Mind the Gap in Sovereign Debt Markets: The U.S. Treasury basis and the Dollar Risk Factor

Arvind Krishnamurthy and Hanno Lustig[1]
Stanford University, Graduate School of Business

August 29, 2019

Abstract

The U.S. dollar exchange rate clears the global market for dollar-denominated safe assets. We find that shifts in the demand and supply of safe dollar assets are important drivers of variation in the dollar exchange rate, bond yields, and other global financial variables. An increase in the convenience yield that foreign investors derive from holding safe dollar assets causes the dollar to appreciate, and incentivizes foreign debtors to tilt their issuance towards dollar-denominated instruments. U.S. monetary policy also affects the dollar exchange rate through its impact on the supply of safe dollar assets and the convenience yield. Interest rate spreads with foreign countries are not sufficient statistics to gauge the impact of the stance of U.S. monetary policy on currency markets. The U.S. Treasury basis, which measures the yield on an actual U.S. Treasury minus the yield on an equivalent synthetic U.S. Treasury constructed from a foreign bond, provides a direct measure of the global scarcity of dollar safe assets.

[1] Prepared for the 2019 Jackson Hole Symposium of the Federal Reserve Bank of Kansas City. Krishamurthy and Lustig are at the Stanford GSB. email: akris@stanford.edu and hlustig@stanford.edu. We thank Zhengyang Jiang, who is a co-author on three of the papers that have led to this paper, for comments and discussions. We also thank Wenxin Du and Matteo Leombroni for their comments. Hanno Lustig is grateful to Adrien Verdelhan for numerous conversations about related topics. We are also grateful to Matteo Maggiori, Brent Neiman, and Jesse Schreger for sharing their data on local currency bias in mutual funds. All remaining errors are our own.

Introduction

The United States plays a unique role in the international financial system. The U.S. dollar is the world's reserve currency of choice. The dollar's role was codified in the Bretton-Woods agreement, but the dollar has maintained its special status even after the collapse of the Bretton-Woods system (Gourinchas & Rey 2007a; Maggiori 2017; Farhi & Maggiori 2018; Gopinath & Stein 2018). In addition, the U.S. is the world's preferred supplier of safe assets (Gourinchas & Rey 2007a; Caballero et al. 2008; Caballero & Krishnamurthy 2009; He et al. 2016). These two roles of the U.S. in the international financial system are intimately connected.

When the U.S. issues dollar-denominated IOUs to foreign investors, the U.S. also exports the liquidity and safety services provided by its supply of dollar-denominated safe assets. Foreign investors derive a convenience yield, which reflects the value of these liquidity and safety services, on their holdings of dollar-denominated safe assets, lowering their required return. Thus, the key footprints of safe asset demand are the exceptionally low effective returns realized by foreign investors purchasing Treasurys whose timing suggests a reverse currency carry trade. The U.S. collects `seignorage' from the rest of the world on its issuance of safe dollar assets.

The U.S. dollar exchange rate plays a key role in clearing the global market for dollar-denominated safe assets. When the marginal willingness of foreign investors to pay for dollar-denominated safe assets rises, the dollar appreciates to induce an expected depreciation and thus lower the returns expected by foreign investors on their holdings of dollar-denominated safe assets. We show that shifts in the demand and supply of safe dollar assets are important drivers of variation in the dollar exchange rate, bond yields, and other global financial variables. The global financial cycle is in part a dollar cycle.[2]

The Federal Reserve's conventional and unconventional monetary policy actions directly impact the global supply of dollar-denominated safe assets and the dollar exchange rate. When the Fed tightens, the bond markets infer that a reduction in the supply of safe dollar assets is imminent. As a result of this supply shift, the marginal willingness of global investors to pay for the safety and liquidity of dollar-denominated assets - as measured by the convenience yield on these assets - increases, leading to an appreciation of the dollar in response to this increase in the convenience yield (even when controlling for interest rates). We refer to this as the *convenience yield channel* of monetary policy, and we document strong empirical support for this channel.

[2] In a paper prepared for this conference, Hélène Rey (2013) first made the case for the existence of a global financial cycle that manifests itself in the co-movement of a large number of financial prices and quantities across borders. We refer to her notion of a global financial cycle.

Dollar liquidity is provided by safe dollar bonds that are issued not only by the U.S. government, but also by foreign governments, U.S. and foreign banks, as well as multinationals. The demand for dollar safe assets, and the convenience yield, drives funding and capital structure decisions inside and outside of the U.S. Outside of the U.S., debtors around the world, especially in emerging market countries, are short the dollar because they seek to benefit from the funding advantages of issuing dollar bonds. As a result, foreign borrowers, especially those not exporting and invoicing in dollars, may be subject to a currency mismatch. When the dollar exchange rate appreciates, e.g., because the Fed tightens and the supply of safe assets shrinks, the debt burden in local currency of these foreign borrowers increases. In countries that rely more heavily on dollar funding, we find that the local currency depreciates more against the U.S. dollar in response to an increase in the safe asset convenience yield, and the net effect of the convenience yield increases on the country's external debt burden is larger.

The demand for safe dollar assets also affects the capital structure inside the U.S. The U.S. collects safe asset seignorage on its issuance of dollar bonds to foreign investors, as attested by the exceptionally low returns foreign investors earn on their net purchases of Treasurys. This has shaped the highly levered aggregate capital structure of the U.S. relative to the rest of the world. On the private side, the demand for safe dollar bonds incentivizes financial intermediaries to issue more `safe' dollar bonds backed by risky collateral, thus increasing private leverage in the U.S. Whenever there is a crisis in global financial markets, the convenience yield on dollar safe assets increases persistently, strengthening the dollar's funding advantage, and incentivizing foreign issuers to tilt future issuance even more towards the dollar, thus sowing the seeds for the next crisis. We refer to this dynamic as the dollar cycle.

The U.S. dollar is special. In times of crisis, the demand for dollar liquidity spikes. During the 2008 financial crisis, this spike manifested itself in a dramatic fall in Treasury yields and the appreciation of the dollar. As the last resort provider of net dollar liquidity, the Fed plays a special role in times of crisis by managing the supply of dollar liquidity and thus potentially avoiding even larger hikes in the convenience yield of dollar safe assets.

Other prominent currencies such as the Euro and the Yen do not play a similar role in international financial markets. We find that the Euro and Yen exchange rates do not display the same dynamics in response to shocks to safe asset demand as the dollar. This puts the U.S. monetary authorities in the unique position of managing the world's supply of safe assets. U.S. monetary policy spills over to other countries through the convenience yield channel, even in the absence of policy rate changes.

A key object in our empirical analysis is the U.S. Treasury basis, which is a measure of the convenience yield on safe dollar bonds. U.S. Treasurys are the world's preferred safe asset. The U.S. Treasury basis measures the yield on an actual U.S. Treasury minus the yield on an equivalent synthetic U.S. Treasury constructed from a foreign bond with the same maturity (Du, Im, et al. 2018; Jiang et al. 2018b). The average U.S. Treasury basis against other G10-currencies is consistently negative, as the synthetic Treasury is not perceived to yield the same safety and liquidity services as the actual Treasury. As a result, actual Treasurys are expensive relative to their synthetic counterparts constructed from foreign bonds.

We show that variation in the market's assessment of current and future convenience yields, as measured by the Treasury basis, is a major driver of variation in the dollar exchange rate (Jiang et al. 2018a; Jiang et al. 2018b).[3] Shocks to the demand and supply of dollar-denominated safe assets will alter the expected path of future convenience yields, the basis, and hence the dollar exchange rate. When the convenience yield increases and the U.S. basis widens, the dollar tends to appreciate against G-10 currencies. Since the financial crisis, as the dominance of the dollar has increased, this convenience yield effect on the dollar exchange rate has strengthened even further. We find the basis of the Euro or Yen has a far more muted relation with FX markets.

Interest rate spreads with foreign countries provide an incomplete picture to gauge the impact of the stance of U.S. monetary policy on currency markets. The Treasury basis, since it measures the convenience yield on dollar safe assets, completes the picture. We show that monetary policy directly impacts the convenience yields (basis) and hence exchange rates, because the stance of monetary policy is perceived by market participants to affect the supply of dollar safe assets. When the Fed tightens by raising the Fed Funds Rate target, the future supply of dollar denominated safe assets is expected to shrink, resulting in a widening of the U.S. Treasury basis and an appreciation of the dollar, even after controlling for interest rate changes. We use FOMC-induced variation in the US Treasury basis around FOMC announcements to help us identify the causal effect of variation in the basis on the dollar exchange rate.[4] Similarly, we also exploit variation in the basis around QE announcements which had large and varying effects on the basis, and on the dollar exchange rate. In both cases, we find that the widening of the basis induces a significant appreciation of the dollar.

While the average Treasury basis against other G-10 currencies is consistently negative, there is a substantial amount of cross-sectional variation amongst the G-10 in the bilateral U.S. Treasury bases against individual currencies. Local institutions (governments, financial intermediaries) may affect the bilateral bases. Convenience yields are not exclusively driven by safe asset demand.[5] Investment currencies, i.e. currencies with high local interest rates (e.g., AUD and NZD), tend to see large positive bilateral Treasury bases, because local institutional investors want to go long in synthetic dollars, not cash

[3] In earlier work, Engel (2016) has argued that liquidity demand can help to understand the pattern of the dollar's deviations from U.I.P., while Valchev (2017) has linked bond convenience yields to exchange rate dynamics.

[4] We use the Fed Funds rate surprises as an instrument.

[5] Du, Tepper and Verdelhan (2018) were the first to point out that there is a carry-like pattern in Libor CIP deviations.

dollars, to hedge their short dollar exposure (Borio et al. 2016).[6] These countries typically see large net inflows of dollar investments. This force offsets the safe asset demand for cash dollars and renders the dollar basis positive. When the average Treasury basis widens, these investment countries see a much larger depreciation of their currency against the dollar: the convenience yield of dollar assets increases more in these investment countries than in funding currencies. As a result, whenever global investors around the world flock to the safety of dollar assets, these countries, which are net short the dollar, experience a larger depreciation of their currency.

We find a similar pattern in EM currencies in the post-crisis era: countries which have accumulated more external debt, tend to see larger depreciations of their currencies when the U.S. Treasury basis against G10-currencies widens. Currency mismatch drives the exposure of these countries to the dollar cycle.
These EM countries also tend to have smaller negative Treasury bases (or even positive Treasury bases). The governments and corporations of these investment countries issue dollar-denominated debt, partly as substitutes for U.S. dollar-denominated safe assets, thus largely arbitraging the negative bases away.

Since the 2008 financial crisis, the dominance of the dollar in credit markets has increased significantly. Issuance of dollar denominated bonds and loans has increased relative to issuance in Euro and Yen. The dollar cycle with its attendant consequences has been strengthening. We find that the dollar exchange rate's sensitivity to the convenience yield has also increased since the financial crisis.

Outline

The rest of the paper is organized as follows. Section 1 documents that the U.S. Treasury basis is negative: the yields on Treasurys are lower than the yields on synthetic Treasurys constructed from foreign bonds. Section 2 demonstrates that foreign investors earn exceptionally low returns when purchasing Treasurys, consistent with safe asset demand, and shows that Treasury flows across borders co-vary with the Treasury basis. In Section 3, we document the large dollar bias in international credit markets. Next, Section 4 establishes that the dollar exchange rate prices in future convenience yields. Whenever safe asset demand increases, the convenience yield increases and the dollar appreciates. Section 5 explains how monetary policy changes the supply of dollar-denominated safe assets, and hence impacts the dollar exchange rate through a new convenience yield channel. Finally, Section 6 offers some concluding remarks as well as some policy implications.

[6] Foreign institutional investors without access to derivatives may drive up local bond prices in investment currencies.

1. The Average U.S. Treasury Basis

Yields on U.S. Treasurys are particularly low when benchmarked against their synthetic equivalents constructed from foreign government bonds. To demonstrate this, we construct the yields on foreign bonds after hedging out currency risk and compare them to Treasury yields.

We use $s_t^{£/\$}$ to denote the log of the spot exchange rate quoted in units of foreign currency per USD, while $f_t^{£/\$,n}$ denotes the log of the *n*-period forward exchange rate. We compute the U.S. Treasury basis as the difference between the yield on a cash position in a U.S. Treasury bond $y_t^{\$,n}$ and the yield on a synthetic position in a U.S. Treasury, created by taking a long position in a foreign government bond (Jiang et al. 2018b), earning the foreign bond yield $y_t^{£,n}$ and hedging the currency risk:

$$x_t^{n,Treasury} = y_t^{\$,n} - \left(y_t^{£,n} - \left(f_t^{£/\$,n} - s_t^{£/\$} \right) \right)$$

The basis construction is very similar to the textbook Covered Interest Rate Parity (CIP) relation of international finance. As we show, CIP fails when constructed from U.S. Treasurys, and does so because foreign investors derive convenience yields from dollar bond holdings leading to a strictly lower yield on the U.S. Treasury (Jiang et al. 2018b).

We update the U.S. Treasury basis data computed by Du, Im and Schreger (2018).[7] Du, Im and Schreger (2018) construct the Treasury basis from the Bloomberg zero yield curves, interest rate swaps and cross-currency basis swaps. For maturities of less than one year, they use forward premiums constructed from forward currency contracts. We follow their procedure.

Figure 1 plots the average 3-month, 1-year and 10-year average Treasury basis for G10-currencies. The US Treasury basis is almost always negative at 3-month and 1-year maturities. At the longer end of the maturity spectrum is mostly negative before the crisis while it turned positive in the latest part of the sample. Table 1 reports summary statistics for the Treasury basis. The average U.S. Treasury basis has been consistently negative against G-10 currencies. Between 1997 and 2019, the average Treasury basis ranged from -23 bps at the 3-month horizon to -6.43 bps at the 10Y horizon. In the pre-crisis sample, the term structure of the bases is essentially flat: the basis varies from -22.47 bps at the short end to -23.14

[7] We replicated Jesse Schreger and Wenxin Du's data available online. We are grateful to them for making this data available on-line. Jiang et al. (2018a; 2018b) use a different dataset. In particular, they do not use zero coupon interpolated yield curves but rather measure the yields on traded bonds at the one-year maturity. The Treasury bases are slightly different, but the main results we report for the dollar are similar across both datasets. Schreger and Du's data has the advantage that the bases can be constructed for multiple maturities.

bps at the long end. In the post-crisis sample, the term structure has tilted and become upward sloping, i.e., the Treasury bases are negative at the short end (-24 bps) and positive at the long end. At the short end, the Treasury bases are similar in size across all of the subsamples. At the long end, the U.S. Treasury basis has turned positive, but this movement appears to be anomalous and due to post-crisis distortions in fixed-for-floating interest rate swap markets: The 10YR Treasury swap spread, i.e. the 10-YR Treasury yield minus the swap rate, has often turned negative in the post-crisis sample (Jermann 2019).

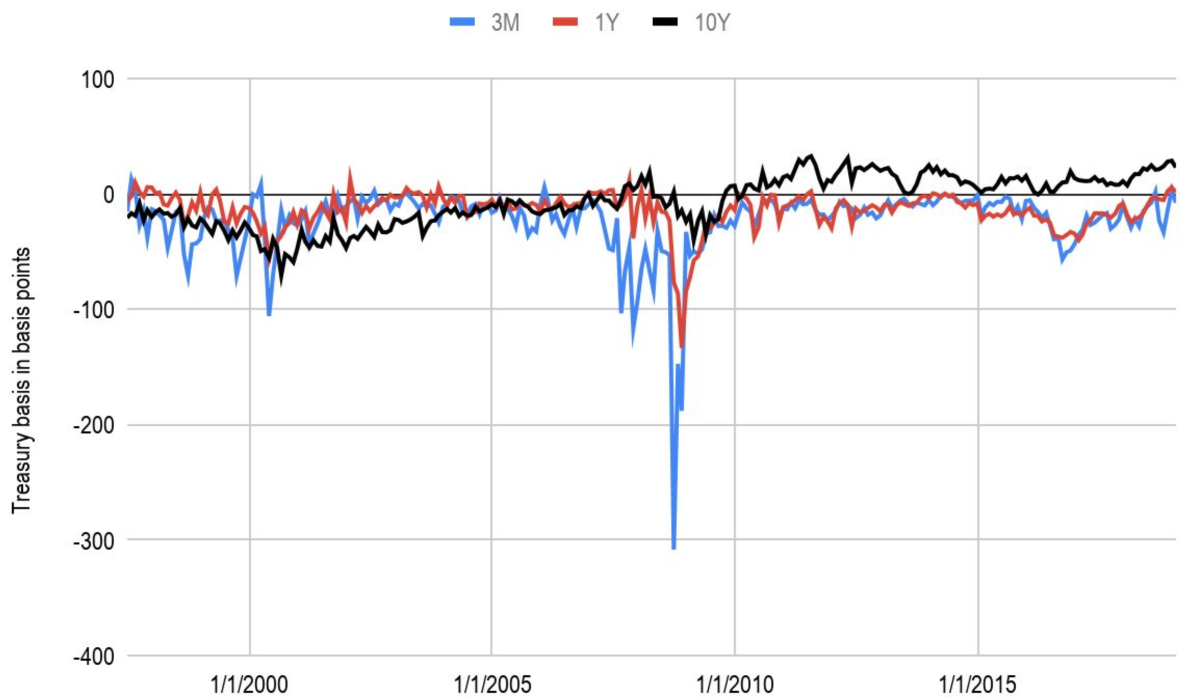


Figure 1: Average U.S Treasury basis against G10 currencies. The average was constructed by computing an equally weighted average of all 9 bilateral Treasury bases.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
whole sample	mean	-23.26	-14.10	-14.02	-14.28	-12.27	-7.20	-6.43
	std	29.05	16.12	15.94	17.34	17.73	17.91	21.49
pre-crisis	mean	-22.47	-10.08	-16.47	-18.30	-20.53	-17.43	-23.14
	std	21.94	11.32	11.32	12.34	12.58	12.20	14.71
post-crisis	mean	-24.00	-17.94	-11.68	-10.44	-4.39	2.58	9.53
	std	34.48	18.86	19.06	20.30	18.34	17.00	13.21

Table 1: Average U.S. Treasury basis against G-10 currencies. The average basis is constructed by computing the equally weighted average of the bilateral Treasury basis across all 9 currencies. Sample: Monthly data from

1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06-30-2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31.

