Covered Interest Parity in Emerging Markets: Measurement and Drivers*

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November 9, 2024

Abstract

This paper studies the behavior of Covered Interest Parity (CIP) deviations – aka the CIP basis - in Emerging Markets (EM). A major challenge in computing the CIP basis in EM's lies in measuring local currency interest rates which are free of credit risk. To do so, we construct the CIP basis for eight major EM currencies using supranational bonds issued in multiple currencies. By extracting the risk-free local currency interest rate, we obtain a measure of "purified" CIP basis for these currencies going back up to twenty years. We show that this "purified" CIP basis conforms with theory-implied predictions for cross-sectional and within-country correlation of the basis with fundamental forces driving supply and demand for Dollar forwards. Shocks and policies that drive global Dollar funding costs, global intermediary's balance sheet capacity, or the demand for Dollar assets all interact with currency-specific Dollar hedging and funding needs in moving the CIP basis in EM's.

*Ignacio Gallardo and Da Hoang provided excellent research assistance. The authors would like to thank Ambrogio Cesa-Bianchi, Wenxin Du, Oleg Itskhoki, Hélène Rey, Jesse Schreger, Hyun Song Shin, Adrien Verdelhan, participants at the IMF, Bank of International Settlement and 2023 CEPR Meetings in London and Paris for helpful comments. The views expressed in this paper are those of the authors and do not necessarily represent views of the IMF, its executive board, or IMF management

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1 Introduction

There has been a growing literature on the deviations from Covered Interest Parity (CIP) in G-10 advanced economies' currency markets. The CIP deviation against the US Dollar is typically used to gauge the degree of stress in Dollar funding in these markets. Prior to the Global Financial Crisis (GFC), the CIP deviation in G-10 currencies was very close to zero, implying little potential arbitrage gains as one would expect for an essentially risk-free arbitrage. This shifted substantially since the GFC, as documented in Du et al. (2018b). Since 2008, the CIP deviation has been fluctuating between 20 and up to 100 basis points or more during stress periods. The common interpretation is that these movements in the CIP deviation reflect fluctuations in the capacity of financial intermediaries to expand their balance sheet to take advantage of risk-free arbitrages, see Du and Schreger (2022).

While much work has covered CIP deviations for AEs, far less is known about the CIP deviation of emerging markets (EM's). Even though financial market data necessary to construct CIP deviations (e.g. interbank interest rates or government bond yields, spot and forward exchange rates or cross currency basis swaps) are available for large emerging market FX markets, its measurement and interpretation poses major challenges.

The first challenge is how to obtain a measure of the risk-free yield for emerging market local currency assets. Unlike in the US or other G-10 advanced economies, local currency government bond yields in emerging markets may reflect substantial credit risk, and one that varies over time. The alternative commonly-used CIP deviation using interbank interest rates such as the LIBOR also faces similar challenges as benchmark interbank rates in EM's arguably also price in credit risk, often co-moving with sovereign yields.

Second, institutional features such as capital controls, differential taxation, legal protection and segmentation across EM onshore and offshore markets complicate the interpretation of CIP deviations for these economies. International investors may not have access to the local money markets, or the onshore currency market, while domestic investors may not have the same access to the offshore currency markets and Dollar funding as foreign ones. They all face different tax burdens on their onshore and offshore investment which are also subject to different domestic and international laws. Such severe segmentation along almost all dimensions of a potential CIP arbitrage trade implies that conventional measures of CIP deviations in EM's cannot be interpreted as limits to arbitrage in the same way as for G10 currencies.

This paper's main contribution is to offer a new and systematic way to construct CIP deviations in EMs that are free of credit and liquidity premia, and at the same time are not subject to the constraints posed by market segmentation. The key insight is to construct the CIP deviation from the market yields of bonds issued by supranational entities in different currencies, distinguish them from conventional measures and characterize their cross-sectional and time-series evolution, including in interaction with key policy parameters.

Supranational entities are multilateral institutions established and jointly backed by the central

governments of a group of countries. An example is the European Investment Bank (EIB), a financing arm of the European Union that benefits from a joint guarantee from members countries and is therefore risk-free. Some sub-national issuers also have impeccable credit records. For instance Germany's Kreditanstalt für Wiederaufbau (KfW) benefits from a full guarantee from the German government and -given the strength of the guarantor- can be considered risk free. In addition, supranational bonds are mostly issued offshore, subject to New York or English law, settled in Dollars and not subject to sanctions, providing strong legal protection and ease of settling. Finally, local withholding and capital gain taxes are not applicable on holdings of supranational bonds, irrespective of the currency denomination.

Our approach can thus be described as follows. Imagine that a supranational entity such as the EIB issues simultaneously zero coupon bonds of the same maturity in US dollars and Turkish lira. Then it is straightforward to compare the return between the US dollar bond and the Turkish lira bond issued by the EIB -swapped into dollars using the FX forward premium between the two currencies. This provides us with a measure of the CIP deviation for the lira that is free of any credit risk -unlike the estimates that would be obtained using local currency Turkish government bonds. We call this the 'purified CIP deviation'.[1]

While the above may sound simple in theory, a number of steps must be taken to ensure that we can indeed construct CIP deviations using supranational issuances. First, supra nationals typically don't issue zero coupons. Nevertheless, they issue coupon bonds in EM currencies and the US dollar sufficiently frequently that we can construct 'purified CIP' estimates at one year tenor for eight emerging market economies.[2] As a check on our methodology, we also construct purified CIP deviations of major G-10 currencies against the US dollar using supranational bonds issued in G-10 currencies, and confirm that they correspond to conventional CIP deviations for these currencies. Since the local currency bonds in these countries don't suffer from credit risk, the 'purified' CIP and the standard estimates obtained using local government bonds or LIBOR rates should coincide. We find that they do.

A second challenge is how to address the differential liquidity of supranational bonds across different currency markets. Our empirical methodology adjusts for differences in the liquidity of the bonds issued by supranationals, using a panel approach that controls for bond-specific bid-ask spreads.

Our first main finding is that the purified CIP deviations for EMs is often much smaller in absolute value, and less volatile, than the naive CIP.

Second, the purified CIP tends to be algebraically larger than the naive one. Taken together,

[1] In principle, the argument could be generalized to risky corporate issuers, such as a multinational entities, as long as the credit risk is perfectly correlated on the dollar and local currency bonds. In practice, this may not be the case -depending on the terms of the bond prospectus, issued in different jurisdictions and possibly by different affiliates- a multinational could decide to default on the local currency bond, and not on the US dollar bond. Moreover, the vast majority of international corporate bond offerings are denominated in the four major currencies (USD, GBP, EUR, JPY), see McBrady et al. (2010).

[2] The EMs are Brazil, China, India, Indonesia, Mexico, Russia, South Africa and Turkiye.

these findings confirm that the naive CIP contains a significant credit risk element -that tends to make it more negative –as higher local currency government rates reflect higher credit risk (see Du and Schreger (2016)).

However, while much smaller, the purified CIP is not identically equal to zero, neither before nor after the 2008 Global Financial Crisis, suggesting that frictions prevent risk-free arbitrage for EMs, as they do for AEs since 2008.

To understand the drivers of CIP deviations, we develop a simple but quite general model of the (purified) CIP basis similar in spirit to Ivashina et al. (2015). The model considers a US-based financial intermediary that offers off-balance sheet dollars forward. Because of regulation or risk management, the intermediary needs to be compensated in equilibrium for offering these forwards. The return to the intermediary is precisely the (purified) CIP basis. Therefore the model produces a 'supply curve' for dollars forward. For a given CIP basis, the supply of forward varies with the balance sheet capacity of the intermediary and with the strength of the regulatory or risk constraints. Local and foreign currency investors with foreign and local currency assets and liabilities form a global dollar hedging demand. The equilibrium on the forward market determines the CIP basis.

In the cross section, the model predicts that the sign of the CIP basis depends on the net dollar hedging demand. Countries with large dollar assets need to sell dollar forward for hedging and funding purposes. For these countries, the CIP basis needs to be negative (forward dollars are cheap) to compensate the intermediary. Conversely, countries with dollar liabilities or foreign investors holding local currency assets need to buy dollar forwards to hedge their exposure. For these currencies, the CIP basis needs to be positive (forward dollars are expensive) to compensate the intermediary.

In the time series, the model predicts that fluctuations in funding conditions widen the basis. When funding conditions tighten, the CIP basis becomes more positive for short dollar countries and become more negative for long dollar countries. Hence tighter funding conditions not only widens the basis but also increases the dispersion of the CIP basis across countries. The model also predicts that tighter financial regulation, especially for global intermediaries, will widen the absolute value of the basis and amplify its response to Dollar funding shocks.

We test these cross-sectional and time series predictions and find that they indeed hold for our sample of EMs when we use our purified CIP – but not so when using the naive basis. These results provide an external validation that we are capturing the true CIP deviation in EM's which reflects financial frictions and suggest that researchers and policy makers should leverage this fast-growing but less explored asset class to construct an alternative measure for financial frictions for emerging markets.

Relation to the literature Our paper builds and expands on a growing body of work at the intersection of international finance and intermediary asset pricing that explores CIP deviations, mostly in advanced economies, after the GFC. The interest in this topic stems from the notion that the CIP is a fundamental no-arbitrage condition, whose violation indicate either sizeable market

inefficiency or regulatory constraints inhibiting arbitrage or both. Du and Schreger (2022) provide a comprehensive overview of the literature. One recent paper that also studies the CIP basis in EM's is Cerutti and Zhou (2024). However, that paper still uses conventional local currency interest rates to construct the CIP basis in EM's and fails to find a relationship between the resulting CIP basis and measures of hedging demand in the cross-section. Another closely related paper is Liao and Zhang (2020), which also emphasizes the hedging channel of exchange rate determination. We build on their insight but expand the empirical analysis beyond advanced economies thanks to the newly constructed "purified" CIP basis. [*Expand discussion of literature here*]

The rest of our paper is organized as follows. Section 2 presents some stylized facts for the conventional (i.e. 'naive') measures of CIP deviation, both for AE and EM currencies. To help frame ideas, section 3 presents our theoretical framework. This may be skipped on a first read if the reader is mostly interested in the details of our 'purified' CIP. Section 4 presents the details of our estimation method while section 5 presents our empirical results on the drivers of CIP for EMs. Section 6 concludes with some observations on future research and policy implications.

2 Stylized facts for conventional measures of CIP deviations

In this section, we establish some key stylized facts about CIP deviations in EMs, including in comparison to CIP deviations in AEs. We highlight their trend evolution and cyclical variation, differences across countries, composition and other statistical properties. We measure the CIP deviation/basis $\tau_{i,n,t}$ for the currency of country i at maturity n and time t according to the standard formula:

$$\tau_{i,n,t} = y^{rf}_{USD,n,t} + \rho_{i,n,t} - y^{rf}_{i,n,t} \tag{1}$$

$y^{rf}_{i,n,t}$ is the country i risk-free interest rate (often measured by an inter-bank money market rate or annualized yield on a zero-coupon sovereign bond in country i in its own currency), maturity n at time t, and $\rho_{i,n,t}$ is the annualized forward premium that converts currency of country i into USD today and back at time t. The classic CIP condition requires $\tau_{i,n,t}$ to be zero. When it is positive, the cash dollar (risk-free) interest rate is higher than the synthetic dollar interest rate constructed from domestic currency interest rate (from benchmark rate or government bond yield) and corresponding exchange rate transactions. One important assumption and condition for CIP to hold is that both the Dollar $y_{USD,n,t}$ and the domestic interest rates $y_{i,n,t}$ are risk-free. Otherwise, deviations from zero in τ could reflect variations in the relative risk priced in different currencies over time.

2.1 AE vs EM differences

In general, LIBOR and government bond based CIP devations are comparable, especially at shorter tenors, and track each other particularly closely after the GFC (see Appendix A). Looking at the daily LIBOR basis for major advanced economies' currencies (G-6 including EUR, CHF, JPY, GBP, AUD, CAD) in Figure 1, we make the following observations.[3]

First, as documented in the literature, the LIBOR basis has widened after the GFC, with the introduction of various regulatory constraints such as Basel III's leverage ratio. Second, CIP deviations are mostly negative, except for AUD. Given our convention, a negative CIP basis means the direct/cash Dollar interest rate is lower than the synthetic Dollar rate (the cost of borrowing in country i's currency, exchange for USD in the spot market and cover the exchange rate risk with a forward that matures at the same time as the local currency loan). Lastly, the CIP basis widens sharply /becomes more negative during stress episodes and crises. In other words, the synthetic Dollar rate (foreign interest rate swapped into Dollar) is higher than the cash Dollar rate for most advanced economies' currencies, and this difference widening in stress episodes.

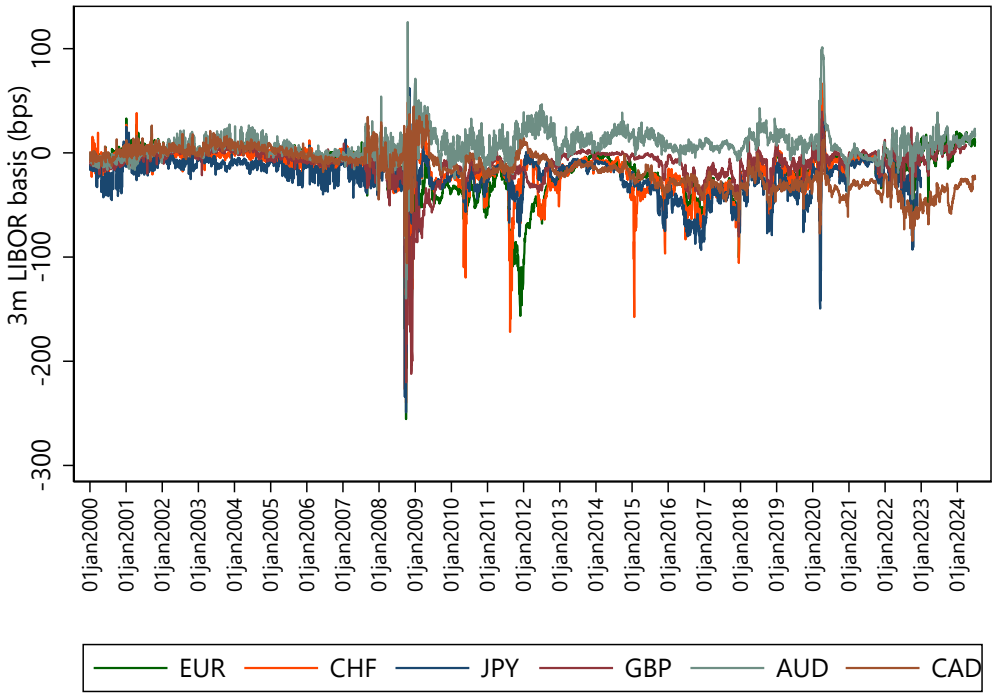


Figure 1: LIBOR-based CIP deviation in major AEs.

For Emerging Markets (EMs), the CIP deviation computed in the same way is more difficult to interpret because of capital controls and/or credit risk.

We show first the LIBOR-based CIP basis in EM's with the deepest markets for Dollar forwards in Figure 2, which are typically those with deliverable offshore forwards: MXN, ZAR, TRY. Brazil

[3]We use interbank rates for each currency as in Du et al. (2018b), for the USD LIBOR, we extend the series by splicing the LIBOR rate with the new SOFR rates for the post-LIBOR period after December 2021.

(BRL) offshore forwards are non-deliverable, but there is an active onshore market for FX forwards and futures that are settled in Real. These derivatives in turn, are priced in close lockstep with the offshore NDF. We therefore show Brazil together with other countries with deliverable forwards for this presentation of EM's with well-developed FX forward markets.

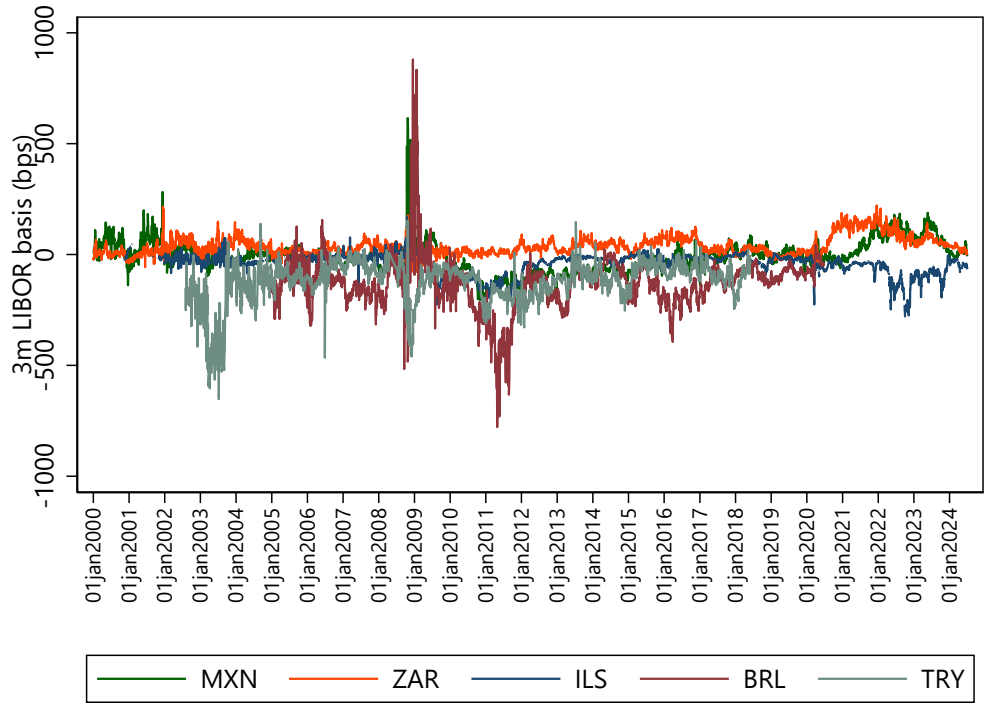


Figure 2: LIBOR-based CIP deviation in EM's with onshore deliverable forwards and Brazil.

The main observation from Figure 2 is that CIP deviations are much more volatile in EM's than AE's, with the scale of the vertical axis being ten times as large for the former than the latter, especially for BRL and TRY. They also vary more between positive and negative values, both across and within countries. Unlike for AE's, there is no visible regime shift after the GFC; CIP deviations in EM's have always been relatively large and volatile.

2.2 CIP basis components

As a matter of accounting, variations in the CIP basis can be driven by two components: the interest rate differential between USD and local currency rates $y_{USD,n,t} - y_{i,n,t}$ and the forward premium $\rho_{i,n,t}$ equal to the log difference between the forward and the spot exchange rate. We decompose the evolution of the LIBOR basis in AEs and EM's into these two components over time.

Figure 3 decomposes the CIP deviation into the interest differential ($y_{USD,n,t} - y_{i,n,t}$) and forward premium components for AE's with negative CIP basis. Up until the GFC, the forward premium always completely offset the interest rate differential between the USD money market and the corresponding AE money market (the forward premium virtually overlaps with the negative interest rate

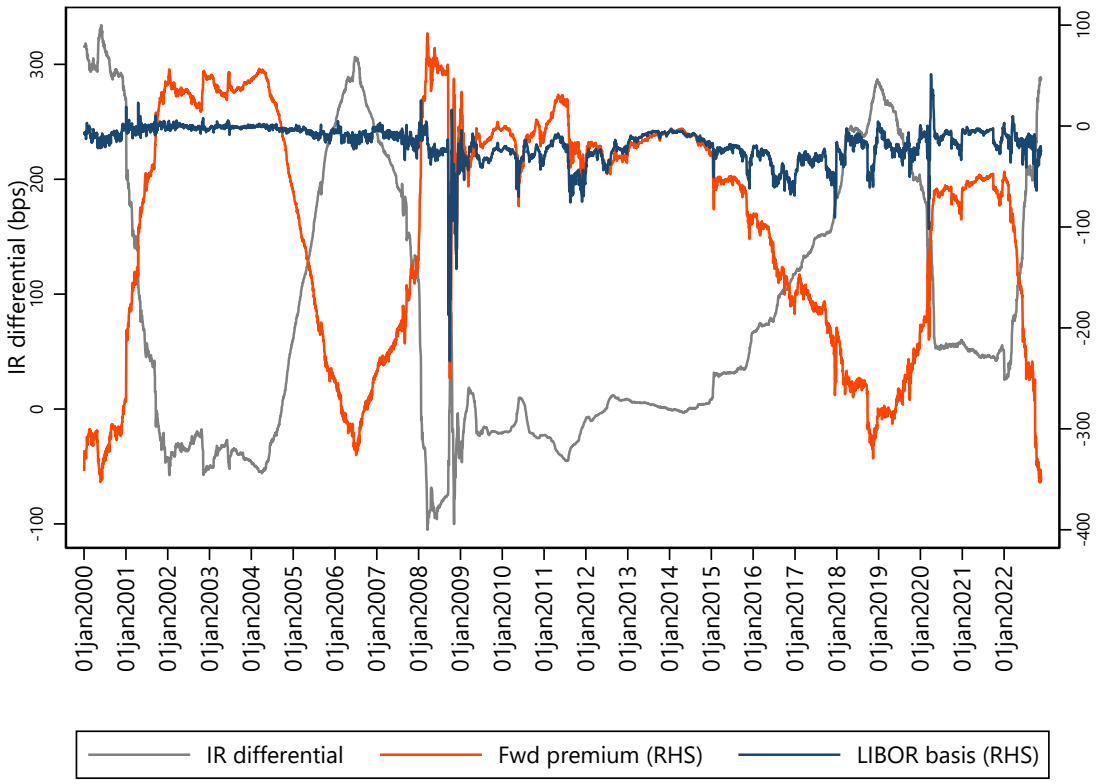
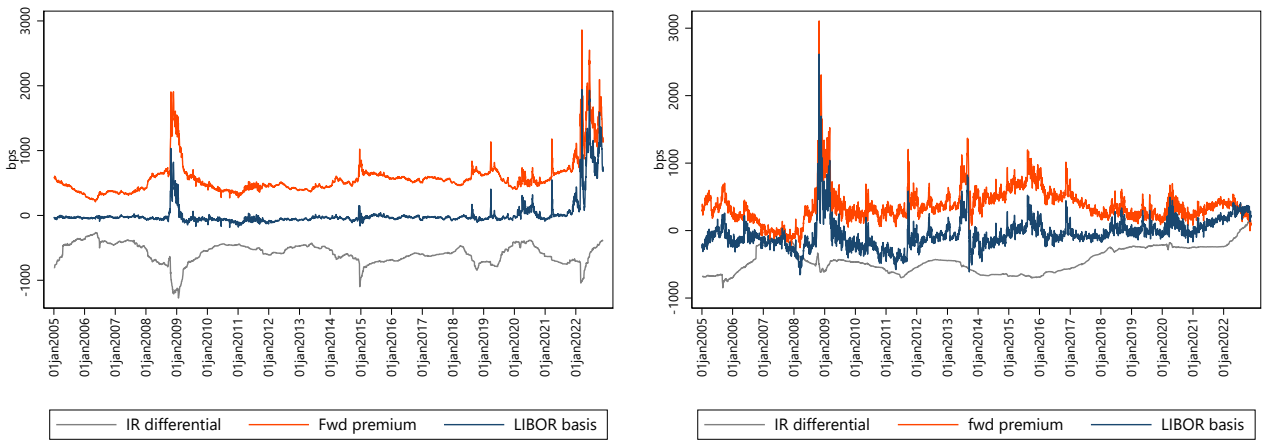


Figure 3: Decomposition of 3-month LIBOR CIP basis in AEs into interest rate differential and forward premium; simple average across EUR, CHF, JPY, GBP in bps.

differential). Since the GFC, however, the basis in most AE's became negative as the interest differential between the US and other AE was not sufficiently offset by a large enough forward premium. In other words, the spot Dollar has been on average overvalued and forward Dollar undervalued relative to the CIP condition (i.e. spot Dollar shortage).

Importantly, since the GFC, the time series volatility of the LIBOR CIP deviation has been primarily driven by volatility in the forward premium, as interest differentials tend to be slow-moving. This excess volatility of the forward premium has continued to persist throughout the sample period: while trends in the interest differential are offset by trend in the forward premia (reflected in the clear negative trend correlation of the orange and gray lines in Figure 3), high-frequency volatility in the LIBOR basis is mainly driven by variation in the forward premium, especially during stress episodes. That is, the typical negative spike in the CIP basis of these AE currencies in stress episodes is driven by a spot Dollar appreciation/forward Dollar discount in excess of what is predicted by the increase in interest differential. Across AE currencies, the correlation coefficient between the change in LIBOR basis and change in forward premium is on average 0.87 while it is only 0.27 for the interest differential. Similarly, a bivariate regression of the change in 3-month LIBOR basis in AE's on the change in the forward premium delivers an R-squared of 77 percent, while the same regression on the change in interest differential yields an R-squared of 7 percent.



