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Uncovering CIP Deviations in Emerging Markets: Distinctions, Determinants and Disconnect

Eugenio Cerutti and Haonan Zhou

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Uncovering CIP Deviations in Emerging Markets: Distinctions, Determinants and Disconnect
Prepared by Eugenio Cerutti and Haonan Zhou*

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ABSTRACT: We provide a systematic empirical treatment of short-term Covered Interest Parity (CIP) deviations for a large set of emerging market (EM) currencies. EM CIP deviations have much larger volatilities than most G10 currencies and move in an opposite direction during global risk-off episodes. While off-shore EM CIP deviations are sensitive to changes in FX dealers' risk-bearing capacities and global risk aversion, on-shore EM CIP deviations are largely unresponsive in segmented FX markets. Moreover, the sensitivity of offshore EM CIP deviations to global risk factors for currencies with segmented FX markets is stronger compared to their counterparts with integrated FX markets. We find weak evidence of country default risk affecting EM CIP deviations after accounting for global factors.

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Author's E-Mail Address:	ECerutti@imf.org, haonan@princeton.edu

WORKING PAPERS

Uncovering CIP Deviations in Emerging Markets: Distinctions, Determinants and Disconnect

Prepared by Eugenio Cerutti and Haonan Zhou[1]

1 Cerutti is at the Strategy Policy and Review Department of the IMF. Zhou is at Princeton University. We thank Agnes Isnawangsih for help with downloading Bloomberg data, Ken Froot for insightful discussion, Jochen Schmittmann for helpful conversations, and Suman Basu, Lukas Boer, Sonali Das, Ken Kang, Jorge Leon, Monica Petrescu, Carlos de Barros Serrao, Tatjana Schulze, Yizhi Xu for comments. Zhou acknowledges generous financial support from the International Economics Section and the Griswold Center for Economic Policy Studies at Princeton University. The opinions expressed herein are solely the responsibility of the authors and should not be interpreted as reflecting hose of the IMF, its Executive Board, or IMF management.

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1 Introduction

More than three decades ago, Krugman and Obstfeld's (1988) bestselling international economics textbook introduced Covered Interest Parity (CIP) as the "Basic Equilibrium Condition" to understand foreign exchange (FX) markets. CIP, set out by Keynes (1923) during the floating exchange rate period after WWI, describes the intimate relationship between the premium of a currency's forward over its spot exchange rate (both rates expressed as the price of foreign currency) to its nominal interest-rate advantage over foreign currency. Absent counterparty default risk and financial frictions, CIP equates the forward premium and interest rate differential via perfect riskless arbitrage. In the case of advanced economies (AEs) and their developed FX markets, CIP appeared to hold quite closely for several decades until the Global Financial Crisis (GFC), but it seems to have broken down since the onset of the GFC, and deviations have remained since.

Emerging markets (EM), on the other hand, have received less attention in the literature analyzing CIP deviations, even after international trading of EM currencies has reached a scale comparable to advanced economy (AE) currencies (Caballero, Maurin, Wooldridge and Xia, 2022). While a lot of attention has been given to the understanding of EM's currency risk premium, represented by deviations from Uncovered Interest Parity (UIP), data constraints and complex market arrangements due to capital controls and FX market underdevelopment have made the analysis of CIP deviations more difficult. Our paper seeks to fill this gap. We provide a systematic discussion on the measurement of short-term CIP deviations, study the role of their macro-financial determinants, and highlight the differences between EMs and AEs. Moreover, we exploit the frequent disconnect between off-shore and on-shore FX markets in EMs and present a novel analysis of their different sensitivities to global macro-financial determinants.

While EMs often have market imperfections that preclude perfect arbitrage, CIP deviations in EMs arguably have more important implications than that of the advanced economies and are relevant to a wider range of agents in the economy. International mutual funds with a focus on emerging markets roll over short-term currency forwards to hedge the currency risk in their local-currency fixed income and equity portfolio. CIP deviations can indicate the costs of accumulating foreign reserves (Amador, Bianchi, Bocola and Perri, 2019). Emerging market firms actively utilize FX forwards as hedging instruments, particularly at short tenors (Alfaro, Calani and Varela, 2021), so that CIP deviations also provide a measure of firms' hedging cost. Long-term CIP deviations based on government bond yields are direct indicators of local-currency sovereign risk

(Du and Schreger, 2016). From a macro perspective, the presence of the dollar basis (deviations from CIP with respect to the dollar interest rate) also implies that one may be able to borrow or lend synthetically in domestic currency at a rate that is different from the domestic central bank rate, but dependent on monetary policies of core countries, such as the United States (Cerutti, Obstfeld and Zhou, 2021).

The presence of CIP deviations affects different economic actors in EMs, especially such key resident players as domestic banks, large firms, as well as non-resident, international investors. From an international investor's perspective, a wider CIP deviation would impact their cross-border investment decisions by affecting their hedge-adjusted returns, usually obtained through forward contracts sold by global banks. From a domestic borrower's side, fluctuations of CIP deviations affect the relative cost between domestic-currency funding and synthetic funding through currency swaps. For countries with open financial accounts free from restrictions in foreign exchange trading, no distinction needs to be made between residents and non-residents when measuring CIP deviations. But this may not be the case in EMs, where off-shore and on-shore CIP deviations do not always closely track each other. Off-shore FX markets, includ- ing Non-Deliverable Forwards (NDFs), can be disconnected from onshore FX markets affecting potentially distinct sets of market players.[1] Both in normal times and during crisis episodes, the wedges between off-shore and on-shore forward exchange rates are non-negligible in the case of several EMs.