The U.S. Treasury bases are quite different from the Libor CIP bases that were studied by Du, Tepper and Verdelhan (2018). Before the crisis, the dollar Libor CIP bases against G-10 currencies were close to zero, but the Treasury bases were significantly negative. As shown in Table 2, the average Libor bases were between 0 and 2 basis points before 2008.

		3M	1Y
whole sample	mean	-15.11	-10.39
	std	20.79	16.54
pre-crisis	mean	-2.63	-0.09
	std	5.33	5.56
post-crisis	mean	-27.12	-20.31
	std	22.95	17.51

Table 2: Average U.S. Libor basis against G-10 currencies. The average basis constructed by computing the cross-sectional average of the bilateral Treasury basis across all 9 currencies. Sample: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06-30-2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31.

To see how this pattern arises, consider the case in which the Libor basis is exactly zero.

$$x_t^{Treas} = \left(y_t^{\$} - y_t^{\$,Libor} \right) - \left(y_t^{£} - y_t^{£,Libor} \right)$$

Then the Treasury basis can only be zero if the spread between the US Treasury yield and the U.S. Libor rate equals the same spread abroad. However, if the Treasury-LIBOR (i.e. TED) spread in the US is larger than the spread abroad, then the US Treasury basis will be negative.

Treasurys are objectively expensive compared to their foreign G-10 equivalents. However, the Treasury basis measures only that part of the convenience yield that is due to the safety and liquidity of *Treasurys*, because we are comparing cash U.S. Treasurys to synthetic (foreign) Treasurys. The second component of the convenience yield is the part that is due to the value of a safe position in *dollars* (Jiang et al. 2018a). According to our estimates, the entire convenience yields which comprise the *combined dollar/Treasury* safety effects are significantly larger (more than 5 times larger) than the Treasury basis itself. The dollar-specific convenience yield can be inferred from the response of the dollar exchange rate to an innovation in the Treasury basis.[8] We will also provide more direct evidence on the size of the entire convenience yield by examining the returns earned by foreign investors on U.S. Treasurys.

[8] Figure 9 below plots an estimate of the entire convenience yield by (Jiang et al. 2018a).

Euro and Yen Bases

The Euro and the Yen have been mentioned in the past as potential reserve currency competition for the U.S. dollar. However, neither the Euro-denominated German sovereign bonds nor the Japanese bonds benefit from a negative bond basis. We construct the average Euro basis by averaging the bilateral bases relative to the Bund for all G-10 currencies, excluding the USD.

	Euro							
		3M	1Y	2Y	3Y	5Y	7Y	10Y
whole sample	mean	4.17	7.30	9.93	11.01	11.98	14.41	11.25
	std	13.75	9.73	9.25	10.24	10.54	11.72	11.49
pre-crisis	mean	8.30	11.42	12.71	15.66	15.81	18.76	15.71
	std	6.10	6.00	5.66	5.88	7.61	7.48	7.30
post-crisis	mean	1.19	4.33	7.93	7.65	9.22	11.26	8.03
	std	16.66	10.77	10.71	11.35	11.46	13.13	12.81
	Yen							
		3M	1Y	2Y	3Y	5Y	7Y	10Y
whole sample	mean	20.73	28.42	38.95	45.5	54.05	57.55	61.01
	std	21.04	15.99	18.52	21.96	25.8	28.19	25.07
pre-crisis	mean	9.84	17.23	22.76	26.14	32	36.38	44.81
	std	14.29	7.34	6.5	6.91	11.19	12.99	15.44
post-crisis	mean	28.59	36.49	50.63	59.48	69.96	72.82	72.7
	std	21.62	15.68	15.32	18.17	21.25	26.27	24.18

Table 3: Average Euro and Yen Bond basis against G-10 currencies. The average basis constructed by computing the cross-sectional average of the bilateral Treasury basis across all 8 currencies, excluding USD. Sample: Monthly data from 2000/01/31 to 2019/02/28. The pre-crisis sample is defined as 2000/01/31 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31.

Table 3 reports summary statistics for the Euro and the Yen basis. The average Euro bases range from *positive* 4.17 to 11.25 bps. The average Yen bases range from *positive* 20.73 bps to 61.01 bps. Du, Tepper and Verdelhan (2018) have argued that low interest rate currencies such as the Yen tend to have positive Libor-based CIP deviations because they are funding currencies in international investors' carry trade positions. The government bond bases in low interest rate countries appear to inherit this property of the Libor-based CIP deviations and thus primarily reflect carry-trade demand rather than safe-asset demand. We conclude that on the safe-asset dimension neither the Euro nor Yen appear to compete with the dollar for reserve currency status.

Recent work on the CIP violations that have opened up in LIBOR markets at the start of the financial crisis has emphasized the role of capital constraints on financial intermediaries (Gabaix & Maggiori 2014; Borio et al. 2016; Rime et al. 2017; Du, Tepper, et al. 2018). Financial intermediaries typically respond by supplying more LIBOR deposits in currencies with high cash LIBOR interest rates compared to the synthetic rates. The U.S. Treasury does not engage in similar arbitrage activities in Treasury markets. As a result, the Treasury basis was negative even prior to the financial crisis.

In the financial intermediation view of the dollar channel, variation in the dollar exchange rates, through their effect on financial intermediaries who are funding themselves in dollars, has an effect on CIP violations in currency markets. An appreciation of the dollar causes financial intermediaries to reduce arbitrage activities and widens the basis (Avdjiev, Du, et al. 2019).

Our work emphasizes the safe asset demand channel rather than financial intermediation in currency and bond markets. Shocks to safe asset demand on the part of foreign investors are simultaneously priced into the dollar exchange rate and the Treasury basis. This channel remains active even when financial intermediaries are unconstrained, even though innovations to the convenience yield are certainly correlated with shocks to the financial sector. There is an active literature which documents that investors and borrowers have a special currency bias towards the dollar (Shin 2012; Bruno & Shin 2015; Gopinath & Stein 2018; Avdjiev, Bruno, et al. 2019; Maggiori et al. 2019). Our work contributes to this literature. We attribute at least part of this bias to safe asset demand for dollar-denominated safe assets.

2. Foreign Investors Buying U.S. Treasurys

The U.S. balance sheet relative to the rest of the world is unconventional: the U.S. shorts domestic dollar-denominated safe assets to fund its risky investments abroad (Obstfeld & Rogoff 2005; Lane & Milesi-Ferretti 2005; Gourinchas & Rey 2007b).[9]

Treasurys obviously account for a large share of these dollar-denominated safe assets. In June of 2018, foreigners held about $6.225 trillion in U.S. Treasurys.[10] The total Treasury debt held by the public was $15.466 trillion. Foreign holdings of Treasurys currently account for 40% of the U.S. federal government debt. The fraction of Treasurys owned by foreign investors has roughly doubled in the past two decades. In March of 2000, foreigners held about $1.252 trillion in Treasurys and T-bills out of a total of $5.77 trillion, accounting for only 21% of outstanding Treasurys.[11]

Treasury Flows and the Basis

Purchases of Treasurys by foreigners co-vary strongly with the Treasury bases. Figure 2 plots the gross flows of Treasurys across borders: purchases by foreigners from U.S. investors and sales by foreign investors to U.S. investors divided by the total foreign holdings of Treasurys.[12] Flows have been steady since the mid-1980s as a fraction of foreign holdings, picking up particularly in the early 2000s and again in the financial crisis.

The gross flows are also strongly negatively correlated with the changes in the basis. For example, the correlation between gross purchases of Treasurys by foreigners and the change in the 3M (10Y) basis is -0.58 (-0.36) at monthly frequencies. This correlation reflects time variation in safe-asset demand: as safe asset demand rises, there is a reallocation of Treasurys to those investors with the strongest safe asset motive, and the volume of cross-border Treasurys trade increases as the basis widens.

[9] Gourinchas, Rey & Govillot (2010) and Maggiori (2017) have argued that the U.S. balance sheet implements an insurance arrangement against economic disasters between the U.S. and its trading partners. In our view, the U.S. essentially exports the safety and liquidity services of its supply of safe assets, and the U.S. charges a convenience yields to the foreign investors who need safe assets. These views, while distinct, are not mutually exclusive.

[10] Source: Major Holders of U.S. Treasury Securities. Treasury International Capital System.

[11] Source: Monthly Statement of the Public Debt, U.S. Treasury.

[12] We use the TICS Table of U.S. Transactions with Foreigners in Long-Term Domestic and Foreign Securities, and we use the Flow of Funds Table Rest of the World Holdings Treasury Securities (LM263061105.Q).

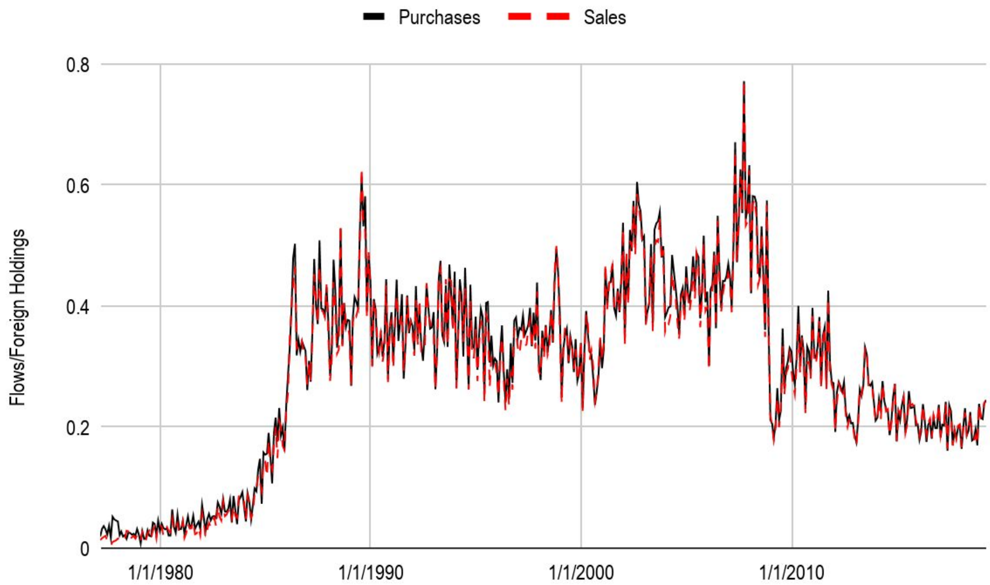


Figure 2: Gross Treasury Flows across Borders. We divide the purchases by foreign investors and sales to foreign investors by the foreign holdings of Treasurys. Flows from the TICS Table of U.S. Transactions with Foreigners in Long-Term Domestic and Foreign Securities. Holdings from the Flow of Funds Table: Rest of the World Holdings Treasury Securities.

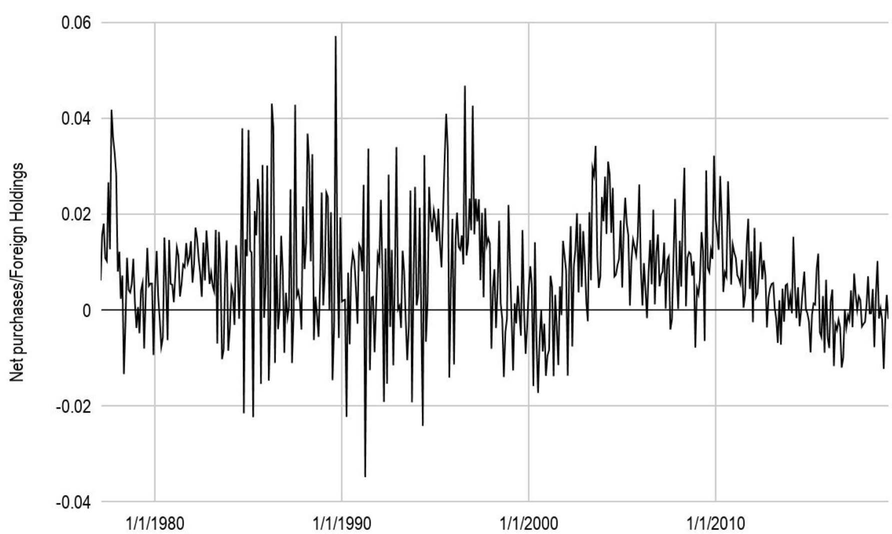


Figure 3: Net Treasury Flows across Borders. We divide the purchases by foreign investors minus sales to foreign investors by the foreign holdings of Treasurys. Flows from the TICS Table of U.S. Transactions with Foreigners in Long-Term Domestic and Foreign Securities. Holdings from the Flow of Funds Table: Rest of the World Holdings of Treasury Securities.

The net flows are informative as well. Figure 3 plots the net flows of Treasurys across the U.S. border. When the net flows are positive, the stand-in foreign investor is buying Treasurys from U.S. entities. An increase in net purchases is predictive of a widening of the basis, as we would expect if these purchases reflect safe asset demand on the part of the stand-in foreign investor. Figure 4 plots the cross-correlations of the change in the Treasury basis and the net flows (Purchases by Foreigners minus Sales to Foreigners divided by Foreign Treasury holdings). To the left of the zero lag, the bars show the correlation of the change in the basis today with net purchases *x* months later. As the lag increases, the correlation between changes in the basis and the net flows turns more negative. Net purchases of Treasurys on average tend to follow a widening of the Treasury basis, as Treasurys become more expensive relative to foreign bonds. Foreign investors buy Treasurys when they are expensive.

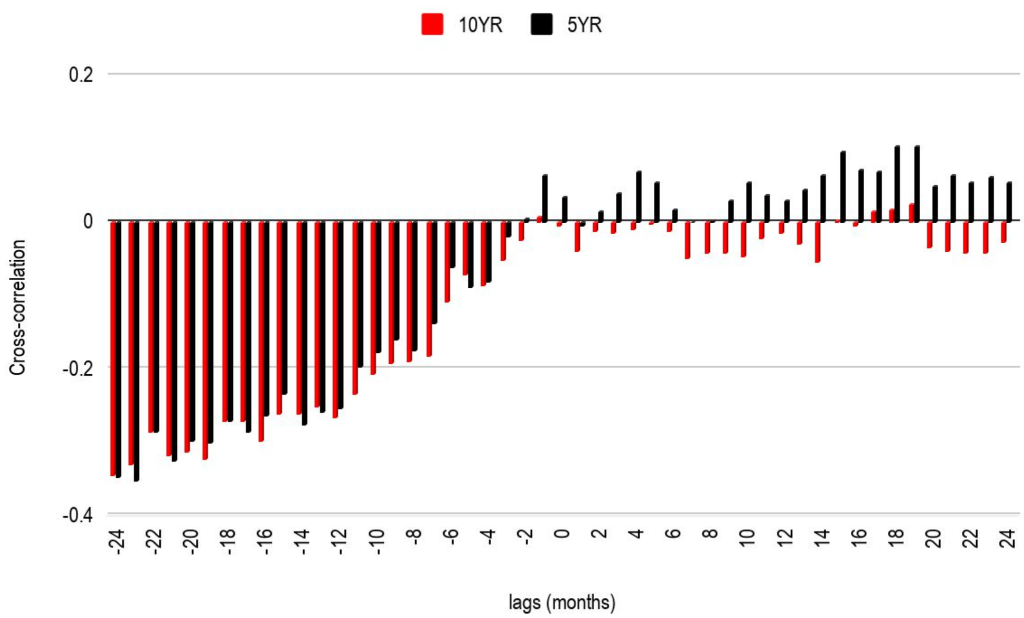


Figure 4: Cross-correlation between the change in the Treasury basis and Net Treasury Flows. We divide the net flows (Purchases minus Sales) by the foreign holdings of Treasurys. Flows from the TICS Table of U.S. Transactions with Foreigners in Long-Term Domestic and Foreign Securities. Holdings from the Flow of Funds Table: Rest of the World Holdings Treasury Securities.