(a) MXN, ZAR, ILS, TRY, RUB average

(b) BRL, IDR, CNY, MYR average

Figure 4: Decomposition of 3-month LIBOR CIP basis into IR differential and forward premium: simple average EMs currencies with offshore deliverable (left) and non-deliverable forwards (right).

In EM's, these patterns of relative volatility are magnified. We distinguish two groups of EM's: one with deliverable offshore forwards, and the other group with non-deliverable forwards (NDFs) which are those EM's with capital controls and other FX trading restrictions, and use the corresponding offshore forward price to construct the CIP basis. Figure 4 shows the decomposition of the average CIP basis for EM's with deliverable forwards (MXN, ZAR, ILS, TRY and RUB, panel (a)) and those with offshore NDFs (BRL, IDR, CNY, MYR, panel (b)). In both groups, we see the volatility in the CIP basis overwhelmingly driven by the forward premium while the interest differential is relatively smooth. The forward premium remains the dominant source of high-frequency variation in the CIP basis for the 6-months and 1-year tenors, especially for EM currencies.

Another stylized fact is that, in contrast to AE currencies, which typically see the CIP basis spike negatively in times of stress, we observe that the basis spikes into large positive values in EM's and are much more pronounced in absolute values. In those instances, the forward premium for the Dollar rises in excess of what is implied by the change in interest rate differential. This asymmetry in cyclical deviation from CIP across AE and EM currency markets is a novel stylized fact which our paper will seek to explain.

The fact that forward premia and CIP deviations are much more volatile in EM's, and among them, especially volatile for EM's with restricted offshore markets is not surprising as we would expect more limits to arbitrage, lower liquidity and stronger price movements in an environment with shallow and segmented FX markets. However, these market features by themselves do not explain the asymmetry in the cyclical variation of the CIP basis.

The fact that, in stress periods such as the GFC, the forward premium becomes large and positive in EM's while it becomes large and negative in AE's suggest that there is an excess demand for dollar forwards in the former and an excess supply of dollar forwards (or a spot Dollar shortage) in the latter, when Dollar liquidity becomes scarce. Our paper provides a theoretical framework for this

asymmetry and an empirical test of the key predictions of the model using different measures of the CIP basis in emerging markets.

3 Constrained intermediation and CIP deviations: some elements of theory

This section sketches a simple but quite general model where CIP deviations capture the balance sheet constraints of financial intermediaries.

The model considers the balance sheet of a US-based financial intermediary with US dollar (USD) and local currency (LC) assets and liabilities. USD positions (assets or liabilities) are denoted with an asterisk.

At time t, the intermediary has an initial USD net worth given by $W_t^* > 0$. It can issue D_t^* US dollar liabilities, with a (gross) borrowing rate of R_t^*, and D_t local currency liabilities with a (gross) borrowing rate R_t. We can think of R_t^* and R_t as the USD and local currency interbank rates respectively, but equivalently, we can think of them as the funding rates with a tenor of one period. Since the period here is arbitrary, all our results apply whether we look at short or long tenors.

On the asset side, the intermediary holds B_t^* in USD, with an associated gross return $\tilde{R}_t^*$, or local currency assets B_t with gross return $\tilde{R}_t$. For reasons that will become clear shortly, we can think of B_t^* as holdings of USD *reserves* and of B_t as a local currency risk-free investment.

Denoting the nominal exchange rate $\mathcal{E}_t$ as the price of the USD in local currency, so that an increase represents a depreciation of the local currency, the balance sheet of the financial intermediary at time t, expressed in USD, satisfies:

$$W_t^* + D_t^* + \frac{D_t}{\mathcal{E}_t} = B_t^* + \frac{B_t}{\mathcal{E}_t} \tag{2}$$

In addition, the financial intermediary can engage in off-balance sheet transactions, selling F_t^* one-period ahead US dollars forward at price $\mathcal{F}_t$ in local currency. The -risky- gross USD return on these forwards is given by $(\mathcal{F}_t/\mathcal{E}_{t+1} - 1)$. When $F_t^* > 0$ the intermediary is short in dollars forward, implying that the rest of the market is long dollars forward. When $F_t^* < 0$, the intermediary is long USD forward, implying that the rest of the market is short dollars forward.

Under these assumptions, and with minimal algebra, the wealth of the intermediary next period can be expressed as:

$$\begin{aligned} W_{t+1}^* =& R_t^* W_t^* + \left(\frac{\tilde{R}_t^*}{R_t^*} - 1\right) R_t^* B_t^* + \left(\frac{\tilde{R}_t}{R_t} - 1\right) R_t^* \frac{B_t}{\mathcal{E}_t} \\ &+ \left(\frac{R_t^*}{R_t}\frac{\mathcal{F}_t}{\mathcal{E}_t} - 1\right) F_t^* + \left(1 - \frac{R_t^* \mathcal{E}_{t+1}}{R_t \mathcal{E}_t}\right) \frac{1}{\mathcal{E}_{t+1}} \left(\tilde{R}_t B_t - R_t D_t + \mathcal{F}_t F_t^*\right) \end{aligned} \tag{3}$$

The first term on the right hand side of eq. (3) represents the gross return on net worth at the USD interbank rate R_t^*.

The second term represents the excess return on USD reserves ($\tilde{R}_t^*/R_t^* - 1$). When $\tilde{R}_t^* \leq R_t^*$, as will be the case in equilibrium, this term is negative and represents the *opportunity cost* of holding USD reserves.

The third term represents the excess return on local currency assets vs. liabilities $(\tilde{R}_t/R_t - 1)$. The fourth term represents the risk-free return on the Covered Interest Rate strategy that invests in USD and borrows in local currency at the interbank rates R_t^* and R_t respectively, covering the FX risk with forwards. The return is given by the *CIP basis* $(R_t^*\mathcal{F}_t/(R_t\mathcal{E}_t) - 1)$.[4]

Finally, the last term represents the return on the net local currency exposure $(\tilde{R}_t B_t - R_t D_t + \mathcal{F}_t F_t^*)$, taking into account the off-balance sheet position F_t^*. When this expression is positive, the intermediary has an open long position in local currency (combined on and off balance-sheet) and the -risky- dollar excess return on that position (the carry) is given by $(1 - R_t^*\mathcal{E}_{t+1}/(R_t\mathcal{E}_t))/\mathcal{E}_{t+1}$.

Under the additional constraint that the financial intermediary cannot take an open local currency position, this last term must be equal to zero:

$$\tilde{R}_t B_t + \mathcal{F}_t F_t^* = R_t D_t \tag{4}$$

In other words, the local currency payable at time $t+1$, $R_t D_t$, must equal the local currency receivable at time $t+1$, $\tilde{R}_t B_t + \mathcal{F}_t F_t^*$.

There are two equivalent interpretations of condition eq. (4). First, given local currency assets B_t and local currency liabilities D_t, the intermediary must sell $(R_t D_t - \tilde{R}_t B_t)/\mathcal{F}_t^*$ US dollars forward to offset the local currency exposure (or buy the corresponding amount of dollar forwards when the expression is negative). Alternatively, and this is our preferred interpretation: in order to supply $F_t^* > 0$ US dollars forward to the market, the intermediary needs to borrow $D_t = \mathcal{F}_t F_t^*/R_t$ in local currency today and invest the proceeds in Dollar assets, while to buy $-F_t^* > 0$ US dollars forward from the market (ie. sell $-F_t^*\mathcal{F}_t$ local currency forward), it needs to borrow in Dollar and invest $B_t = -\mathcal{F}_t F_t^*/\tilde{R}_t > 0$ in local currency assets.

In what follows, we impose the restriction that the intermediary is not allowed to carry any local currency exposure, i.e. eq. (4) holds. The wealth of the intermediary W_{t+1}^* is then riskless, and given by: [5]

$$W_{t+1}^* = R_t^* W_t^* + \left(\frac{\tilde{R}_t}{R_t^*} - 1\right) R_t^* B_t^* + \left(\frac{\tilde{R}_t}{R_t} - 1\right) R_t^* \frac{B_t}{\mathcal{E}_t} + \left(\frac{R_t^*}{R_t}\frac{\mathcal{F}_t}{\mathcal{E}_t} - 1\right) F_t^* \tag{5}$$

[4] This is the gross CIP basis. The net CIP basis obtains by taking logs: $\tau_t = i_t^* - i_t + f_t - e_t$, where $i_t^* = \ln R_t^*$, $i_t = \ln R_t$, $f_t = \ln \mathcal{F}_t$ and $e_t = \ln \mathcal{E}_t$.

[5] This allows us to focus on Covered Interest Parity deviations, which is the object of interest for this paper. In ongoing work, we explore the case where the intermediary is allowed to take currency risk. This allows to characterize simultaneously Covered and Uncovered interest parity deviations.

The intermediary wants to maximize next period's wealth, but is subject to a regulatory constraint that takes the following form:

$$B_t^* \geq \alpha_t \left| F_t^* \right| . \tag{6}$$

This constraint states that the intermediary needs to hold some reserves B_t^* against the (absolute) value of its off-balance sheet book $|F_t^*|$, with α_t capturing the intensity of the constraint. When α_t is high, off-balance sheet positions 'consume' more reserves, while when α_t is low, fewer reserves are required. The constraint eq. (6) can be interpreted as a constraint imposed by the regulator, or equivalently as a self-imposed constraint imposed by a financial intermediary concerned about counterparty risks or other Value-at-Risk consideration. The key idea is that the bank incurs costs to expand its off-balance sheet position, even if no risk is involved. This way of modeling frictions in derivative markets follows Ivashina et al. (2015) and Garleanu and Pedersen (2011).

We assume further that the tightness of the regulatory constraint is increasing in the overall off-balance sheet exposure. That is, we posit:

$$\alpha_t = \frac{\mathrm{a}}{1+\alpha} \left(\frac{|F_t^*|}{W_t^*} \right)^{\alpha}, \tag{7}$$

where $\alpha \geq 0$ captures the convexity of the regulatory constraint. Under this assumption, the larger is the absolute net forward position of the intermediary, relative to its net worth, the more expensive is a marginal increase in off balance sheet exposure.

Under these assumptions, the intermediary maximizes its net worth W_{t+1}^* by choosing reserves B_t^*, local currency assets B_t, and off balance sheet position F_t^*. The equilibrium conditions yield a simple and quite general formula for the CIP basis:

$$\frac{R_t^*}{R_t} \frac{\mathcal{F}_t}{\mathcal{E}_t} - 1 = \mu_t a \left(\frac{|F_t^*|}{W_t^*} \right)^{\alpha} \operatorname{sign}(F_t^*) \tag{8}$$

where $\mu_t \geq 0$ is the Lagrange multiplier on the regulatory constraint eq. (6) and represents the shadow cost of reserves.[6] Through the shadow cost of reserves and its negative impact on net worth, the regulatory constraint and its parameterization can capture the increased cost of bank intermediation and balance sheet expansion that arose after the GFC.

Eq. (8) has a number of important features. First, when the regulatory constraint does not bind

[6]For completeness, the remaining equilibrium conditions with respect to B_t^* and B_t imply that $\tilde{R}_t^* = R_t^* - \mu_t$, so that μ_t is also the *convenience yield* on USD reserves. Furthermore, in the absence of additional constraints, arbitrage between local currency assets and local currency funding imposes $\tilde{R}_t = R_t$. From eq. (4) this requires that the forward position F_t^* offsets the net local currency exposure $B_t - D_t$: $F_t^* = R_t(D_t - B_t)/\mathcal{F}_t$.

(either $\mu_t = 0$ or $\mathrm{a} = 0$), CIP holds and the basis is zero:

$$\frac{R_t^*}{R_t}\frac{\mathcal{F}_t}{\mathcal{E}_t} = 1.$$

Deviations from CIP only occur because off-balance sheet positions are costly in terms of reserves.

Second, since $\mu_t \geq 0$, the sign of the basis is the same as that of the net off-balance sheet position of the intermediary F_t^*. Consider the case where $F_t^* > 0$. This means that the intermediary sells dollars forward. Equilibrium on the forward market implies that the rest of the market buys dollars forward. This happens either if local investors want to hedge dollar liabilities, and/or foreign investors want to hedge local currency assets holdings. According to eq. (8), the hedging demand for dollars translates into a *positive basis*. Intuitively, everything else equal, if the market wants to buy dollars forward, these dollars will be expensive, i.e. $\mathcal{F}_t$ will be high. The positive basis incentivizes the intermediary to manufacture these dollar forwards and bear the corresponding balance sheet cost on the right hand side of eq. (8).

Consider now the case where $F_t^* < 0$. This means that the intermediary buys dollars forward (sells local currency). Equilibrium in the forward market implies that the rest of the market buys local currency forward (or sells dollars). This happens either if local investors want to hedge dollar assets, and/or foreign borrowers want to hedge local currency liabilities. According to eq. (8), the hedging demand for local currency translates into a *negative basis*. Intuitively, everything else equal, if the market wants to buy local currency forward, the local currency will be expensive, i.e. $\mathcal{F}_t$ will be low. The negative basis incentivizes the intermediary to manufacture these local currency forwards and bear the corresponding balance sheet cost.

Finally, the size of the CIP basis is directly related to the size of the off-balance sheet exposure $|F_t^*|$, scaled by the net worth of the intermediary and the strength of funding conditions. A stronger hedging demand translates into a larger absolute equilibrium CIP basis, for a given degree of financial tightness. A weaker or less well capitalized financial intermediary, or tighter funding conditions, translates into a proportionately larger CIP basis the larger is the hedging demand.

We can think of eq. (8) as tracing out the supply of dollar forwards as a function of the basis. As the demand for dollar hedging fluctuates, so does the equilibrium basis necessary to clear the market. In addition, shifts in the tightness of the intermediary's balance sheet (shocks to μ_t) or to its financial wealth W_t^* translate into supply shifts, and require an adjustment in the equilibrium basis.

The model outlined so far describes how the CIP basis for a single foreign currency against the Dollar is pinned down. In practice, there are many currencies that trade against the Dollar in the spot and derivative markets, along with each of their CIP basis. Conceptually, we can think of the intermediary as partitioning its aggregate wealth and balance sheet into different segments/currency desks, each indexed by the currency i. By doing so, the global intermediary allocates a portion of its net worth W_i to trading in currency i. Each currency desk therefore is subject to its own balance sheet constraint and maximizes its own profit, but all face the same shadow cost of Dollar reserves

μ_t. In other words, for each currency i, the CIP basis would be:

$$\frac{R_t^*}{R_{it}}\frac{\mathcal{F}_{it}}{\mathcal{E}_{it}} - 1 = \mu_t a_i \left(\frac{|F_{it}^*|}{W_{it}^*}\right)^{\alpha_i} \text{sign}(F_{it}^*) \tag{9}$$

Such balance sheet segmentation can result from frictions within large banking organization which prevent perfect reallocation of balance sheet capacity across trading desks. The segmentation assumption can also be validated by the empirical finding that banks tend to specialize across different FX markets, possibly due to sticky counterpart relationships and local information advantage (see Moskowitz et al. (2024)).

Applied to a cross section of currencies, eq. (9) implies that the net demand for Dollar forwards vis a vis each currency will determine the cross-sectional variation in the CIP basis. Countries with net long dollar exposure –either because they hold dollar assets, or because foreign investors hold local currency liabilities– will have a negative CIP basis. Conversely, countries with short dollar exposure –either because they hold dollar liabilities, or because foreign investors hold local currency assets– will have a positive CIP basis.

In the time series, some of the movements in the CIP basis are likely to be related to shifts in the supply curve, either because of sudden tightening of funding conditions (increases in μ_t or a) or to a deterioration in the net worth of the financial intermediaries (a decrease in W_t^*). For a given hedging demand, tighter funding conditions make a negative CIP basis *more negative*, and a positive CIP basis *more positive*. Hence we should expect *more dispersion* in CIP bases across countries when financial conditions tighten. This insight explains the stylized fact that, subject to financial stress, the CIP basis would spike negatively for major AE currencies (as they have net long Dollar exposure and hence $\text{sign}(F_{it}^*) < 0$), while EM's, being net borrowers, typically have net short Dollar exposure, $\text{sign}(F_{it}^*) > 0$) and therefore face a positive spike in CIP basis instead. At the same time, due to the fundamental measurement problems for EM CIP deviations, a systematic analysis of such adjustment has not been possible so far.

Liao and Zhang (2020) document the predicted correlation between the CIP basis and net USD debt position in a cross section of major advanced economies (AE) at the aggregate level. Among major AEs, most countries have a long net USD asset position at the aggregate level and this position is slow-moving. Avdjiev et al. (2019) also document how advanced G-10 countries load on the Dollar index with consistently different beta's. Although they do not link these varying beta's to the net Dollar position, we see that G-10 countries with large positive USD positions have a large negative beta, consistent with eq. (9). No such correlation has been documented for EM currencies. Our framework offers a unifying explanation for these empirical results from the literature and extends them to the much less explored but rapidly growing market of EM currencies.

Variation in hedging demand can also explain why the CIP basis and local currency interest rates are negatively correlated, as discussed by Du et al. (2018b). Countries with large current account

deficits tend to have both higher interest rates and higher dollar liabilities. The latter implies a positive basis according to equation (9) to compensate the intermediary for the balance sheet cost of supplying net Dollar forwards. Consequently, despite a high local currency interest rate, their swapped dollar rate is low compared to the cash dollar rate. Conversely, countries with current account surpluses tend to have both lower domestic interest rates and higher dollar assets, implying a negative basis to compensate the intermediary for the cost of supplying local currency forwards.

4 Supranational bonds and the "purified" CIP basis

4.1 What does the CIP basis measure for EMs?

We unpack further the CIP basis into conceptual components. As LIBOR rates are not available for tenors above 12 months we will use the government bond CIP basis in the following as the benchmark from which we derive our variables of interest.

Following the decomposition of interest rate parity conditions such as in Du et al. (2018a) or Obstfeld and Zhou (2022), we define the 'naive' CIP constructed using local government yields as:

$$\begin{aligned}
\phi^{Gov}_{i,n,t} &= y^{Gov}_{USD,n,t} + \rho_{i,n,t} - y^{Gov}_{i,n,t} \\
&= \left(y^{Gov}_{USD,n,t} - y^{rf}_{USD,n,t}\right) - \left(y^{Gov}_{i,n,t} - y^{rf}_{i,n,t}\right) + y^{rf}_{USD,n,t} + \rho_{i,n,t} - y^{rf}_{i,n,t} \\
&= \left(I_{USD,n,t} - \lambda_{USD,n,t}\right) - \left(I^{Gov}_{i,n,t} - \lambda^{Gov}_{i,n,t}\right) + \tau_{i,n,t} \\
&= \hat{\lambda}^{Gov}_{i,n,t} - \hat{I}^{Gov}_{i,n,t} + \tau_{i,n,t}
\end{aligned} \tag{10}$$

where $y^{Gov}_{i,n,t}$ is the yield on country i's local currency zero coupon government bond with maturity n at time t, and $\rho_{i,n,t}$ is the annualized forward premium that converts currency of country i into USD today and back at time t.

The second line adds and subtract the (possibly unobserved) risk free interest rate at the corresponding maturity $y^{rf}_{i,n,t}$. The third line expresses the local currency spread $y^{Gov}_{i,n,t} - y^{rf}_{i,n,t}$ as the difference between the credit spread $I_{i,n,t}$, and a possible convenience yield for government bonds $\lambda^{Gov}_{i,n,t}$. A higher convenience yield lowers the local currency spread. A higher credit risk increases the spread. $\tau_{i,n,y}$ denotes the 'true' n-year risk-free CIP deviation defined in eq. (1). The last line defines $\hat{\lambda}$ as the *relative* convenience yield (country i minus the US) and $\hat{I}$ as the relative credit risk.

The government bond CIP deviation decreases with relative credit spreads, increases with relative convenience yield and increases with the purified CIP deviation.

Note that in this derivation, consistent with the derived CIP deviation from our model, the risk-free (or purified) CIP deviation $\tau_{i,n,t}$ could also come from a relative convenience yield on the risk-free assets themselves. In particular, to the extent there is a convenience yield on the Dollar risk-free asset (the so-called 'specialness' of the Dollar), it would be consistent with the Dollar being

the funding currency of large global intermediaries and hence a tightening of their balance sheet frictions would be associated with a higher premium on Dollar intermediation.[7] In terms of our model notation, such an increase in the Dollar convenience yield would be captured by the parameter μ_t, which in turn affects the CIP basis in all countries proportional to the net forward demand (equation 9).

Different authors have made different assumptions about the various components in eq. (10). Du and Schreger (2016) argue that $\phi^{Gov}_{i,n,t} = \hat{I}^{Gov}_{i,n,t} = I^{Gov}_{i,n,t}$. That is, they argue that the main source of CIP deviations for EM is local currency credit risk: $I^{Gov}_{USD,n,t} = 0, \hat{\lambda} = \tau = 0$. Instead, Jiang et al. (2020) assume that the naive CIP basis reflects the relative convenience of US Treasuries, i.e. $\phi^{Gov}_{i,n,t} = \hat{\lambda}^{Gov}_{i,n,t}$. It is clear from eq. (10) that all three terms could potentially matter.

We are interested in recovering $\tau_{i,n,t}$. Clearly, for EMs, using government bonds is problematic because there is substantial credit risk: the term $\hat{I}^{Gov}_{i,n,t}$ is non-negligible and varies over time. Moreover, as argued by Du and Schreger (2016), it cannot be covered using sovereign CDS since the latter only apply to foreign currency/foreign jurisdiction issuance of domestic sovereign bonds. Estimating true deviations in CIP for EM's is further complicated by the presence of capital controls, differential tax treatment and financial market segmentation in most EM jurisdictions: international and domestic investors/borrowers do not have access to the same currencies and money markets to conduct arbitrage trades, and face differential tax burdens across onshore/offshore investments. To address these challenges, we propose to use Supranational bonds issued in EM currencies, which we introduce in the following.

4.2 What are supranational bonds?

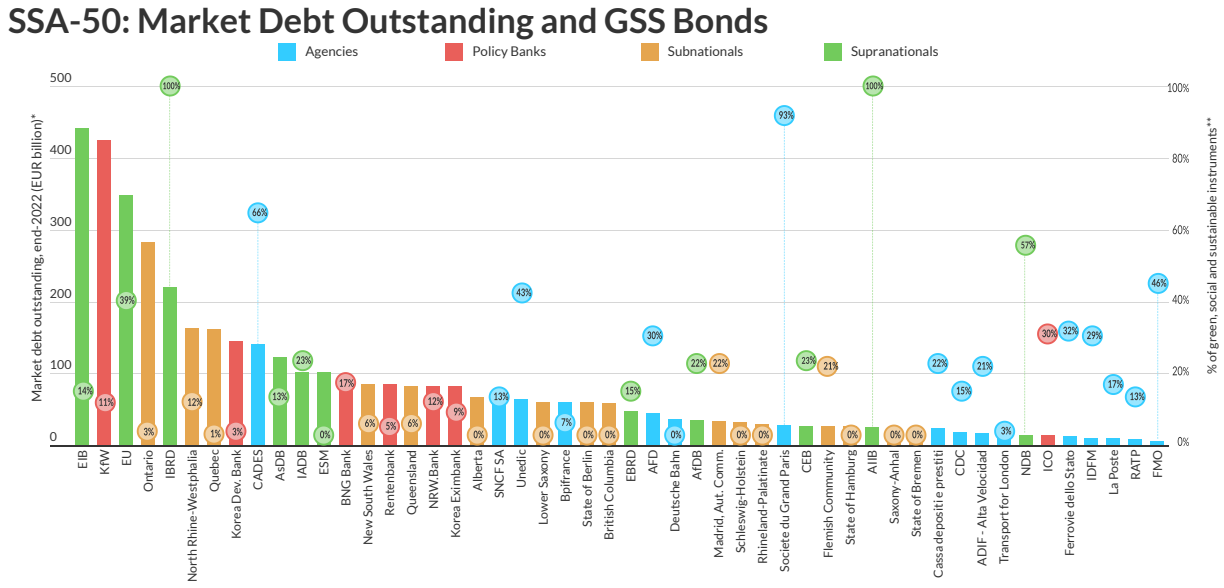
Supranational bonds are debt securities issued by institutions that are owned or established by central governments of two or more countries. These institutions are usually established by international treaties to pursue specified policy objectives, most commonly to promote economic development and integration of member countries. They form a subset of the so-called *Sovereigns, Supranationals and Agencies (SSA)* fixed-income asset class, which, in addition to supranationals, also include bonds issued by quasi-sovereign entities with explicit government guarantees such as national development banks or sovereign wealth funds, and subnational entities (see Fitch Ratings SSA Handbook, 2023). The size of the SSA bond market has been growing globally, with the largest 50 SSA issuers having over 4 trillion USD in outstanding debt, and over 600 billion USD in issuance volume in 2021 (Deutsche Bank, 2021).