Building on previous work (Cerutti, Obstfeld and Zhou, 2021), we focus on analyzing the evolution of short-term CIP deviations – relevant at the "macro-financial" level – to evaluate the importance over time of key drivers of CIP deviations.[2] We start by documenting that the evolution of CIP deviations is much more heterogenous and segmented in EMs than AEs. While it is also clear that there is not a single factor or specific group of factors that uniformly apply across EM CIP deviations and over time, as highlighted in Cerutti, Obstfeld and Zhou (2021) for AEs, the reality is that EMs present a much more complex case. EM CIP deviations are more volatile than those of advanced econ- omy currencies, with significant deviations from zero even before the global financial

[1]A non-deliverable FX forward (NDF) is an outright forward FX contract in which counterparties settle the difference between the contracted NDF rate and the prevailing spot rate on an agreed notional amount, generally from OTC markets in international finance centers such as Singapore, Hong Kong, London, Dubai, and New York. Unlike a deliverable forward, no physical delivery of currencies is necessitated at settlement. Only the profit and loss are exchanged. Usually settled in U.S. dollar, NDF has been the dominant hedging instrument for a number of currencies with limited offshore convertibility.

[2]We follow the convention of the literature and define the short-term CIP deviation (also known as the cross-currency "basis") as the relative difference between direct USD interest rate in the cash market and synthetic USD rate in the swap market from swapping local currency cash flow using FX forward and spot transactions.

crisis. Cross-sectionally, the correlations between EM CIP deviations and interest rate differential or net international investment position have opposite signs to those in AEs.

Consistent with empirical literature documenting the role of global risk factors in driving CIP deviations in AEs (Du, Tepper and Verdelhan, 2018; Avdjiev, Du, Koch and Shin, 2019, among others), as well as recent theoretical advances on the macro-financial channel of exchange rate determination (Gabaix and Maggiori, 2015; Liao and Zhang, 2020), we find evidence that global financial intermediaries' time-varying risk-bearing capacity has a strong influence on the dynamics of EM CIP deviations based on offshore forward exchange rates. We first show that CIP deviations for Emerging European currencies with relatively integrated FX markets spike during quarter-ends and year-ends after 2016, when FX intermediation activities decline due to regulatory window-dressing of European banks and Global Systemically Important Banks (G-SIBs). The average size of the jump – more than 20 basis points – is nearly twice the amount estimated by Cerutti, Obstfeld and Zhou (2021) for G10 currencies.

The costly financial intermediation theory yields a number of testable predictions in the EM context. Given that most major emerging market economies are net international debtors (excluding reserves), CIP deviations should respond to a tightening of intermediation capacity in the opposite way to that of net creditors, including most advanced economies (Liao and Zhang, 2020). We construct a measure of major foreign exchange dealer banks' leverage ratio in the spirit of He, Kelly and Manela (2017), and show that this measure is strongly correlated with EMs' off-shore CIP deviations. Importantly, as the leverage ratio increases (dealers' average capital ratio declines), off-shore CIP deviations become more positive, indicating a relative decrease of implied dollar interest rate in the swap market, a pattern in stark contrast to that of G-10 currencies.

The sensitivity of off-shore CIP deviations to global risk factors is most pronounced when we focus on a set of currencies with significant degrees of segmentation between the onshore and offshore FX forward markets. For these currencies, however, we do not find evidence that on-shore CIP deviations comove with global risk factors. Our findings are thus also consistent with theories that highlight the role of financial frictions and limits to arbitrage: Shocks to the intermediation capacity of global FX dealers propagate to CIP deviations of currencies with integrated markets. Segmentation insulates the onshore market from shocks, but it may also increase the sensitivity of offshore FX markets due to the worsening of efficient risk-sharing.

For emerging markets designing regulatory measures on foreign exchange markets, our finding of a disconnect between onshore and offshore CIP deviations in their sensitivity to global factors has ample policy implications. The theoretical literature on capital flow management (Korinek, 2011; Boz, Unsal, Roch and Gopinath, 2020, among others) and some recent empirical studies (Das, Gopinath and Kalemli-Özcan, 2021) show that when capital flow management measures are used in a "preemptive" manner, they could lead to a lower level of foreign currency FX debt, a lower sensitivity to global risk factors, and a reduced risk of future sudden stops and financial crises. Segmentation of the FX markets could also afford the monetary authorities wider policy space to intervene in the onshore markets in order to keep funding cost low and provide hedges to foreign-currency borrowers in the face of depreciation pressure. Going further, as prescribed by Gourinchas (2022), an EM with partial currency convertibility could supplement its interest policy rule with a target of CIP deviations. Imposing constraints on participation are not without downside, however, as segmentation amounts to levying a "tax" on hedging currency risks, which may discourage foreign participation in the local bond market if the degree of segmentation is sufficiently large (e.g., Malaysia's effective tightening of residents' participation in off-shore FX markets in 2016). As EM central banks increasingly tap into onshore FX markets for intervention, the disconnect also calls into question central banks' ability to alleviate adverse sentiments and capital outflow pressure in the off-shore market. Limited risk-bearing capacity of global FX dealers and other arbitrageurs may in fact amplify the volatility of off-shore CIP deviations and increase the hedging cost for global investors, especially when global risk perception worsens.

Our contributions to the literature are threefold. First, we extend the analysis of the evolution and the macro-financial determinants of short-term CIP deviations to EMs. Focusing on AEs, different authors have stressed a range of often complementary potential drivers, ranging from regulation-induced or other arbitrage limits (Du, Tepper and Verdelhan, 2018; Cenedese, Della Corte and Wang, 2021), to changes in banks' balance sheet or risk-taking capacity connected with U.S. dollar appreciation (Avdjiev, Du, Koch and Shin, 2019; Cerutti, Obstfeld and Zhou, 2021). A few studies have included sev- eral EMs in their samples, but their focus was different from ours. Hutchison, Pasricha and Singh (2012) and Aggarwal, Arora and Sengupta (2021) discuss the effectiveness of capital flow management measures by focusing on CIP deviations of the Indian Rupee NDF and onshore FX derivative market. Du and Schreger (2016) measure long-term deviations from CIP for EM local-currency government bond. Using regulatory data from Mexico, Bush (2019) establishes a significant influence of hedging demand on CIP deviations. Hong, Oeking, Kang and Rhee (2020) focused on the Asia-Pacific region, highlighting that a widening of CIP deviations tightens financial conditions in net debtor countries, while easing financial conditions in net creditor countries. An early related paper is Skinner and Mason (2011). Like us, they relate CIP deviations in EMs to global risk factors. Relative to them, we provide refined measurement of CIP deviations and systematically study the off-shore / on-shore disconnect in CIP deviations' sensitivity to global factors.