Treasury Flows and Returns

The foreign investors' special demand for the safety of cash positions in U.S. dollar-denominated safe instruments drives down the returns that foreign investors expect to earn on long positions in these assets: the signature of safe asset demand on the part of foreign investors are low returns earned by foreign investors. There are two mechanisms that deliver lower returns when foreign investors buy Treasurys: lower future bond returns in U.S. dollars together with a depreciation of the U.S. dollar.

We show that both mechanisms contribute to low realized returns. We measure the returns actually earned by a stand-in foreign investor going long in U.S. Treasurys. To do so, we assume that foreign investors simply hold the Treasury market. We use the Barclays U.S. Treasury Index as our proxy for the Treasury market, and we use the TIC Treasury data plotted in Figure 3 to measure net purchases of Treasurys by foreign investors.[13] To measure the actual returns on the net purchases of Treasurys by the stand-in foreign investor properly accounting for her timing, we compute the dollar-weighted return which is the IRR (Internal rate of Return) for the net cash flows invested by foreigners in Treasurys.[14] We also compute the time-weighted (buy-and-hold) returns. The difference between these two measures is indicative of the stand-in foreign investor's market timing. The results are reported in Table 4.

Between 1980 and 2019, the nominal dollar-weighted return earned by a typical foreign investor on their Treasury investments is only 5.46% per annum, compared to a time-weighted average of 10.33%. The gap between these two measures is 4.87% per annum. Foreign investors have spectacularly poor market timing: large net purchases of Treasurys by foreigners predict low nominal bond returns. The dollar-weighted real return in dollars after U.S. inflation is only 3.24%. In our view, the low returns we document really reflect the convenience yields that foreigners derive from their Treasury purchases.[15]

When translated into local (i.e., the foreign investor's home) currency, the differences are even larger, consistent with the additional dollar-depreciation channel. The foreign investor realizes a return of 5.43% in local currency, compared to a time-weighted average of 13.74%, leading to a gap of 8.32% per annum. Hence, foreign purchases of Treasurys predict both low future dollar bond returns as well as a depreciation of the dollar.

---

[13] Net Purchases of U.S. Treasurys, Bonds and Notes by major foreign sector in U.S. Transactions with Foreign-Residents in Long-Term Securities. TIC.

[14] The dollar-weighted average return reflect the timing of net purchases of Treasurys by foreign investors, while the time-weighted average return or geometric mean does not and reflects the returns on a buy-and-hold strategy.

[15] Demand curves slope downwards in Treasury markets in the case of safe asset demand. As investors hold more Treasurys, the convenience yields earned by investors declines and so does the price of the safe asset in equilibrium (Krishnamurthy & Vissing-Jorgensen 2012). When the demand curve shifts out because of increased demand for safe assets, bond prices rise, holding the supply of bonds fixed.

		dollar-weighted	time-weighted	gap
		Total		
Treasurys	nominal USD	5.46%	10.33%	4.87%
	real USD	3.24%	7.00%	3.77%
	Local currency	5.43%	13.74%	8.32%
risk-free	nominal USD	1.66%	4.27%	2.61%
	real USD	-0.38%	1.13%	1.51%
	Local currency	1.42%	7.00%	5.59%
		Private		
Treasurys	nominal USD	4.90%	10.81%	5.91%
	real USD	2.77%	7.05%	4.28%
	effective USD	4.41%	13.75%	9.34%
risk-free	nominal USD	1.48%	4.27%	2.79%
	real USD	-0.50%	1.13%	1.63%
	effective USD	0.73%	7.00%	6.27%

Table 4: Dollar-weighted Returns earned by Foreign Investors on net purchases of U.S. Treasurys. Sample: 1980.01-2019.02. TIC Treasury data on net purchases of U.S. Treasurys by foreigners. We assume these flows are fully invested in the Barclays Treasury Bond Index. We used the Federal Reserve's dollar exchange rate index to convert dollar returns into local currency returns. The dollar-weighted return is the IRR realized on the cash flows invested by foreign investors. The terminal cash flow is the market value of the foreign investor's Treasury holdings. The time-weighted return is the geometric mean.

We consider the same strategy from the perspective of an investor who invests in the U.S. risk-free asset (3-month T-bills) instead. These low dollar returns are partly due to foreign investor purchasing Treasurys when the risk-free rate in the U.S. is low. The gap between the local currency return realized by a typical foreign investor and the time-weighted average is 5.59% per annum. Foreign investors buy Treasurys when U.S. interest rates are lower than average for the U.S. As a result, foreign Treasury investors take the wrong side of the dollar carry trade (Lustig, Roussanov & Verdelhan 2014). The dollar carry trade goes long in foreign currency when U.S. interest rates are low, and reverses this trade when U.S. interest rates are high. This investment strategy realizes high Sharpe ratios. Net purchases of U.S. Treasurys are instead concentrated in times of low U.S. interest rates. As a result, foreign investors are implementing the wrong side of the dollar carry trade when they buy U.S. Treasurys. To see this, note that the dollar-weighted risk-free return is 1.66%, a full 261 bps. lower than the time-weighted return.

The gap between the dollar-weighted and time-weighted returns is even larger for private flows; these low returns are not solely attributable to the behavior of foreign central banks. Private foreign investors realize an even lower dollar-weighted return of only 4.90% or 2.77% real, compared to a time-weighted average return of 10.81% or 7.05% real. Foreign investors are engaged in a reverse currency carry trade, locking in low U.S. yields. These patterns paint a consistent picture of global safe asset demand being an important driver of asset prices and returns on safe dollar bonds.

To the extent that Treasury flows are driven by the dynamics of the current account, these results are consistent with the findings of Gourinchas & Rey (2007b) who find that larger U.S. current account deficits, which coincide with larger capital inflows, predict low local currency returns for foreign investors and future depreciations of the dollar. In our mechanism, the local currency returns on dollar safe assets decline after net purchases of Treasurys by foreigners, because the convenience yield that foreign investors derive from their holdings on U.S. Treasurys increased. However, the nature of the flows matters. As shown in Table 5, foreign investors earn equally low dollar-weighted returns on their purchases of U.S. corporate bonds, but not so for equities. Equities do not benefit from safe asset demand.

		dollar-weighted	time-weighted	gap
		Total		
Corporates	nominal USD	6.65%	12.50%	5.85%
	real USD	4.37%	9.11%	4.75%
	effective USD	6.12%	15.49%	9.37%
Equities	nominal USD	9.02%	11.34%	2.32%
	real USD	6.62%	7.98%	1.36%
	effective USD	8.76%	14.34%	5.58%

Table 5: Dollar-weighted Returns earned by Foreign Investors on U.S. Corporates and Equities. Sample: 1980.01-2019.02. TIC Treasury data on net purchases of U.S. Treasurys by foreigners. We assume these flows are

fully invested in the Barclays Corporate Bond Index and the Russell 3000 respectively. We used the Federal Reserve's dollar exchange rate index to convert dollar returns into local currency returns.

3. The Dollar Bias in International Credit Markets

Treasurys are the preferred dollar-denominated safe asset, but the private sector can provide close substitutes for Treasurys. A theme of recent work in banking in the domestic U.S. context is that both Treasury bonds and private bonds, such as bank deposits, repo, and other forms of short-term debt have money-like features (Gorton 2008; Greenwood et al. 2010; Krishnamurthy & Vissing-Jorgensen 2015).

This phenomenon extends to foreign issuers. Liao (2016) documents a negative corporate basis for dollar issuers, particularly for high grade issuers of bonds with a maturity of less than three years. However, the asset pricing evidence for private bonds is not as well developed as for U.S. Treasurys. We look to quantities instead, where the data paints a clear picture of a broad demand for safe dollar bonds.

If dollar-denominated safe assets earn low returns, foreign governments, corporations and other issuers have a strong incentive to issue IOUs denominated in dollars. We document that quantities are consistent with this prediction, which explains the strong dollar bias in international credit markets.

We start by looking at holdings of credit instruments by foreign investors. Foreign investors are defined here as investors not residing in the country of issuance, along the lines of the BIS analysis by McCauley et al. 2015. In June of 2018, foreign investors collectively owned about $11.46 trillion in dollar-denominated credit instruments, including bank loans, as shown in Figure 5. In contrast, foreign investors only owned about $3.66 trillion of Euro-denominated credit instruments and $0.41 trillion in Yen-denominated instruments. In percentage terms, dollar-denominated credit instruments now account for 74% of total non-resident holdings, while the Euro-denominated assets only account for 24%, and the Yen-denominated assets absorb the remaining 2%. In contrast, back in 2000, dollar-denominated assets only accounted for 60% of non-resident holdings, while the Euro and the Yen accounted for 22% and 18% respectively. The dollar's status as the world's reserve currency has also strengthened over the period represented in the figure.

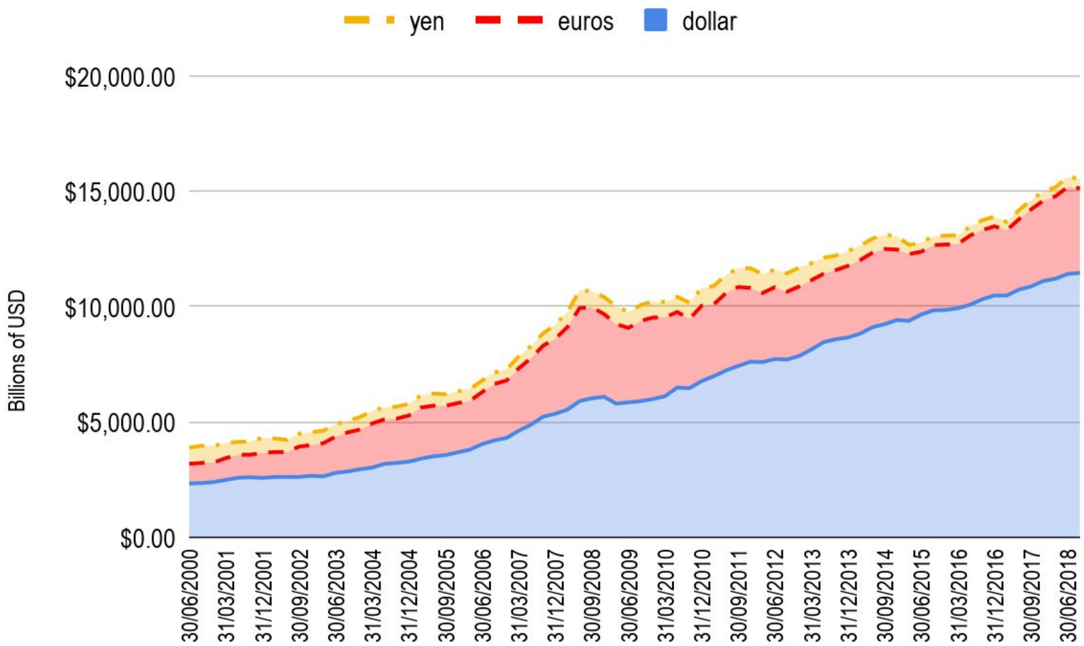


Figure 5. Non-resident Non-bank Holdings of Credit Instruments by Currency Denomination. Source BIS Statistics. Table E2. Total Credit to Non-bank Borrowers.

Next, we consider issuance in currencies that are not the issuer's local currency. We refer to this as non-resident issuance. Figure 6 plots the share of U.S. Dollars, Euros and Yen in non-resident corporate debt and syndicated loan issuance in each of these currencies for high-rated bonds. Figure 7 plots the same share metric for short-maturity bonds. Entities who are able to issue safe, dollar-denominated debt (i.e., high-rated, short-maturity) have been doing so. The dominance of the dollar in new issuances in credit markets has increased since the start of the crisis, while the Euro's importance has declined. This pattern is also consistent with the persistent widening of the U.S. Treasury bases at the onset of the crisis. Other issuers (foreign governments, foreign corporations) have stepped in to capture part of this convenience yield by issuing (imperfect) substitutes for Treasurys.

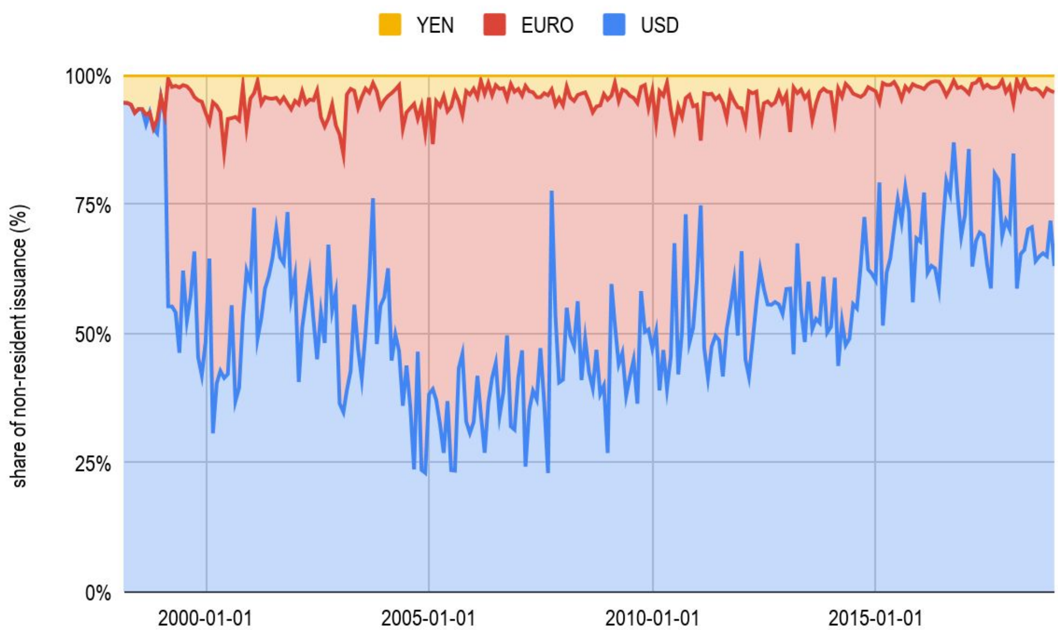


Figure 6: **Share of Non-resident bond issuance by currency denomination for Investment grade bonds.** Total non-resident corporate debt and syndicated loan issuance in USD, Euro and Yen combined. Source: Thomson One.

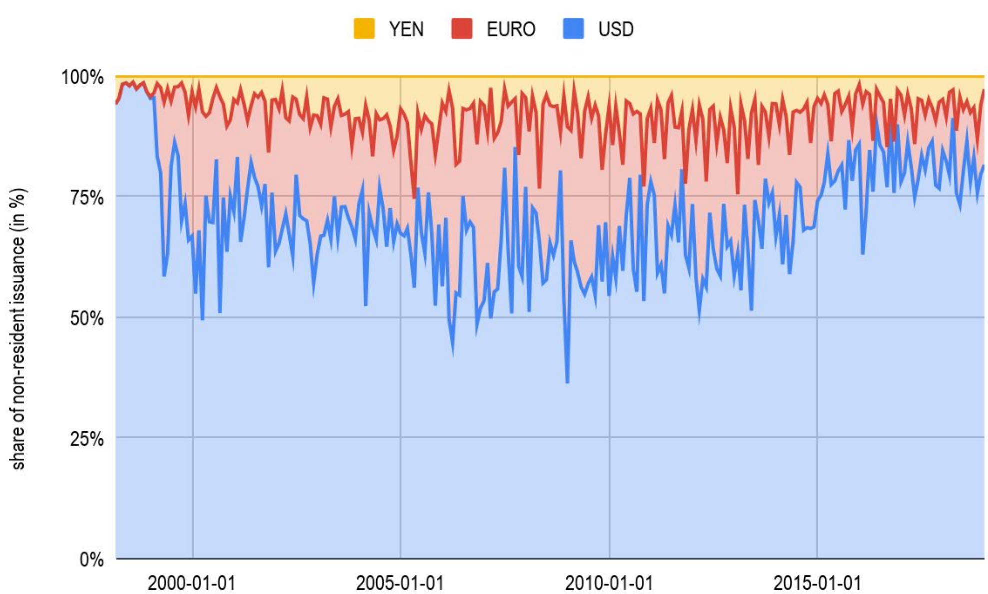


Figure 7: Share of Non-resident bond issuance by currency denomination for short maturity (<5 years) bonds. Total non-resident corporate debt and syndicated loan issuance in USD, Euro and Yen combined. Source: Thomson One.