With the shareholder base being composed of major advanced economies, the large supranational issuers typically enjoy AAA rating and are considered of very low default risk (*S & P Supranationals 2023 Special Edition*). The European Investment Bank (EIB) and the World Bank (IBRD) are the top supranationals with the largest market shares, and together with the German development

[7] Obstfeld and Zhou (2022) and Diamond and Van Tassel (2021) derive and estimate such Dollar convenience yields.

bank KfW (Kreditanstalt für Wiederaufbau) make up over 1 trillion USD in debt outstanding (see Figure 5).

Figure 5: Top 50 SSA issuers.



*Except for Transport for London, Alberta, British Columbia, Ontario and Quebec, whose debt outstanding is as of 31 March 2022 (end of FY22); and IBRD, New South Wales and Queensland, whose debt outstanding is as of 30 June 2022 (end of FY22) ** Green, social and sustainable instruments data is per issuers' own classification and may include labelled, as well as non-labelled instruments
Note: Market debt outstanding includes senior bonds and loans. The USD, CAD, AUD, XDR and KRW amounts have been converted into EUR at market rates, source: Bloomberg
Source: Fitch Ratings, as of 15 September 2023

The AAA-rated supranational bonds typically have zero risk weighting (for Basel II and III capital requirement), are eligible as HQLA, and are increasingly associated with sustainability and social impact. They are therefore traded by a broad investor base, but thanks to the quasi risk-free nature, are particularly attractive to central banks, followed by commercial bank treasuries, and insurance and pension funds. We focus on this AAA subgroup of supranationals, whose business goals are described in Table 1.

We propose using supranational bonds issued in emerging market local currencies to compute local-currency risk-free interest rates and CIP deviations and test predictions on drivers of the purified CIP basis in emerging markets. Du and Schreger (2016) explored this possibility with bonds issued by the European Investment Bank and the Kreditanstalt für Wiederaufbau in Turkish Lira and Brazilian Real. We expand the construction of CIP basis using supranational bonds to eight issuers in 11 EM currencies, and 8 advanced economies to test the general validity of the exercise. Table 1 gives an overview of the supranational issuers and the currencies they issue in.

One useful feature of these supranational bonds crucial for our analysis is that they issue in multiple currencies, including emerging market currencies (see major currency of issuance in Table 1, column 3). In addition, they are subject to international law, exempt from local withholding and capital gain taxes, and not subject to international sanctions. Although denominated in EM currency, supranational bonds usually settle in Dollar through global platforms such as *Euroclear*. Primary market issuances are placed through global dealer banks who also manage liquidity in

Table 1: Sovereigns, Supranationals and Agencies (SSA) bonds

Issuers	Description	Currencies in Sample
Asian Development Bank (ADB)	Multilateral develoment bank; aids economic and social development in Asia and the Pacific; lends to countries and the private sector.	USD, CHF, JPY, ZAR, TRY, HKD.
African Development Bank (AFDB)	Multilateral development bank; aids economic development and social progress in Africa; lends to eligible (i.e. creditworthy) countries and, to a lesser extent, the private sector.	USD, BRL, IDR, INR.
European Bank for Reconstruction and Development (EBRD)	Multilateral development bank; funds development of market economies in 36 countries from central Europe to central Asia by providing project finance, mainly to the private sector.	USD, BRL, HUF, IDR, INR, MXN, PLN, RUB, TRY, ZAR.
European Investment Bank (EIB)	Development bank of the European Union; mainly engage in financing infrastructure projects in EU countries.	AUD, CAD, CHF, EUR, GBP, JPY, USD, BRL, HUF, PLN, TRY.
Inter-American Development Bank (IADB)	Multilateral development bank established in 1959; lends to Latin American and Caribbean countries making it the world's first regional development bank.	USD, BRL, IDR, INR.
International Bank for Reconstruction and Development (IBRD)	Largest part of World Bank Group; Main goals are to end poverty in middle-income and creditworthy poorer countries, and to promote sustainable economic development.	AUD, CAD, EUR, GBP, JPY, USD, BRL, CNY, HUF, IDR, INR, MXN, PLN, RUB, TRY, ZAR.
International Finance Corporation (IFC)	Part of World Bank Group; development finance for private sector enterprises in developing countries.	JPY, USD, BRL, CNY, HKD, MXN, RUB, TRY, ZAR.
Kreditanstalt fuer Wiederaufbau (KFW)	Germany's flagship federal development bank; activities include financing for SMEs, housing and infrastructure, as well as export and project finance and assistance for developing countries.	AUD, CAD, CHF, EUR, JPY, GBP, USD, BRL, CNY, HKD, MXN, TRY, ZAR.

AE: AUD (Australian Dollar), CAD (Canadian Dollar), CHF (Swiss Franc), EUR (Euro), GBP (Pound Sterling), JPY (Japanese Yen) and USD (United States Dollar). ***EM:*** BRL (Brazilian Real), CNY (Chinese Yuan), HKD (Hong Kong Dollar), HUF (Hungarian Forint), IDR (Indonesian Rupiah), INR (Indian Rupee), MXN (Mexican Peso), PLN (Polish Zloty), RUB (Russian Ruble), TRY (Turkish Lira), and ZAR (South African Rand).

secondary markets.[8] As such, supranational bonds in EM currencies offer international investors the exposure to EM currencies without exposure to EM credit risks and with the ease and safety of offshore settlement. For the supranational issuer, EM debt issuance offers financing of local activities and attractive funding costs in hard currency as foreign exchange exposure is often hedged via the

[8]See institutional and operational details for one of the largest supranational– the IBRD in "Demystifying Supranationals", The World Bank Treasury, November 2014.

same dealer bank.

The size and liquidity of the market for supranational bonds differ across issuers and currencies. Figure 5 shows that the EIB, KfW, IBRD capture almost half of the market of SSA bonds. But also across currencies, there is a wider variation in supranational issuance activity. The distribution of Supranational issuers across EM currencies in our sample spanning the last 25 years is summarized in Table 2.

Table 2: Percent of total bonds issued across major currencies by SSA issuer, 1998-2022

	IBRD	KFW	EIB	IFC	EBRD	ADB	IADB	AFDB
USD	58.0	20.2	22.5	38.9	28.3	63.0	75.4	40.4
AUD	4.5	2.3	2.6	15.6	4.1	6.6	6.8	11.2
CAD	3.7	0.6	1.7	2.9	0.1	2.6	3.6	0.1
CHF	0.0	0.2	0.8	0.0	0.0	0.3	0.0	0.0
EUR	12.3	66.0	56.6	1.4	15.3	7.3	0.1	24.1
GBP	9.5	7.7	9.4	7.4	13.1	8.7	9.8	6.7
JPY	0.0	0.5	0.4	1.7	0.4	0.3	0.0	0.1
NZD	2.3	0.1	0.1	4.1	0.0	4.1	1.5	0.5
BRL	0.5	0.0	0.2	2.5	2.3	0.1	0.1	1.2
CNY	0.5	0.4	0.1	1.5	1.7	1.4	.	1.3
IDR	0.2	0.0	0.1	0.2	2.5	0.1	1.1	0.1
INR	0.3	0.0	0.0	2.0	1.3	0.5	0.1	0.3
MXN	0.8	0.0	0.3	7.8	4.2	0.2	1.0	2.2
PLN	0.0	0.1	1.7	0.0	1.0	0.3	.	.
RUB	0.1	0.0	0.0	0.7	2.4	0.1	0.0	0.1
TRY	0.3	0.0	0.4	4.6	9.3	0.5	0.1	1.4
ZAR	2.5	0.3	0.7	1.5	7.1	0.6	0.0	5.5

Source: Bloomberg; IBRD: International Bank for Reconstruction and Development (the World Bank), KfW: Kreditanstalt für Wiederaufbau (German Development Bank), EIB: European Investment Bank, EBRD: European Bank fuer Reconstruction and Development, ADB: Asian Development Bank, IADB: Inter-American Developmen Bank, AFDB: African Development Bank.

The USD is by far the most common currency for supranational bond issuance, making up on average 43 percent and up to 75 percent of outstanding supranational debt, followed by the Euro, the British Pound and the Australian Dollar. The share of bonds issued in EM currencies is in the single digit, and is accounted for by issuances in Turkish Lira, South African Rand, The Mexican Peso, and Brazilian Real.

To take an example, we zoom in on supranational issuances in Turkish Lira in Table 3 to provide an overview of the distribution of issuance activity over time and across supranational institutions, as well as the variation in original maturity of these bonds. The Turkish Lira is one of the most commonly used EM currency for supranational issuances. Among them, the EIB is the largest issuer and its bonds have the longest original maturity (of up to 8 years).

To construct the CIP deviation, we have to choose the tenor n which would determine jointly the maturity of the local currency supranational bond, the USD supranational bond, the USD for-

Table 3: TRY: Amount Issued and Original Maturity 2005-2022

	EBRD		IFC		EIB		IBRD		ADB			
Year	Orig. Mat.	Issued Amt.	Orig. Mat.	Issued Amt.	Orig. Mat.	Issued Amt.	Orig. Mat.	Issued Amt.	Orig. Mat.	Issued Amt.	Total Issued	Avg. Orig. Mat.
2005					4.5	4280	2	73			4353	3.2
2006			3	33	5.6	1452			4	55	1540	4.1
2007					6	4410	4.8	910	3.8	274	5594	4.8
2008	2.7	36	3	313	7	222	2.5	169	3.2	1399	2139	3.6
2009	4.4	1199	3.2	1142	2.5	471	3	312	3.3	872	3996	3.2
2010	5.5	438	5	558	4.5	1395	3.5	811	4.6	763	3965	4.6
2011	4.7	1174	4.7	289	5.1	2627	3	148	4.6	468	4706	4.4
2012	3.8	917	4	215	5	670	3	99	4.2	1824	3725	4
2013	5.1	1931			4.5	3012	4	51	4.1	63	5057	4.4
2014	2.5	85	3	136	6.2	3728	3	409	3	342	4700	3.5
2015	3	553	4.1	1040	4.5	703	3.1	529	3.5	136	2961	3.6
2016	3	7	3.8	144	8	175	3.6	104	4	36	466	4.4
2017	3	1205	4.7	2605	7.5	340	4.1	1381	3.7	545	6076	4.5
2018	2.9	2053	3.1	511	5.2	283	4.2	618	4	280	3745	3.8
2019	3.7	2421	3.1	225			4	25	3.5	422	3093	3.5
2020	4.1	367			2	71	2	204	1.8	409	1051	2.4
2021	3.6	597					4	133	1	156	886	2.8
2022	2.9	431									431	2.9

Notes: Original Maturity are in years and Amount Issued in million Dollars. Source: Bloomberg.

ward premium and other variables that are necessary to construct the basis.[9] In choosing n, we are guided by the data. The goal is to pick the tenor for which the supranational bonds are traded most frequently. Figure 6 plots the distribution of remaining time to maturity of four SSA-currency pairs over the sample period. The horizontal axis denotes the remaining years to maturity and the the vertical axis the average amount of bonds observed per day with that remaining maturity. From the distribution of these four currency-issuer pairs as well as more systematically across other pairs in our sample, we can conclude that 1 year is the modal tenor and choose it to be the baseline tenor to construct the purified CIP basis.

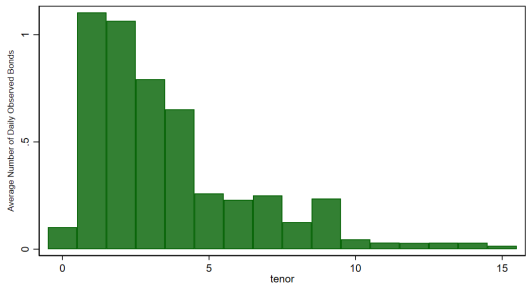
4.3 Using Supranational bonds to construct 'purified' CIP deviations

4.3.1 Constructing the supra-specific basis

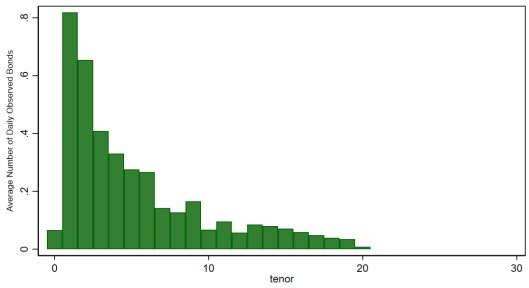
Suppose we observe the one-year zero-coupon yields issued by supranational j both in currency i and in USD, denoted $y^{Supra}_{i,j,t}$ and $y^{Supra}_{USD,j,t}$. Then we can construct the excess return or supra-specific basis to be:

[9] As discussed in Du et al (2018), there is no liquid market for FX forwards beyond 3 months and we resort to constructing longer-term FX forwards by combining prices for nondeliverable forwards, interest rate swaps and cross-currency swaps.

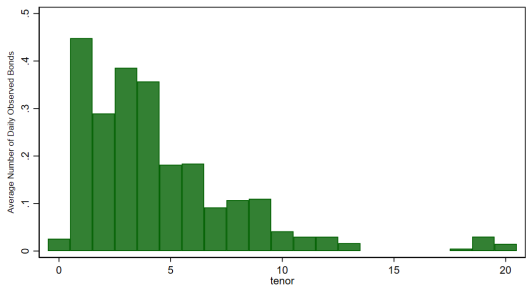
Figure 6: Summary statistics of supranational bonds in EM currencies: histogram of remaining maturity distribution of select bonds.



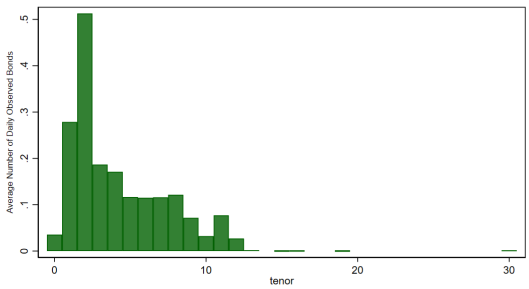
(a) TRY EIB bonds remaining maturity profile



(b) ZAR IBRD bonds remaining maturity profile



(c) BRL-IBRD bonds remaining maturity profile



(d) MXN-IBRD bonds remaining maturity profile

$$\phi_{i,j,t}^{Supra} = y_{i,j,t}^{Supra} - \rho_{i,t} - y_{USD,j,t}^{Supra} \tag{11}$$

In practice, relying only on bond yields at a single maturity term to compute the basis as the difference in average yields to maturity could render the computation highly volatile as the yield does not account for the profile in spot rates throughout the coupon payment schedule of the bond. Assuming a constant yield at every coupon payment date implicitly assumes a flat zero-coupon yield curve for the remaining maturity of the bond and abstracts from coupon re-investment risk. Therefore, we follow Du and Schreger (2016) in computing the basis with the z-spread method. That is, we calculate the spread over the entire yield curve for the remaining maturity of the bond that would be required to equalize the discounted schedule of cash flows (coupon and principal payments) with the observed market price. This method utilizes the information across the entire maturity structure of the supra bond to calculate the basis as each periodic cash flow is discounted with a different discount rate. The z-spread for the supranational bond issued by j in USD with residual maturity n, measured as a parallel shift in the Dollar IRS curve by $s_{j,t,t+n}^{\$}$, is calculated iteratively using:

$$P_{j,t,t+n}^{\$} = \sum_{\tau=1/q}^{n} \frac{c^{\$}}{\left(1 + y_{t,t+\tau}^{j,IRS} + s_{j,t,t+n}^{\$}\right)^{\tau}} + \frac{1}{\left(1 + y_{t,t+\tau}^{j,IRS} + s_{j,t,t+n}^{\$}\right)^{n}} \tag{12}$$

where q is the annual coupon payment frequency, $c^{\$}$ the Dollar coupon rate and $P^{\$}_{j,t,t+n}$ the bond's market price at time t. The z-spread for the same supra issuer in currency i, with cash flows swapped into USD at the pre-determined schedule is calculated as a spread over Dollar IRS curve correspondingly:

$$P^{i}_{j,t,t+n} = \sum_{\tau=1/q}^{n} \frac{c^{i}}{\left(1 + y^{i,IRS}_{t,t+\tau} + \chi^{i,xccy}_{t,t+\tau} + \overline{s}^{i}_{t,t+n}\right)^{\tau}} + \frac{1}{\left(1 + y^{i,IRS}_{t,t+\tau} + \chi^{i,xccy}_{t,t+\tau} + \overline{s}^{i}_{t,t+n}\right)^{n}} \tag{13}$$

To obtain the IRS rates $y^{i,IRS}_{t,t+\tau}$ and the cross-currency basis swap rates from currency i to Dollar $\chi^{i,xccy}_{t,t+\tau}$ at maturities $t+\tau$, we fit a Nelson Siegel model to estimate the zero-coupon rate curve for both rates. Calculating the the z-spread of the currency i bond over the LIBOR IRS and the cross-currency basis swap rate (xccy) yields the z-spread of the respective bond in currency i over the Dollar LIBOR IRS rate of the same maturity, and hence makes the z-spreads comparable across currencies. Note that we only use the estimated zero curve to fill in for the corresponding xccy and IRS rates at the coupon payment dates, and not to impute bond prices themselves. Unlike the supra bonds themselves, the xccy and Dollar IRS are much more liquid at a range of tenors and amenable to estimating a zero-coupon yield curve using daily prices. The z-spread and as a result, the supranational basis is only calculated for issuers and dates where we have actually observed bond prices on secondary markets. Moreover, to calculate the z-spread, we match pairs of supranational bonds in Dollar and the corresponding emerging market currency with residual maturities within five months of each other to calculate the z-spread and basis.

Under the no arbitrage assumption, the Dollar and swapped z-spreads have to be equal if markets price the supranational credit risk to be the same.[10] Otherwise, the supranational basis for currency i is given by:

$$\phi_{i,j,t,t+n} = s^{\$}_{j,t,t+n} - \overline{s}^{i}_{j,t,t+n} \tag{14}$$

4.3.2 Extracting the currency-specific CIP deviation

How can we combine the information contained in a set of supranational bonds issued by different issuers in a given currency into a currency-specific 'purified' CIP deviation? For exposition, we focus on the one-year purified CIP ($n = 1$), which is the modal remaining maturity for many SSA issuers in emerging markets in our sample. As derived above, we can express each basis as:

$$\begin{aligned} \phi_{i,j,t} &= s^{\$}_{j,t} - \overline{s}^{i}_{j,t} \\ &= \tau_{i,t} - \hat{\lambda}_{i,j,t} \end{aligned} \tag{15}$$

[10] Note that we do not strictly need the zero credit risk assumption here.

where we follow the same decomposition as in eq. (10) with $\hat{I}_{i,j,t} = 0$ and $\hat{\lambda}_{i,j,t}$ the relative convenience/liquidity yield for supra issuer j in local currency i vs. in US dollar.

It is likely that supranational convenience yields in EM's are very small, especially relative to those in Dollar and Euro, as these bonds are still mainly issued in G-7 currencies and their liquidity in secondary markets in EMs tends to be low.[11] The Supra convenience yield in EMs can even be negative if liquidity in the secondary market is lower than for other (potentially more risky but more liquid) local currency assets. Figure 20 in the Appendix illustrates the wide and volatile bid-ask spreads for supranational bonds in four emerging market currencies relative to the local government bond bid-ask spread of the same tenor. The relatively low secondary market liquidity presents the main challenge that comes with constructing a supranational-based CIP basis for EM's.

To address the varying liquidity premium across time and issuers for supranational bonds, we proxy the convenience yield of the local currency supranational bond with its bid-ask spread, which varies across issuers/currencies as well as over time for each issuer/currency.[12] That is, we assume for supranational j :

$$\lambda_{i,j,t}^{Supra} = \lambda_{i,j}^{Supra} + \alpha_j \times BidAskS_{i,j,t} + \epsilon_{i,j,t},$$

where $\alpha_j < 0$.

That is, we assume the liquidity yield of supranational j in market i is on average equal to $\lambda_{i,j}^{Supra}$, depending on that issuer's presence in that market (i.e. issuance volume/frequency) as well as characteristic of that market and any joint characteristics of the currency market with the supranational issuer. The market-issuer fixed effect in this liquidity decomposition therefore captures slow-moving institutional features of the EM currency market and the issuer. At high frequency, liquidity conditions also vary with fast-moving market conditions as captured by the issuer-specific sensitivity to the bid-ask spread, as well as residual idiosyncratic fluctuations in liquidity yields $\epsilon_{i,j,t}$, for example, due to idiosyncratic change in liquidity for other safe assets in that market.

With this assumption for the non-USD supranational convenience yield, eq. (15) can thus be rewritten as follows :

$$\begin{aligned} \phi_{i,j,t}^{Supra} &= \tau_{it} - (\lambda_{i,j,t}^{Supra} - \lambda_{USD,j,t}^{Supra}) \\ \tilde{\phi}_{i,j,t}^{Supra} &= \tau_{it} + \tilde{\lambda}_{i,j}^{Supra} + \tilde{\alpha}_j BidAskS_{i,j,t} + \varepsilon_{i,j,t}, \end{aligned} \tag{16}$$

[11] In the US, for example, the KfW convenience premium is on average positive due to ample secondary market liquidity. It averages at around 7 bps over the last 10 years, with the interquartile range at 2.5 to 11 bps.

[12] We plot the distribution and evolution of bid-ask spreads in the Appendix.

where

$$\begin{aligned}\tilde{\phi}_{i,j,t}^{Supra} &= \phi_{i,j,t}^{Supra} - \lambda_{USD,j,t}^{Supra} = \phi_{i,j,t}^{Supra} - (y_{USD,n,t}^{rf} - y_{USD,n,t}^{Supra}),\\ \tilde{\lambda}_{i,j}^{Supra} &= -\lambda_{i,j}^{Supra}, \tilde{\alpha}_j = -\alpha_j.\end{aligned}$$

Since all variables (except for the last term, the residual) are now measurable, the "pure CIP basis" τ_{it} can thus be estimated by extracting market-time fixed effects in the corresponding regression equations using at least two different Supra issuers in a given market over the sample period. In other words, to identify a path for τ_{it}, we need $j > 1$ for each i and t.

Alternatively, we can also assume that the EM supranational bond liquidity is market-issuer specific around a mean level $\lambda_{i,j}^{Supra}$, with deviations from this mean level being orthogonal to the market-time fixed effect (in other words, assume $\alpha_j = 0$).

We extract the "pure" CIP basis using both methods and report the results below. The key advantage of our "pure" CIP basis is that it is conceptually free of relative credit risk premia, purged for differential liquidity premia, and by the unique properties of the asset class, overcomes the market segmentation as well as legal, fiscal differences in treatments that plague the conventional measure. Constructing the pure CIP deviation using bonds by a given SSA issuer also overcomes the problem of not capturing the effective borrowing cost and investment return by heterogenous investors on either side of the CIP trade. Augustin et al. (2022) show how using uncollateralized interbank rates, such as LIBOR, to compute the CIP deviation may not be appropriate due to heterogeneity in counterparty risks. By constructing deviations from CIP for a single issuer across different currencies overcomes the problem of heterogeneity in credit/counterparty risk. In this case, the CIP deviation indeed reflects the violation of law of one price for a given issuer who is actually facing the observed borrowing rates in different currencies.