Second, our work complements efforts in the analysis of Uncovered Interest Parity (UIP) in EMs and AEs. Our findings highlighting that the forward FX markets are key in explaining the differences across EMs and AEs are in line with Kalemli-Özcan and Varela's (2021) analysis of the differences across UIP in EMs and AEs. They find that, unlike the case of AEs, the UIP for EMs does not hold regardless of the measurement of exchange rate changes (e.g., with expected or realized movements). They argue that uncertainty surrounding non-exchange rate policies (which include but are not limited to – expropriation risk, government accountability, risk of profit repatriation, as well as monetary policy) affect the formation of exchange rate expectations in emerging markets leading to a UIP risk premium.

Third, we also contribute to the on-shore and off-shore FX market literature. Patel and Xia (2019) and Schmittmann and Chua (2020) provide recent overviews of NDF markets in EMs.[3] While activity continued to be influenced by restrictions on currency convertibility, Patel and Xia (2019) highlight that an important driver of the surge in offshore FX NDF trading during 2016-19 was the growing appetite of global investors for EM assets. They also find that during times of global market stress, it is more likely that the offshore NDF markets will drive onshore prices. Similarly, while Schmittmann and Chua (2020) find that influences tend to run both ways after controlling for differences in time zones between markets, for the COVID-19 pandemic they find some evidence of NDFs leading onshore markets for a few Asian currencies. Our contribution to this segment of the literature is to document how different macro-financial factors can affect CIP deviations calculated using on-shore and off-shore FX market forwards.

The structure of the rest of the paper is as follows: the next section presents the measurement of CIP deviations, after which we evaluate the evolution of EM CIP deviations across times and currencies. We proceed to estimate the influence of global and coun- try specific factors on EM CIP deviations in Section 4. We conclude and present policy implications in the last section.

[3]We also refer the readers to an earlier summary by Lipscomb (2005), with input from market participants on the factors affecting the pricing of NDF.

2 FX market development and CIP deviation measurement

We start by introducing the concept of CIP deviations in the context of a generic EM. The pervasive financial frictions faced by international investors in gaining and hedging EM exposure warrant an extensive discussion of market openness and structural barriers, in particular in the FX forward market. Against this backdrop, we discuss issues in measuring and interpreting CIP deviations in emerging markets.

Consider an international investor with investment opportunities in an EM. For most of our empirical exercise below, we assume that the investment opportunities come in the form of short-term money-market deposits, denominated in the local currency of the emerging market economy. Let the annualized log return on the investment be denoted as $i_{t,t+n}$, where n is the tenor of the instrument. Provided that she has access, the investor could seek to use a forward FX contract to hedge her currency exposure, by selling her investment proceeds forward in exchange for the currency by which she funds the investment. We focus on CIP deviations against the U.S. dollar in this paper. Let the (log) spot exchange rate be denoted as s_t, and the (log) n-period exchange rate be denoted as $f_{t,t+n}$, both in units of local currency per USD. The hedged return on this investment is given by

$$i_{t,t+n} - (f_{t,t+n} - s_t).$$

In the ideal world in which the money-market deposit is free of default risk and the FX market is frictionless, the return on the trade must equalize the dollar funding cost $i^{\$}_{t,t+n}$, giving rise to the CIP condition (1):

$$i^{\$}_{t,t+n} = i_{t,t+n} - (f_{t,t+n} - s_t). \tag{1}$$

Financial frictions and default risk eliminate riskless arbitrage opportunities, giving rise to potentially profitable CIP trades. Following the convention in the literature (see, for example, Du, Tepper and Verdelhan (2018)), a negative deviation from CIP in the form of

$$x_{t,t+n} = i^{\$}_{t,t+n} - [i_{t,t+n} - (f_{t,t+n} - s_t)] < 0 \tag{2}$$

indicates that the returns on the hedged investment in the EM money market exceeds the cost of direct dollar funding, or the return on direct dollar investment in securities of similar maturities.

Deviations from CIP can also be interpreted through the lens of an emerging market borrower. Rewrite (2) as

$$x_{t,t+n} = [i^{\$}_{t,t+n} + (f_{t,t+n} - s_t)] - i_{t,t+n}. \quad (3)$$

The borrower could either fund herself in local currency at rate $i_{t,t+n}$, or in dollar (with cost $i^{\$}_{t,t+n}$) and convert the amount raised to local currency in the spot FX market.

To alleviate the concern of currency mismatch and debt revaluation upon depreciation, she could further hedge the currency risk from the dollar borrowing by entering into a contract that stipulates the buying of U.S. dollar in the forward market at exchange rate $f_{t,t+n}$ to repay the debt obligations maturing n periods later.[4] A negative $x_{t,t+n}$ indicates that this synthetic funding arrangement is cheaper than raising local-currency funding directly.

