This figure plots the cumulative contribution of each structural shock to the evolution of the 5-year unadjusted premium (demeaned and detrended) over time. Structural shocks were obtained by taking the upper triangular Cholesky decomposition of residuals from a four-lag reduced form VAR of three variables: the CDS differential, CIP deviations, and the 5-year unadjusted premium, in that order. Bars in red represent the contribution of a liquidity shock; bars in blue, a CIP shock; bars in gold, a CDS shock. The black line is the demeaned, and detrended undjusted premium.