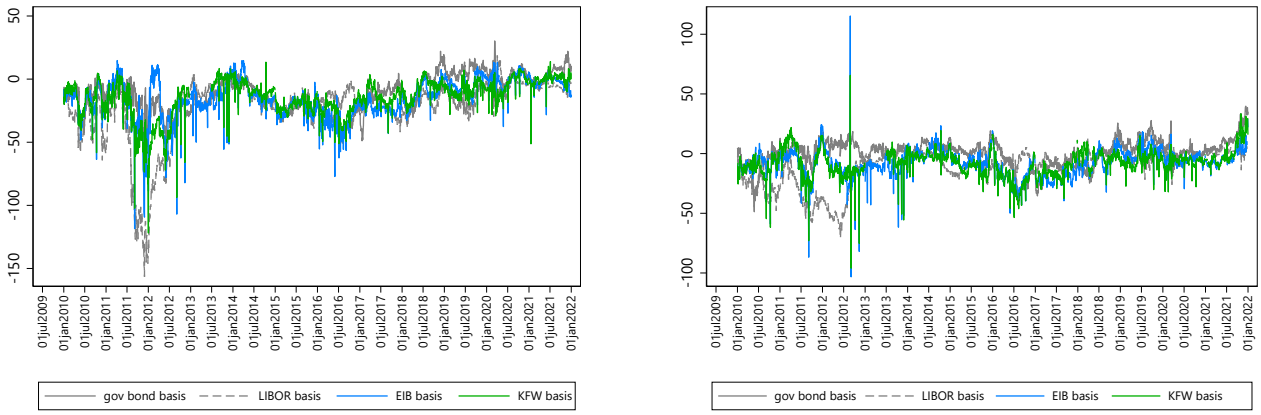
5 Purified CIP deviations

5.1 Purified CIP deviations in G-10 markets

Before turning to the purified CIP deviation in EM's, we look at the purified and conventional CIP basis in advanced economies. We can think of this exercise as a 'sanity check' on our approach: since interbank and sovereign credit risks should be negligible for major advanced economies that issue reserve currencies, we should expect the 'purified' CIP basis computed with supranational bonds and the 'naive' CIP basis in these G-10 currencies to coincide.

As reported in Table 2, apart from the Dollar, the next two G-10 currencies in which supranationals issue most often are the Euro (EUR) and the British Pound (GBP). Thus for these two currencies, we should expect that first, there is no relative credit risk priced into the supra basis (i.e. $\hat{I}_{i,j,t} = 0$)

Figure 7: Purified and conventional CIP for EUR and GBP.



(a) 1y EUR Supra (EIB) and Treasury/LIBOR basis

(b) 1y GBP Supra (EIB) and Treasury/LIBOR basis

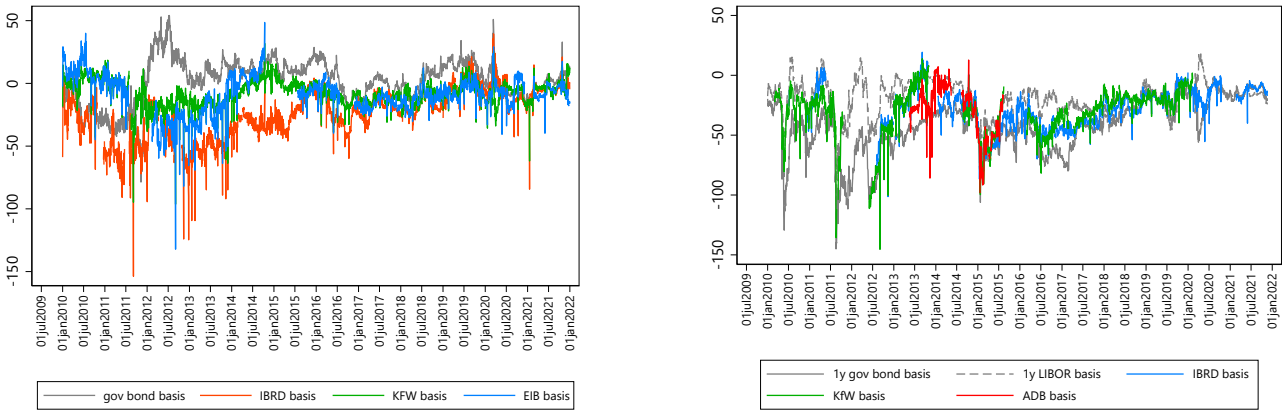
and second, that the relative liquidity or convenience premium is small (i.e. $\hat{\lambda}_{i,j,t} \approx 0$).[13] If this is true, the (purified) supranational basis should closely match the LIBOR and Treasury/government bond basis of the same tenor for the Euro and British Pound. We plot the purified CIP basis computed using the methodology above and compare it with the conventional measures of CIP basis using LIBOR and government bond yields for the Euro and British Pound in fig. 7. All series are for 1 year maturity. Treasury and LIBOR bases are constructed using the 1-year zero-coupon government bond yield or the 1-year interbank rate swapped from EUR and GBP into Dollar. The purified supra basis is computed using the z-spread method and bonds issued by the EIB and KFW in EUR, GBP and Dollar. As expected, we confirm that for these two G-10 currencies, both supranational CIP bases closely track the Treasury basis, and most of the time also the LIBOR one. The supra CIP deviations are, however, much more volatile than the LIBOR and treasury bases as the supranational bonds are much less liquid than the local government bonds or LIBOR funds.

The impact of illiquidity on the supra basis becomes more evident when we look at other G-10 currencies in which supranational bonds are issued, but at lower volumes. According to Table 2, two such currencies would be the Australian Dollar (AUD) and the Swiss Franc (CHF). With a much smaller volume of supranational bonds being issued and traded on the secondary market in these currencies, relative to the corresponding issuances by the same supranationals and the associated secondary market trading in Dollar, we would expect the relative liquidity premium/convenience yield to be significantly negative (i.e. $\hat{\lambda}_{i,j,t} < 0$), although the relative credit risk should still be negligible, especially in the case of the CHF (i.e. still $\hat{I}_{i,j,t} = 0$). Overall, we would expect the purified CIP basis to track the conventional bases less well in AUD and CHF compared to the extent they do so in EUR and GBP. Figure 8 shows that this is indeed the case. While still tracking the overall trends

[13] For the EUR government bond basis, we use the 1-year yield on the German Bund.

in the LIBOR and Treasury bases, the supra CIP basis displays much more volatility spikes and in such instances, tends to be lower than the Treasury basis. This is because the supra convenience yield is arguably more negative than the Treasury convenience yield due to lower liquidity of, say the IBRD/KFW/ADB bonds in CHF than the Swiss government bond in CHF. When computing the underlying purified supra basis for currencies with relatively low secondary market liquidity in supranational bonds, it is therefore important to adjust for the differential liquidity premia to arrive at the purely frictional basis–that is, to extract τ_{it} in our decomposition of equation (16).

Figure 8: Purified and conventional CIP for AUD and CHF.



(a) 1y AUD Supra and Treasury/LIBOR basis

(b) 1y CHF Supra and Treasury/LIBOR basis

5.2 Purified CIP deviations in emerging markets

We are currently able to estimate the pure CIP basis using supranational bond data for eight EM currencies, six of which offer sufficient data to examine the behavior of CIP basis over time.[14] Regarding the set of supranational issuers, we have six issuers who have issued bonds in EM currencies over the last two decades: the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the World Bank (IBRD), the International Finance Corporation (IFC), and the German development bank Kreditanstalt für Wiederaufbau (KfW). Not all issuers have been active in all markets at all times. Overall, the IBRD, KFW and EIB have been the most active issuers in EM currencies (see Table 11 in the Appendix).

Having shown that the purified CIP basis passes our sanity checks using AE currencies (even prior to purging for liquidity differentials), we move on to applying the purification methodology to EM currencies. Importantly, as supra bonds in EM currencies are much less liquid than in USD or

[14]Note that to have a a time-series for supra basis, we need to observe at least [x] monthly transaction prices in a given currency and the Dollar for a given supra issuer in the secondary market with a specific residual maturity (for example 1-year maturity) to compute the corresponding z-spread over time.

EUR, it is crucial to adjust the supra CIP basis in EM currencies for the differential liquidity premium as shown above.

Let us look at the three EM currencies with the most liquid supranational bond trading: Brazilian Real in Figure 9, Turkish Lira in Figure 10 and South African Rand in Figure 11. These three EM currencies have absorbed a relatively high volume in supranational issuances (see Table 2 and Table 11 in the Appendix).[15] We have four to five supranational issuers' bonds being traded on the secondary markets in these currencies since the early or mid-2000 (going back the longest for the South African Rand), allowing us to construct purified CIP deviations in Emerging Markets since before the GFC. For each currency, we plot the z-spread computed for each supranational issuer that had 1-year residual maturity bond traded during the sample period. Even before any adjustment for liquidity differential, we see that the supra z-spreads are clustered above the conventional LIBOR and government bond bases, consistent with them pricing in no relative credit risk unlike the conventional ones.

Using these daily z-spreads for each supranational bond in a given currency market, we extract the common time fixed effect following the procedure behind equation (16). To smooth over daily volatilities, we aggregate all spreads to monthly averages and use secondary market bond prices of at least two supranational issuers in a given EM currency with the same or adjacent residual maturity observed in the same month to extract the common CIP basis. At the same time, we net out the impact of differential liquidity of the Dollar bond versus the local currency bond of each issuer using the bid-ask spread. The resulting purified CIP bases are plotted as blue lines in Figures 9, 10 and 11. This is to our knowledge the first computation of CIP deviations for such a long sample period across multiple major EM currencies, stretching back to the early or mid-2000 and updated to the recent post-COVID period.

What first stands out is that, unlike in AE's as shown in the sanity check above, in EM's the supranational basis differs widely from the LIBOR and treasury basis, indicating large default risk premia and convenience yields priced in the conventional CIP basis in EM's. The salience of credit risk is why Du and Schreger (2016) refer to the treasury CIP deviations in EM's as the "local currency credit spread".

Moreover, three main observations can be drawn:

1. In line with the decomposition above, the higher credit risk for EM's sovereigns and banks together with negative relative treasury premium (vis a vis the US) indeed result in the government bond and LIBOR basis being lower than the riskless supra CIP deviation (which is free of credit risk and adjusts for liquidity differentials). The discrepancy is less stark for South African Rand, though the purified series is still more stable than the conventional one. The government bond basis typically exhibits the largest swings, likely due to the higher and more

[15] In the appendix, we show the corresponding results for the Mexican Peso, Indian Rupee, Indonesian Rupee, (offshore) Chinese Yuan, and the Russian Ruble. However, the supra CIP bases computed for these currencies are much less reliable as they have much lower issuance volumes and liquidity, and for most of the sample period, have too few overlapping supra bonds traded on the secondary markets with adjacent residual maturities.

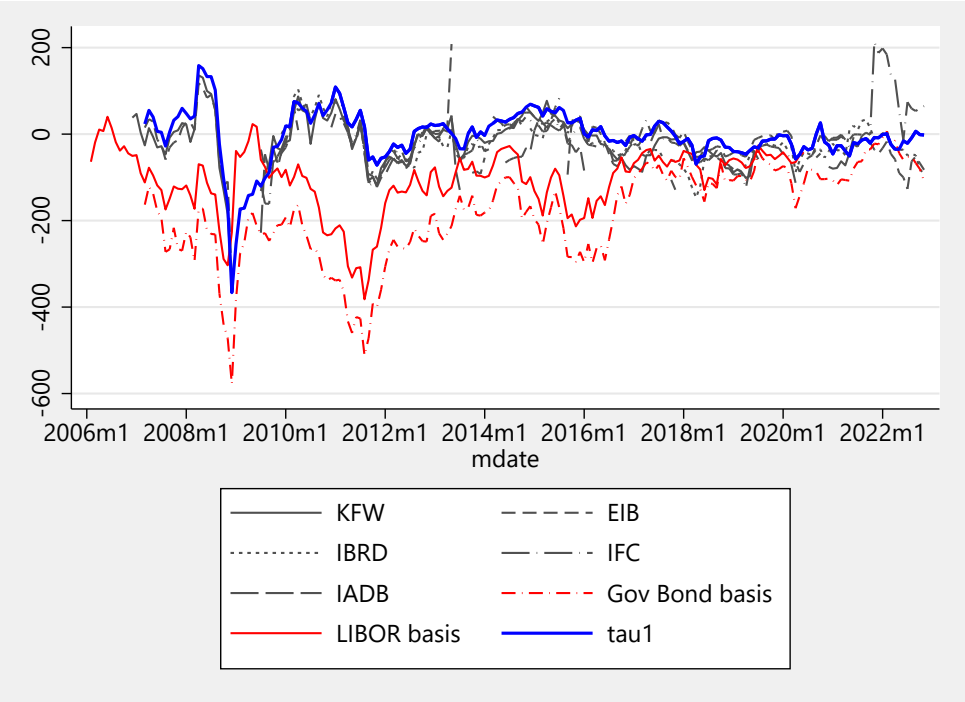


Figure 9: Brazilian Real–CIP basis derived from individual supranational bonds by issuer, extracted purified CIP basis (tau1) and conventional LIBOR and Government bond basis.

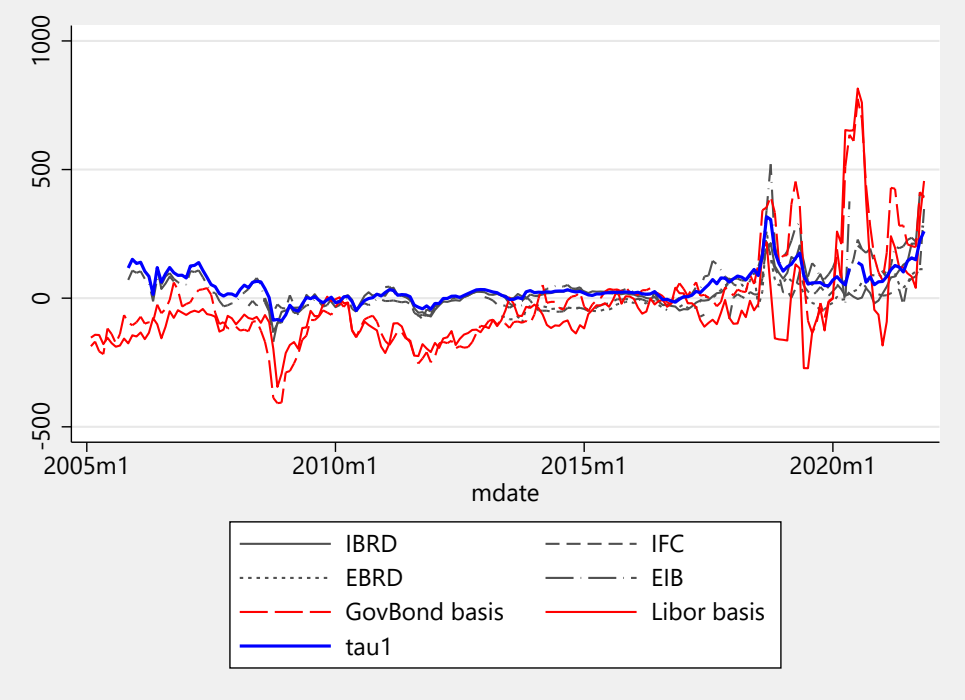


Figure 10: Turkish Lira–CIP basis derived from individual supranational bonds by issuer, extracted purified CIP basis (tau1) and conventional LIBOR and Government bond basis.

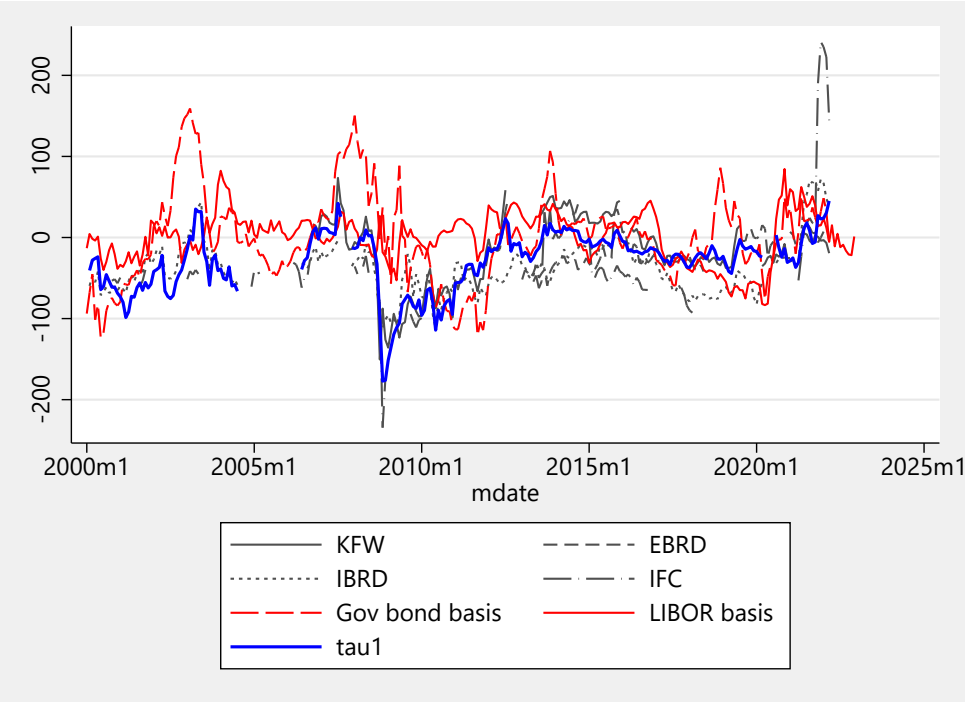


Figure 11: South African Rand–CIP basis derived from individual supranational bonds by issuer, extracted purified CIP basis (tau1) and conventional LIBOR and Government bond basis.

volatile sovereign credit risk than banking sector credit risk priced in LIBOR, in addition to the negative relative convenience yield of EM government bonds (relative to US treasury bonds). However, we also see that LIBOR contains substantial risk-premium when comparing the LIBOR basis with the supranational one. Using the LIBOR basis (the conventional measure of CIP deviation) can therefore be especially misleading in EM's (and also in AE's, though by less, as shown e.g. in Rime et al. (2022), Augustin et al. (2021)).

2. As the pure CIP basis is purged from risk-and liquidity premia, it is more stable and likely reflects slower-moving intermediation frictions. It is precisely the empirical measure of the intermediary pricing wedge in equation (8) which in turn are due to balance sheet constraints, FX market shallowness, as well as capital and liquidity regulations. As part of the balance sheet constraint, the riskless CIP basis also reflects the so-called Dollar premium (see Obstfeld and Zhou (2022)) and can rise and fall with the "specialness" of the Dollar, in turn reflecting the shadow cost of Dollar funding of the intermediary.

3. The most striking difference compared with conventional measures of CIP basis is the frequently flipped sign: using the estimated risk-less CIP basis, the deviation becomes more positive (with the exception of the GFC), meaning that the riskless synthetic Dollar yields in EM markets are lower than the cash Dollar yields. Arbitrage would call for risk-less/low-risk issuers to borrow in EM's, hedge the currency risk and invest in riskless Dollar assets. Our model framework illustrated how this arbitrage opportunity exist in countries with net

Table 4: Mean CIP deviations (and standard deviations) at 1-year tenor using naive (LIBOR and Government Bond) vs. (Supranational bond) purified measures for overlapping sample periods.

Currency	Libor CIP Basis	Government bond CIP Basis	Purified CIP	Time Period
BRL	-103.59 (69.01)	-149.52 (98.72)	3.32 (2.60)	05/2011-05/2023
CNY	10.08 (130.68)	30.53 (126.80)	-43.46 (6.07)	03/2013-12/2013; 02/2015-06/2018
IDR	-443.02 (107.79)	67.96 (121.41)	-1.64 (4.47)	01/2016-03/2022
INR	-511.18 (140.22)	-87.32 (127.99)	6.24 (3.12)	01/2013-10/2019;02/2022-10/2022
MXN	40.93 (60.89)	-25.17 (37.59)	15.35 (2.1)	07/2014-06/2023
RUB	-43.43 (75.47)	-0.90 (62.01)	-29.23 (20.66)	12/2009-12/2010;01/2013-03/2022
TRY	-2.71 (240.68)	48.08 (246.97)	50.62 (5.89)	09/2009-03/2022
ZAR	-1.23 (35.21)	-11.53 (44.99)	-20.42 (2.30)	09/2009-06/2023

Note: Time periods are those with overlapping data available for all three measures of CIP deviations at 1-year tenor. Purified CIP is calculated according to the procedure described in section 4, only available for months when at least two supranational bonds with 1-year (or adjacent) residual maturity have been traded for a given currency.

Dollar liabilities: due to constrained balance sheet space of intermediaries, this arbitrage gain must exist for them to provide the FX forwards and swaps demanded by local USD debtors. As this CIP deviation goes in the opposite direction of the conventional (LIBOR and Treasury) CIP deviations driven by credit risk and convenience yield, it makes sense that purging for risk-premia would reveal the underlying hedging-channel of the CIP deviation.

Table 4 summarizes the average level of CIP deviations for each emerging market currency, calculated for all eight EM currencies for which we have at least some overlapping supranational bonds being traded at the same time. We can therefore use both the naive versus purified procedure over sample periods where we have overlapping data for both measures and compare the results. The first difference to note, in line with the example cases above, is that the absolute value of the purified CIP deviation is often by orders of magnitude smaller than the conventional ones. Second, in many cases, the sign is flipped, suggesting that risk and convenience yields embedded in the conventional CIP likely completely masks the degree of intermediation frictions in currency markets. The sign of the 'purified' CIP basis on the other hand, is qualitatively consistent with the prediction of our model-implied CIP equation: EM's with large net external debt tend to have a positive purified CIP basis (Turkey, Mexico, Brazil), while EM's which traditionally run current account surpluses and have net external assets on average have negative purified CIP basis (China, Russia). We turn to a more systematic analysis of this cross-sectional pattern in the following subsection.

5.3 Cross-sectional variation in CIP

Assuming $\alpha = 1$ in eq. (9) and averaging across time for a given currency i, we get the following simple expression:

$$CIP_i = \bar{\mu} a \left(\frac{F_i^*}{W_i^*} \right), \tag{17}$$

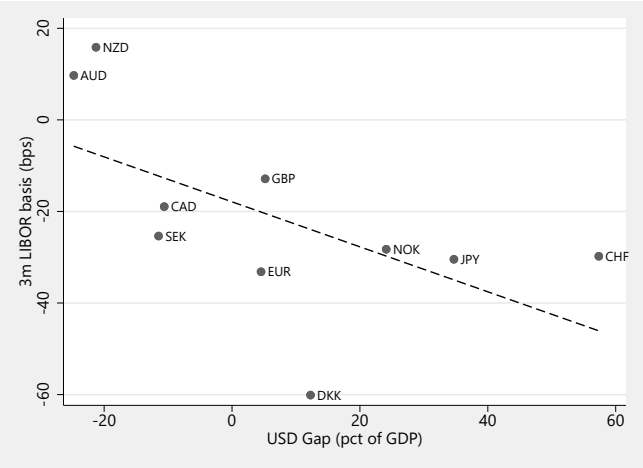
with all variables indexed with i being averages over time for country i.

As argued above, we expect countries with net hedging demand for forward dollars to require $F^* > 0$, hence $CIP_i = \bar{\mu} a \left(\frac{F_i^*}{W_i^*} \right) > 0$. At the aggregate level, these should be countries that are Dollar debtors like AUD, NZD and currency account deficit EM's. Dollar surplus countries, that is, where residents have net Dollar assets that they want to hedge, should have the opposite sign for their CIP_i since on net, they would have a supply of Dollar forwards (see Liao and Zhang (2020)).

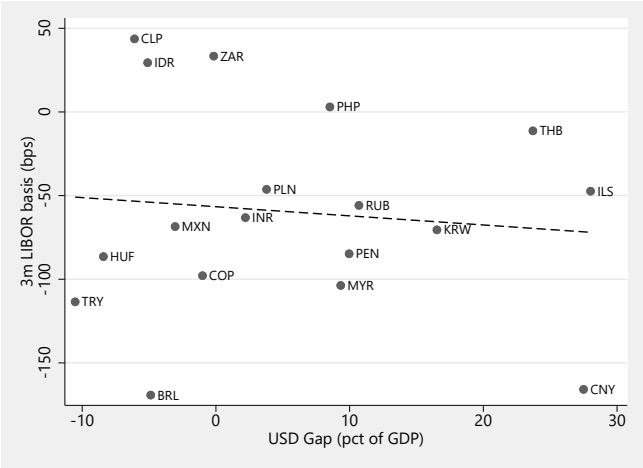
To measure the net Dollar exposure and associated hedging demand at the aggregate level, we use the dataset constructed by Benetrix et al. (2019) and updated in Allen and Juvenal (2024), which provides a decomposition of the gross external asset and liability position in each country by different currencies over time, encompassing major reserve currencies as well as the local currency. This data allows us to measure the hedging demand for Dollar forwards with a so-called Dollar gap. We calculate this Dollar gap as the difference between external Dollar debt asset and external Dollar debt liabilities as a share of GDP in each country, with the focus on debt instruments motivated by the evidence that debt instruments are hedged at higher ratios than equity (see Campbell et al. (2010); Du and Huber, 2023). A positive Dollar gap according to this measure of net external Dollar position would imply that residents have a net demand for spot Dollar (to fund the assets) and net supply of forward Dollars (to hedge the asset exposure back to local currency), in other words, $F^* < 0$. Conversely, countries with net external Dollar debt would tend to have a net demand for Dollar forwards to hedge the Dollar liabilities, i.e. $F^* > 0$.