It's now well known that up until the Global Financial Crisis (GFC), the CIP condition (1) holds well for the advanced economies (Du, Tepper and Verdelhan, 2018). The breakdown of the canonical Libor basis after the GFC, while significant, is small in magnitude compared to the currency risk premium measured by deviations from the Uncovered Interest Parity condition (Kalemli-Özcan and Varela, 2021). For advanced economies, as a result, the sources of interest rates and exchange rates that enter (2) is largely immaterial from a macro-financial standpoint. However, as discussed in Du and Schreger (2016, 2022), among others, and as our exercise would show, various forms of market segmentation, counterparty risk, and data availability issues would complicate the analysis of CIP deviations in emerging markets at the outset. We cover in the rest of this section market segmentation and default risks in more detail, finishing with our preferred approach to estimate EM CIP deviations.

Market segmentation and regulatory barriers to arbitrage Partial convertibility of currencies and capital accounts remain a central characteristic of most EMs, despite significant development over the past two decades. Many EM currencies are convertible on the current account but with limited convertibility on the capital account, with considerable degrees of market segmentation. Regulation-induced limits to arbitrage come in a number of forms, including limits on onshore net open position (NOP) of forwards and swaps, prohibition of resident participation in offshore FX derivatives markets, as well as documentation requirements of underlying investment for non-resident access to

[4] For comparison, the ex-post unhedged amount to repay in local currency with a debt face value equal to 1 USD is given by $i^{\$}_{t,t+n} + (s_{t,t+n} - s_t)$.

onshore FX hedging instruments.[5] The levels and dynamics of CIP deviations according to (1) and (2) are thus complicated by the gap between forward exchange rates faced by offshore non-resident investors versus on-shore resident borrowers.

Default risk While counterparty risk in the FX forward market is negligible, as deliverable currency forward contracts are usually collateralized, and NDF contracts are net-settled, purely risk-free investment opportunities in emerging markets are scarce. In the presence of default risk, riskless arbitrage is no longer feasible even absent market frictions. Investors would demand additional compensation corresponding to loss due to default, on top of the covariance between the pricing kernel and the time-varying default risk.

Canonical dollar interest rates, such as Libor, provide at best an incomplete picture of short-term dollar funding cost for emerging market institutions. On the one hand, the relative underdevelopment of EM financial markets precludes the use of near-risk- free interest rates of instruments such as Overnight Index Swaps (OIS), except for very few countries. On the other hand, benchmark interest rates may describe funding costs faced by only a subset of market players (Morales and Vergara, 2017; Rime, Schrimpf and Syrstad, 2022), and they may be derived from estimates rather than from actual trades.

One could seek to adjust for the impact of default risk, by adding a proxy for the loss-upon-default compensation to (2), usually using CDS spread, denoted l_t (Du and Schreger, 2016, 2022):

$$x^{adj}_{t,t+n} = {}^{\$}_{t,t+n} - [(i_{t,t+n} - l_t) - (f_{t,t+n} - s_t)]. \quad (4)$$

Usually, the data on sovereign CDS is used to make such adjustment (see Du, Im and Schreger (2018)). Nonetheless, any adjustment using CDS spreads is subject to the issue that at short tenors relevant at the macro-financial level (e.g., three-months), CDS contracts are either not written, have unobservable prices, or are illiquid.[6] Therefore, adjustments according to (4) may introduce additional measurement errors and reduce data coverage dramatically.

More importantly, we run the risk of introducing spurious dynamics by adding l_t. It is well known that emerging market CDS spreads share a common factor that is closely related to shifts in global risk aversion (González-Rozada and Yeyati, 2008; Longstaff,

[5] Bank for International Settlements (2022) provide a systematic documentation of regulations on FX derivatives markets in Asia-Pacific EMEs.

[6] Major provider of CDS data, such as Markit, only report CDS spreads from the tenor of 6-month onwards.

Pan, Pedersen and Singleton, 2011; Gilchrist, Wei, Yue and Zakrajšek, 2022). As the CDS contracts linked to dollar-denominated debt instruments are primarily traded off-shore, adjusting the basis using CDS may mechanically reduce the sensitivity of the offshore basis to global factors, while increasing that of the on-shore basis. To gauge the impact of sovereign risk, we instead use the benchmark unadjusted basis, and consider country default risk as a potential determinant of the dynamics in our regression exercise.

Our approach The above discussion motivates our construction of benchmark CIP deviations, characterized by the following:

- *Short tenors*: We focus on 1-month and 3-month CIP deviations. The markets for short-tenor forwards and domestic interbank lending are the most liquid, and the concern for credit risk is smaller relative to longer tenors.
- *Off- and on-shore forward exchange rate*: For currencies with segmented markets for currency forward transactions (often countries with a large NDF market), we compute CIP deviations using forward exchange rates faced by both on-shore and off-shore market participants.[7]
- *Dollar interest rate partially reflecting EM default risk*: In advanced economies, dollar interest rate benchmark – the Libor rate – is not the marginal funding rate or investment instruments for most participants (Rime, Schrimpf and Syrstad, 2022). We make a stronger case for emerging market CIP deviations to reflect this fact. We compute one version of CIP deviations based on the canonical Libor dollar rate. Yet our preferred measure of U.S. dollar interest rate faced by emerging markets is the *A2/P2* non-financial commercial paper interest rate. This interest rate accounts for the credit risk of EM dollar borrowers with fundamentals close to the A2/P2 rating tier.[8] To the extent that EM money market interest rates also price the same

[7]We make no distinction between offshore and onshore interest rates, instead using domestic interbank rates as the representative rates. Even in the case where non-resident investors face barriers to entering the domestic interbank markets directly, domestic interest rates remain important benchmarks for trading instruments. Administrative filings (e.g., https://www.sec.gov/Archives/edgar/data/810893/000081089322003451/xslFormNPORT-P_X01/primary_doc.xml) indicate that large international mutual funds investing in EM fixed income securities, such as PIMCO, actively use interest rate swaps indexed to short-term domestic money market rates to hedge interest rate risk.