Our work argues that demand forces play an important role in shaping the lopsided currency composition of international debt. In recent work, Maggiori, Neiman & Schreger (2019) find that mutual fund investors have a home currency bias in corporate bonds, except when the bonds are dollar-denominated corporate bonds. Figure 8 shows the fraction of corporate bonds held by domestic and foreign mutual funds for different issuer countries and currencies. The U.S. dollar is the only currency that makes up a substantial share of the foreign investors' portfolio, consistent with our demand-side argument. All other denominations are mainly held by domestic investors.[16]

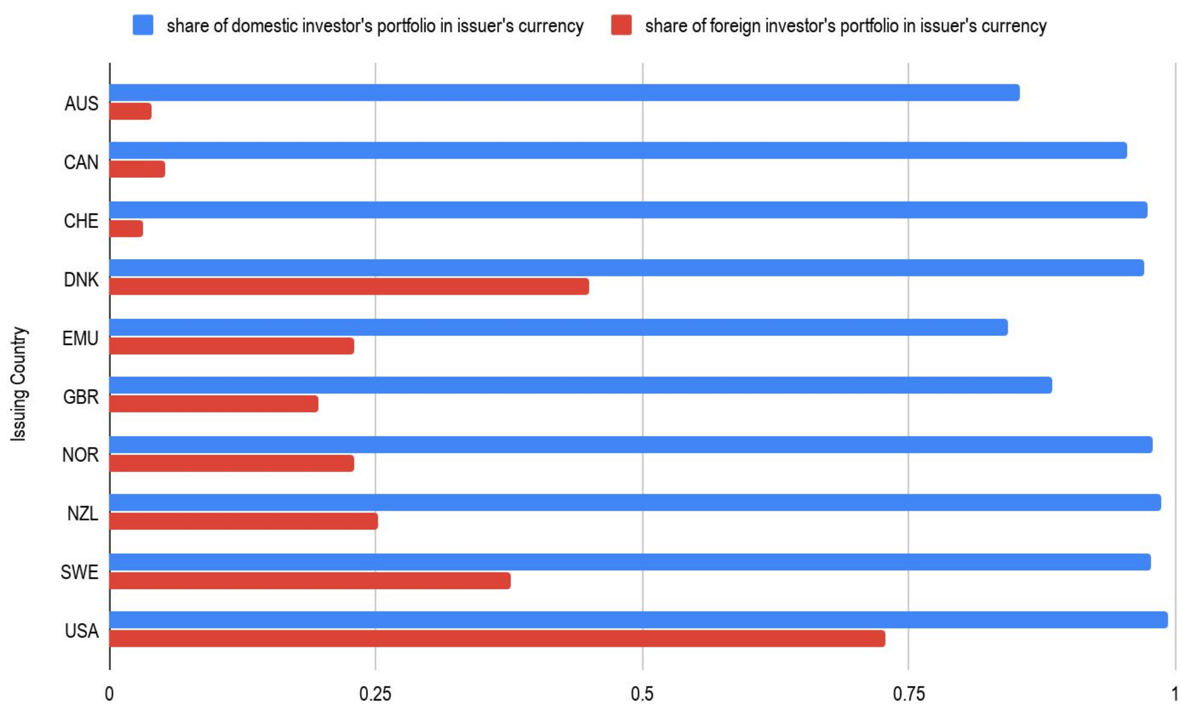


Figure 8: Share of Domestic/Foreign Investor's portfolio of corporate bonds in issuer's currency. The variables are the share of all domestic and foreign investors' corporate bond positions that are denominated in the currency of the bond's issuer, respectively. Rows correspond to issuing countries. Source: This figure reproduces Figure 2 in Maggiori, Neiman and Schreger (2019). See that paper for details.

[16] The dollar bias in credit markets also incentivizes corporations to invoice in dollars to hedge their short exposure to the dollar. Thus, as Gopinath and Stein (2018) argue, the dominance of dollar invoicing is also due to safe asset demand and the low return on dollar-denominated safe assets.

4. The U.S. Treasury Basis and the Dollar Exchange Rate

Bilateral exchange rates have a strong factor structure: exchange rates co-vary, much like stocks and other securities (Lustig et al. 2011; Menkhoff et al. 2012; Lustig & Richmond 2017; Verdelhan 2018). Researchers have identified carry and dollar factors as key drivers of bilateral exchange rates around the globe. Much less is known about the economic drivers of this covariation. This section identifies changes in the U.S. Treasury basis as a key driver of exchange rate covariation not only among G-10 currencies, but also among emerging market currencies, even though we measure the Treasury basis only against G-10 currencies. The dollar exchange rate is a global risk factor, because it measures the scarcity of dollar safe assets. Carry trades which go long in high interest rate currencies and short low interest rate currencies will be exposed to this global dollar risk factor, even though they are nominally dollar-neutral.

In traditional models in international finance, the value of the exchange rate is determined by future interest rate differences and currency risk premia (Froot & Ramadorai 2005). The dollar appreciates when US yields increase relative to foreign yields, and when the currency risk premia on dollar decline. We add a new component to the determination of exchange rate value: the *convenience yields* that foreign investors expect to earn are also priced into the dollar exchange rate today.[17] The exchange rate reflects the cumulative value of all future convenience yields λ, future yield differences, less the future currency risk premia RP_t.

$$s_t = \mathbb{E}_t \sum_{\tau=0}^{\infty} \lambda^*_{t+\tau} + \mathbb{E}_t \sum_{\tau=0}^{\infty} (y^{\$}_{t+\tau} - y^*_{t+\tau}) - \mathbb{E}_t \sum_{\tau=0}^{\infty} \left(RP^*_{t+\tau} - \frac{1}{2} Var_{t+\tau}[\Delta s_{t+\tau+1}] \right) + \mathbb{E}_t [\lim_{\tau \to \infty} s_{t+\tau}].$$

In our work, we assume that the convenience yield on U.S. Treasurys is proportional to the average Treasury basis. If β denotes the fraction of the total convenience yield that is due to the dollar safety, then the convenience yield can be related to the measured basis:

$$\lambda_t = -\frac{1}{1-\beta} x_t$$

where x_t is the Treasury basis.

A wider and hence more negative basis corresponds to a larger convenience yield. The top panel of Table 6 reports the correlations between the change in the dollar index constructed from bilateral exchange rates

[17] See Jiang et al. (2018a; 2018b).

against other G-10 currencies and the change in the U.S. Treasury basis. The Treasury basis is strongly negatively correlated with the percentage rate of appreciation of the dollar. As predicted, an increase in the perceived convenience yield coincides with a strengthening of the US dollar against G10 currencies. Over the entire sample, the correlation between the appreciation of the dollar and the change in the basis is largest for tenors ranging from 3 to 5 years, but in the pre-crisis sample, the correlation is higher at longer maturities.

The bottom panel of Table 6 reports the correlations between the change in the dollar index constructed from bilateral exchange rates against other EM currencies and the change in the U.S. Treasury basis. Interestingly, even though the U.S. Treasury basis is constructed using only G-10 yields and exchange rates, the emerging market exchange rates are also strongly correlated with the changes in the U.S. Treasury basis. Shifts in dollar safety premia affect global exchange rates.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
	whole	-0.09	-0.27	-0.31	-0.37	-0.36	-0.25	-0.26
	pre-crisis	-0.06	-0.06	-0.14	-0.19	-0.20	-0.23	-0.28
G10	post-crisis	-0.41	-0.41	-0.41	-0.48	-0.49	-0.27	-0.25
	whole	-0.12	-0.30	-0.34	-0.38	-0.42	-0.26	-0.23
	pre-crisis	-0.10	-0.10	-0.24	-0.15	-0.33	-0.21	-0.22
emerging	post-crisis	-0.39	-0.39	-0.36	-0.46	-0.48	-0.29	-0.24

Table 6: Correlation between change in U.S. Treasury basis and dollar. Sample for dollar index against G10 currencies: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. Dollar index constructed by averaging all G-10 log bilateral exchange rates against the dollar. Sample for dollar index against emerging market currencies starts only in 2001/01/31.

In Table 7, we regress changes in the dollar exchange rate on changes in the U.S. Treasury basis. Variation in the U.S. Treasury basis explains up to 13% in dollar exchange rate the whole sample. For emerging market currencies, that fraction increases to 17%. At the 5-year tenor, a one-standard deviation widening of the basis by 17.71 bps coincides with a one-month appreciation of the dollar by 2.02% (2.25%) against G-10 currencies (emerging market currencies).

In the post-crisis sample, the one-month appreciation in response to a one-standard deviation widening increases to 3.22% (3.08%) against G10-currencies (emerging market currencies). The variation in the 5Y basis now accounts for almost a quarter of the variation in the dollar exchange rate, up from 4% before the crisis. The convenience yield channel becomes more important, as the dominance of the dollar increases after the crisis.

Panel A: G10 currencies							
	3M	1Y	2Y	3Y	5Y	7Y	10Y
	whole sample						
coeff	-0.009	-0.060	-0.078	-0.101	-0.114	-0.081	-0.087
s.e.	0.006	0.013	0.015	0.016	0.018	0.019	0.020
R^2	0.009	0.075	0.096	0.134	0.129	0.064	0.069
	pre-crisis						
coeff	-0.011	-0.012	-0.036	-0.049	-0.054	-0.065	-0.079
s.e.	0.010	0.018	0.023	0.023	0.024	0.024	0.025
R^2	0.010	0.004	0.019	0.037	0.039	0.054	0.077
	post-crisis						
coeff	-0.008	-0.095	-0.099	-0.138	-0.176	-0.095	-0.094
s.e.	0.007	0.018	0.019	0.022	0.027	0.029	0.031
R^2	0.009	0.172	0.165	0.234	0.243	0.073	0.064
Panel B: EM currencies							
	3M	1Y	2Y	3Y	5Y	7Y	10Y
	whole sample						
coeff	-0.01	-0.061	-0.079	-0.099	-0.127	-0.079	-0.069
s.e.	0.005	0.013	0.015	0.016	0.018	0.019	0.02
R^2	0.015	0.09	0.112	0.144	0.176	0.069	0.051
	pre-crisis						
coeff	-0.024	-0.014	-0.053	-0.03	-0.067	-0.044	-0.044
s.e.	0.008	0.014	0.022	0.021	0.02	0.021	0.02
R^2	0.087	0.01	0.059	0.022	0.107	0.045	0.048
	post-crisis						
coeff	-0.007	-0.088	-0.087	-0.13	-0.168	-0.1	-0.088
s.e.	0.007	0.018	0.019	0.022	0.027	0.029	0.031
R^2	0.008	0.151	0.131	0.215	0.229	0.085	0.058

Table 7: Regression of changes in dollar index on changes in U.S. Treasury basis. The average basis is constructed by computing the cross-sectional average of the bilateral Treasury basis across all 9 currencies. Sample for dollar index against G10 currencies: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. Dollar index constructed by averaging log bilateral exchange rates against the dollar. Sample for dollar index against emerging market currencies starts only in 2000/01/31.

These results are robust to controlling for average yield differences. Table 8 reports the results of regressing the change in the dollar index on the U.S. Treasury basis and the cross-sectional average of yield differences. Panel A reports results for a regression of the dollar's appreciation against G10 currencies on the changes in the US Treasury basis and the changes in the average yield difference for G-10 currencies. Over the whole sample, yield differences have some explanatory power but do not drive out the changes in the average basis. For G10-currencies, an increase in U.S. yields or a decrease in foreign yields leads to an appreciation of the dollar, consistent with the theory. When we consider EM currencies, we find that an increase in foreign yields leads to a dollar appreciation. This counterintuitive result can probably be attributed to time-varying-default risk premia. An increase in a country's CDS spread coincides with a depreciation of the currency (Della Corte et al. 2018)

In the post-crisis sample, yield differences have little or no explanatory power, as shown in Table 9. The U.S. Treasury basis drives all of the action. However, the explanatory power of the basis is much higher in the post-crisis sample, consistent with the findings of Lilley, Maggiori, Neiman & Schreger (2019) who explore the explanatory power of flows for changes in exchange rates and find that dollar bond flows explain dollar exchange movements in the post-crisis sample.

G10 currencies								
		3M	1Y	2Y	3Y	5Y	7Y	10Y
		whole sample						
Δ G-10 basis	coeff	-0.098	-0.086	-0.132	-0.175	-0.090	-0.082	-0.098
	s.e.	0.021	0.021	0.022	0.030	0.031	0.044	0.021
Δ G10 ydiff	coeff	3.386	6.910	6.982	6.705	6.137	4.832	3.386
	s.e.	1.590	2.118	1.487	1.176	1.488	2.101	1.590
	R^2	0.214	0.289	0.388	0.402	0.203	0.151	0.214
EM currencies								
		whole sample						
Δ G-10 basis	coeff	-0.001	-0.044	-0.054	-0.077	-0.103	-0.058	-0.052
	s.e.	0.005	0.012	0.014	0.016	0.019	0.018	0.019
Δ EM ydiff	coeff	-2.489	-2.220	-2.452	-1.668	-1.848	-2.535	-2.685
	s.e.	0.421	0.385	0.406	0.421	0.467	0.404	0.450
	R^2	0.148	0.208	0.236	0.200	0.230	0.208	0.181

Table 8: Regression of changes in dollar index on changes in U.S. Treasury basis and yield differences. The average basis and yield difference is constructed by computing the cross-sectional average of the bilateral Treasury basis and yield differences across all 9 currencies. Sample for dollar index against G10 currencies: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. Dollar index constructed by averaging log bilateral exchange rates against the dollar. Sample for dollar index against emerging market currencies starts only in 2000/01/31.

G10 currencies							
		1Y	2Y	3Y	5Y	7Y	10Y
		post-crisis					
Δ G10 basis	coeff	-0.008	-0.098	-0.086	-0.132	-0.175	-0.090
	s.e.	0.013	0.021	0.021	0.022	0.030	0.031
Δ G10 ydiff	coeff	-0.527	3.386	6.910	6.982	6.705	6.137
	s.e.	1.163	1.590	2.118	1.487	1.176	1.488
	R^2	0.011	0.214	0.289	0.388	0.402	0.203
		1Y	2Y	3Y	5Y	7Y	10Y
EM currencies							
		post-crisis					
Δ G10 basis	coeff	-0.064	-0.076	-0.084	-0.117	-0.079	-0.042
	s.e.	0.018	0.017	0.023	0.028	0.026	0.027
Δ G10 ydiff	coeff	-3.558	-4.019	-2.852	-3.164	-4.474	-4.445
	s.e.	0.715	0.592	0.670	0.745	0.739	0.642
	R^2	0.287	0.359	0.311	0.323	0.286	0.312

Table 9: Post-Crisis Regression of changes in dollar index on U.S. Treasury basis and yield differences. The average basis and yield difference is constructed by computing the cross-sectional average of the bilateral Treasury basis and yield differences across all 9 currencies. Sample for dollar index against G10 currencies: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. Dollar index constructed by averaging log bilateral exchange rates against the dollar. Sample for dollar index against emerging market currencies starts only in 2000/01/31.

Other Currency Bases

We extend our analysis to the Euro and the Japan Yen. The Euro basis was computed by using the German bond as the stand-in bond for the Eurozone. We compare the yield on the German bond in Euros to the currency-hedged yield on foreign bonds. For Japan, we followed the same procedure.

	3M	1Y	2Y	3Y	5Y	7Y	10Y
	Euro basis						
whole	0.06	-0.01	-0.07	-0.10	-0.15	-0.08	-0.06
pre-crisis	0.07	0.07	-0.06	-0.05	-0.43	-0.28	-0.16
post-crisis	-0.03	-0.03	-0.08	-0.11	-0.09	-0.04	-0.05
	Yen basis						
whole	-0.1	-0.15	-0.08	-0.09	-0.13	-0.04	-0.06
pre-crisis	0.03	0.03	0.17	0.12	0.05	0.05	0.11
post-crisis	-0.19	-0.19	-0.14	-0.13	-0.18	-0.06	-0.12

Table 10: Correlation between change in Euro/Yen basis and change in Euro/Yen exchange rate. Sample for dollar index against G10 currencies: Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. Euro/Yen index constructed by averaging all log bilateral exchange rates against the Euro/Yen. The average Euro/Yen basis is constructed by computing the cross-sectional average of the bilateral Euro/Yen basis across all 8 currencies excluding the dollar.