The focus on the demand for hedging in explaining the cross-sectional variation in the CIP deviation is appropriate for the long-run perspective, as variation in balance sheet costs, the key determinant for hedging supply in our framework, are more pronounced at higher frequency. Does this simple prediction hold up in the data?

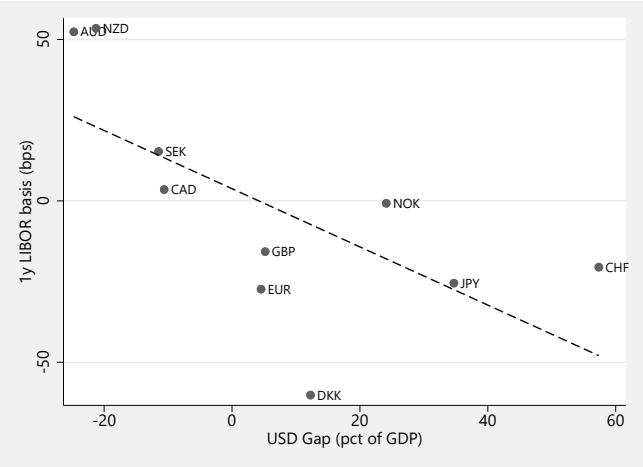
In fig. 12 panel (a), we see that using the conventional 3-month LIBOR basis, the predicted cross-sectional correlation between the CIP basis and the Dollar gap holds well for AE currencies (sample correlation of -0.59), similar to results in Liao and Zhang (2020). However, no such correlation can be observed for EM currencies in panel (b), as has also been noted in Cerutti and Zhou (2024). A similar asymmetric pattern holds for the 1-year LIBOR CIP basis in panels (c) and (d), which again show a strong negative correlation between the average Dollar gap and the CIP basis for AE currencies (sample correlation o f -0.65), and if anything, a weak positive correlation for EM currencies. The same result is obtained if we use government bond-based CIP basis at different tenors (see Figure 22 in the Appendix).



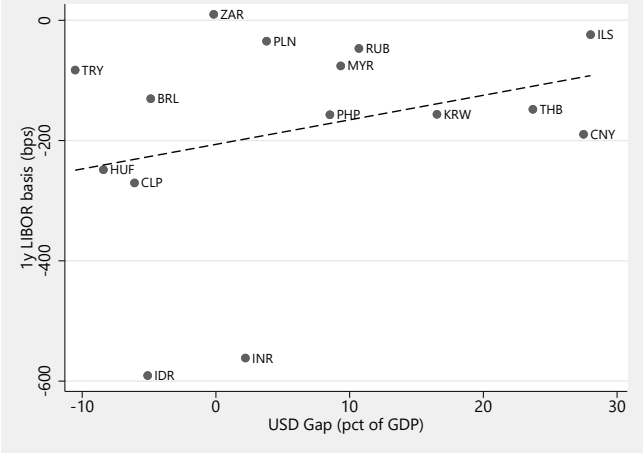
(a) 3m LIBOR CIP basis in AE's



(b) 3m LIBOR CIP basis in EM's



(c) 1y LIBOR CIP basis in AE's

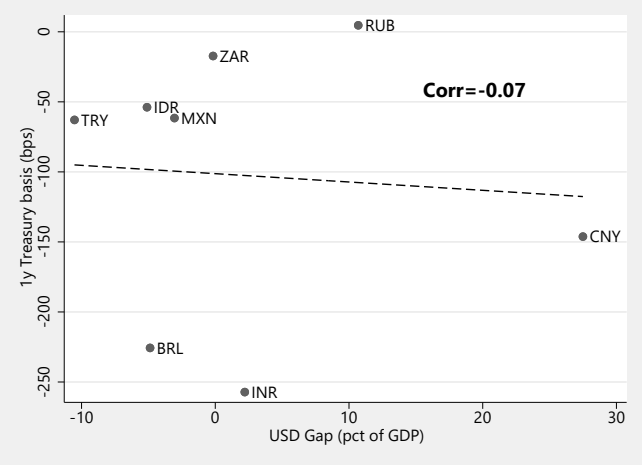


(d) 1y LIBOR CIP basis in EM's

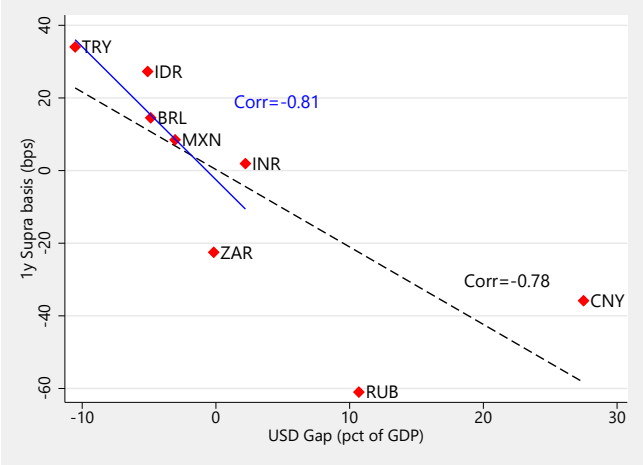
Figure 12: Net Dollar debt asset position (USD Gap) and average 3-month and 1-year LIBOR CIP basis in AE's and EM's: 2010-2017 averages by country/currency. For EUR, the GDP-weighted average of national USD gaps is taken.

Conventional CIP deviations constructed using interbank rates and government bonds in EM show no correlation at all with the net Dollar debt position, whereas we expect the hedging demand channel to result in a negative correlation like we observe in AE's. This points to the possibility that interbank interest rates and government bond yields in EM's contain sizeable risk and liquidity premia, blurring the forces of financial frictions and hedging demand.

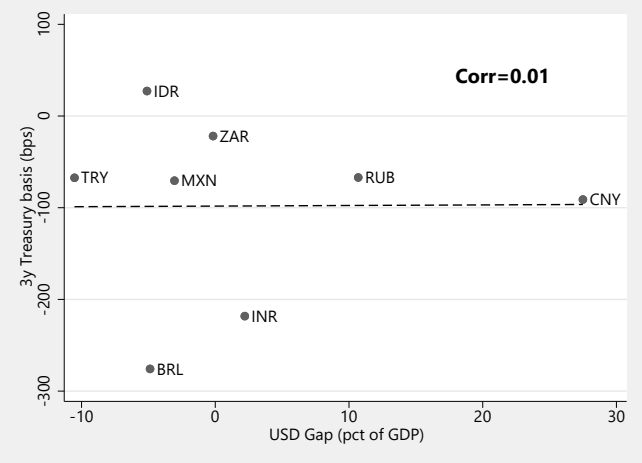
Can our "purging strategy" recover the predicted relationship between underlying hedging demand and the purified CIP basis? We use CIP deviations computed with supranational bonds as explained in the previous section for EM currencies that have supranational bonds by more than 1 issuer, with available overlapping prices over at least parts of the sample period (2010-2017), to compute the supra-based CIP deviation. Since we can only perform the exercise for our set of 8 EM currencies, we compare the correlation before and after the purification procedure for this subsample only in fig. 13.



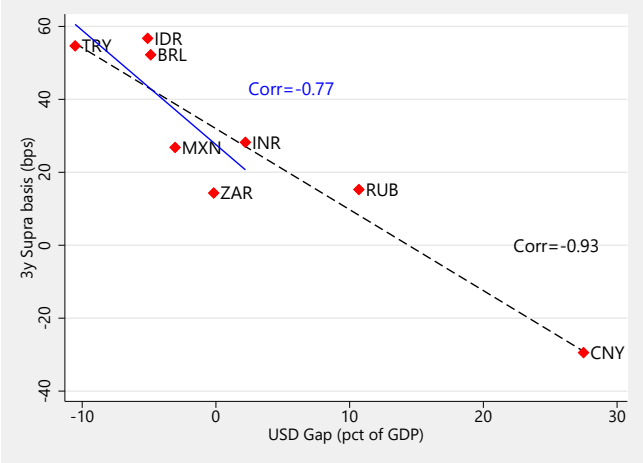
(a) 1y Treasury CIP basis in EM's



(b) 1y Supra CIP basis in EM's



(c) 3y Treasury CIP basis in EM's



(d) 3y Supra CIP basis in EM's

Figure 13: Net Dollar debt asset position (USD Gap) and average 1-year and 3-year Treasury vs. Supranational CIP basis for the subsample of EM's with supranational bonds: 2010-2017 averages by country/currency.

We choose the 1-year tenor for the construction of the purified CIP basis as it is the modal tenor available from the bond price data (cf. Figure 6). Similar as for the sample of all EM currencies in panel (c) of Figure 12, the 1-year LIBOR basis for the eight EM subsample also does not show any cross-sectional correlation with the Dollar gap in panel (a) of Figure 13. When we replace the CIP basis with the supranational one, however, a clear negative correlation emerges as predicted by the hedging demand channel (sample correlation turns from zero in panel (a) to -0.8 in panel (b) of Figure 13). These results regarding the cross-sectional correlation are also obtained, if not strengthened, when we use the second most frequent tenor in our supra bond price distribution of 3-years: the sample correlation turns from zero in panel (c) using the 3-year Treasury basis to -0.9 using the 3-year supra basis in panel (d) of Figure 13. The correlations also hold, with even a steeper slope, if we exclude the data points for RUB and CNY, which exhibit the most volatile swings among the supra bases (see Figure 21 in the Appendix).

This stark difference in cross-sectional correlation between the conventional and purified CIP deviations suggests, as has been long assumed in the literature, that conventional measures of CIP deviations in EM's reflect in large parts credit and liquidity risk instead of arbitrage violation or financial frictions. Therefore, the purification of the CIP deviation for EM currencies with our procedure using supranational bonds in local currencies appears promising, as it recovers the model-implied correlation between the purified CIP basis and aggregate hedging demand in the cross section of major emerging market currencies. In the remainder of the paper, we explore other dimensions of variation in the purified CIP bases of EM currencies, as well as their interaction with key parameters of the model.

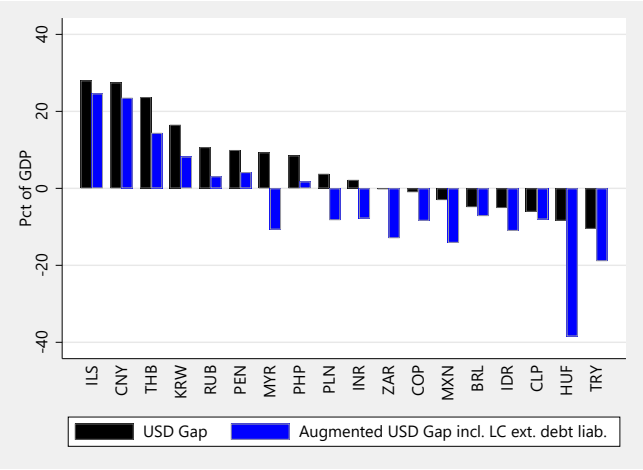
5.3.1 Foreign investors' hedging demand

The Dollar gap we measure so far captures the demand for hedging stemming from domestic borrowers' and lenders' exposure to exchange rate risk, reflecting the currency/Dollar mismatch on the aggregate domestic balance sheet. Over the past two decades, global investors, primarily Dollar-funded ones, have greatly increased their footprint in emerging market local currency asset markets, generating potentially a new channel for Dollar hedging demand resulting from currency mismatches on foreign investors' balance sheets. Domestic Dollar borrowers and international local currency investors (who fund themselves in Dollars) would both have a motive to hedge against Dollar appreciation by buying Dollar forwards. We can therefore augment the Dollar gap by substracting external Dollar debt *and* external local currency debt from external Dollar assets, as both types of liability positions generate a demand for Dollar forwards and hence make the Dollar gap more negative:

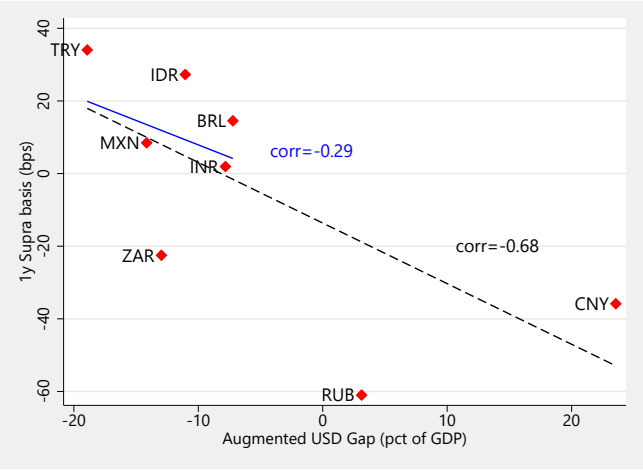
$$USDGAP^{aug} = \frac{Ext.DebtAssets_t^{USD} - Ext.DebtLiabilities_t^{USD} - Ext.DebtLiabilities_t^{LC}}{GDP_t} \tag{18}$$

How does the augmented Dollar gap compare with the domestic Dollar gap and how is it correlated with the average CIP basis? Figures 14a shows for major EM's, the addition of foreign local currency debt holding makes the Dollar gap substantially more negative, with the difference being particularly pronounced for ZAR, MXN and TRY among the EM currencies in our sample.

In the cross-section, we see the augmented Dollar gap still being negatively correlated with the supra CIP basis, but weaker compared to the domestic one (Figure 14b). This is not surprising considering that foreign investment into EM local currency is, to a significant extent, a form of carry trade that seeks exposure to the local currency, and correspondingly, generates a net demand for local currency forwards or net supply of Dollar forwards (see Brunnermeier et al. (2008)). However, we also know that foreign investors' positions can be especially volatile (a phenomenon coined as "Original Sin Redux", see Bertaut et al. (2021)), and that the demand for hedging goes up in times of financial stress (Liao and Zhang (2020), Du and Huber (2024)). Taken together, we should expect the



(a) Augmented measure for Dollar gap



(b) 1y Supra CIP basis vs. Augmented USD Gap

Figure 14: Augmented Dollar gap in the cross-section of major EM's, 2010-2017 average.

demand for Dollar forwards coming from external local currency debt to be low or even negative (i.e. turning to net supply) during periods with abundant Dollar liquidity while turning positive during periods of Dollar scarcity. Therefore, the cross sectional correlation between foreign investors' local currency assets and the CIP basis is effectively averaging across these shifting correlation patterns over time, returning only a weak correlation.

In the following, we therefore go beyond the cross-sectional correlation and expore the time-series dimension of the CIP deviation within currencies to analyze how its fluctuation is shaped by the Dollar cycle and the underlying demand for Dollar funding and hedging. We use the augmented Dollar gap as the baseline proxy for Dollar forward demand in emerging market currency markets to account for foreign investor's demand for Dollar forwards.

5.4 Time variation in the purified CIP

5.4.1 CIP covariation with the global Dollar cycle

After characterizing the cross-sectional variation, we now turn to variation of the CIP deviation over time within currencies. We seek to estimate the relationship between the CIP deviation, cost of Dollar funding (μ_t), proxies for intermediary balance sheet capacity (W_t^*) and the net hedging demand F_{it}^* as predicted by our model:

$$CIP_{it} = \frac{\mathcal{F}_{it}}{\mathcal{E}_{it}} \frac{R_t^*}{R_{it}} - 1 = a \frac{\mu_t}{W_{it}^*} \left(F_{it}^*\right), \tag{19}$$

where all variables are currency i specific except for the intermediary's shadow cost of Dollar financing μ_t and the Dollar borrowing rate R_t^*.

While we do not have a high-frequency measure of each currency's total net forward position

intermediated by global banks F_{it}, we can proxy for its slow-moving trend using the augmented Dollar gap as argued in the previous section. Motivated by the cross-sectional correlation pattern, we use the negative of the net augmented Dollar gap as a share of GDP $(-USDGAP_i)$ to proxy for the aggregate hedging demand against the Dollar. As shown above, a higher underlying net external Dollar and external local currency liability positions imply a larger demand for Dollar forwards when the cost of Dollar funding rises,which the intermediary needs to accommodate by supplying Dollar forwards $F^*_{it} > 0$. In other words, we assume $\frac{F_i}{Y_i} \propto -USDGAP_i$, where we suppress the time index as data on the Dollar gap is only available at the annual as opposed to monthly level as the CIP basis.

We assume that the global intermediary segments its balance sheet across destination markets in proportion to destination GDP. That is, the intermediary's net worth dedicated to the local market i, in other words, the portion of its balance sheet and amount of arbitrage capital W^*_{it} available for arbitrage between the Dollar and currency i, is proportional to the size of the local economy Y_{it} by a factor κ, i.e. $W^*_{it} = \kappa Y_{it}$, so that we have[16]:

$$CIP_{it} = \frac{a}{\kappa}\mu_t \left(\frac{F^*_{it}}{Y_{it}}\right) \propto \mu_t \left(-USDGAP_t\right) \tag{20}$$

with the factor of proportionality varying with the aggregate hedging ratio of external debt asset and liability, the liquidity coverage parameter a and the degree of financial depth κ.

We can test the CIP equation above by estimating the following empirical linear relationship implied by its first-order approximation:

$$\Delta CIP_{it} = \alpha_i + \beta_1 \Delta Dollar_t + \beta_2 \Delta Dollar_t \times (-USDGAP_i) + \gamma' X_{it} + \varepsilon_{it} \tag{21}$$

We follow the literature and use the log change in the Broad Dollar Index ($Dollar$) as a shock to global USD funding that pins down the shadow cost of Dollar funding μ_t in the model (see Bruno and Shin (2017), Obstfeld and Zhou (2022), Avdjiev et al. (2019)). The key coefficient to estimate is β_2, which measures the impact of the interaction term between the Dollar funding cost and the (negative of) country-specific Dollar gap (as proxy for F^*). This interaction term between the change in the broad Dollar index and net hedging demand for dollar exposure should capture the predicted relationship that CIP deviation widens when funding constraint tightens in an environment with large demand for Dollar hedging, with the direction pinned down by the direction of hedging demand. We measure hedging demand with the opposite of the country-specific net Dollar Gap (so $-USDGAP_i$ should have the same sign as F^*_i in the model). A positive $USDGAP_i$ means the country is a net Dollar debt creditor and will seek to demand dollar today to swap it back to local currency in the future (i.e. $-USDGAP_i < 0$ and $F^* < 0$). This would reflect the net hedging demand of investors in Japan for example, who hold large positions in US Treasuries and other Dollar assets. A negative net Dollar debt position ($USDGAP_i < 0$ or $-USDGAP_i > 0$) implies that residents seek to pur-

[16]Similar assumptions regarding the global balance sheet segmentation is made in Du and Huber (2024). In practice, κ could vary across countries and time depending on variation in financial depth and capital controls.

chase forward dollars to hedge current Dollar debt, or foreign investors do so to hedge their local currency assets, in other words, both demand $F^* > 0$. We therefore expect $\beta_2 > 0$.

Apart from the main interaction term, we also control for a currency fixed-effect, the change in log Dollar index (as a standalone variable), and other variables in the vector X_{it}: the lagged level of the CIP basis to capture mean reversion, that change in the Dollar gap (note these are at annual as opposed to monthly frequency), and other variables for robustness check discussed below.

In Table 5, we estimate eq. (21) using conventional CIP measures in AEs and EMs. While the coefficient estimates for the AE sample deliver the right positive sign–albeit statistically insignificant, it is not the case for the EM sample. Similar as for the cross-sectional correlation, using the conventional CIP basis does not yield the theory-predicted relationship for the interaction between Dollar funding cost and underlying Dollar gap. Results even go in the opposite direction, possibly driven by a higher risk premium on the local currency government bond yield and similarly on interbank borrowing rate (and hence pulling the CIP deviation into negative direction) when dollar funding costs increase (columns 3-4 and 7-8).

Table 5: Baseline regressions with LIBOR and Government Bond CIP basis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	3-month tenor				12-month tenor			
	AE		EM		AE		EM	
Dep.var: ΔCIP_t	LIBOR	GOV	LIBOR	GOV	LIBOR	GOV	LIBOR	GOV
CIP_{t-1}	-0.196***	-0.200***	-0.190***	-0.170***	-0.113***	-0.133***	-0.032***	-0.042***
	(0.034)	(0.040)	(0.016)	(0.019)	(0.028)	(0.025)	(0.008)	(0.013)
$\Delta Dollar_t$	-1.702***	-3.593*	5.549***	8.501***	-1.111**	-2.058***	2.974***	1.847*
	(0.451)	(1.905)	(0.634)	(0.973)	(0.450)	(0.682)	(0.829)	(0.944)
$\Delta Dollar_t * (-USDGAP_i)$	0.007	0.015	-0.122*	-0.220**	-0.009	0.002	-0.199**	-0.269***
	(0.015)	(0.010)	(0.071)	(0.105)	(0.011)	(0.007)	(0.083)	(0.094)
$-USDGAP_i$	-0.026	-0.067*	-0.007	0.283**	-0.013	0.023	0.130*	0.238**
	(0.028)	(0.038)	(0.068)	(0.130)	(0.017)	(0.030)	(0.073)	(0.116)

Notes: Driskoll-Kraay heteroskedasticity and autocorrelation robust standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Table presents regression results for equation (21) at monthly frequency for G10 AE currencies and EM currencies with available data, using the LIBOR CIP and the Supra CIP basis at 3-month and 1-year tenor. $Dollar$ stands for the log Broad Dollar Index. $USDGAP_i$ denotes the augmented Dollar gap: Dollar net external asset position plus the external debt in local currency position (in percent country i GDP) to capture hedging demand of domestic borrowers and foreign investors in local currency assets. Currency fixed effect included in all regressions. Sample period: February 2006 to December 2020.

If instead, we replace the conventional CIP deviation in EM's with the supranational CIP deviation for the six EM currencies where we have sufficient bond data to extract common time effects for each month in the sample, we obtain results in Table 6.[17] The estimated coefficient on the interaction term between Dollar funding cost and the Dollar gap now yields the positive coefficient implied by

[17] The 6 EM's with sufficient bond price data from several supranational issuers in local currency over a common time span to allow for extraction of a common time factor are: Brazil, Turkey, Mexico, South Africa, Indonesia, India.

the model. The interaction term is larger and more precisely estimated when we use only the three most liquid markets for supranational bonds in local currency (Brazil, Turkiye and South Africa). [*Discuss magnitudes.*]

Finally, in columns 3-4 , we replicate the same regression using the conventional government bond CIP basis for exactly the same sample of observation as in column 1-2 to facilitate comparison. As before, the estimation does not detect any significant effect of the hedging channel of the Dollar cycle as predicted by theory. The same non-result also holds when we use the Libor CIP basis (column 5-6).

Table 6: Baseline regression with Supranational CIP basis in EM's

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔCIP_t measure:					
	$\Delta\tau_t$	$\Delta\tau_t$	ΔGOV_t	ΔGOV_t	$\Delta Libor_t$	$\Delta Libor_t$
CIP_{t-1}	-0.137***	-0.121***	-0.0817***	-0.0552***	-0.106***	-0.148***
	(0.0203)	(0.0211)	(0.0210)	(0.0198)	(0.0290)	(0.0427)
$\Delta Dollar_t$	-3.654**	-5.806***	-2.585	-6.192***	-1.289	-2.494
	(1.825)	(1.807)	(2.717)	(1.798)	(1.418)	(1.711)
$\Delta Dollar_t * -(USDGAP_i)$	0.198**	0.261***	0.0955	0.136	-0.0153	0.0600
	(0.0871)	(0.0754)	(0.180)	(0.160)	(0.137)	(0.163)
$-(USDGAP_i)$	0.260*	0.223**	0.494**	0.350*	0.0542	0.138
	(0.135)	(0.113)	(0.245)	(0.182)	(0.154)	(0.160)
Observations	801	493	801	493	658	487
Number of EM currencies	6	3	6	3	5	3
Within R2	0.0849	0.110	0.0441	0.0585	0.0546	0.0792

Notes: Driskoll-Kraay heteroskedasticity and autocorrelation robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table presents regression for equation (21) using Supra CIP basis at 1-year tenor for six EM currencies with available data (column 1) and using the sub-ample with the top 3 most liquid EM supranational bond markets (column 2). Columns 3-4 and 5-6 repeat the regressions in col 1-2 using the 1-year government bond CIP basis and Libor interbank basis respectively. 1-year Libor swap rates are not available for the Mexican Peso. $Dollar$ stands for the log Broad Dollar Index. $USDGAP_i$ denotes the augmented hedging demand proxy: Dollar net external asset position plus the external debt in local currency position (in percent country i GDP) to capture hedging demand of foreign investors in local currency assets. Currency fixed effect included in all regressions.