[8]On Refinitiv, we search short-term credit ratings of major banks headquarterd in the EMs we consider with operations in the U.S (based on the latest foreign bank structure data: https://www.federalreserve.gov/releases/iba/202203/default.htm). Most banks in emerging markets are assigned a rating of B, A3/P3 or A2/P2. Examples of the A2/P2 category include Banco de Crédito e Inversiones (Chile), Banco de Crédito del Perú (Peru), and Bangkok Bank (Thailand).

underlying credit risk, the credit risk component in the CIP deviations (2) would be partially offset by the interest rate differential.[9]

We obtain spot, forward exchange rates as well as money-market interest rates from Bloomberg and Refinitiv. We include both the offshore (often non-deliverable) and the onshore forward rates (if explicitly indicated by Bloomberg or Refinitiv as so).[10] We choose benchmark short-term interbank domestic interest rates based on availability. To achieve the maximum coverage and overcome issues with sporadically missing observations, our measure for the dollar interest rate is a simple average of the U.S. commercial paper interest rate provided by the Federal Reserve (FRED ticker RIFSPPNA2P2D90NB for 90-day issuances) and Bloomberg (ticker DCPD090Y for 90-day issuances). We use continuously compounded interest rates, making sure that the deviations account for day count conventions for individual currencies, as well as maturity date differences for forward contract priced at different points in the calendar, following Du, Tepper and Verdelhan (2018) and Cerutti, Obstfeld and Zhou (2021).[11]

From Bloomberg and Refinitiv forward exchange rates, we select representative series with the best coverage to calculate our benchmark on-shore and off-shore CIP deviations. For a subset of EM currencies, we observe significant wedges between off-shore forwards and on-shore forwards.[12] We adopt a wide definition of emerging markets to cover 20 non-G10 currencies. Our sample spans the period 2002 to 2021, although currencies differ in the availability of data. We report the Bloomberg and Refinitiv tickers in the Appendix Table A1.

3 Time-series and cross-sectional stylized facts

We focus in this section on analyzing the evolution and cross-country differences of EM CIP deviations. The description in this section centers initially on using offshore EM CIP deviations, as they are the standard in the literature and by doing so it facilitates comparison with AEs. Then, we cover the differences between off-shore and on-shore EM CIP deviations

[9]Currency-specific variations in default prospects remain unaccounted for.

[10]For Refinitiv, onshore forward quotes refer to quotes submitted by domestic data providers.

[11]As we use closing quotes and intraday prices are scarce for emerging markets, we do not account for time differences in daily data releases that potentially make the hypothetical CIP trade infeasible should markets be accessible. This is less of a concern, however, given that EMs' interbank money market interest rates are usually slow-moving.

[12]We discuss the disconnect in more detail in the next two sections. The currencies are BRL, CNY, IDR, INR, MYR, PHP, THB, and TWD. Also see Figure A1.

3.1 Evolution of CIP deviations

Figure 1 displays our benchmark 3-month off-shore CIP deviations across EMs. We divide the EMs into two groups to facilitate the visualization: (i) countries with NDF in the first row of charts, and (ii) countries with the more traditional FX deliverable forwards in the second row of charts. The right-hand chart in each row has countries with larger CIP deviations.

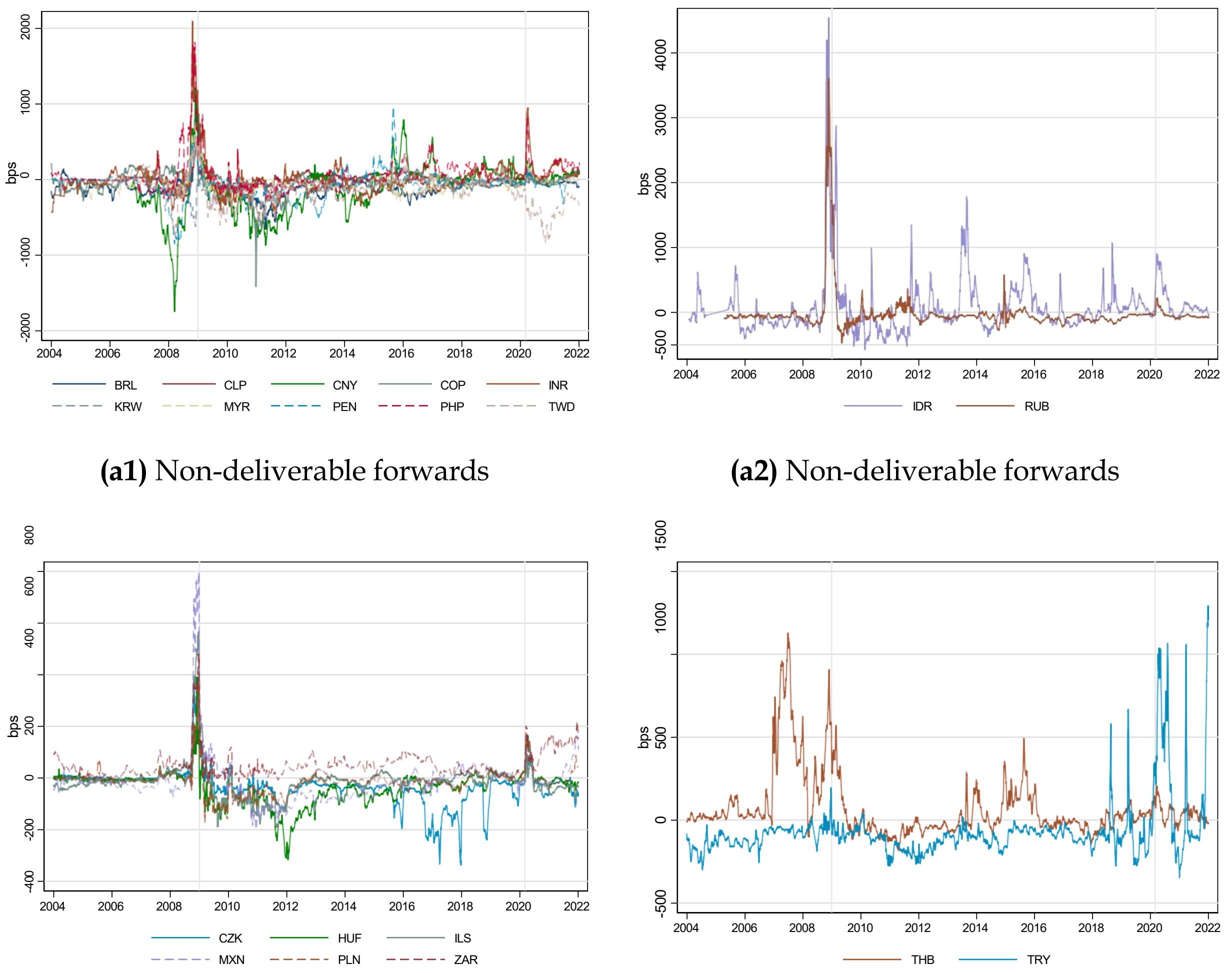
In general, although there is substantial heterogeneity across EMs as well as over time, CIP deviations widened during the GFC, and they fluctuate after the crisis with some recognizable common peaks such as the Taper Tantrum in 2013 and the beginning of the COVID-19 crisis in January 2020. Offshore CIP deviations of EM currencies are considerably larger and more volatile than their G-10 currency counterparts. Moreover, offshore CIP deviations fluctuate from negative to positive territories during crisis periods in many EMs. This switching is not so prevalent in AEs, where post-GFC CIP deviations are persistently negative for most AEs except Australia and New Zealand. Pervasive use of capital flow management measures in EMs may explain this fact, as they affect the relative scarcity of US dollars to different investors (see Keller (2021) for an analysis of Peruvian banks).