On the whole, changes in the Euro basis do not covary as strongly with the Euro exchange rate against non-USD G-10 currencies, as shown in Table 10. Furthermore, the correlations, while mostly negative, decrease in the post-crisis era. Finally, changes in the Yen basis are weakly correlated with the Yen exchange rate. There is little evidence to support the notion that the Euro and Yen exchange rates price in future convenience yields earned by non-resident investors. Table 11 reports results for the Euro in Panel A and for the Yen in Panel B. Variation in interest rate changes have a lot of explanatory power for exchange rate changes, but variation in the Euro-basis or Yen-basis does not explain more than 2% of the variation in the Euro and the Yen. When we control for interest rate changes, the basis adds some incremental explanatory power, which reflects the negative correlation between rate changes and basis changes. These results largely confirm the special role of the dollar and safe dollar bonds in the international financial system.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
	Panel A: Euro							
Δ G10 ydiff	coeff	2.513	3.481	3.315	3.955	3.725	4.070	4.311
	s.e.	0.920	0.970	0.819	0.899	0.929	1.212	1.335
	R^2	0.060	0.104	0.106	0.120	0.101	0.091	0.085
Δ G10 basis	coeff	0.005	-0.001	-0.014	-0.017	-0.027	-0.014	-0.013
	s.e.	0.004	0.011	0.014	0.017	0.018	0.017	0.019
	R^2	0.004	0.000	0.005	0.009	0.022	0.006	0.004
Δ G10 basis	coeff	-0.002	-0.016	-0.043	-0.038	-0.059	-0.027	-0.035
	s.e.	0.004	0.011	0.013	0.016	0.016	0.018	0.021
Δ G10 ydiff	coeff	2.591	3.764	4.141	4.637	5.214	4.531	5.184
	s.e.	0.988	1.015	0.875	0.928	1.013	1.249	1.443
	R^2	0.060	0.113	0.148	0.161	0.189	0.113	0.114
	Panel B: Yen							
Δ G10 ydiff	coeff	6.509	6.537	6.824	6.313	6.017	5.593	6.236
	s.e.	1.760	1.700	1.496	1.341	1.333	1.293	1.325
	R^2	0.079	0.097	0.128	0.121	0.114	0.098	0.109
Δ G10 basis	coeff	-0.014	-0.045	-0.034	-0.034	-0.056	-0.013	-0.026
	s.e.	0.031	0.060	0.074	0.074	0.067	0.044	0.042
	R^2	0.010	0.023	0.007	0.007	0.017	0.001	0.004
Δ G10 basis	coeff	-0.030	-0.059	-0.043	-0.055	-0.087	-0.051	-0.055
	s.e.	0.021	0.042	0.062	0.065	0.062	0.042	0.039
Δ G10 ydiff	coeff	8.090	7.142	6.944	6.671	6.706	6.331	6.672
	s.e.	2.310	1.785	1.535	1.480	1.420	1.392	1.347
	R^2	0.120	0.136	0.139	0.140	0.154	0.117	0.125

Table 11: Regression of changes in Euro/Yen index on Euro Bund/Yen basis and yield differences. Euro/Yen index constructed by averaging all G10 log bilateral exchange rates against the Euro/Yen. Sample: Monthly data from 2000/01/31 to 2019/02/28.

Measuring the Dollar Convenience Yield

The quantitatively significant estimates of the effects of the Treasury basis on the dollar exchange rate can inform our assessment of the total convenience yield that accrues to foreign investors from holdings of safe dollar assets. More precisely, we can use the exchange rate valuation equation introduced at the start of this section as well as observed variation in the basis, interest rates and exchange rates to infer the unobserved convenience yield.[18] Figure 9 plots the observed Treasury basis and the estimated convenience yield. Note the magnitude of the movements in the estimated convenience yields. At the height of the 2008 financial crisis, foreign investors are willing to forgo up to 2% of quarterly return to own a dollar safe asset. This 2% number is inferred from the large appreciation of the dollar in the crisis. This high valuation falls over the next few months before spiking up again during the European sovereign debt crisis of 2011.

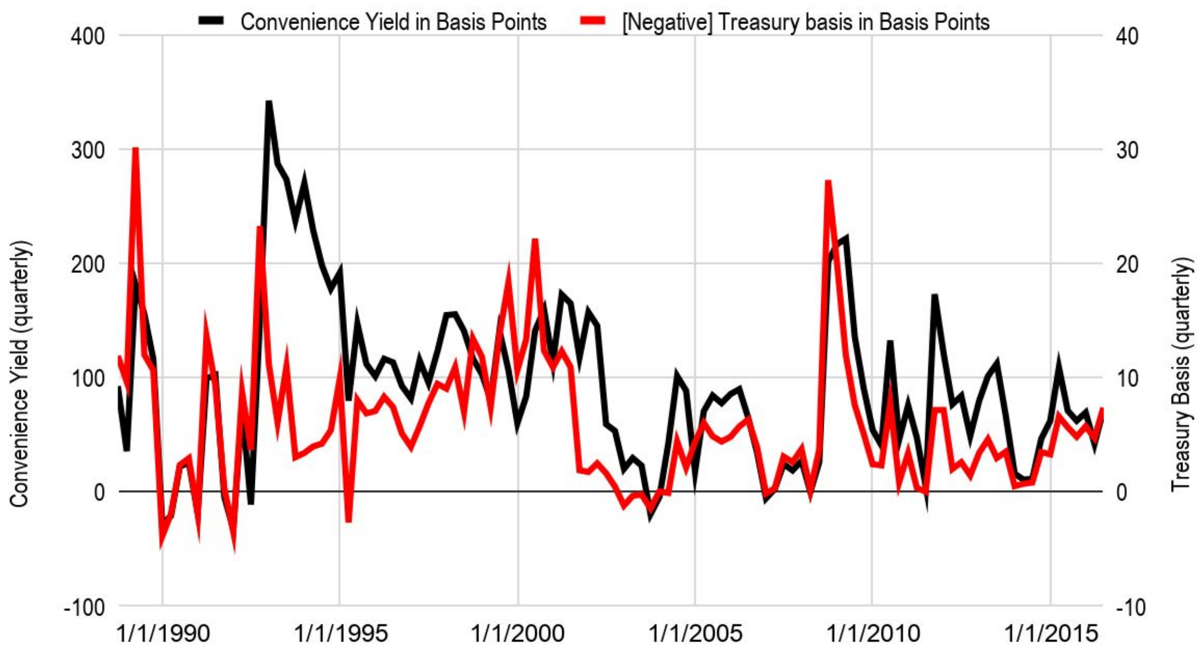


Figure 9: **Estimated convenience yield on dollar safe assets.** The variables are the negative of the U.S. average 1Y-Treasury basis (right axis) and a model-implied estimate of the convenience yield on dollar safe assets (left axis). All variables expressed in basis points per quarter. See Jiang et al. (2018a) for details of the estimation.

[18] See Jiang, Krishnamurthy & Lustig (2018a) for the estimation details.

Cross-sectional Variation in Exposure to U.S. Treasury Basis Risk

Thus far, we have focused on the average Treasury basis, the cross-sectional average of the bilateral Treasury bases. However, the average hides interesting cross-sectional variation. The actions of local governments and institutions, who respond to the convenience yield, will also impact the local, bilateral basis. Moreover, different currencies have different exposure to the U.S. Treasury basis and the dollar cycle.

G10-Currencies

The change in the (cross-sectional) *average* U.S. Treasury basis has more explanatory power for the variation in the bilateral spot exchange rate than the change in the *bilateral* U.S. Treasury basis. The average basis drives out the country-specific bilateral basis in most cases.[19] The key factor driving bilateral exchange rate variation against the dollar is the average U.S. Treasury basis: when it widens, the dollar appreciates against most other currencies. This result holds for most countries and most maturities. Moreover, there are interesting cross-sectional variation in the *loadings* on the changes in the Treasury basis. The loadings on the US Treasury basis are much larger in absolute value for the investment currencies (e.g., AUD, NZD) than for the funding currencies (e.g., JPY). As the basis widens, carry investment currencies depreciate significantly more against the dollar than funding currencies.

Figure 10 plots the loading of a country's currency on the change in the U.S. Treasury basis against the country's average 5YR yield spread against the U.S. for the pre-crisis period. Clearly, before the crisis, the investment currencies with high yields like the AUD and the NZD had larger exposure to changes in the U.S. Treasury basis than funding currencies. As a result, currency carry traders are exposed to the risk that the U.S. Treasury basis widens.

[19] Table A.1 in the Appendix reports the results of regressing the rate of appreciation of the dollar on the change in the bilateral Treasury basis and the change in the average Treasury basis.

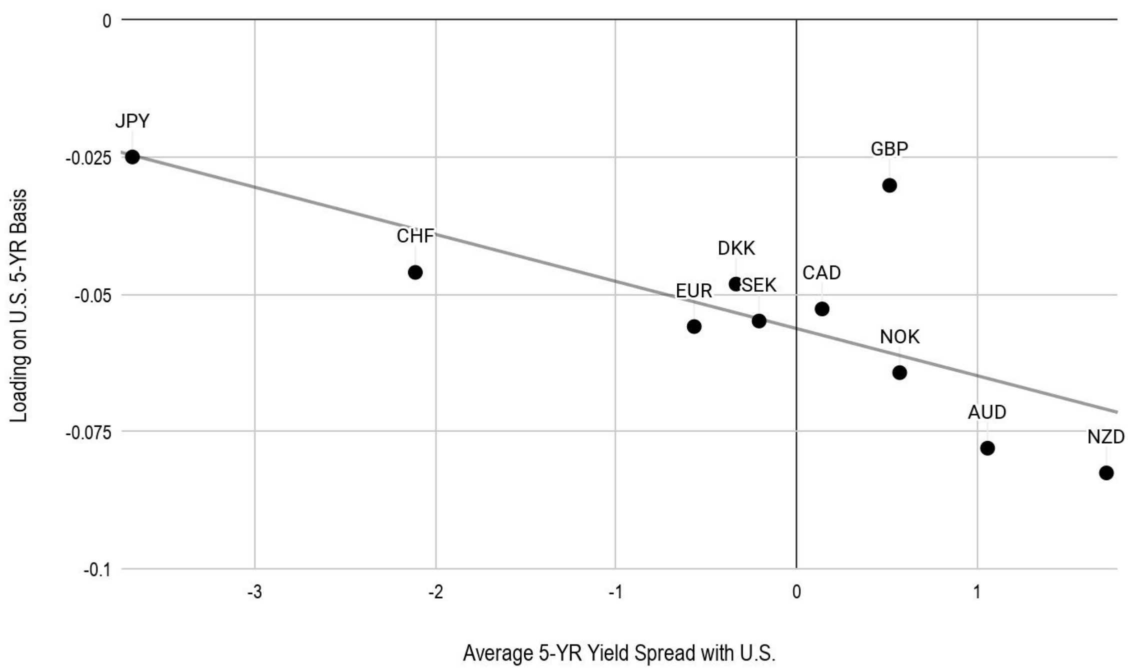


Figure 10: Plot of Loadings of change in log bilateral exchange rate on change in U.S. Treasury basis against 5YR Yield Spread in pre-crisis sample. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31.

Figure 11 shows the loadings on the basis risk factor (i.e. the risk that the Treasury basis widens) for 5 portfolios of developed currencies: currencies are sorted each month by their interest rate differences into portfolios, with the first portfolio containing the lowest interest rate currencies.[20] After the crisis, all of the loadings have increased in absolute value, and the carry pattern is even stronger than before the crisis.

[20] See Lustig, Roussanov & Verdelhan (2011) for details on portfolio construction.

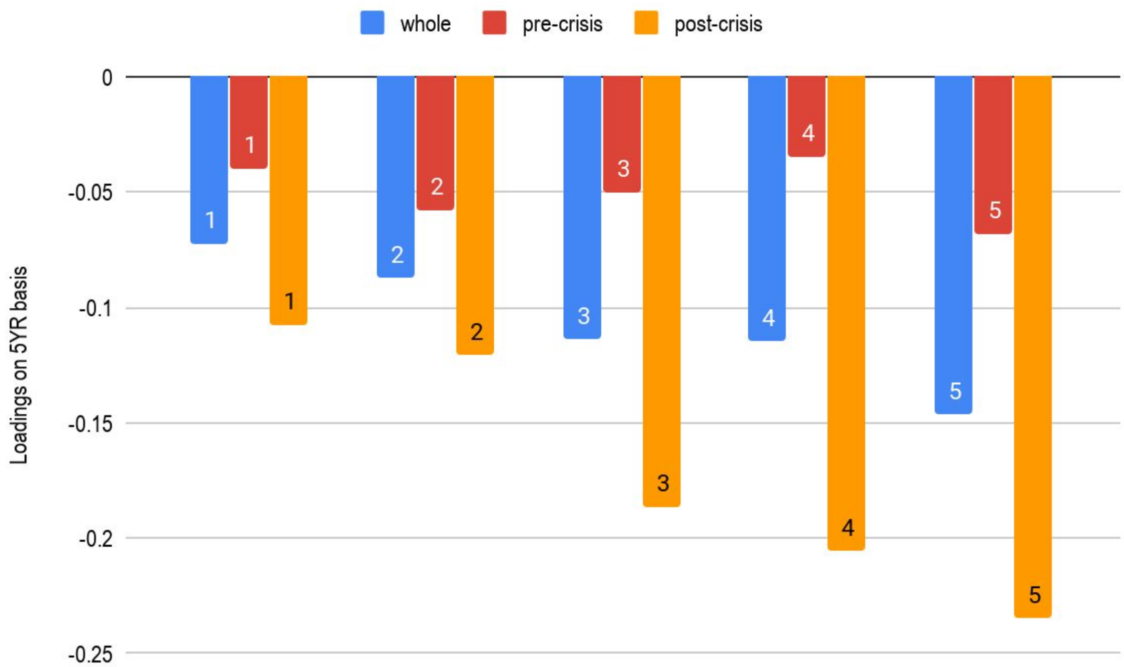


Figure 11: **Currency Carry Portfolio loadings on change in 5YR Treasury basis.** Loadings on change in 5YR basis for (absolute value) for 5 Currency Carry Portfolios constructed by sorting currencies into portfolios based on 3M forward discount (Lustig et al. 2011). Monthly data from 1997/06/30 to 2019/01/31. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31.

The bilateral dollar Treasury bases tend to be less negative or even positive against investment currencies.[21] In other words, when we consider high interest rate currencies, synthetic dollars tend to be cheaper to borrow than cash dollars. These high interest rate countries typically receive large inflows of dollars: institutional investors and financial intermediaries borrow in dollars on a large scale.[22] In order to partly hedge this short position in the dollar, these institutional investors will seek to invest in synthetic dollars, thus exerting downward pressure on the rate of return on synthetic dollars. This hedging force offsets the safe asset demand for Treasurys and accounts for a positive Treasury basis.

In these investment countries, as Figure 11 shows, an increase in the foreign investors' convenience yields generates a larger depreciation (and expected appreciation) of their currency against the dollar. This suggests that investors in these countries now derive an even larger convenience yield from a long position in dollars than other foreign investors, because their expected return on a long position in dollars

[21] See Figure A.2 in the separate appendix.

[22] For example, banks in Australia have a small local depositor base and rely on dollar funding (Borio et al. 2016). On average, borrowing in dollars will be cheaper than borrowing in local currency. The gap is proportional to the carry or interest rate gap with the U.S. These local investors are engaged in a local version of the currency carry trade.

is even lower going forward.[23] On the other hand, in low carry (funding) currencies, we tend to see negative bilateral Treasury bases. In other words, synthetic dollars are expensive. These countries are more likely to be net investors in cash dollars (e.g. Japan has a large Yen depositor base), because the dollar interest rate exceeds their own interest rate.[24]

During and after the crisis, the gap between funding and investment currencies in terms of exposure to the U.S. Treasury basis grows much larger. Interestingly, the Euro/USD and the Euro-linked exchange rates (DKK, SEK, CHF) have become much more exposed to the Treasury basis. The Euro starts trading more like a risky investment currency, in spite of the lower (German) yields. This change is presumably related to the sovereign debt crisis within the Eurozone.[25]

EM Currencies

Note that we have measured the Treasury basis relative to other G10 currencies rather than against all currencies including both G10 and EM. We have taken this approach because the same measure for EM countries is contaminated by default risk on these countries' sovereign bonds.

As with the G10 results, for EM currencies, the average U.S. Treasury basis (against G10-currencies) is typically not driven out by the bilateral Treasury basis.[26] But there is significant variation in the currency's exposure to the basis risk factor. Figure 12 plots these exposures (loadings on the Treasury basis) of EM currencies against their external debt/GDP ratio. The currencies of those EM countries which substantially increased their external debt relative to the pre-crisis levels (e.g. Hungary and Poland) has the largest exposures to the Treasury basis risk factor after the financial crisis. For example, the HUF has a loading of -0.3 on the Treasury basis risk factor. In countries which have seen large increases in external debt, governments, corporations, and even some households have typically relied on borrowing in foreign currency, mainly in dollars (Kalemli-Ozcan et al. 2018; Verner & Gyongyosi 2018; Keller 2018). The

[23] Given that the stand-in investor in these investment currency countries is still short in dollars (unless they are fully hedged) in high carry countries, an increase in the average basis, and an appreciation of the dollar is bad news for high carry countries. Their bilateral exchange rate depreciates more: a larger depreciation of the exchange rate may be needed to restore the external balance of these countries.

[24] Institutional investors and financial intermediaries in these countries invest in dollars on a large scale. In order to hedge this exposure, these institutional investors will borrow synthetic dollars, pushing up the rate of return on synthetic dollars. This accounts for a negative Treasury basis: synthetic dollars are actually expensive in these high carry countries.

[25] See Figure A.1 in the Separate Appendix.

[26] Table A.2 in the separate Appendix reports the results of regressions of changes in bilateral exchange rate on the bilateral basis and the average basis.

pattern these graphs illustrate is that these EM currencies are more exposed to the basis risk factor, and hence the dollar cycle.