5.4.2 Supply and Demand shifters

Fluctuations in the Dollar exchange rate can reflect both supply shifts in intermediary's capacity to provide Dollar funding (Avdjiev et al. (2019), Bruno and Shin (2017)) as well as demand shifts for Dollar relative to other currencies' assets (Jiang et al. (2020)). Such demand shifts in turn would be

associated with corresponding demand shifts for Dollar forwards, either for speculative or hedging purposes. On net, higher demand for Dollar safe assets would lead to more demand for Dollar forwards against emerging market currencies as investors unwind their long FX forward positions and/or seek more hedging against Dollar appreciation. How can we disentangle supply from demand effects on the CIP basis?

In the following, we unpack the estimating equation further by allowing the total intermediary net worth (the aggregate net worth over all segmented currency markets) $W_t^* = \sum_i W_{it}^*$ to vary over time. Denoting the leverage ratio of the intermediary, that is, the ratio of its liability (book value of debt plus net worth) to its net worth with η_t, we can write out the currency-specific arbitrage capital (the portion of the net worth available for currency i) as:

$$W_{it}^* \propto \kappa \frac{Y_{it}}{(\eta_t - 1)}$$

so that the CIP basis can be expressed as:

$$CIP_{it} \propto \mu_t \left(\eta_t - 1\right) \left(\frac{F_{it}^*}{Y_{it}}\right) \tag{22}$$

We measure the intermediary's leverage ratio using the reciprocal of the market capital ratio of primary dealer counterparties of the NY Fed from He et al. (2017). These are globally active dealer banks who are the marginal price setters in many asset markets, especially FX derivatives markets involving the Dollar. Finally, we proxy for shifts in high-frequency demand for Dollar forwards with each currency's exposure to fluctuations in the Treasury basis (Jiang et al. (2020)):

$$\Delta \left(\frac{F_{it}^*}{Y_{it}}\right) = \Delta x_t^{Treas} \times (-USDGAP_i)$$

where x_t^{Treas} is the average US Treasury basis against G-10 currencies, constructed as in Krishnamurthy and Lustig (2019). This variable is considered a measure of the convenience yield on US Treasury relative to other government bonds, itself resulting from changes in global demand for safe Dollar assets. Global demand for US Treasuries typically rises and the Treasury basis becomes more negative when there is higher risk aversion with associated "flight to safety".

Substituting the expressions for intermediary leverage ratio and the Dollar forward demand in terms of exposure to the Treasury basis, the estimating equation can be further expanded to:

$$\begin{aligned} \Delta CIP_{it} \quad = \quad & \alpha_i + \beta_1 \Delta Dollar_t + \beta_2 \Delta Dollar_t \times (-USDGAP_i) \\ & + \beta_3 \Delta \eta_t + \beta_4 \Delta \eta_t \times (-USDGAP_i) \\ & + \beta_5 \Delta x_t^{Treas} + \beta_6 \Delta x_t^{Treas} \times (-USDGAP_i) \\ & + \gamma' X_{it} + \varepsilon_{it} \end{aligned} \tag{23}$$

We can control for the intermediary leverage ratio (supply shocks) and the Treasury basis (demand shocks) separately and jointly, to estimate their marginal impact on the CIP basis in EM's. Of course, supply and demand shifts in Dollar funding and asset markets are correlated, so we do not expect to disentangle them entirely with the leverage ratio and the Treasury basis. What is important is whether our purified measure of the CIP deviation responds as implied by theory to these global drivers. We report the key estimates for equation (23) in Table 7.

Table 7: Impact of intermediary balance sheets and Treasury basis

	(1)	(2)	(3)	(4)	(5)
			Dep. Var.: $\Delta\tau_t$		
τ_{t-1}	-0.131***	-0.128***	-0.126***	-0.130***	-0.113***
	(0.0180)	(0.0210)	(0.0199)	(0.0208)	(0.0216)
$\Delta\eta_t$	-3.300***		-2.754**	-2.207**	-2.197**
	(1.263)		(1.101)	(0.998)	(1.068)
$\Delta\eta_t(-USDGAP_i)$	0.152*		0.122*	0.0861	0.0857
	(0.0776)		(0.0675)	(0.0677)	(0.0584)
Δx_t^{Treas}		44.26***	35.58***	31.63***	31.88***
		(15.80)	(12.50)	(12.02)	(11.20)
$\Delta x_t^{Treas}(-USDGAP_i)$		-2.121**	-1.629*	-1.425	-1.276
		(1.037)	(0.934)	(0.986)	(1.025)
$\Delta Dollar_t$				-1.610	-3.517***
				(1.256)	(1.259)
$\Delta Dollar_t * (-USDGAP_i)$				0.101	0.159***
				(0.0613)	(0.0522)
Observations	856	803	803	801	493
Number of groups	6	6	6	6	3
Within R2	0.088	0.085	0.1	0.104	0.132

Notes: Driskoll-Kraay heteroskedasticity and autocorrelation robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table presents regression for equation (23) using Supra CIP basis at 1-year tenor for six EM currencies with available data (column 1-4) and using the sub-ample with the top 3 most liquid EM supranational bond markets (column 5). η_t denotes the intermediary leverage ratio from He et al, x_t^* is the Treasury basis averaged across g-20 currencies as in JKL. $Dollar$ stands for the log Broad Dollar Index. $USDGAP_i$ denotes the augmented hedging demand proxy: Dollar net external asset position plus the external debt in local currency position (in percent country i GDP) to capture hedging demand of foreign investors in local currency assets. Currency fixed effect included in all regressions.

We find that the intermediary leverage ratio and the treasury basis have the predicted impact on the purified CIP basis: higher intermediary leverage, which occurs with negative shocks to the intermediary's net worth and balance sheet capacity, and a more negative Treasury basis are both associated with a more negative CIP basis as synthetic Dollar funding becomes more expensive. This is the funding channel for the CIP deviation. In addition, we also detect the interaction effect with the Dollar gap as predicted by our hedging channel: a higher intermediary leverage ratio increases the

CIP basis more/lowers it by less in EM's with larger (negative) Dollar gap, as underlying demand for Dollar hedging is higher (column 1). In turn, a given widening of the Treasury basis leads to a higher CIP basis in countries with larger (negative) Dollar gap, as a larger demand for Dollar forwards is triggered in markets with large domestic Dollar liabilities and/or foreign investor base in local currency debt assets. A standard deviation widening of the Treasury basis during the sample period would predict a decline of 6.6 bps in the purified CIP basis for an EM with zero Dollar gap, whereas the change would be zero or slightly positive in a country with the Dollar gap in the 90th percentile of the distribution.[18] These are sizeable differentials for the CIP basis considering that the median absolute change of the purified CIP in the sample is 8.1 bps.

Column 4-5 confirm that shocks to the intermediary's leverage ratio and the Treasury basis are correlated, and each strongly correlated with the Dollar, since the point estimates are attenuated when we jointly control for all three variables. However, the sign and magnitudes of each channel is broadly retained.

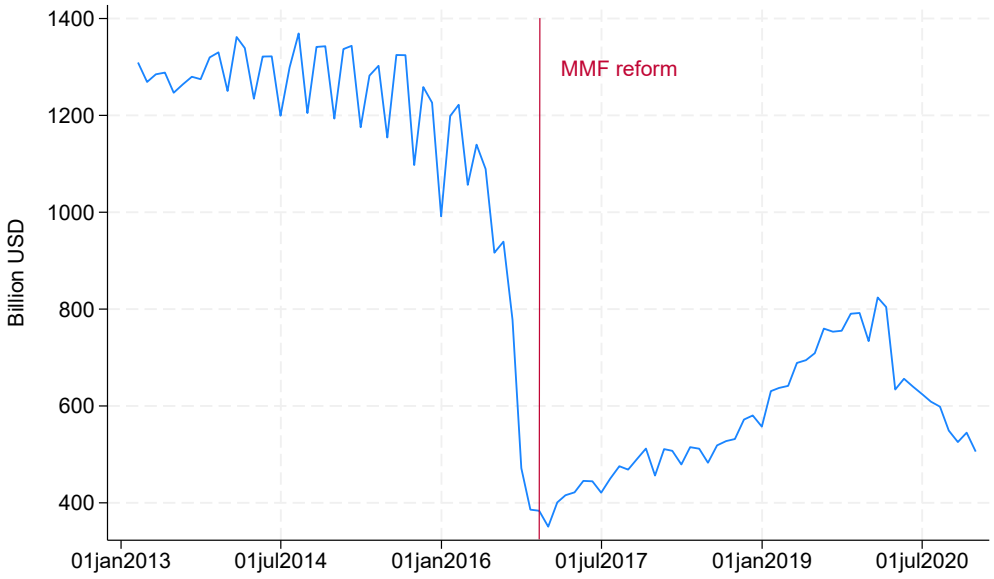
5.4.3 Impact of financial regulation on global arbitrage capital

Large global banks in the US and other advanced economies have undergone a substantial tightening of regulatory and prudential standards after the GFC with the implementation of Basel III reforms. Although the timeline for Basel III implementation varied across jurisdictions, for US and European G-SIBs, the main changes to capital and liquidity requirements started to bite around 2015, as documented for example in Krohn and Sushko (2022), who also show that these regulatory changes made capital and liquidity constraints more binding for global FX dealers. Around the same time, starting October 2016, a major money market reform in the US introduced floating net asset valuation with redemption gates for institutional prime money market funds. This led to large outflows from prime money market funds, which provide wholesale funding to banks, to government funds which invest in Treasuries. Figure 15 shows that between end-2015 and October 2016, when the reforms took full effect, banks experienced a decline of around 800 billion Dollar in wholesale funding supply from prime money market funds. With US prime money market funds being the main provider of short-term wholesale funding to banks engaged in CIP arbitrage trade prior to the reform, Anderson et al. (2021) show how this reform led a cutback in CIP arbitrage positions by global banks, in effect steepening the supply curve for Dollar swaps and forwards in the FX derivatives markets.

So far almost all papers that analyze the impact of regulatory policy change on CIP deviations focused on CIP behavior for G-10 advanced economies' currencies, most commonly for the Yen and Euro CIP basis, as data for EM CIP is constrained by reasons we highlighted in this paper. We provide new evidence below that these policy changes during 2015-2016 also led to significant shifts in the price for Dollar funding and hedging for emerging market currencies. As in the above analysis, such

[18] A standard deviation change in the Treasury basis is -0.15 ppt, hence the impact per column 2 of Table 7 on the basis for zero Dollar gap is 44.26*-0.15=-6.6 bps. The 90th percentile of the (negative) Dollar gap distribution is 21.6 pct of GDP, hence the impact changes to -6.6+0.15*21.6*2.12=0.3 bps, a differential of around 7 bps.

Figure 15: Prime MMF's holdings of bank securities.



Source: SEC Money Market Fund Statistics.

shifts in pricing can only be uncovered using our purified as opposed to conventional CIP deviations in EM's.[19]

In Table 8 we report the estimation results for equation (23), distinguishing between the period before Basel III and the MMF reforms were introduced (i.e. before October 2015) versus the post-reform period after October 2016, when Basel III started to be phased in and post-MMF reform outflows from prime MMF's have stabilized at lower levels. We limit the regressions to the three currencies with the most liquid supranational bond trading but show in the Appendix that the pattern holds for the whole sample.

In examining potential differentials in CIP basis response to supply and demand shifters for Dollar forwards in emerging markets, we focus on the primary dealer leverage ratio and the Treasury basis which we take as proxies for supply and demand shocks respectively. As stricter capital and liquidity regulation from Basel III in effect tighten the balance sheet constraint of the bank (raising a in our model), we expect any given increase in demand for F^* to lead to larger increase in the CIP basis in the post-reform period. Similarly, with less Dollar liquidity available through wholesale funding for CIP arbitrage in all FX markets (decline in κ and thus lower W_{it}^* for all i in our model), any increase in demand for F^* will lead to a larger increase in the CIP basis.

What about the impact of the intermediary's leverage ratio? As shown in Anderson et al. (2021), as global banks rely mainly on unsecured wholesale funding to conduct CIP intermediation, a smaller pool of such funding available to global banks would lead them to cut back on arbitrage positions,

[19]Repeating the same regressions as in Table 8 using conventional measures of CIP basis does not deliver significant results (add to Appendix).

Table 8: CIP basis: pre and post-reform differences

	(1)	(2)	(3)	(4)	(5)	(6)
	Dep. Var.: $\Delta\tau_t$					
	Pre October 2015			Post October 2016		
τ_{t-1}	-0.342***	-0.316***	-0.303***	-0.220***	-0.230***	-0.220***
	(0.0652)	(0.0620)	(0.0567)	(0.0543)	(0.0547)	(0.0547)
Δx_t^{Treas}	50.68*		37.23	212.3***		216.9***
	(30.22)		(25.09)	(44.53)		(40.13)
$\Delta x_t^{Treas}(-USDGAP_i)$	-3.440		-2.607	-9.656***		-9.834***
	(2.183)		(1.909)	(1.589)		(1.520)
$\Delta\eta_t$		-6.826***	-6.514***		-2.577	-3.334**
		(1.218)	(1.376)		(1.575)	(1.498)
$\Delta\eta_t(-USDGAP_i)$		0.365***	0.344***		0.0971	0.127
		(0.0631)	(0.0749)		(0.0782)	(0.0977)
Observations	150	150	150	150	150	150
Number of currencies	3	3	3	3	3	3
Within R2	0.230	0.295	0.303	0.163	0.132	0.167

Notes: Driskoll-Kraay heteroskedasticity and autocorrelation robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table presents regression for equation (23) using Supra CIP basis at 1-year tenor for the sub-ample of supranational CIP basis with the top 3 most liquid EM supranational bond markets (TRY, ZAR, BRL). Equidistant sample periods before (column 1-3) and after (column 4-6) the introduction of Basel III reforms and US MMF reforms are shown for each specification. η_t denotes the intermediary leverage ratio from He et al, x_t^* is the Treasury basis averaged across g-20 currencies as in JKL. $Dollar$ stands for the log Broad Dollar Index. $USDGAP_i$ denotes the augmented hedging demand proxy: Dollar net external asset position plus the external debt in local currency position (in percent country i GDP) to capture hedging demand of foreign investors in local currency assets. Currency fixed effect included in all regressions.

muting any impact of a given shock to dealer banks' balance sheet constraint on the CIP basis. Instead, other more price-sensitive intermediaries such as non-banks and smaller banks would instead enter the market, intensifying the steepening of the supply curve for Dollar forwards. Overall, we should expect the prime dealer leverage ratio to have less of an impact while and the treasury basis to have a stronger impact on the CIP basis post MMF reforms.

This expected differential in estimated CIP basis response is precisely what we find in Table 8. The time window before and after the reform period is chosen to be of the same length (we exclude the year of transition October 2015-October 2016), but results are robust to small changes to the reform cutoff and variation in length of the pre-reform time period. The impact of a given widening of the Treasury basis on the CIP deviation is three times as large in the post-reform period (column 1 and 4). In contrast, the same increase in the primary dealers' leverage ratio is strongly singificant in the pre-reform, but not the post-reform period. The results hold when we jointly control for both of these forces jointly, corroborating our interpretation of them being proxies for supply and demand shocks to Dollar funding and hedging.

6 Conclusion

We construct a novel measure of CIP deviation in several major Emerging Markets using supranational bonds, which allow us to compute a "purified" CIP basis (using risk-free local currency interest rate) adjusted for relative credit risk and convenience yields. We are able to document the evolution of the deviation from pure CIP for major Emerging Markets since before the GFC and establish the new stylized fact that the deviation from CIP in EM's, unlike in AE's, have not widened post GFC. If anything, CIP deviations in AE have become more similar to those in EM's, when the latter are computed properly.

The "purified" CIP basis conforms with model-implied prediction for cross-sectional and within-currency correlation with fundamental forces driving supply and demand for USD forwards/swaps. Shocks and policies that impact Dollar funding, global intermediary's balance sheet capacity, demand for Dollar assets all interact with underlying USD hedging needs in shaping the deviation from CIP in emerging markets. We provide evidence of how financial regulation can impact the CIP basis differentially depending on the underlying hedging demand. More generally, the purified CIP basis offers a valuable metric to gauge the impact of various policies affecting emerging market currencies, such as spot and forward FX intervention, capital controls, and macro-prudential policies which future research should explore. The purified CIP basis also allows for an empirical analysis of how central bank swap lines between the Federal Reserve and emerging market central banks (as in the case of Brazil and Mexico) can lower hedging costs and promote local currency investment as documented for advanced economies by Bahaj and Reis (2022). In fact, the benefits of Dollar swap lines in emerging markets could be larger as hedging markets are less developed while hedging needs stemming from local Dollar borrowing and foreign local currency investments are growing.

Beyond understanding the determinants of hedging costs for domestic borrowers and foreign investors in emerging markets, the 'purified basis' provides a measure of the strength of the financial and aggregate demand externalities faced by Emerging Market economies. As deviations from CIP also introduce a wedge between the domestic borrowing costs under the control of central banks and the synthetic local currency borrowing rate of banks with dollar financing, the results of our paper can shed light on the transmission of monetary policy in emerging markets. Policy makers can strengthen the monetary transmission mechanism by targeting this wedge in addition to the level of domestic policy rates as proposed in Gourinchas (2022).

References

Cian Allen and Luciana Juvenal. The role of currencies in external balance sheets. *Available at SSRN 4852463*, 2024.

Alyssa G Anderson, Wenxin Du, and Bernd Schlusche. Arbitrage capital of global banks. Technical report, National Bureau of Economic Research, 2021.

Patrick Augustin, Mikhail Chernov, Lukas Schmid, and Dongho Song. Benchmark interest rates when the government is risky. *Journal of Financial Economics*, 140(1):74–100, 2021.

Patrick Augustin, Mikhail Chernov, Lukas Schmid, and Dongho Song. The term structure of covered interest rate parity violations. *Hong Kong Institute for Monetary and Financial Research (HKIMR) Research Paper WP*, No. 01/2022, 2022.

Stefan Avdjiev, Wenxin Du, Catherine Koch, and Hyun Song Shin. The dollar, bank leverage, and deviations from covered interest parity. *American Economic Review: Insights*, 1(2):193–208, 2019.

Saleem Bahaj and Ricardo Reis. Central bank swap lines: Evidence on the effects of the lender of last resort. *The Review of Economic Studies*, 89(4):1654–1693, 2022.

Agustin Benetrix, Deepali Gautam, Luciana Juvenal, and Martin Schmitz. Cross-border currency exposures. *IMF Working Papers*, 2019/299, 2019.

Carol C Bertaut, Valentina Bruno, and Hyun Song Shin. Original sin redux. *Available at SSRN*, 3820755, 2021.

Markus K Brunnermeier, Stefan Nagel, and Lasse H Pedersen. Carry trades and currency crashes. *NBER macroeconomics annual*, 23(1):313–348, 2008.

Valentina Bruno and Hyun Song Shin. Global dollar credit and carry trades: a firm-level analysis. *Review of Financial Studies*, 30(3):703–749, 2017.

John Y Campbell, Karine Serfaty-De Medeiros, and Luis M Viceira. Global currency hedging. *The Journal of Finance*, 65(1):87–121, 2010.

Eugenio Cerutti and Haonan Zhou. Uncovering cip deviations in emerging markets: Distinctions, determinants, and disconnect. *IMF Economic Review*, 72(1):196–252, 2024.

William Diamond and Peter Van Tassel. Risk-free rates and convenience yields around the world. *Jacobs Levy Equity Management Center for Quantitative Financial Research Paper*, 2021.

Wenxin Du and Amy Huber. Dollar asset holdings and hedging around the globe. Technical report, National Bureau of Economic Research WP No. 32453, 2024.

Wenxin Du and Jesse Schreger. Local currency sovereign risk. *Journal of Finance*, 71(3), 2016.

Wenxin Du and Jesse Schreger. Cip deviations, the dollar, and frictions in international capital markets. In *Handbook of International Economics*, volume 6, pages 147–197. Elsevier, 2022.

Wenxin Du, Joanne Im, and Jesse Schreger. The u.s. treasury premium. *Journal of International Economics*, 112:167–181, 2018a.

Wenxin Du, Alexander Tepper, and Adrien Verdelhan. Deviations from covered interest rate parity. *Journal of Finance*, 73(3), 2018b.

Nicolae Garleanu and Lasse Heje Pedersen. Margin-based asset pricing and deviations from the law of one price. *The Review of Financial Studies*, 24(6):1980–2022, 2011.

Pierre Olivier Gourinchas. International macroeconomics: From the great financial crisis to covid-19, and beyond. *IMF Economic Review*, pages 1–34, 2022.

Zhiguo He, Bryan Kelly, and Asaf Manela. Intermediary asset pricing: New evidence from many asset classes. *Journal of Financial Economics*, 126(1):1–35, 2017.

Victoria Ivashina, David Scharfstein, and Jeremy Stein. Dollar funding and the lending behavior of global banks. *The Quarterly Journal of Economics*, 130(3):1241–1281, 2015.

Zhengyang Jiang, Arvind Krishnamurthy, and Hanno Lustig. Foreign safe asset demand and the dollar exchange rate. *Journal of Finance*, 2020.

Arvind Krishnamurthy and Hanno N Lustig. Mind the gap in sovereign debt markets: The us treasury basis and the dollar risk factor. In *2019 Jackson Hole Economic Symposium, Stanford University Graduate School of Business Research Paper*, number 3443231, 2019.

Ingomar Krohn and Vladyslav Sushko. Fx spot and swap market liquidity spillovers. *Journal of International Money and Finance*, 120:102476, 2022.

Gordon Liao and Tony Zhang. The hedging channel of exchange rate determination. *International Finance Discussion Papers*, 1283, 2020.

Matthew R McBrady, Sandra Mortal, and Michael J Schill. Do firms believe in interest rate parity? *Review of Finance*, 14(4):695–726, 2010.

Tobias J Moskowitz, Chase P Ross, Sharon Y Ross, and Kaushik Vasudevan. Quantities and covered-interest parity. *Available at SSRN 4820243*, 2024.

Maurice Obstfeld and Haonan Zhou. The global dollar cycle. *Brookings Papers on Economic Activity, Fall 2022*, 2022.

Dagfinn Rime, Andreas Schrimpf, and Olav Syrstad. Covered interest parity arbitrage. *The Review of Financial Studies*, 35(11), 2022.