It is also visible in Figure 1 that countries with NDF have larger CIP deviation than countries with deliverable forwards. FX market segmentation could play a role, as the existence and size of offshore NDF markets is also a function of capital restrictions on foreign participation in domestic FX markets and the offshore deliverability of the domestic EM (McCauley and Shu, 2016). The growing appetite of global investors for EM assets has been one important driver in off-shore FX trading in recent years, led by the robust growth in NDF trading (Patel and Xia, 2019).

Table 1, panels (a) and (b) show the differences between the off-shore and on-shore CIP deviations for two groups of countries in our sample. In the first group, we show 8 currencies in our sample with wide difference between off-shore and on-shore CIP calculations. All but Thailand correspond to jurisdictions with NDF. Thailand, which does not have a NDF market due to the presence of an offshore deliverable forward market, has been imposing limitations on non-residents engagement with onshore financial institutions to manage currency risks related to the Thai Baht (e.g., requirement of providing proof of underlying for each transaction; end of the day outstanding position limit for non-residents).[13] Malaysian authorities took a different approach and they tightened restrictions in 2016 by effectively banning off-shore trading of NDFs by domestic enti-

[13]Some of these limitations on non-residents were relaxed in January 2021 according to the 2022 AREAER.

Figure 1: Benchmark offshore 3-month CIP deviations



(a1) Non-deliverable forwards

(a2) Non-deliverable forwards

(b1) Deliverable forwards

(b2) Deliverable forwards

Note: Gray vertical lines correspond to Jan 2009 and Mar 2020. 10-day moving averages, 2004-2021. The benchmark 3-month CIP deviations are offshore quotes or quotes on non-deliverable forwards. Sources: Bloomberg, Refinitiv, authors' calculation.

ties.[14] This resulted in a fall of 48 percent in off-shore trading (see Patel and Xia (2019); Schmittmann and Chua (2020) for more details).

Panel (b) instead highlights EMs for which off-shore and on-shore CIP deviations are similar despite the fact of the existence of NDFs in all four countries. Korea had the largest NDF market among EMs in the 2019 BIS triennial survey (close to USD 60 billion in daily average turnover). Despite a generally open capital account, Korea maintains limits on non-resident domestic currency borrowings from domestic banks and registration requirements for non-resident portfolio investors. Nonetheless, Korean residents

[14]The requirement not to engage in the NDF market was already present before 2016 but it was not strictly enforced.

can freely participate in the NDF market, and their arbitrage activities ensure close integration between off-shore and on-shore FX forward markets.

Finally, panel (c) displays the remaining 8 EMs in our sample. Their currencies are mostly convertible currencies (including through deliverable forwards), so there are no significant differences between off-shore and on-shore calculations. We instead present the difference between A2/P2 commercial rate paper and the US dollar Libor rate (IBOR). There are some differences, but CIP deviations using commercial rate paper are generally larger than IBOR calculated ones, due to the embedded credit risk in the dollar CP rate.[15]

3.2 Cross-sectional correlations with macro-financial variables

There exist sharp differences between EMs and AEs in the cross-sectional relationships between the bases and key macro-financial variables, as shown in Figure 2. There is a strong positive correlation (about 0.72) between AEs' CIP deviations and the level of interest rates in the cross-section. Australia and New Zealand, in particular, have high-rate currencies and positive CIP deviations, indicating that direct USD dollar borrowing is more expensive than synthetic dollar interest in the FX forward market. As highlighted in the literature (see Du and Schreger (2022) for a summary), the high yield in those two countries prompt investors in low-interest AE countries to be long in Australian/New Zealand dollars, generating USD dollar funding and hedging demand that translate into positive CIP deviations.

There is also a strong correlation (in this case negative, about -0.6) between AE's CIP deviations and their net international investment position (excluding reserves). In the case of net creditors countries (e.g., Japan and Norway, countries with high domestic savings and relatively low interest rates), they will have more negative cross-currency basis and face a higher premium to borrow and hedge UD dollars in the FX forward market. This negative correlation is also consistent with Liao and Zhang's (2020) hedging demand channel that links the cross-country pattern of CIP deviations to net USD dollar asset holdings.