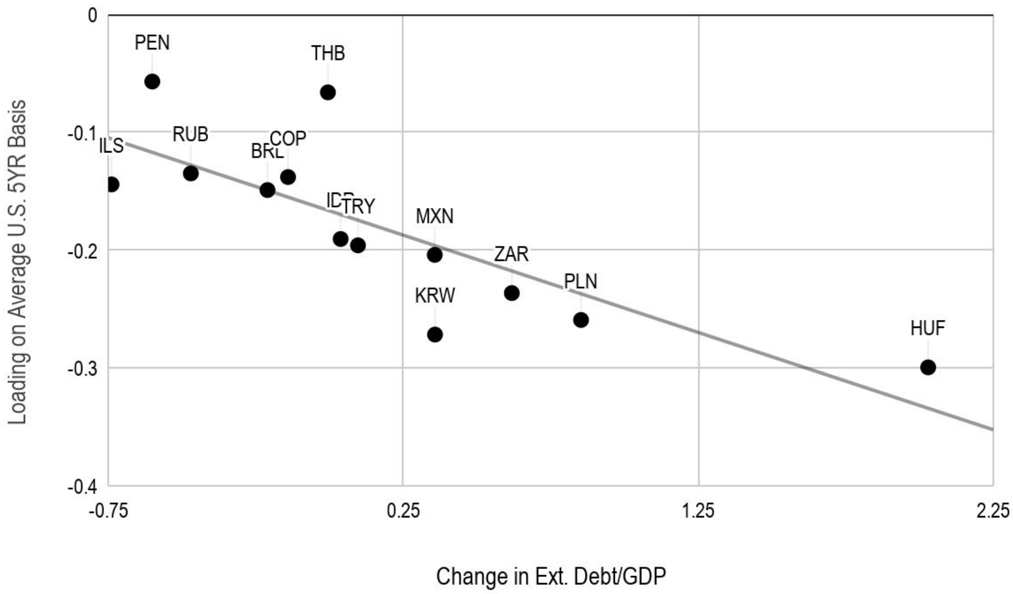
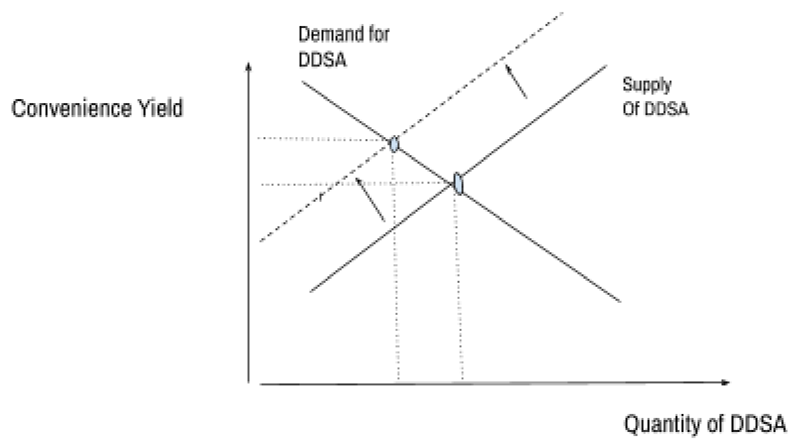


Figure 12: Plot of Loadings of change in log bilateral exchange rate on change in U.S. Treasury basis against external debt/GDP ratio in post-crisis sample. The pre-crisis sample is defined as 2000/01/30 to 2007/12/31. The post-crisis sample is 2008/01/31 to 2019/01/31. The external debt/GDP ratio plotted is the average in the post-crisis sample minus the average in the pre-crisis sample. We drop MYR and PHP due to lack of pre-crisis data.

5. U.S. Monetary Policy, the Treasury Basis and the Dollar.

This section turns to the role of monetary policy. We provide direct evidence on how Fed actions change the basis and the dollar exchange rate through the convenience yield channel.

Before we do so, we re-interpret the evidence we have provided through the lens of a simple equilibrium model. The equilibrium convenience yield on dollar-denominated safe assets (DDSA) depends on the marginal willingness to pay for the services of DDSA, and on the supply of these services, i.e. the stock of DDSA. As the price of these services increases, the quantity foreign investors demand increases. The supply of DDSA is upward sloping because other issuers (governments, banks and corporations) supply more DDSA as the price for these services increases.



Our empirical evidence has shown that there is a positive convenience yield on dollar safe assets, reflected both in dollar bond prices and in movements in the dollar exchange rate. These asset price facts are unique to the dollar. We have also shown quantity facts regarding flows into safe dollar assets that confirm the special demand for dollar safe assets. Finally, we have presented evidence on the dollar bias in international credit markets that describes the supply of DDSA.

We next turn to the role of monetary policy. By altering the supply of dollar-denominated safe assets, monetary policy makers in the U.S. directly impact the Treasury basis, which in turn feeds back into the dollar exchange rate. For example, a more restrictive stance of monetary policy shifts the supply curve inwards, which would raise the equilibrium convenience yields, widening the basis and causing the dollar to appreciate. Alternatively, in purchasing mortgage-backed securities funded either by increasing bank reserves or by selling Treasury securities, the Fed actually increases the supply of DDSA and will therefore lead to a narrowing of the basis and a depreciation of the dollar.[27]

To provide causal evidence for this supply mechanism, we exploit shocks around the FOMC announcements for both conventional and unconventional monetary policy.

FOMC announcements and Kuttner surprises

We use the monetary surprise around FOMC announcements to create exogenous variation in the U.S. Treasury basis. In the first stage, we run a regression of changes in the U.S. Treasury basis on the innovation in the Fed Funds futures price of the nearest contract on the day of the FOMC announcement. The latter is often referred to as the Kuttner surprise measure in the literature (Kuttner n.d.; Kuttner 2001).[28] In the second stage, we use the fitted value for the change in the Treasury basis as an instrument to infer how innovations in the basis affect the dollar exchange rate.[29]

We use a sample of 102 FOMC announcements between 1997 and 2008. We include all FOMC announcements including FF target rate changes in between regularly scheduled meetings. The results are reported in Table 12. As expected, a surprise increase in the FFR widens the U.S. Treasury basis, because it signals a decrease in the supply of safe, dollar-denominated assets in the future. A one standard deviation FFR surprise of 6 bps results in a 1.86 bps (=0.31*6) widening of the 3M basis in the 2 days after the announcement (including the announcement day). These effects are qualitatively similar across maturities of the measured basis.

In the second stage, we run a regression of the rate of appreciation of the dollar on the fitted basis to measure the causal effect of variation in the basis due to monetary policy shocks on the dollar. We control

[27] Outright purchases of Treasurys by the Fed would be expected to widen the basis.
[28] We used the monetary surprises posted by Kuttner on his web site. We found similar results using the Nakamura & Steinsson (2013) FFR and policy news surprises. These results are reported in Table A.3 and Table A.4 of the separate Appendix.
[29] We are not the first to look at the effect of monetary surprises on exchange rates (Shah 2017; Mueller et al. 2017; Wiriadinata 2018).

for changes in the US yield differences with G-10 currencies.[30] The coefficient estimates vary between 0.065 and 0.083 in absolute value, in line with OLS estimates reported earlier. Thus, a one standard deviation FFR surprise results in a 12.09 bps appreciation of the dollar as a result of the 1.86 bps widening of the basis. We find similar results for EM currencies. [31]

		3M	1Y	2Y	3Y	5Y	7Y	10Y
Panel A: 2-day window								
		1st stage						
Kuttner	coeff	-31.867	-16.888	-36.288	-30.039	-36.202	-41.825	-31.071
	se	15.454	7.318	6.622	6.419	6.219	5.850	5.392
	R^2	0.041	0.051	0.231	0.180	0.253	0.338	0.249
		2nd stage						
IV (Δ US basis)	coeff	-0.075	-0.083	-0.062	-0.077	-0.065	-0.063	-0.080
	se	0.028	0.048	0.022	0.026	0.021	0.018	0.025
Δ ydiff	coeff	-0.013	3.701	1.625	0.903	2.479	2.661	2.733
	se	0.753	1.109	1.108	1.135	1.139	0.944	1.189
	R^2	0.085	0.177	0.104	0.091	0.127	0.153	0.131
Panel B: 3-day window								
		1st stage						
Kuttner	coeff	-36.316	-2.667	-32.095	-25.754	-26.675	-31.769	-20.894
	se	17.738	7.493	7.145	7.528	6.413	7.081	6.159
	R^2	0.040	0.001	0.168	0.105	0.147	0.168	0.103
		2nd stage						
IV (Δ US basis)	coeff	-0.102	-0.945	-0.096	-0.120	-0.122	-0.116	-0.164
	se	0.027	0.340	0.026	0.033	0.030	0.025	0.038
Δ ydiff	coeff	-0.809	2.307	2.007	2.187	3.806	4.329	4.706
	se	0.778	1.096	1.058	1.103	1.127	0.928	1.166
	R^2	0.135	0.163	0.157	0.159	0.216	0.284	0.250

Table 12: IV Regression of changes in dollar index (G-10) on FOMC-induced variation in U.S. Treasury basis. 1st stage regression of change in basis on Kuttner surprise. 2nd stage regression of change in dollar index on IV (fitted change in basis from 1st stage) and change in yield difference. 102 FOMC meetings between Jan 1997 and Dec 2008. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

[30] The exclusion restriction here entails that, after controlling for interest rates, the FOMC surprises have no direct effect on the exchange rates (other than through the effect on yields). Most of the news released on these days is the news about future short rates. Excluding inter-meeting changes weakens the first stage results. However, the slope coefficients in the second stage are even larger in absolute value.

[31] Table A.5 in the separate appendix report the results for EM currencies.

Quantitative Easing

We next use the Fed's purchases of long-dated assets as a laboratory to explore the relation between changes in the US Treasury basis induced by shifts in DDSA and the dollar. When the Fed purchases long-term assets, it is effectively changing the supply of USD denominated safe assets. When the Fed purchases Treasurys, this reduces the effective supply of Treasurys available to investors and could result in a widening of the U.S. Treasury basis. However, when the Fed purchases other assets, such as MBS, and substitutes these for reserves or sales of Treasurys, this should result in an increase of the supply of USD denominated safe assets and therefore a narrowing of the basis.[32] We include the following QE event dates: 25-Nov-08, 1-Dec-08, 16-Dec-08, 28-Jan-09, 18-Mar-09, 12-Aug-09, 23-Sep-09, 4-Nov-09, 3-Nov-10, 21-Sep-11, 13-Sep-12, 22-May-13, 19-Jun-13, and 18-Dec-13. This gives us a total of 14 observations; the first seven dates pertain to QE I. The first of these FOMC statements, which kicked off quantitative easing, triggered substantial widening of the U.S. Treasury basis by 21 bps, while the third event narrowed the 10Y basis by 18 bps, presumably because the FOMC statement emphasized a commitment to buying agency-debt and mortgage backed securities. The statement also mentioned that the FOMC was still evaluating the benefits of purchasing longer term Treasury securities.

We examine the relation between changes in the dollar and changes in the basis. We include the event day and define the change from close of trading on the day prior to the event day to the close of trading *x* days later. Table 13 reports the regression result and Figure 13 presents a scatterplot of the data. In the appendix, we include the results obtained when excluding the actual event date, because European and Asian bond markets are closed when the announcement occurs. In addition, the exchange rate fix occurs at 4.00 PM GMT before the announcement. The results are quantitatively similar, but the standard errors are larger.

We note from the figure that in some events the basis widens and the dollar appreciates, while in others the basis contracts and the dollar depreciates. This effect is consistent with our characterization of quantitative easing actions as expanding or contracting DDSA depending on the type of action. We also see the strong relation between the movement in the Treasury basis induced by these supply changes and the movements in the dollar. From the table we note that the magnitude of the effects are also in line with the estimates on the whole sample. Panel A considers the results in a 2-day window. At the 1-YR maturity, a one standard-deviation widening in the basis by 9.6 bps induces a 1.59% appreciation of the dollar against G-10 currencies in a 2-day window. At the 10-YR maturity, a one standard-deviation widening in

[32] The dollar swap lines established by the Fed effectively increased the supply of safe dollar bonds; i.e., Euro banks could give Euros up in exchange for dollar deposits. There is event study evidence that these interventions reduced the basis and led to a depreciation of the U.S. dollar (Baba & Packer 2009).

the basis by 9.8 bps induces a 1.85% appreciation of the dollar against G-10 currencies in a 2-day window. In a 2-day window, the variation in the 10-YR basis accounts for 56 % of the variation in the dollar. That fraction increases to 82% at the 1-YR maturity.

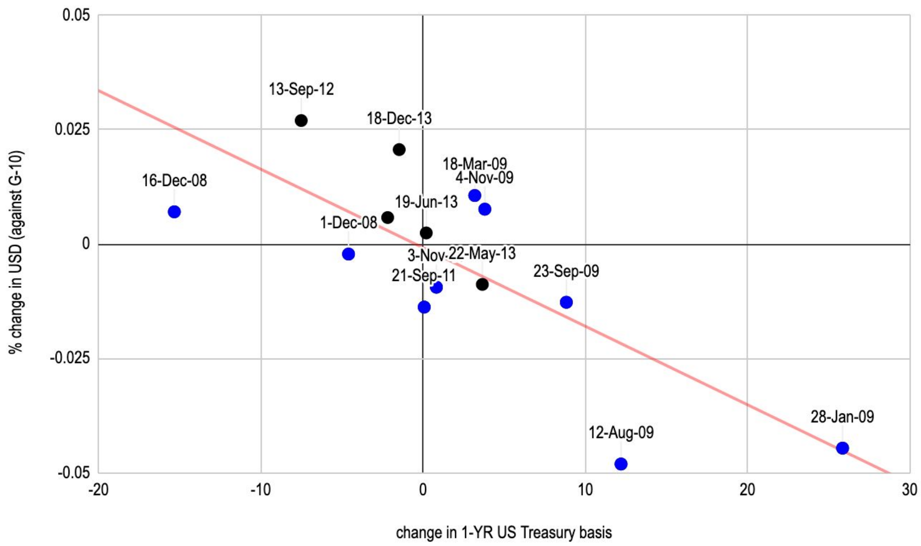


Figure 13: G-10 Dollar appreciation against change in basis around QE event dates. Sample of 14 QE event dates. 2-day window after QE-event dates. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

When we consider the same relation for EM currencies, the results are similar. We use the U.S. Treasury basis against G10-currencies and consider its event-day relation to EM currencies.[33] The relation is strongest at shorter maturities. At the 1Y maturity, variation in the U.S. Treasury basis explains 44% of the variation in the dollar against EM currencies.

[33] Table A.6 in the separate appendix considers the same relation for the dollar index against EM currencies.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
		Panel A: 2-day window						
Δ U..S. basis	coeff	-0.247	-0.166	-0.240	-0.225	-0.170	-0.189	-0.152
	s.e.	0.057	0.028	0.035	0.037	0.034	0.047	0.050
Δ ydiff	coeff	20.012	31.381	17.501	16.338	12.568	12.857	11.231
	s.e.	9.066	8.031	3.092	2.951	2.610	2.624	3.195
	R^2	0.637	0.828	0.837	0.800	0.751	0.697	0.563
		Panel B: 3-day window						
		3M	1Y	2Y	3Y	5Y	7Y	10Y
Δ U..S. basis	coeff	-0.219	-0.188	-0.175	-0.183	-0.135	-0.106	-0.083
	s.e.	0.051	0.027	0.036	0.037	0.036	0.037	0.043
Δ ydiff	coeff	15.319	22.568	15.494	13.861	12.186	12.068	11.944
	s.e.	7.054	6.307	3.227	2.541	2.064	2.253	2.685
	R^2	0.624	0.811	0.745	0.779	0.778	0.724	0.643

Table 13: Regression of changes in dollar (G-10) on QE-induced changes in U.S. Treasury basis and changes in yields. We include 14 QE event dates. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading *x* days later.

6. Implications for Policy

We have presented evidence that imputes a key role to the U.S. dollar exchange rate in clearing the global market for dollar safe assets. In a paper written for this conference in 2013, Hélène Rey presented evidence detailing a global financial cycle in financial prices and quantities (Rey 2013). Our evidence suggests that this global financial cycle is in part a dollar cycle. Shifts in the demand and supply of safe dollar assets drive movements in the dollar exchange rate, bond prices, and financial quantities around the world. To close our paper, we highlight some policy implications of our perspective.

There has been an active debate among policy makers about the spillovers of US monetary policy to the rest of the world (Rajan 2015; Bernanke 2017; Powell 2018). Our analysis indicates that such spillovers are intrinsic to the mechanics of international credit and currency markets. The Fed's monetary policy actions impact the global supply of dollar safe assets and the dollar exchange rate, even holding interest rates constant.

A stronger dollar also weakens the balance sheet of currency-mismatched borrowers around the world. As the literature points out, this can result in financial spillovers to such borrowers and their home economies. Why do foreign borrowers take on currency-mismatch? Our analysis indicates that an important factor is the funding advantage of issuing dollar bonds. That is, the currency mismatch is a manifestation of the dollar equilibrium. Home country bailout incentives (Schneider & Tornell 2000) or a combination of financial underdevelopment and regulation (Keller 2018) can account for currency mismatch, but these explanations do not account for why the mismatch is in dollars. The dollar bias of foreign borrowers is what drives the dollar cycle.