Appendix A Data Appendix

Table 9: Variables and data sources

Variable	Data source	Description
Spot exchange rate	Bloomberg	Daily spot exchange rate
Forward exchange rate	Bloomberg	Daily forward point (3 month/ 6 month)
Interbank rate	Bloomberg	Daily interbank rate (3 month/ 6 month)
Cross-currency basis swap (XCCY)	Bloomberg	Daily cross-currency basis swap rate (1y, 2y, 3y, 5y, 7y, 10y)
Interest rate swap (IRS)	Bloomberg	Daily vanilla interest rate swap rate (1y, 2y, 3y, 5y, 7y, 10y)
Non-deliverable swap (NDS)	Bloomberg	Daily non-deliverable swap (1y, 2y, 3y, 5y, 7y, 10y): In replacement of XCCY and IRS for BRL, INR, CNY, IDR, KRW, PHP, COP, PEN, RUB
Government bond yields	Bloomberg	Daily government bond yields (1y, 2y, 3y, 5y, 7y, 10y)
SSA bonds	Bloomberg	Daily bond prices (bid, ask) and bond yields

Bloomberg Tickers and Description

Currency	Type	Ticker	Name
AUD	Spot	AUD	USDAUD Spot Exchange Rate - Price of 1 USD in AUD
AUD	Forward	AUD3M, AUD6M, AUD12M	Australian Dollar Forward Points (3M, 6M, 12M)
AUD	Interbank Index	BBSW3M, BBSW6M, BBSW1Y	ASX Australian Bank Bill Short Term Rates Mid (3M, 6M, 12M)
AUD	Basis Swap (vs US LIBOR)	ADBS1 - ADBS10	AUD-USD Basis Swap (90D Bank Bill vs 3M Libor) (1Y - 10Y)
AUD	Basis Swap (vs SOFR)	ADBSQQ1 - ADBSQQ10	AUD-USD Basis Swap (BBSW vs SOFR) (1Y - 10Y)
AUD	Interest Rate Swap (3M)	ADSWAP1Q - ADSWAP10Q	AUD Quarterly (vs. 3M Bank Bills) (1Y - 10Y)
AUD	Interest Rate Swap (6M)	ADSWAP1 - ADSWAP10	AUD Semi Annual (vs. 6M Bank Bills) (1Y - 10Y)
AUD	Government bond index	C1273M, C1276M, C1271Y - C12710Y	BFV AUD AUSTRALIA SOVEREIGN (3M, 6M, 1Y - 10Y)
CAD	Spot	CAD	USDCAD Spot Exchange Rate - Price of 1 USD in CAD
CAD	Forward	CAD3M, CAD6M, CAD12M	Canadian Dollar Forward Points(3M, 6M, 12M)
CAD	Interbank Index	CDOR03, CDOR06, CDOR12	Canada Bankers Acceptances (3M, 6M, 12M)
CAD	Basis Swap (vs US LIBOR)	CDBS1 - CDBS10	CAD-USD Basis Swap 3M vs 3M (1Y - 10Y)
CAD	Basis Swap (vs SOFR)	CDXOQQ1 - CDXOQQ10	CAD USD Basis Swap CORRA VS SOFR (1Y - 10Y)
CAD	Interest Rate Swap (3M)	CDSW1 - CDSW10	CAD Semi Annual (vs 3M CDOR) (1Y - 10Y)
CAD	Government bond index	C1013M, C1016M, C1011Y - C10110Y	BFV CAD CANADA SOVEREIGN (3M, 6M, 1Y - 10Y)
CHF	Spot	CHF	USDCHF Spot Exchange Rate - Price of 1 USD in CHF
CHF	Forward	CHF3M, CHF6M, CHF12M	Swiss Franc Forward Points (3M, 6M, 12M)
CHF	Interbank Index	SF0003M, SF0006M, SF0001Y	ICE LIBOR CHF (3M, 6M, 12M)
CHF	Basis Swap (vs US LIBOR)	SFBS1 - SFBS10	CHF-USD Basis Swap (3M vs 3M IBOR) (1Y - 10Y)
CHF	Basis Swap (vs SOFR)	SFXOQQ1 - SFXOQQ10	CHF USD Basis Swap SARON vs SOFRRATE (1Y - 10Y)
CHF	Interest Rate Swap (3M)	SFSW1V3 - SFSW10V3	CHF Annual (vs. 3M LIBOR) (1Y - 10Y)
CHF	Interest Rate Swap (6M)	SFSW1 - SFSW10	CHF Annual (vs. 6M LIBOR) (1Y - 10Y)
CHF	Government bond index	C2563M, C2566M, C2561Y - C25610Y	BFV CHF SWITZERLAND SOVEREIGN (3M, 6M, 1Y - 10Y)
DKK	Spot	DKK	USDDKK Spot Exchange Rate - Price of 1 USD in DKK
DKK	Forward	DKK3M, DKK6M, DKK12M	Danish krone Forward Points (3M, 6M, 12M)
DKK	Interbank Index	CIBO03M, CIBO06M, CIBO01Y	COPENHAGEN INTERBANK OFFERED RATES (3M, 6M, 12M)
DKK	Basis Swap (vs US LIBOR)	DKBS1 - DKBS10	DKK-USD Basis Swap 3M vs 3M (1Y - 10Y)
DKK	Interest Rate Swap (3M)	DKSW1V3 - DKSW10V3	DKK Annual (vs. 3M CIBOR) (1Y - 10Y)
DKK	Interest Rate Swap (6M)	DKSW1 - DKSW10	DKK Annual (vs. 6M CIBOR) (1Y - 10Y)
DKK	Government bond index	C2673M, C2676M, C2671Y - C26710Y	BFV DKK DANISH SOVEREIGN (3M, 6M, 1Y - 10Y)
EUR	Spot	EUR	USDEUR Spot Exchange Rate - Price of 1 USD in EUR
EUR	Forward	EUR3M, EUR6M, EUR12M	Euro Forward Points (3M, 6M, 12M)
EUR	Interbank Index	EUR003M, EUR006M, EUR001Y	Euribor ACT/360 (3M, 6M, 12M)

EUR	Basis Swap (vs US LIBOR)	EUBS1 - EUBS10	EUR-USD Basis Swap (3M Euribor vs 3M Libor) (1Y - 10Y)
EUR	Basis Swap (vs SOFR)	EUXOQQ1 - EUXOQQ10	EUR USD Basis Swap ESTRON vs SOFRRATE (1Y - 10Y)
EUR	Interest Rate Swap (3M)	EUSW1V3 - EUSW10V3	EUR Annual (vs. 3M EURIBOR) (1Y - 10Y)
EUR	Interest Rate Swap (6M)	EUSA1 - EUSA10	EUR Annual (vs. 6M EURIBOR) (1Y - 10Y)
EUR	Government bond index	C9103M, C9106M, C9101Y - C91010Y	BFV EUR GERMANY SOVEREIGN (3M, 6M, 1Y - 10Y)
GBP	Spot	GBP	USDGBP Spot Exchange Rate - Price of 1 USD in GBP
GBP	Forward	GBP3M, GBP6M, GBP12M	BRITISH POUND Forward Points (3M, 6M, 12M)
GBP	Interbank Index	BP0003M, BP0006M, BP0001Y	ICE LIBOR GBP (3M, 6M, 12M)
GBP	Basis Swap (vs US LIBOR)	BPBS1 - BPBS10	GBP-USD Basis Swap 3M vs 3M (1Y - 10Y)
GBP	Basis Swap (vs SOFR)	BPXOQQ1 - BPXOQQ10	GBP USD Basis Swap SONIA vs SOFRRATE (1Y - 10Y)
GBP	Interest Rate Swap (3M)	BPSW1V3 - BPSW10V3	GBP Quarterly (vs. 3M LIBOR) (1Y - 10Y)
GBP	Interest Rate Swap (6M)	BPSW1 - BPSW10	GBP Semi Annual (vs. 6M LIBOR) (1Y - 10Y)
GBP	Government bond index	C1103M, C1106M, C1101Y - C11010Y	BFV GBP UK GILTS (3M, 6M, 1Y - 10Y)
JPY	Spot	JPY	USDJPY Spot Exchange Rate - Price of 1 USD in JPY
JPY	Forward	JPY3M, JPY6M, JPY12M	JAPANESE YEN Forward Points (3M, 6M, 12M)
JPY	Interbank Index	JY0003M, JY0006M, JY0001Y	ICE LIBOR JPY (3M, 6M, 12M)
JPY	Basis Swap (vs US LIBOR)	JYBS1 - JYBS10	JPY-USD Basis Swaps(3M vs 3M IBOR) (1Y - 10Y)
JPY	Basis Swap (vs SOFR)	JYBSS12M, JYBSS2 - JYBSS10	JPY USD Basis Swap TONA vs SOFRRATE (1Y - 10Y)
JPY	Interest Rate Swap (6M)	JYSW1 - JYSW10	JPY Semi Annual (vs. 6M LIBOR) (1Y - 10Y)
JPY	TBS	JYBC1 - JYBC10	JPY Basis Swap (3M VS 6M IBOR) (1Y - 10Y)
JPY	Government bond index	C1053M, C1056M, C1051Y - C10510Y	BFV JPY JAPAN SOVEREIGN (3M, 6M, 1Y - 10Y)
NOK	Spot	NOK	USDNOK Spot Exchange Rate - Price of 1 USD in NOK
NOK	Forward	NOK3M, NOK6M, NOK12M	NORWEGIAN KRONE Forward Points (3M, 6M, 12M)
NOK	Interbank Index	NIBOR3M, NIBOR6M, NIBOR1Y	OSLO BORS NORWAY INTERBANK OFFERED RATE FIXING (3M, 6M, 12M)
NOK	Basis Swap (vs US LIBOR)	NKBS1 - NKBS10	NOK-USD Basis Swap (3M VS 3M IBOR) (1Y - 10Y)
NOK	Interest Rate Swap (6M)	NKSW1 - NKSW10	NOK Annual (vs. 6M NIBOR) (1Y - 10Y)
NOK	TBS	NKBFVC1 - NKBFVC10	NOK Swap Spread (6M VS 3M NIBOR) (1Y - 10Y)
NOK	Government bond index	C2663M, C2666M, C2661Y - C26610Y	BFV NOK NORWAY SOVEREIGN (3M, 6M, 1Y - 10Y)
NZD	Spot	NZD	USDNZD Spot Exchange Rate - Price of 1 USD in NZD
NZD	Forward	NZD3M, NZD6M, NZD12M	NEW ZEALAND DOLLAR Forward Points (3M, 6M, 12M)
NZD	Interbank Index	NDBB3M, NDBB6M, NDBB1Y	New Zealand Dollar Bank Bills (3M, 6M, 12M)
NZD	Basis Swap (vs US LIBOR)	NDBS1 - NDBS10	NZD-USD Basis Swap (3M vs 3M IBOR) (1Y - 10Y)
NZD	Interest Rate Swap (3M)	NDSWAP1 - NDSWAP10	NZD Semi Annual (vs. 3M Bank Bills) (1Y - 10Y)
NZD	Government bond index	C2503M, C2506M, C2501Y - C25010Y	BFV NZD NEW ZEALAND GOVERNMENT (3M, 6M, 1Y - 10Y)
SEK	Spot	SEK	USDSEK Spot Exchange Rate - Price of 1 USD in SEK
SEK	Forward	SEK3M, SEK6M, SEK12M	SWEDISH KRONA Forward Points (3M, 6M, 12M)
SEK	Interbank Index	STIB3M, STIB6M, STIB1Y	STOCKHOLM INTERBANK OFFERED RATES (3M, 6M, 12M)

SEK	Basis Swap (vs US LIBOR)	SKBS1 - SKBS10	SEK-USD BASIS SWAP (3M VS 3M LIBOR) (1Y - 10Y)
SEK	Interest Rate Swap (3M)	SKSW1 - SKSW10	SEK Annual (vs. 3M STIBOR) (1Y - 10Y)
SEK	Government bond index	C2593M, C2596M, C2591Y - C25910Y	SWEDISH GOVERNMENT (3M, 6M, 1Y - 10Y)
USD	Interbank Index	US0003M, US0006M, US0001Y	ICE LIBOR USD (3M, 6M, 12M)
USD	Interest Rate Swap (3M)	USSW1 - USSW10	USD Semi Anl 30/360(vs3MLIBOR) (1Y - 10Y)
USD	TBS	USBA1 - USBA10	USD Basis Swap 1Mv3M (1Y - 10Y)
USD	TBS	USBC1 - USBC10	USD Basis Swap 3Mv6M (1Y - 10Y)
USD	Government bond index	C0823M, C0826M, C0821Y - C08210Y	BFV USD US Treasury Bonds/Notes (3M, 6M, 1Y - 10Y)
BRL	Spot	BRL	USDBRL Spot Exchange Rate - Price of 1 USD in BRL
BRL	Forward	BCN3M, BCN6M, BCN12M	BRAZILIAN REAL Non-Deliverable Forward Points (3M, 6M, 12M)
BRL	Interbank Index	PREDI90 - PREDI180 - PREDI360	PRExDI SWAP AVG (3M, 6M, 12M)
BRL	NDS	BCNI12M, BCNI2 - BCNI10	BRL ND CCS 1 YR (1Y - 10Y)
BRL	Government bond index	I39303M, I39306M, I39301Y - I393010Y	BRL BRAZIL GOVT BENCHMARK (3M, 6M, 1Y - 10Y)
CLP	Spot	CLP	USDCLP Spot Exchange Rate - Price of 1 USD in CLP
CLP	Forward	CHN3M, CHN6M, CHN12M	Chilean Peso Non-Deliverable Forward Points (3M, 6M, 12M)
CLP	Interbank Index	CHSWPC - CHSWPF - CHSWP1	CLP FIXED VS. CAMARA SWAP (3M, 6M, 12M)
CLP	Basis Swap (vs US LIBOR)	CHUSBS1 - CHUSBS10	CLP-USD BASIS SWAP CAM VS. 6M (1Y - 10Y)
CLP	Interest Rate Swap	CHSWP1 - CHSWP10	CLP FIXED VS. CAMARA (1Y - 10Y)
CLP	Government bond index	BV3MCLPG, BV6MCLPG, BV01CLPG - BV10CLPG	CLP Bonos Tesoreria Pesos NY 4PM BVAL Curve (3M, 6M, 1Y - 10Y)
CLP	Government bond index	C9903M, C9906M, C9901Y - C99010Y	CLP CHILE SOVEREIGN (POST 2016) (3M, 6M, 1Y - 10Y)
CNY	Spot	CNY	USDCNY Spot Exchange Rate - Price of 1 USD in CNY
CNY	Forward	CCN3M, CCN6M, CCN12M	CHINESE RENMINBI Non-Deliverable Forward Points (3M, 6M, 12M)
CNY	Interbank Index	SHIF3M, SHIF6M, SHIF1Y	CFETS SHIBOR FIXING (3M, 6M, 12M)
CNY	NDS	CCSWN1 - CCSWN10	CNY NDS Semi Annual (vs. 6M LIBOR) (1Y - 10Y)
CNY	Government bond index	C0203M, C0206M, C0201Y - C02010Y	CNY CHINA SOVEREIGN (3M, 6M, 1Y - 10Y)
COP	Spot	COP	USDCOP Spot Exchange Rate - Price of 1 USD in COP
COP	Forward	CLN3M, CLN6M, CLN12M	COLOMBIAN PESO Non-Deliverable Forward Points (3M, 6M, 12M)
COP	Interbank Index	COOVIBR3 - COOVIBR6 - COOVIBRY	Colombia IBR Nominal Rate (3M, 6M, 12M)
COP	NDS	CLSWU1 - CLSWU10	COP-USD NDS Semi-annual(vs. 6M LIBOR) (1Y - 10Y)
COP	Government bond index	C4773M, C4776M, C4771Y - C47710Y	BFV COP COLOMBIA SOVEREIGN (3M, 6M, 1Y - 10Y)
HUF	Spot	HUF	USDHUF Spot Exchange Rate - Price of 1 USD in HUF
HUF	Forward	HUF3M, HUF6M, HUF12M	Hungarian Forint Forward Points (3M, 6M, 12M)
HUF	Interbank Index	BUBOR03M, BUBOR06M, BUBOR01Y	NATIONAL BANK OF HUNGARY BUDAPEST INTERBANK OFFERED RATES INDEX (3M, 6M, 12M)
HUF	Basis Swap (vs US LIBOR)	HFEBS1 - HFEBS10	HUF-EUR Basis Swap 3M vs 3M (1Y - 10Y)
HUF	Interest Rate Swap (6M)	HFSW1 - HFSW10	HUF Annual (vs. BUBOR06M Index) (1Y - 10Y)
HUF	Government bond index	C1143M, C1146M, C1141Y - C11410Y	BFV HUF HUNGARY SOVEREIGN (3M, 6M, 1Y - 10Y)

IDR	Spot	IDR	USDIDR Spot Exchange Rate - Price of 1 USD in IDR
IDR	Forward	IHN3M, IHN6M, IHN12M	Indonesian Rupiah Non-Deliverable Forward Points (3M, 6M, 12M)
IDR	Interbank Index	JIIN3M, JIIN6M, JIIN1Y	BANK INDONESIA JAKARTA INTERBANK OFFERING RATE (3M, 6M, 12M)
IDR	NDS	IHSWN1 - IHSWN10	IDR NDS Semi-annual (vs. 6M LIBOR) (1Y - 10Y)
IDR	Government bond index	C1323M, C1326M, C1321Y - C13210Y	INDONESIA GOVERNMENT (3M, 6M, 1Y - 10Y)
ILS	Spot	ILS	USDILS Spot Exchange Rate - Price of 1 USD in ILS
ILS	Forward	ILS3M, ILS6M, ILS12M	Israeli Shekel Forward Points (3M, 6M, 12M)
ILS	Interbank Index	TELBOR03, TELBOR06, TELBOR12	BANK OF ISRAEL TEL AVIV INTERBANK OFFERED (3M, 6M, 12M)
ILS	Basis Swap (vs US LIBOR)	ISBS1 - ISBS10	ILS-USD Basis Swap 3M vs 3M (1Y - 10Y)
ILS	Interest Rate Swap (3M)	ISSW1 - ISSW10	ILS Annual (vs. 3M TELBOR) (1Y - 10Y)
ILS	Government bond index	I32503M, I32506M, I32501Y - I325010Y	ILS ISRAEL SOVEREIGN (3M, 6M, 1Y - 10Y)
INR	Spot	INR	USDINR Spot Exchange Rate - Price of 1 USD in INR
INR	Forward	IRN3M, IRN6M, IRN12M	INDIAN RUPEE Non-Deliverable Forward Points (3M, 6M, 12M)
INR	Interbank Index	MIFORIM3, MIFORIM6, MIFORM12	MIFOR Mumbai Interbank Forward Offer Rates (3M, 6M, 12M)
INR	NDS	IRSWN1 - IRSWN10	INR-USD NDS Semi-annual(vs. 6M LIBOR) (1Y - 10Y)
INR	Government bond index	F12303M, F12306M, F12301Y - F123010Y	INDIA SOVEREIGN BENCHMARK (3M, 6M, 1Y - 10Y)
KRW	Spot	KRW	USDKRW Spot Exchange Rate - Price of 1 USD in KRW
KRW	Forward	KRW3M, KRW6M, KRW12M	SOUTH KOREAN WON Non-Deliverable Forward Points (3M, 6M, 12M)
KRW	Interbank Index	KWCDC, KRBO6M, KRBO12M	South Korean Won Certificate of Deposit Rates (3M, 6M, 12M)
KRW	NDS	KWSWN1 - KWSWN10	KRW NDS Semi Annual (vs. 6M LIBOR) (1Y - 10Y)
KRW	Government bond index	C2323M, C2326M, C2321Y - C23210Y	BFV KRW KOREA TREASURY (3M, 6M, 1Y - 10Y)
MXN	Spot	MXN	USDMXN Spot Exchange Rate - Price of 1 USD in MXN
MXN	Forward	MXN3M, MXN6M, MXN12M	Mexican Peso Forward Points (3M, 6M, 12M)
MXN	Interbank Index	MXIB91DT, MXIB182D	MEXICO INTERBANK TIIE (91D, 182D)
MXN	Basis Swap (vs US LIBOR)	MPBS1A, MPBS2B, MPBS3C, MPBS5E, MPBS7G, MPBS10J	MXN-USD Basis Swap (28D VS 1M IBOR) (13M, 26M, 39M, 65M, 91M, 130M)
MXN	BS - SOFR	MPBSM1A, MPBSM2B, MPBSM3C, MPBSM5E, MPBSM7G, MPBSM10J	MXN-USD Basis Swap (28DTIIE VS SOFR) 364Day
MXN	Interest Rate Swap (1M)	MPSW1A - MPSW10K	MXN Monthly (vs. 28D TIIE) (1Y - 10Y)
MXN	Government bond index	C4763M, C4766M, C4761Y - C47610Y	BFV MXN MEXICO SOVEREIGN (3M, 6M, 1Y - 10Y)
MYR	Spot	MYR	USDMYR Spot Exchange Rate - Price of 1 USD in MYR
MYR	Forward	MRN3M, MRN6M, MRN12M	Malaysian Ringgit Non-Deliverable Forward Points (3M, 6M, 12M)
MYR	Interbank Index	KLIB3M, KLIB6M, KLIB1Y	Bank Negara Malaysia Klibor Interbank Offered Rate Fixing (3M, 6M, 12M)
MYR	Basis Swap (vs US LIBOR)	MRBS1 - MRBS10	MYR-USD Basis Swap (3M VS 3M IBOR) (1Y - 10Y)
MYR	Interest Rate Swap (3M)	MRSWNI1 - MRSWNI10	MYR NDIRS Quarterly (vs 3M KLIBOR) (1Y - 10Y)
MYR	Government bond index	C1283M, C1286M, C1281Y - C12810Y	BFV MYR MALAYSIA GOVERNMENT (3M, 6M, 1Y - 10Y)
PEN	Spot	PEN	USDPEN Spot Exchange Rate - Price of 1 USD in PEN
PEN	Forward	PSN3M, PSN6M, PSN12M	PERUVIAN SOL Non-Deliverable Forward Points (3M, 6M, 12M)

PEN	Interbank Index	PRBOPRB3, PRBOPRB6, PRBOPRB1	Asbanc Peru Nominal Rate (3M, 6M, 12M)
PEN	NDS	PSSWN1 - PSSWN10	PEN-USD NDS Semi-annual(vs. 6M LIBOR) (1Y - 10Y)
PEN	Government bond index	C9953M, C9956M, C9951Y - C99510Y	PEN PERU SOVEREIGN (3M, 6M, 1Y - 10Y)
PHP	Spot	PHP	USDPHP Spot Exchange Rate - Price of 1 USD in PHP
PHP	Forward	PPO3M, PPO6M, PPO12M	United States Dollar / Philippine Peso Onshore Forward Points (3M, 6M, 12M)
PHP	Interbank Index	PREF3M, PREF6M, PREF1Y	Philippines Interbank Reference Rate PHIREF at 1130am (3M, 6M, 12M)
PHP	NDS	PPSWN1 - PPSWN10	PHP NDS Semi Annual (vs. 6M LIBOR) (1Y - 10Y)
PHP	Government bond index	PDSR3MO, PDSR6MO, PDSR1YR - PDSR10YR	PDEX PDST-R1 Fixing (3M, 6M, 1Y - 10Y)
PLN	Spot	PLN	USDPLN Spot Exchange Rate - Price of 1 USD in PLN
PLN	Forward	PLN3M, PLN6M, PLN12M	Polish Zloty Forward Points (3M, 6M, 12M)
PLN	Interbank Index	WIBR3M, WIBR6M, WIBR1Y	GPW BENCHMARK WIBOR PLN (3M, 6M, 12M)
PLN	Basis Swap (vs US LIBOR)	PZBSEC1 - PZBSEC10	PLN-EUR Basis Swap (3M vs 3M IBOR) (1Y - 10Y)
PLN	Interest Rate Swap (3M)	PZSW1 - PZSW10	PLN Annual (vs. 3M WIBOR) (1Y - 10Y)
PLN	Government bond index	C1193M, C1196M, C1191Y - C11910Y	BFV PLN Poland Sovereign (3M, 6M, 1Y - 10Y)
RUB	Spot	RUB	USDRUB Spot Exchange Rate - Price of 1 USD in RUB
RUB	Forward	RUB3M, RUB6M, RUB12M	Russian Ruble Forward Points (3M, 6M, 12M)
RUB	Interbank Index	MOSKP3, MOSKP6	NFEA MosPrime Rate (3M, 6M, 12M)
RUB	NDS	RRUSSW1 - RRUSSW10	RUB-USD Annual (vs. 3M LIBOR) (1Y - 10Y)
RUB	Government bond index	C4963M, C4966M, C4961Y - C49610Y	RUB RUSSIA SOVEREIGN (3M, 6M, 1Y - 10Y)
THB	Spot	THB	USDTHB Spot Exchange Rate - Price of 1 USD in THB
THB	Forward	THB3M, THB6M, THB12M	Thai Baht Forward Points (3M, 6M, 12M)
THB	Interbank Index	BOFX3M, BOFX6M, BOFX1Y	BANK OF THAILAND BIBOR FIXINGS (3M, 6M, 12M)
THB	Basis Swap (vs US LIBOR)	TBBS1 - TBBS10	THB-USD Basis Swap (6M SIB VS 6M IBOR) (1Y - 10Y)
THB	Interest Rate Swap (6M)	TBSWNI1 - TBSWNI10	THB NDIRS Semi-Annual (vs 6M THFX) (1Y - 10Y)
THB	Government bond index	C1223M, C1226M, C1221Y - C12210Y	BFV THB THAILAND SOVEREIGN (3M, 6M, 1Y - 10Y)
TRY	Spot	TRY	USDTRY Spot Exchange Rate - Price of 1 USD in TRY
TRY	Forward	TRY3M, TRY6M, TRY12M	Turkish Lira Forward Points (3M, 6M, 12M)
TRY	Interbank Index	TRLIB3M, TRLIB6M, TRLIB1Y	BANK ASSOCIATION OF TURKEY TRLIBOR ASK RATES (3M, 6M, 12M)
TRY	CCS	TYUSSW1 - TYUSSW10	TRY-USD Annual (vs. 3M LIBOR) (1Y - 10Y)
TRY	Government bond index	C9653M, C9656M, C9651Y - C96510Y	BFV TRY TURKEY SOVEREIGN (3M, 6M, 1Y - 10Y)
ZAR	Spot	ZAR	USDZAR Spot Exchange Rate - Price of 1 USD in ZAR
ZAR	Forward	ZAR3M, ZAR6M, ZAR12M	South African Rand Forward Points (3M, 6M, 12M)
ZAR	Interbank Index	JIBA3M, JIBA6M, JIBA1Y	SAFE SOUTH AFRICA JOHANNESBURG INTERBANK AGREED RATE (3M, 6M, 12M)
ZAR	Basis Swap (vs US LIBOR)	SABS1 - SABS10	ZAR-USD Basis Swap 3M vs 3M (1Y - 10Y)
ZAR	Basis Swap (vs SOFR)	SAJSQQ1 - SAJSQQ10	ZAR USD Basis Swap JIBAR vs SOFRRATE (1Y - 10Y)
ZAR	Interest Rate Swap (3M)	SASW1 - SASW10	ZAR Quarterly (vs. 3M JIBAR) (1Y - 10Y)

ZAR	Government bond index	C2623M, C2626M, C2621Y - C26210Y	BFV ZAR SOUTH AFRICA SOVEREIGN (3M, 6M, 1Y - 10Y)

t Note: Bloomberg tickers for FX Spot, FX Forward, Basis Swap, IRS, NDS, CCS are with suffix CURNCY and abbreviated here.

t Bloomberg tickers for interbank rate and Government bond rate are with suffix INDEX and abbreviated here.