On the other hand, not only is the level of the correlations much smaller (about 0.35 and 0.30 for the level of the interest rate and the NIIP position, respectively), but also the sign in both cases is different in the case of EMs' CIP deviations. In addition

[15]The magnitude of ex-ante deviations from *uncovered interest rate parity* (based on exchange rate expectations from survey data) are typically larger than CIP deviations in emerging markets. However, for most currencies, the correlations between CIP and UIP deviations are often very small (Kalemli-Özcan and Varela, 2021).

Table 1: Average CIP deviations by currency (bps)

Panel (a): Currencies with wide offshore/onshore forward differential: dollar-CP bases

	Offshore forward			Onshore forward		
	02-07 mean/sd	08-09 mean/sd	10-21 mean/sd	02-07 mean/sd	08-09 mean/sd	10-21 mean/sd
BRL	-261.18	48.65	-122.20	-313.83	-77.50	-139.28
	(542.58)	(293.88)	(102.95)	(1047.24)	(103.25)	(104.87)
CNY	-329.56	-202.18	-61.84	-154.40	-157.29	-127.51
	(211.00)	(685.55)	(269.09)	(205.45)	(418.48)	(180.77)
IDR	-85.12	546.05	83.47	-49.32	140.87	-16.92
	(205.09)	(1298.53)	(336.09)	(102.23)	(242.22)	(99.82)
INR	29.96	192.54	-3.36	-32.03	-19.92	16.58
	(135.85)	(630.61)	(160.19)	(146.55)	(250.39)	(91.04)
MYR	-55.11	66.45	-68.76	-18.31	23.27	-39.09
	(76.40)	(264.97)	(98.45)	(19.22)	(96.83)	(33.75)
PHP	33.63	345.16	48.59	5.49	37.42	17.23
	(151.27)	(548.80)	(144.27)	(22.79)	(72.88)	(22.38)
THB	153.66	245.01	14.62	12.07	60.59	-17.97
	(260.51)	(235.84)	(93.25)	(17.72)	(109.04)	(30.85)
TWD	35.32	-123.52	-167.52	-3.28	13.26	-68.80
	(88.67)	(348.94)	(177.30)	(12.58)	(109.03)	(45.09)

Panel (b): Non-deliverable currencies with comparable offshore/onshore CIP deviations

	Offshore forward (NDF) mean/sd	Onshore forward mean/sd
CLP (9/15/2017-12/31/2021)	-6.92	-8.39
	(44.31)	(60.32)
COP (11/29/2018-12/31/2021)	4.99	3.19
	(49.37)	(46.26)
KRW (8/16/2004-12/31/2021)	-52.36	-53.10
	(77.11)	(79.40)
PEN (9/30/2002-12/31/2021)	-56.18	.
	(183.28)	(.)

Note: Table 1 reports average 3-month CIP deviations by currency. The CIP deviations are defined according to Equation (1), using USD A2/P2 commercial paper rate as the dollar interest rate, so that a negative CIP deviation correspond to a lower direct dollar interest rate relative to the synthetic dollar interest rate. Panel (a) reports summary statistics for 8 currencies with substantial data coverage on both on-shore and off-shore forward exchange rates whose CIP deviations differ widely according to the type of forward exchange rate used. Panel (b) reports non-deliverable currencies whose offshore/onshore CIP deviations are close in levels with the data available. PEN, whose data on onshore forward exchange rate is not available, is also reported in Panel (b). Standard deviations are reported in parentheses.

to large heterogeneity across EMs due to the frequent segmentation of the off-shore and the onshore FX markets, the cross-sectional relationship for EM currencies may reflect the fact that our sample of EMs includes only net debtor countries and countries

Table 1: Average 3-month CIP deviations by currency and time period (bps, cont'd)

Panel (c): Currencies with data on deliverable forward, by types of dollar interest rates

	Dollar rate: A2/P2 CP			Dollar rate: IBOR		
	02-07	08-09	10-21	02-07	08-09	10-21
	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd
CZK	8.36	53.11	-57.61	-1.10	-38.28	-74.39
	(15.12)	(108.89)	(62.96)	(9.53)	(35.80)	(57.67)
HUF	1.18	4.23	-48.25	-7.74	-91.06	-67.18
	(24.93)	(136.49)	(65.48)	(22.35)	(101.53)	(61.09)
ILS	-11.03	85.36	-22.80	-20.75	-21.59	-43.11
	(21.58)	(168.66)	(43.39)	(17.88)	(70.44)	(42.78)
MXN	-10.07	141.07	-31.06	-19.47	36.76	-50.48
	(32.22)	(246.14)	(58.98)	(28.57)	(121.60)	(55.90)
PLN	4.04	5.66	-14.70	-5.39	-93.11	-35.53
	(17.80)	(115.13)	(36.18)	(13.30)	(62.40)	(33.23)
RUB	-57.70	303.41	-57.44	-62.14	132.50	-73.20
	(33.56)	(1001.67)	(90.27)	(33.17)	(814.97)	(87.78)
TRY	-168.51	-56.43	-54.94	-174.80	-136.87	-75.42
	(138.58)	(63.42)	(235.15)	(141.71)	(91.09)	(224.41)
ZAR	38.38	96.17	55.17	29.22	6.16	36.60
	(30.67)	(122.03)	(41.92)	(25.05)	(31.49)	(42.64)

Note: Table 1 reports average 3-month CIP deviations by currency. The CIP deviations are defined according to Equation (1), so that a negative CIP deviation correspond to a lower direct dollar interest rate relative to the synthetic dollar interest rate. Panel (c) reports the summary statistics for currencies with data on off-shore forward exchange rates only. The first three columns use A2/P2 commercial paper rate as the proxy for direct USD interest rate. The last three columns use dollar Libor rate. For currencies with an asterisk, we compute CIP deviations using offshore non-deliverable forward exchange rates. Other currencies have deliverable FX forwards. Standard deviations are reported in parentheses.