During financial crises, dollar liquidity is the world's most desired asset. The fall in Treasury yields and the appreciation of the dollar during the 2008 financial crisis are another manifestation of the dollar equilibrium. As an external provider of net dollar liquidity, the Fed plays a special role in times of crisis by managing the supply of dollar liquidity. The dollar swap lines utilized in the 2008 crisis were evidently an important stabilizer for foreign dollar borrowers (Ivashina et al. 2015; Bahaj & Reis 2018). In the world's dollar-centric equilibrium, dollar swap lines will likely be needed again in the next crisis.

The demand for safe dollar assets has a deep impact on the nature and composition of private and public funding inside the U.S. U.S. bond issuers collect the safe asset `seignorage' on their issuance of dollar bonds to foreign investors. But there is a dark side to the convenience yield-driven issuance. On the private side, the demand for safe dollar bonds can exacerbate the US credit cycle of high bank leverage and real booms and busts by incentivizing financial intermediaries to issue `safe' dollar bonds backed by risky collateral. A number of analysts have pointed out the role that global imbalances play in driving the U.S. housing boom and bust (Caballero & Krishnamurthy 2009; Bernanke et al. 2011). These boom/bust patterns should also be seen as a manifestation of the dollar equilibrium. It is not insignificant that the 2008 global financial crisis started in the U.S. On the public side, these convenience yields weaken the fiscal discipline provided by bond markets in the U.S. Some observers have conjectured that the U.S. Treasury could simply roll over deficits indefinitely. But this argument ignores that convenience yields are endogenously determined by demand and supply: they likely will dissipate in the face of large increases in the supply of Treasury bonds.

In 1960, the Yale economist Robert Triffin pointed to a structural imbalance in the Bretton Woods system in which the dollar was backed by gold (Triffin 1968). Triffin anticipated that, as the world economy grew, the demand for dollar liquidity would rise, but with the supply of gold fixed, the world would arrive at a tipping point where investors would no longer trust the backing of the dollar, triggering a convertibility crisis. Triffin's prediction proved prophetic, as witnessed by the demise of Bretton Woods in 1971. Triffin's logic can be extended to the current situation. As the world economy grows, the demand for dollar liquidity will rise commensurately. The supply of safe dollar assets is no longer backed by gold; however, the supply is fueled by increases in public and private leverage. Will dollar leverage be supplied in a manner consistent with financial stability? The events of the last 15 years suggest that policy makers should pay close attention to this question.

Avdjiev, S., Du, W., et al., 2019. The Dollar, Bank Leverage, and Deviations from Covered Interest Parity. *American Economic Review: Insights*. Available at: https://www.aeaweb.org/articles?id=10.1257/aeri.20180322 [Accessed July 9, 2019].

Avdjiev, S., Bruno, V., et al., 2019. The Dollar Exchange Rate as a Global Risk Factor: Evidence from Investment. *IMF Economic Review*, 67(1), pp.151–173.

Baba, N. & Packer, F., 2009. Interpreting deviations from covered interest parity during the financial market turmoil of 2007–08. *Journal of Banking & Finance*, 33(11), pp.1953–1962.

Bahaj, S. & Reis, R., 2018. Central Bank Swap Lines. Available at: https://papers.ssrn.com/abstract=3235226 [Accessed July 21, 2019].

Bernanke, B.S., 2017. Federal Reserve Policy in an International Context. *IMF Economic Review*, 65(1), pp.1–32.

Bernanke, B.S. et al., 2011. International Capital Flows and the Return to Safe Assets in the United States, 2003-2007. *FRB International*. Available at: https://papers.ssrn.com/abstract=1837780 [Accessed July 28, 2019].

Borio, C.E.V. et al., 2016. Covered Interest Parity Lost: Understanding the Cross-Currency Basis. *BIS Quarterly Review*. Available at: https://papers.ssrn.com/abstract=2842331 [Accessed July 13, 2019].

Bruno, V. & Shin, H.S., 2015. Capital flows and the risk-taking channel of monetary policy. *Journal of monetary economics*, 71, pp.119–132.

Caballero, R.J., Farhi, E. & Gourinchas, P.-O., 2008. An equilibrium model of" global imbalances" and low interest rates. *The American economic review*, 98(1), pp.358–393.

Caballero, R. & Krishnamurthy, A., 2009. Global Imbalances and Financial Fragility. Available at: http://dx.doi.org/10.3386/w14688.

Della Corte, P. et al., 2018. Exchange Rates and Sovereign Risk. *Available at SSRN*. Available at: https://papers.ssrn.com/abstract=2354935 [Accessed July 14, 2019].

Du, W., Im, J. & Schreger, J., 2018. The U.S. Treasury Premium. *Journal of International Economics*, 112, pp.167–181. Available at: http://dx.doi.org/10.1016/j.jinteco.2018.01.001.

Du, W., Tepper, A. & Verdelhan, A., 2018. Deviations from Covered Interest Rate Parity. *The Journal of finance*, 73(3), pp.915–957.

Engel, C., 2016. Exchange Rates, Interest Rates, and the Risk Premium. *The American economic review*, 106(2), pp.436–474.

Farhi, E. & Maggiori, M., 2018. A Model of the International Monetary System. *The quarterly journal of economics*, 133(1), pp.295–355.

Froot, K.A. & Ramadorai, T., 2005. Currency returns, intrinsic value, and institutional-investor flows. *The Journal of finance*, 60(3), pp.1535–1566.

Gabaix, X. & Maggiori, M., 2014. International Liquidity and Exchange Rate Dynamics. Available at:

http://dx.doi.org/10.3386/w19854.

Gopinath, G. & Stein, J.C., 2018. Banking, Trade, and the making of a Dominant Currency. Available at: http://www.nber.org/papers/w24485.

Gorton, G., 2008. The Panic of 2007. Available at: http://dx.doi.org/10.3386/w14358.

Gourinchas, P.-O. et al., 2010. *Exorbitant privilege and exorbitant duty*, Institute for Monetary and Economic Studies, Bank of Japan. Available at: http://www.fperri.net/discussions/GRG.pdf.

Gourinchas & Rey, 2007a. From world banker to world venture capitalist: US external adjustment and the exorbitant privilege. *G7 current account imbalances: sustainability and*. Available at: https://www.nber.org/chapters/c0121.pdf.

Gourinchas & Rey, 2007b. International Financial Adjustment. *The journal of political economy*, 115(4), pp.665–703.

Greenwood, R., Hanson, S. & Stein, J.C., 2010. A gap-filling theory of corporate debt maturity choice. *The Journal of finance*, 65(3), pp.993–1028.

Hanno Lustig, Nikolai Roussanov and Adrien Verdelhan, 2014. Countercyclical currency risk premia. *Journal of financial economics*, 111(3), pp.527–553.

He, Z., Krishnamurthy, A. & Milbradt, K., 2016. A Model of Safe Asset Determination. Available at: http://dx.doi.org/10.3386/w22271.

Ivashina, V., Scharfstein, D.S. & Stein, J.C., 2015. Dollar Funding and the Lending Behavior of Global Banks. *The quarterly journal of economics*, 130(3), pp.1241–1281.

Jermann, U., 2019. Negative Swap Spreads and Limited Arbitrage. Available at: http://www.nber.org/papers/w25422.

Jiang, Z., Krishnamurthy, A. & Lustig, H., 2019. Dollar safety and the global financial cycle. *Available at SSRN 3328808*. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3328808.

Jiang, Z., Krishnamurthy, A. & Lustig, H., 2018a. Foreign Safe Asset Demand and the Dollar Exchange Rate. Available at: https://papers.ssrn.com/abstract=3149263 [Accessed June 9, 2019].

Jiang, Z., Krishnamurthy, A. & Lustig, H., 2018b. Foreign Safe Asset Demand for US Treasurys and the Dollar. *AEA Papers and Proceedings*, 108, pp.537–541.

Kalemli-Ozcan, S., Liu, X. & Shim, I., 2018. Exchange Rate Appreciations and Corporate Risk Taking. Available at: https://papers.ssrn.com/abstract=3150386 [Accessed July 16, 2019].

Keller, L., 2018. Capital Controls and Risk Misallocation: Evidence From a Natural Experiment. *Available at SSRN 3099680*. Available at: https://papers.ssrn.com/abstract=3099680 [Accessed July 20, 2019].

Krishnamurthy, A. & Vissing-Jorgensen, A., 2012. The Aggregate Demand for Treasury Debt. *The journal of political economy*, 120(2), pp.233–267.

Krishnamurthy, A. & Vissing-Jorgensen, A., 2015. The impact of Treasury supply on financial sector lending and stability. *Journal of financial economics*, 118(3), pp.571–600.

Kuttner, K.N., 2001. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market.

Journal of monetary economics, 47(3), pp.523–544.

Kuttner, K.N., Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Markets. *SSRN Electronic Journal*. Available at: http://dx.doi.org/10.2139/ssrn.933694.

Lane, P. & Milesi-Ferretti, G.M., 2005. A Global Perspective on External Positions. Available at: http://dx.doi.org/10.3386/w11589.

Liao, G.Y., 2016. Credit migration and covered interest rate parity. *Project on Behavioral Finance and Financial Stability Working Paper Series*, 7, p.2016. Available at: http://scholar.harvard.edu/files/gliao/files/creditcip.pdf.

Lilley, A. et al., 2019. Exchange Rate Reconnect. Available at: http://www.nber.org/papers/w26046.

Lustig, H. & Richmond, R., 2017. Gravity in FX R-Squared: Understanding the Factor Structure in Exchange Rates. Available at: http://dx.doi.org/10.3386/w23773.

Lustig, H., Roussanov, N. & Verdelhan, A., 2011. Common risk factors in currency markets. *The review of financial studies*, 24(11), pp.3731–3777.

Maggiori, M., 2017. Financial Intermediation, International Risk Sharing, and Reserve Currencies. *The American economic review*, 107(10), pp.3038–3071.

Maggiori, M., Neiman, B. & Schreger, J., 2019. International Currencies and Capital Allocation. *Journal of Political Economy*, (24673). Available at: http://www.nber.org/papers/w24673.

McCauley, R.N., McGuire, P. & Sushko, V., 2015. Global dollar credit: links to US monetary policy and leverage. *Economic Policy*, 30(82), pp.187–229.

Menkhoff, L. et al., 2012. Carry Trades and Global Foreign Exchange Volatility. *The Journal of finance*, 67(2), pp.681–718.

Miranda-Agrippino, S. & Rey, H., 2015. US Monetary Policy and the Global Financial Cycle. Available at: http://dx.doi.org/10.3386/w21722.

Mueller, P., Tahbaz-Salehi, A. & Vedolin, A., 2017. Exchange Rates and Monetary Policy Uncertainty. *The Journal of finance*, 72(3), pp.1213–1252.

Nakamura, E. & Steinsson, J., 2013. High Frequency Identification of Monetary Non-Neutrality: The Information Effect. Available at: http://dx.doi.org/10.3386/w19260.

Obstfeld, M. & Rogoff, K.S., 2005. Global current account imbalances and exchange rate adjustments. *Brookings papers on economic activity*. Available at: https://muse.jhu.edu/article/191333/summary.

Powell, J., 2018. Speech by Chairman Powell on monetary policy influences on global financial conditions and international capital flows. *Board of Governors of the Federal Reserve System*. Available at: https://www.federalreserve.gov/newsevents/speech/powell20180508a.htm [Accessed July 29, 2019].

Rajan, R., 2015. Competitive monetary easing: is it yesterday once more? *Macroeconomics and Finance in Emerging Market Economies*, 8(1-2), pp.5–16.

Rey, H., 2013. Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence. In Jackson

Hole Conference, organized by the Federal Reserve Bank of Kansas City. Available at: http://dx.doi.org/10.3386/w21162.

Rime, D., Schrimpf, A. & Syrstad, O., 2017. Segmented Money Markets and Covered Interest Parity Arbitrage. Available at: https://papers.ssrn.com/abstract=3057973 [Accessed July 13, 2019].

Schneider, M. & Tornell, A., 2000. Balance SHeet Effects, Bailout Guarantees and Financial Crises. Available at: http://dx.doi.org/10.3386/w8060.

Shah, N., 2017. *Monetary spillovers in financial markets: Policymakers and premia*, Technical report, Harvard University. Available at: https://scholar.harvard.edu/files/nshah/files/jmp_shah.pdf.

Shin, H.S., 2012. Global banking glut and loan risk premium. *IMF Economic Review*. Available at: https://link.springer.com/article/10.1057/imfer.2012.6.

Triffin, R., 1968. *Gold and the Dollar Crisis: The Future of Convertibility*,

Valchev, R., 2017. Bond Convenience Yields and Exchange Rate Dynamics. *Sloan Foundation Economics Research Paper*. Available at: https://papers.ssrn.com/abstract=2755048 [Accessed July 13, 2019].

Verdelhan, A., 2018. The share of systematic variation in bilateral exchange rates. *The Journal of finance*, 73(1), pp.375–418.

Verner, E. & Gyongyosi, G., 2018. Household Debt Revaluation and the Real Economy: Evidence from a Foreign Currency Debt Crisis. Available at: https://papers.ssrn.com/abstract=3241309 [Accessed July 17, 2019].

Wiriadinata, U., 2018. External Debt, Currency Risk, and International Monetary Policy Transmission. *SSRN Electronic Journal*. Available at: http://dx.doi.org/10.2139/ssrn.3210336.

Separate Appendix

		AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
1Y	Δ country	-0.025	0.009	-0.019	-0.041	0.068	0.037	-0.002	-0.040	0.005	-0.029
	s.e.	0.024	0.019	0.011	0.021	0.040	0.026	0.038	0.021	0.019	0.028
	Δ U..S.	-0.074	-0.058	-0.045	-0.030	-0.131	-0.071	0.000	-0.027	-0.088	-0.044
	s.e.	0.027	0.025	0.027	0.027	0.045	0.028	0.045	0.031	0.034	0.029
	R^2	0.077	0.043	0.074	0.091	0.089	0.046	0.000	0.112	0.056	0.066
2Y	Δ country	-0.005	-0.019	-0.023	-0.080	0.022	0.036	-0.004	0.036	-0.040	-0.056
	s.e.	0.030	0.040	0.024	0.028	0.051	0.029	0.042	0.018	0.028	0.032
	Δ U..S.	-0.106	-0.036	-0.071	-0.021	-0.118	-0.075	-0.004	-0.165	-0.075	-0.054
	s.e.	0.039	0.046	0.044	0.034	0.048	0.031	0.050	0.035	0.032	0.030
	R^2	0.086	0.033	0.107	0.154	0.102	0.034	0.001	0.102	0.093	0.108
3Y	Δ country	0.009	-0.029	-0.038	-0.023	-0.006	0.000	-0.015	0.008	0.016	-0.059
	s.e.	0.032	0.039	0.030	0.029	0.044	0.026	0.043	0.025	0.010	0.031
	Δ U..S.	-0.146	-0.059	-0.068	-0.101	-0.123	-0.064	0.000	-0.116	-0.153	-0.062
	s.e.	0.038	0.034	0.038	0.040	0.050	0.026	0.058	0.039	0.032	0.043
	R^2	0.115	0.067	0.114	0.154	0.149	0.051	0.003	0.070	0.093	0.120
5Y	Δ country	-0.006	-0.036	-0.025	-0.019	0.007	-0.017	-0.014	-0.010	-0.046	-0.014
	s.e.	0.026	0.039	0.025	0.034	0.049	0.024	0.050	0.026	0.032	0.034
	Δ U..S.	-0.158	-0.068	-0.086	-0.110	-0.144	-0.051	0.012	-0.112	-0.132	-0.139
	s.e.	0.047	0.024	0.037	0.040	0.054	0.034	0.068	0.034	0.047	0.048
	R^2	0.115	0.080	0.090	0.123	0.128	0.044	0.001	0.087	0.142	0.128
7Y	Δ country	-0.011	-0.032	-0.028	-0.021	-0.026	0.003	0.017	-0.031	0.014	-0.075
	s.e.	0.032	0.033	0.024	0.037	0.046	0.006	0.045	0.022	0.009	0.034
	Δ U..S.	-0.103	-0.021	-0.067	-0.068	-0.067	-0.085	-0.035	-0.038	-0.146	-0.052
	s.e.	0.043	0.032	0.034	0.039	0.051	0.018	0.052	0.034	0.040	0.036
	R^2	0.055	0.028	0.065	0.055	0.060	0.060	0.004	0.032	0.062	0.076
10Y	Δ country	-0.041	-0.021	-0.035	0.042	0.038	-0.028	0.021	-0.024	-0.011	-0.020
	s.e.	0.040	0.034	0.022	0.036	0.049	0.021	0.053	0.020	0.032	0.034
	Δ U..S.	-0.063	-0.036	-0.045	-0.145	-0.140	-0.045	-0.034	-0.090	-0.115	-0.107
	s.e.	0.049	0.036	0.042	0.050	0.061	0.031	0.058	0.039	0.050	0.044
	R^2	0.047	0.026	0.049	0.074	0.070	0.049	0.003	0.084	0.058	0.075

Table A.1: Regression of changes in bilateral exchange rate (G10 currencies) on changes in U.S. Treasury basis and changes in bilateral Treasury basis. Monthly data from 2000/01/31 to 2019/02/28.