Appendix B Additional Tables and Figures

Table 11: Number of bonds per SSA by currencies

	IBRD	KFW	EIB	IFC	EBRD	ADB	IADB	AFDB
AE's								
USD	1223	721	526	515	236	344	278	139
AUD	265	75	57	56	27	116	47	40
CAD	31	29	30	7	2	13	10	4
CHF	5	21	76	2	2	7	4	3
EUR	181	646	315	33	112	35	7	28
GBP	84	91	117	21	29	31	23	9
JPY	23	287	29	68	9	13	7	13
NZD	118	41	21	38	8	33	16	18
EM's								
BRL	197	54	61	127	109	61	55	68
CNY	41	85	9	81	13	39	.	10
HKD	46	92	16	45	13	101	7	17
HUF	10	8	28	4	10	3	2	.
IDR	39	10	18	1	59	2	57	56
INR	227	1	9	20	62	8	40	45
MXN	102	13	19	64	47	31	28	26
PLN	37	10	36	1	21	9	.	.
RUB	58	5	17	51	43	13	3	15
TRY	96	50	66	142	147	160	24	73
TWD	.	.	37	.	.	20	.	.
ZAR	313	79	75	95	107	148	20	85

For both the EUR and JPY (and similarly for other G6 currencies), the Treasury basis has always been negative, even before the GFC, while the LIBOR basis used to be zero. Since the GFC, the 2 basis are very similar, with the LIBOR basis tracking the treasury basis. The tracking is particularly close starting 205 for the JPY.

Looking at longer maturities: the pattern is very similar at the 6-months tenor. However, for the 1-year tenor, the tracking between the LIBOR and Treasury CIP bases is less close in AE's, as shown in Figure 18 again for the examples of EUR and JPY.

Looking at the Treasury basis in **EM's**, we note that:

- The LIBOR basis, although being as volatile as the treasury basis already before the GFC, started tracking the treasury basis more closely after the GFC. Figure 19 shows this pattern using the examples of MXN and BRL.
- Similar to AE, the tracking is less close for the 1y tenor, with the treasury basis in general being more negative (not shown).
- Some exceptions to this general pattern: ZAR has little co-movement between the 2 bases (even at the 3-m tenor), while for IDR and INR, the 2 bases diverge at the 1-year tenor starting around 2012 (treasury basis shifting to much higher level above the LIBOR basis). [Will put this in Appendix]

The below Figure 20 plots the bid-ask spreads in major Emerging Markets for individual supranational issuers, compared with local currency sovereign bonds, all at 1-year tenor.

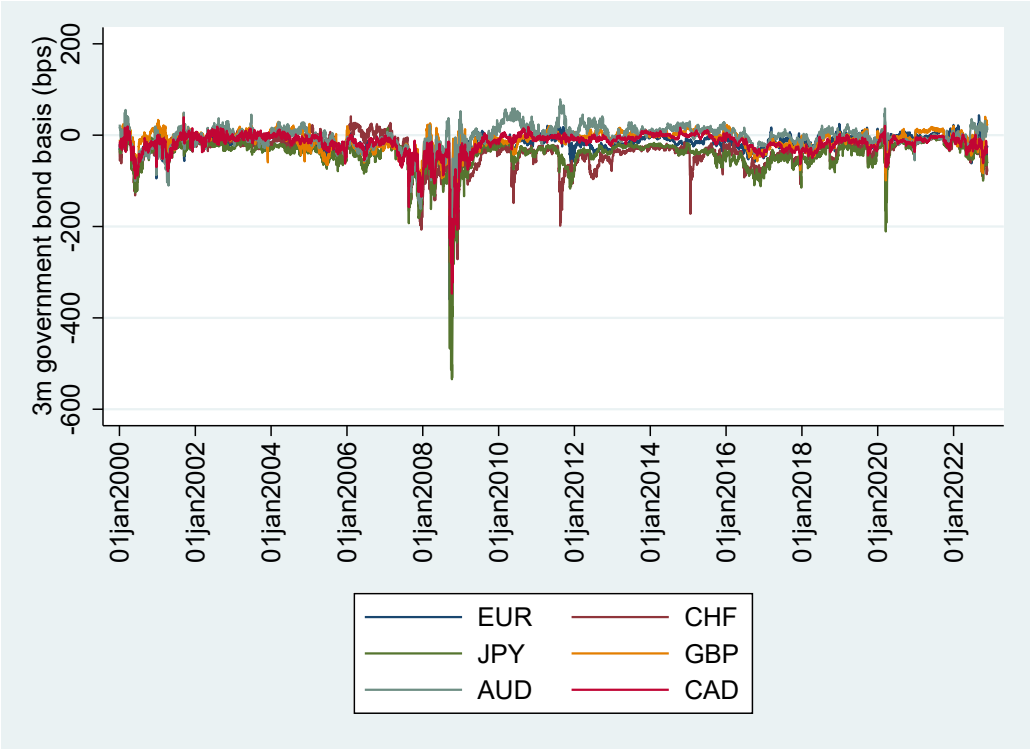
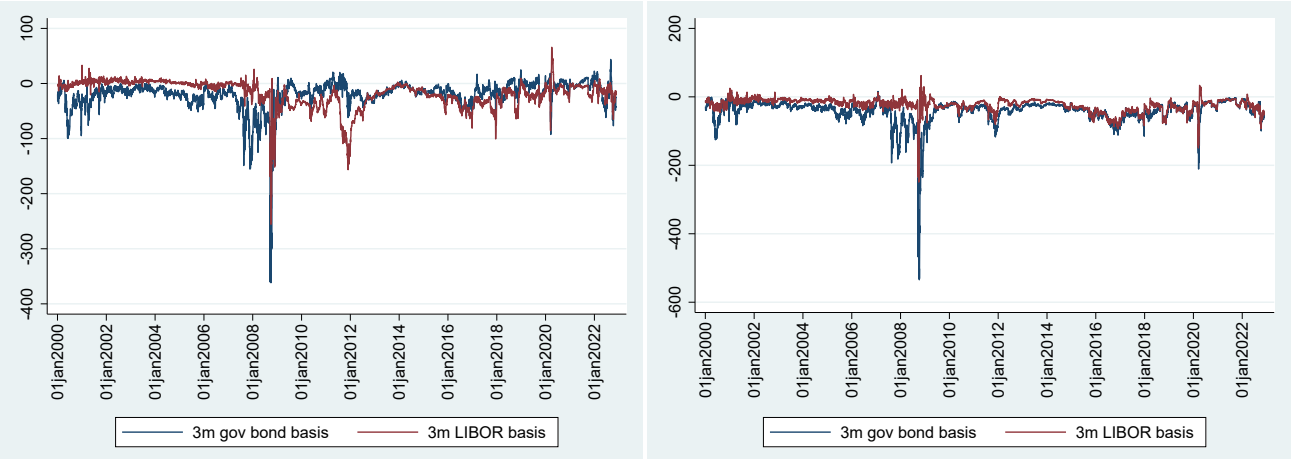
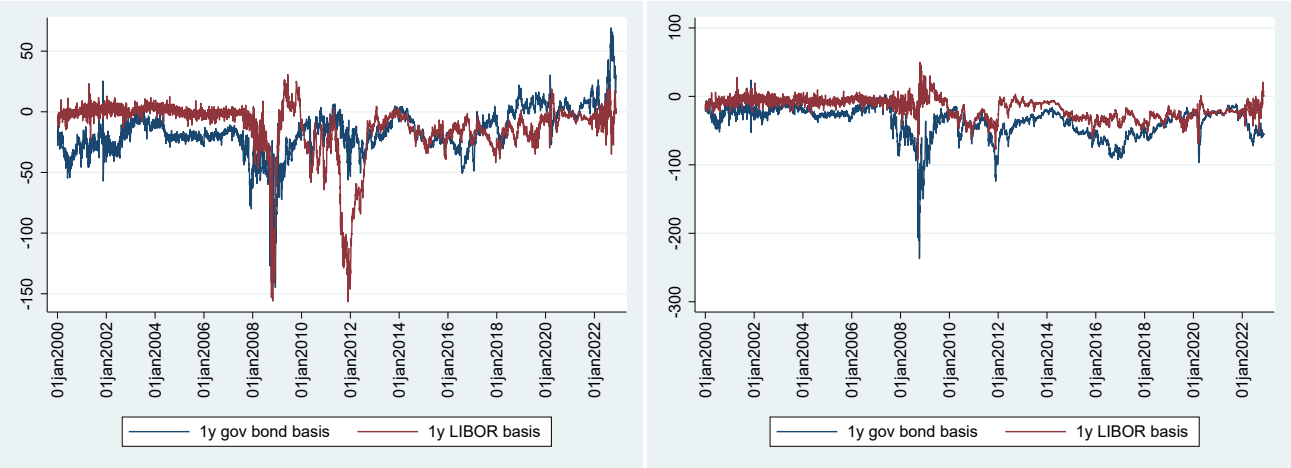


Figure 16: Government bond-based CIP deviation in AEs.



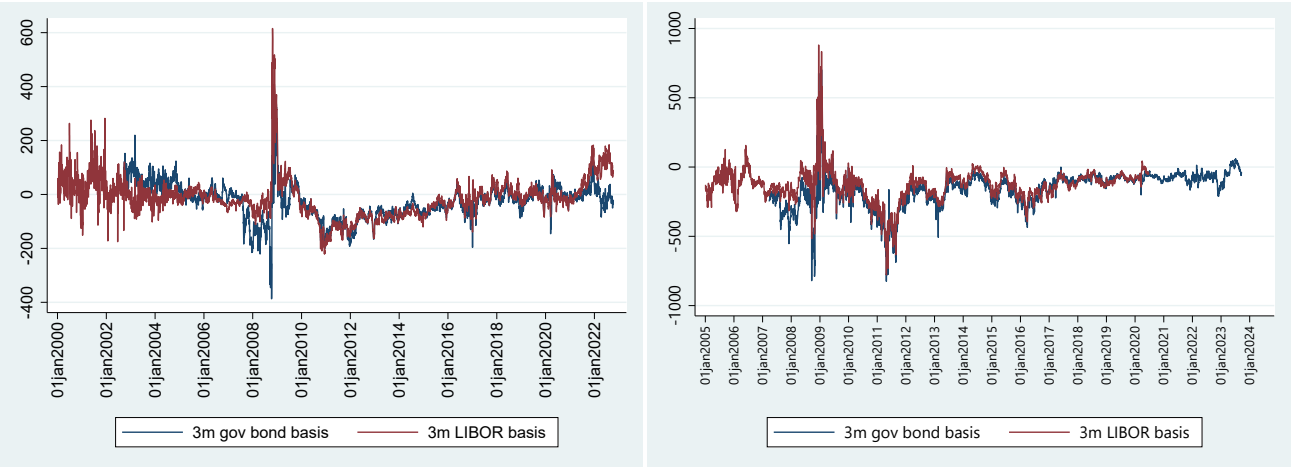
(a) EUR. (b) JPY.

Figure 17: 3-months LIBOR and Treasury-based CIP bases in for EUR and JPY



(a) EUR. (b) JPY.

Figure 18: 1-year LIBOR and Treasury-based CIP bases in for EUR and JPY



(a) MXN (b) BRL

Figure 19: 3-month LIBOR and Treasury-based CIP bases in for MXN and BRL

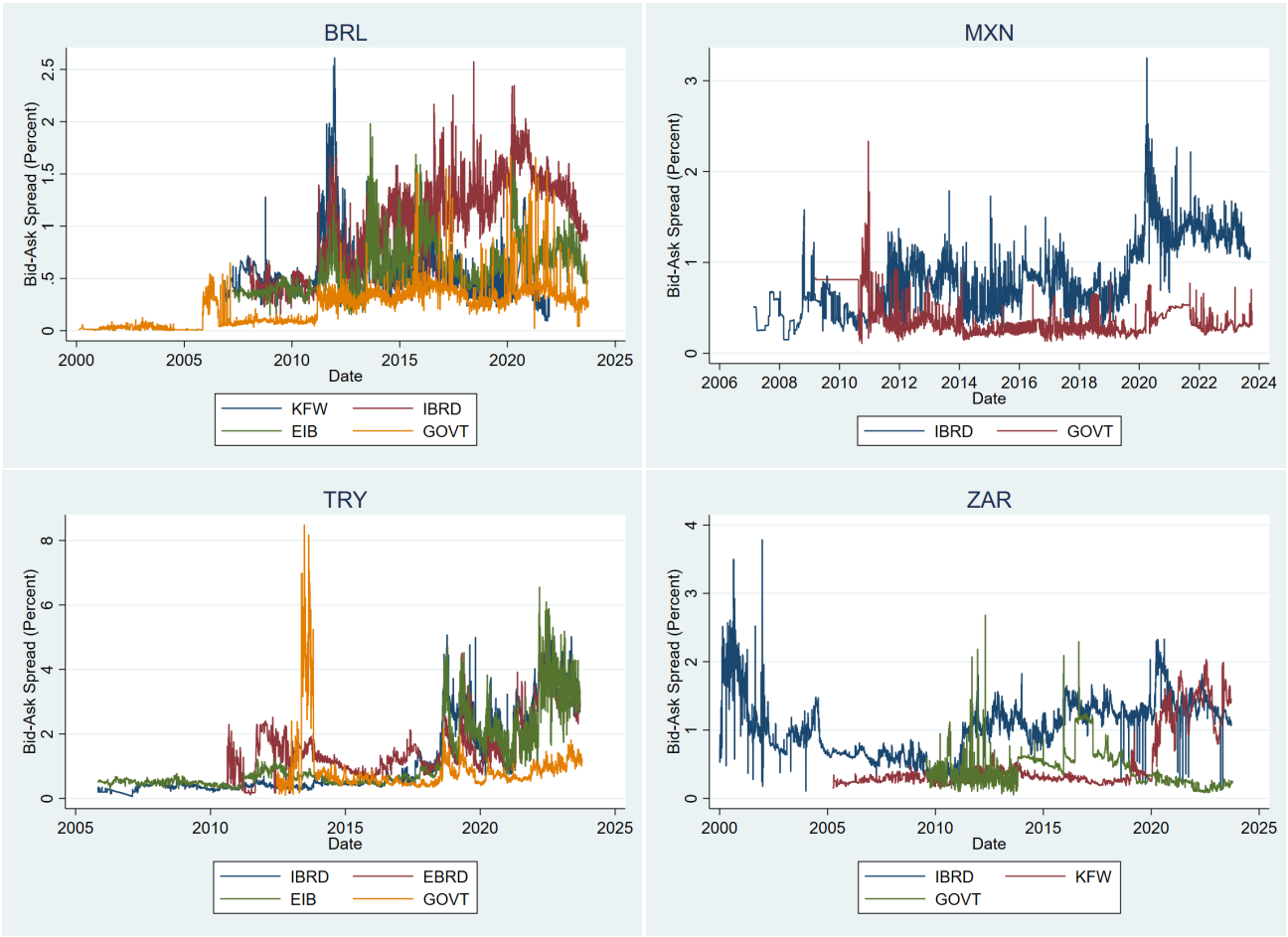
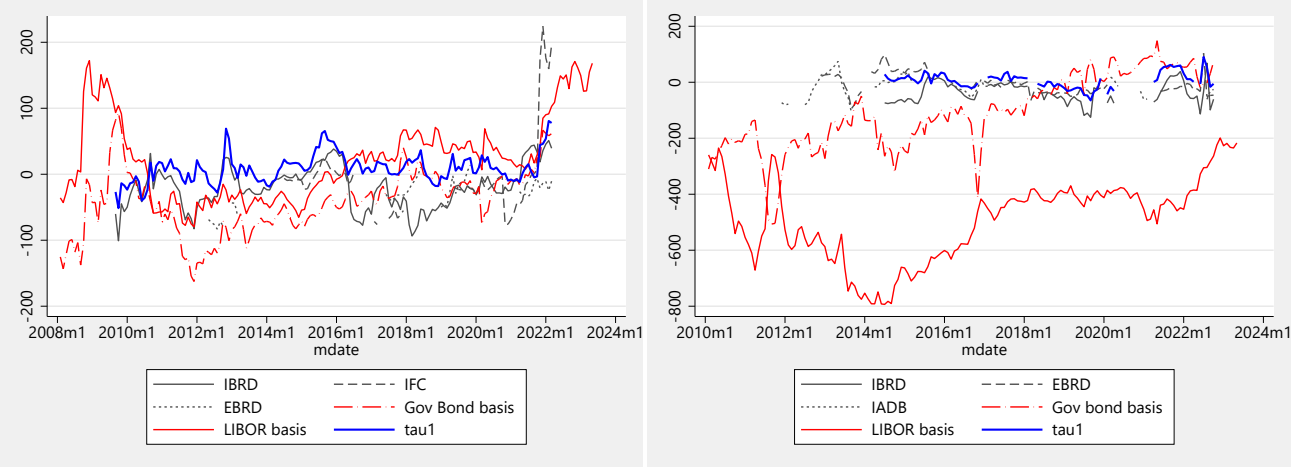


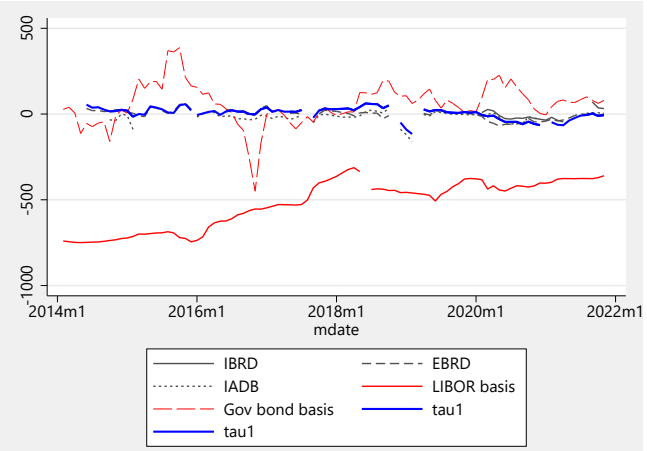
Figure 20: Daily Bid-Ask spreads for supranational and government bonds in major EM's (1-year tenor).

Figure 4 shows the purified CIP deviations for the remaining EM currencies not shown in the main text.

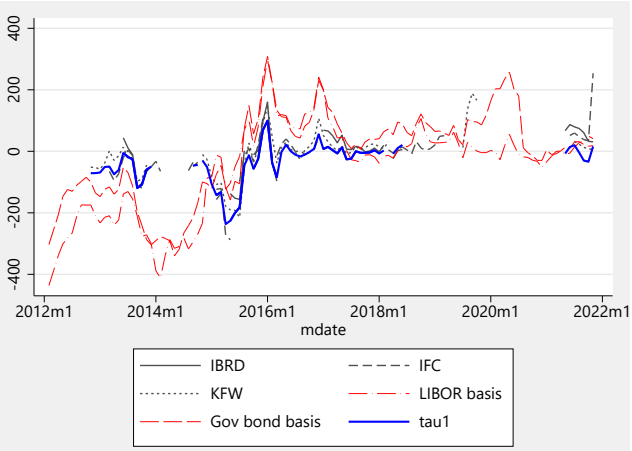


(a) MXN

(b) INR

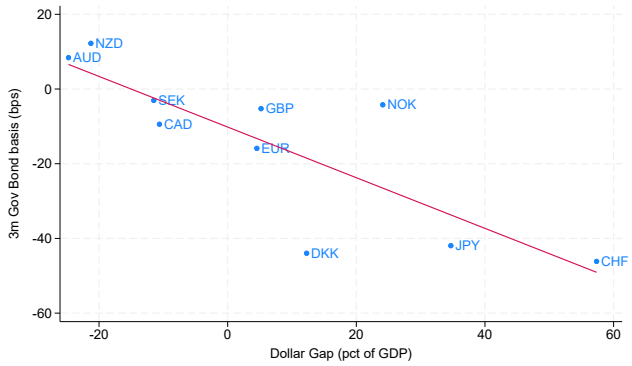


(c) IDR

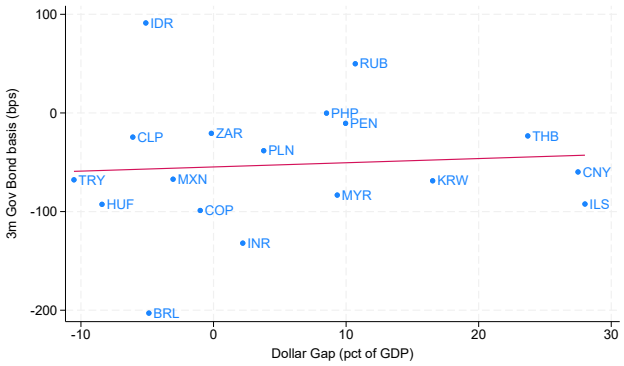


(d) CNY

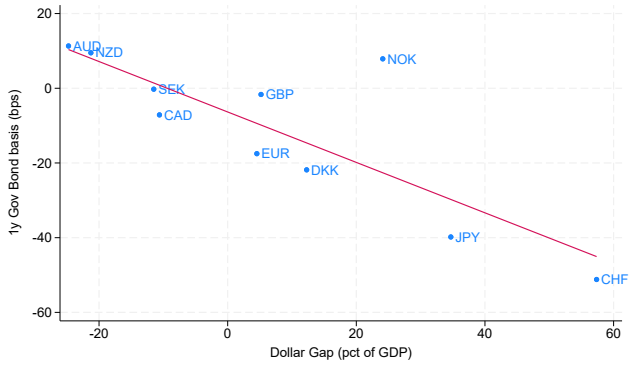
Figure 21: Purified versus conventional CIP deviations (1-year tenor).



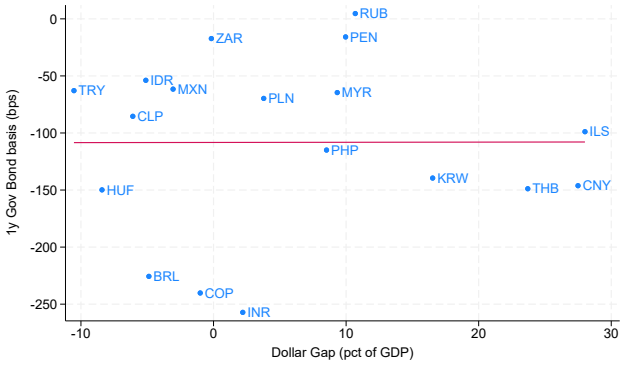
(a) 3m Treasury CIP basis in AE's



(b) 3m Treasury CIP basis in EM's



(c) 1y Treasury CIP basis in AE's



(d) 1y Treasury CIP basis in EM's

Figure 22: Net Dollar debt asset position (USD Gap) and average 3-month and 1-year Treasury (Government Bond) CIP basis in AE's and EM's: 2010-2017 averages by country/currency. For EUR, the GDP-weighted average of national USD gaps is taken.