		COP	HUF	IDR	ILS	KRW	MXN	MYR	PEN	PHP	PLN	RUB	THB	TRY	ZAR
1Y	country	-0.013	-0.003	-0.022	0.000	0.007	-0.027	0.025	-0.035	0.010	0.006	-0.073	0.004	-0.012	0.010
	s.e.	0.008	0.006	0.012	0.000	0.007	0.007	0.016	0.008	0.003	0.001	0.020	0.003	0.010	0.016
	U.S.	-0.089	-0.076	-0.093	0.000	-0.058	-0.057	-0.102	-0.012	-0.027	-0.029	0.007	-0.043	0.009	-0.089
	s.e.	0.035	0.032	0.049	0.000	0.025	0.030	0.028	0.021	0.011	0.012	0.057	0.040	0.019	0.029
	R^2	0.096	0.047	0.177	0.000	0.069	0.227	0.127	0.225	0.166	0.157	0.250	0.035	0.018	0.052
2Y	country		-0.003	-0.035	0.017	0.029	-0.036	0.026		0.011	0.007	-0.081	-0.001	-0.005	-0.008
	s.e.		0.004	0.012	0.004	0.012	0.007	0.023		0.003	0.002	0.017	0.005	0.008	0.016
	U.S.		-0.087	-0.055	-0.051	-0.087	-0.080	-0.097		-0.022	-0.044	0.028	-0.051	-0.004	-0.068
	s.e.		0.036	0.050	0.024	0.022	0.029	0.031		0.015	0.012	0.053	0.044	0.018	0.030
	R^2		0.053	0.227	0.280	0.120	0.343	0.087		0.100	0.151	0.266	0.014	0.007	0.034
3Y	country	-0.024		-0.025	0.013	0.020	-0.038	0.024	-0.020		0.005	-0.077	0.000	-0.004	-0.010
	s.e.	0.009		0.010	0.004	0.012	0.008	0.016	0.012		0.002	0.012	0.002	0.009	0.009
	U.S.	-0.098		-0.138	-0.114	-0.100	-0.070	-0.152	-0.045		-0.052	-0.009	-0.076	-0.015	-0.120
	s.e.	0.055		0.055	0.033	0.028	0.029	0.044	0.025		0.014	0.053	0.052	0.023	0.039
	R^2	0.134		0.274	0.233	0.113	0.308	0.153	0.122		0.133	0.298	0.023	0.012	0.098
5Y	country	-0.016	-0.011	-0.027	0.013	0.016	-0.037	0.012	-0.012	0.008	0.003		-0.007	-0.002	-0.008
	s.e.	0.006	0.011	0.010	0.003	0.014	0.006	0.016	0.011	0.004	0.002		0.006	0.007	0.008
	U.S.	-0.116	-0.147	-0.191	-0.126	-0.145	-0.086	-0.186	-0.076	-0.064	-0.067		-0.161	-0.051	-0.166
	s.e.	0.051	0.036	0.063	0.023	0.033	0.037	0.052	0.027	0.021	0.016		0.065	0.021	0.048
	R^2	0.103	0.083	0.290	0.296	0.152	0.301	0.155	0.093	0.091	0.098		0.060	0.042	0.100
7Y	country		-0.007	-0.040	0.010		-0.046	-0.009	-0.010	-0.001	0.004	-0.066	-0.003	-0.004	0.001
	s.e.		0.010	0.011	0.007		0.007	0.019	0.012	0.005	0.002	0.014	0.006	0.007	0.018
	U.S.		-0.079	-0.059	-0.116		-0.099	-0.110	-0.051	-0.047	-0.046	-0.072	-0.132	-0.032	-0.184
	s.e.		0.048	0.057	0.041		0.039	0.040	0.022	0.020	0.017	0.041	0.045	0.018	0.086
	R^2		0.026	0.208	0.129		0.301	0.062	0.041	0.044	0.051	0.201	0.040	0.022	0.042
10Y	country	-0.022	-0.005	-0.043	0.008	0.016	-0.045		0.001	-0.008	0.004	-0.072	-0.007	-0.005	
	s.e.	0.008	0.010	0.009	0.006	0.013	0.008		0.011	0.005	0.002	0.016	0.008	0.007	
	U.S.	-0.063	-0.078	-0.099	-0.083	-0.054	-0.085		-0.054	-0.027	-0.033	-0.077	-0.072	-0.001	
	s.e.	0.042	0.032	0.031	0.024	0.026	0.028		0.015	0.012	0.013	0.031	0.038	0.015	
	R^2	0.121	0.048	0.294	0.132	0.078	0.320		0.072	0.056	0.059	0.236	0.036	0.005	

Table A.2: Regression of changes in bilateral exchange rate (EM currencies) on changes in U.S. Treasury basis and changes in bilateral Treasury basis. Monthly data from 1997/06/30 to 2019/01/31.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
Panel A: 2-day window								
		1st stage						
Kuttner	coeff	-58.076	-14.581	-13.367	-18.791	-17.408	-22.298	-11.377
	se	19.715	8.977	8.104	8.085	8.041	7.708	7.477
	R^2	0.057	0.018	0.019	0.036	0.032	0.055	0.016
		2nd stage						
IV (Δ US basis)	coeff	-0.060	-0.128	-0.242	-0.191	-0.209	-0.179	-0.324
	se	0.021	0.088	0.090	0.063	0.066	0.052	0.104
Δ ydiff	coeff	0.830	4.702	3.547	3.716	4.507	3.787	3.579
	se	0.638	1.285	1.139	1.099	0.991	0.837	0.992
	R^2	0.073	0.142	0.121	0.131	0.180	0.179	0.140
Panel B: 3-day window								
		1st stage						
Kuttner	coeff	-64.873	-11.623	-22.363	-15.343	-18.004	-21.972	-8.882
	se	20.621	8.975	7.826	7.945	7.200	7.258	7.212
	R^2	0.064	0.012	0.054	0.025	0.042	0.060	0.010
		2nd stage						
IV (Δ US basis)	coeff	-0.057	-0.210	-0.151	-0.216	-0.196	-0.181	-0.400
	se	0.021	0.121	0.057	0.082	0.066	0.053	0.137
Δ ydiff	coeff	0.420	3.229	3.842	4.581	5.661	5.619	5.599
	se	0.763	1.193	1.067	1.044	0.970	0.862	1.075
	R^2	0.059	0.103	0.135	0.169	0.238	0.273	0.207

Table A.3 IV Regression of changes in dollar index (G-10) on FOMC-induced variation in U.S. Treasury basis. 1st stage regression of change in basis on Nakamura & Steinsson *FFR surprise*. 2nd stage regression of change in dollar index on IV (fitted change in basis from 1st stage) and change in yield difference. 146 FOMC meetings between Jan 1997 and Dec 2014. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
Panel A: 2-day window								
		1st stage						
Kuttner	coeff	-89.084	-45.650	-46.847	-54.673	-51.446	-42.213	-38.467
	se	30.702	13.572	12.115	11.977	11.968	11.824	11.280
	R^2	0.055	0.073	0.094	0.126	0.114	0.081	0.075
		2nd stage						
IV (Δ US basis)	coeff	-0.103	-0.160	-0.181	-0.160	-0.166	-0.209	-0.232
	se	0.021	0.042	0.039	0.032	0.034	0.041	0.046
Δ ydiff	coeff	0.576	3.602	2.845	3.122	3.947	3.264	3.164
	se	0.606	1.228	1.104	1.058	0.956	0.804	0.947
	R^2	0.168	0.210	0.200	0.210	0.252	0.249	0.223
Panel B: 3-day window								
		1st stage						
Kuttner	coeff	-101.011	-32.724	-40.657	-34.252	-30.267	-24.252	-11.689
	se	32.084	13.779	12.050	12.192	11.161	11.470	11.239
	R^2	0.064	0.038	0.073	0.052	0.049	0.030	0.007
		2nd stage						
IV (Δ US basis)	coeff	-0.092	-0.237	-0.200	-0.230	-0.250	-0.317	-0.649
	se	0.020	0.064	0.048	0.056	0.061	0.074	0.162
Δ ydiff	coeff	0.174	2.420	3.212	3.987	5.051	4.978	4.844
	se	0.724	1.149	1.051	1.029	0.962	0.856	1.072
	R^2	0.138	0.164	0.191	0.220	0.277	0.302	0.245

Table A.4 IV Regression of changes in dollar index (G-10) on FOMC-induced variation in U.S. Treasury basis. 1st stage regression of change in basis on Nakamura & Steinsson *Policy News*. 2nd stage regression of change in dollar index on IV (fitted change in basis from 1st stage) and change in yield difference. 146 FOMC meetings between Jan 1997 and Dec 2014. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

		3M	1Y	2Y	3Y	5Y	7Y	10Y
	2-day window							
		1st stage						
Kuttner	coeff	-36.764	-21.187	-38.993	-32.193	-37.803	-42.947	-32.217
	se	18.107	7.255	7.473	7.170	7.054	6.537	5.946
	R^2	0.052	0.102	0.266	0.212	0.277	0.365	0.281
		2nd stage						
IV (Δ US basis)	coeff	-0.042	-0.048	-0.026	-0.031	-0.027	-0.024	-0.032
	se	0.017	0.027	0.014	0.018	0.015	0.014	0.018
Δ ydiff	coeff	-1.091	-0.026	-0.798	-0.090	0.274	0.127	0.044
	se	0.485	0.306	0.388	0.323	0.670	0.438	0.420
	R^2	0.100	0.039	0.091	0.040	0.041	0.040	0.039
	3-day window							
		1st stage						
Kuttner	coeff	-32.378	-3.826	-32.524	-28.449	-27.725	-31.230	-21.096
	se	20.607	7.896	7.790	8.505	7.361	8.044	7.082
	R^2	0.032	0.003	0.189	0.130	0.159	0.167	0.106
		2nd stage						
IV (Δ US basis)	coeff	-0.073	-0.377	-0.039	-0.047	-0.050	-0.048	-0.074
	se	0.019	0.171	0.020	0.023	0.025	0.023	0.033
Δ ydiff	coeff	-1.879	-0.516	-1.015	-0.329	-0.105	0.214	0.390
	se	0.421	0.329	0.400	0.355	0.724	0.520	0.476
	R^2	0.256	0.087	0.132	0.067	0.056	0.058	0.065

Table A.5: IV Regression of changes in dollar index (EM) on FOMC-induced variation in U.S. Treasury basis. 1st stage regression of change in basis on Kuttner surprise. 2nd stage regression of change in dollar index on IV (fitted change in basis from 1st stage) and change in yield difference. 77 FOMC meetings between Jan 2000 and Dec 2008. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

	3M	1Y	2Y	3Y	5Y	7Y	10Y
	Panel A: 1-day window						
Δ U..S. basis	-0.054	-0.069	-0.052	-0.095	-0.120	-0.087	-0.062
	0.042	0.023	0.059	0.050	0.037	0.059	0.048
Δ ydiff	-7.805	-14.214	-4.240	3.993	7.320	4.484	2.876
s.e.	4.946	3.579	5.671	4.205	3.191	3.733	3.228
R^2	0.355	0.767	0.235	0.242	0.495	0.166	0.137
	Panel B: 2-day window						
Δ U..S. basis	-0.050	-0.068	-0.028	-0.046	-0.091	-0.012	-0.026
	0.039	0.017	0.037	0.063	0.043	0.042	0.041
Δ ydiff	-5.157	-5.495	-4.782	-2.166	6.236	2.523	4.888
s.e.	2.968	1.272	2.621	4.450	2.771	3.249	2.989
R^2	0.477	0.838	0.354	0.201	0.375	0.053	0.196

Table A.6: Regression of changes in dollar (EM currencies) on QE-induced changes in U.S. Treasury basis and changes in yields. We include 14 QE event dates. We include the event day and define the change in the basis (Δ Basis) and the change in the dollar from the close of trading on the day prior to the event day to the close of trading x days later.

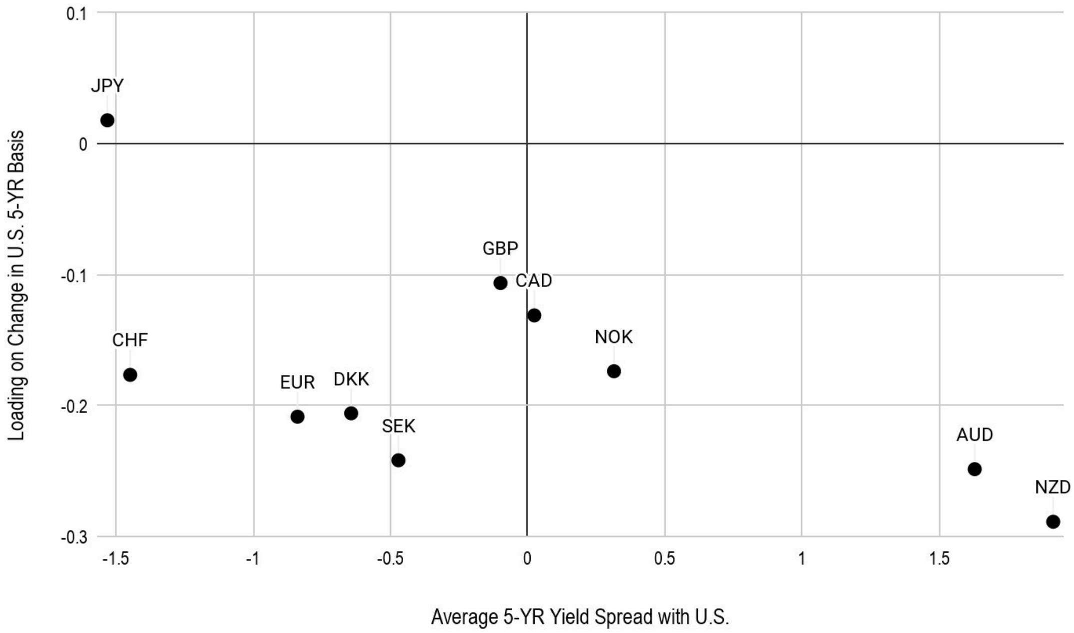


Figure A.1: Plot of Loadings of change in log bilateral exchange rate on change in U.S. Treasury basis against 5YR Yield Spread in post-crisis sample. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31.

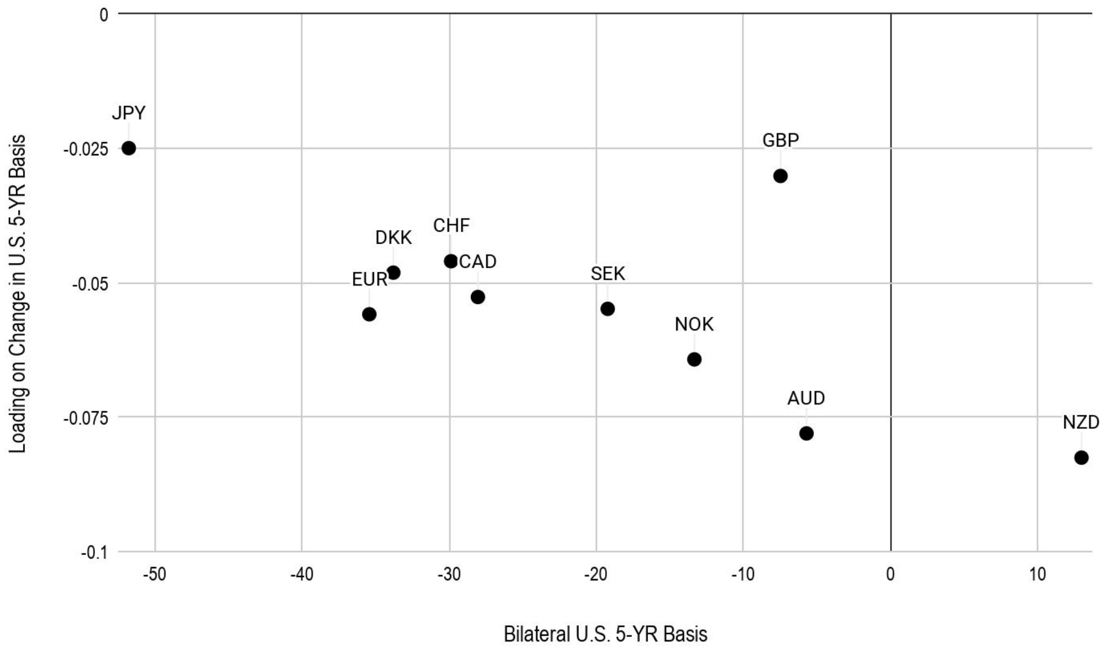


Figure A.2: Plot of Loadings of change in log bilateral exchange rate on change in U.S. Treasury basis against average of the bilateral US Treasury basis in pre-crisis sample. The pre-crisis sample is defined as 1997/06/30 to 2007/12/31.