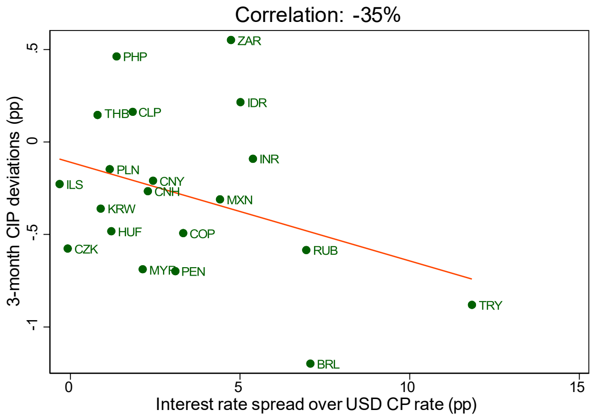
with positive interest spreads over US rates, thus rendering the heterogeneity among currencies less stark than that in the G10 currency group.[16]

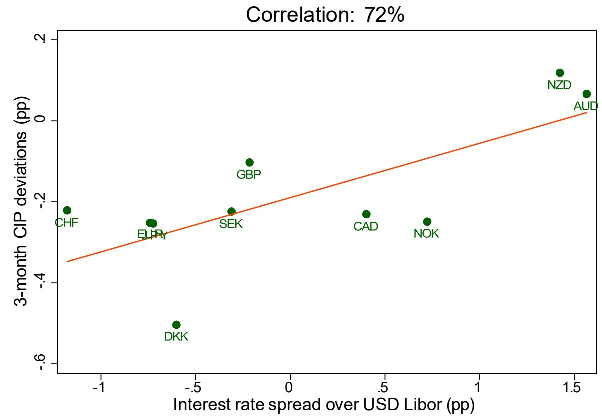
3.3 Costly financial intermediation and period-end dynamics

CIP deviations of G10 currencies are closely related to regulation-driven financial constraints imposed on global banks. Du, Tepper and Verdelhan (2018) suggest that spikes of CIP deviations near regulatory reporting dates can be interpreted as clear evidence on the role of regulatory constraints on currency arbitrageurs' balance sheets, as window-dressing activities temporarily reduces intermediation capacity of banks. Figure 3 plots the evolution of the benchmark 1-month CIP deviations at quarter ends. While the impacts are larger during the last quarter of the year, there is also movement during other

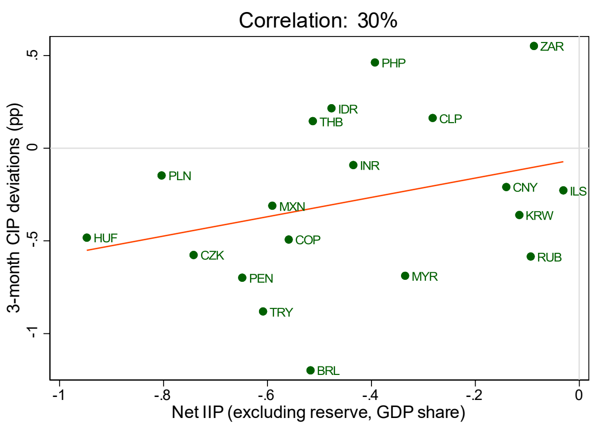
[16] In this set of figures, we drop TWD as an outlier. TWD's CIP deviations behave in a similar way to G10 currencies. See A3 for scatterplots where we put TWD back.

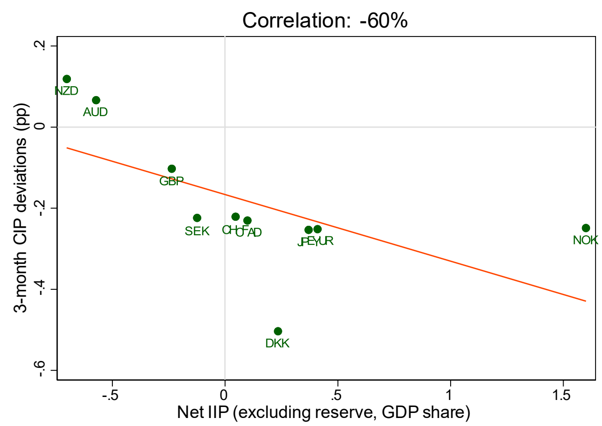
Figure 2: CIP deviations and macro correlates across countries (2010-2021)





(a1) Interest rate differential: EM **(a2)** Interest rate differential: AE





(b1) Net IIP (minus reserves) to GDP ratio: EM **(b1)** Net IIP (minus reserves) to GDP ratio: AE

Note: Figure 2 plots time-series averages of benchmark 3-month CIP deviations against key macro-financial aggregates of emerg- ing markets and advanced economies. The benchmark 3-month CIP deviations are offshore quotes or quotes on non-deliverable forwards. Interest rate spread for emerging market currencies is calculated by taking the difference between 3-month money market rate and 3-month US A2/P2 commercial paper rate. For advanced economies, dollar interest rate is Libor rate. Net international investment position (IIP) are annual observations from the Milesi-Ferretti and Lane (2017) dataset, updated to 2021 (link: https://www.brookings.edu/research/the-external-wealth-of-nations-database/). We subtract reserves from the aggregate international investment position for each country. Sample period: 2010-2021. The outlier TWD is dropped (see Appendix Figure A3) The daily CIP deviations are winsorized at 1% and 99% before being aggregated for the graphs.

quarter-ends, especially in the case of Eastern European EM currencies (CZK, HUF, PLN, RUB) with a relatively more globally-integrated FX markets. European banks subject to quarter-end reporting regulation tend to have a large role in Eastern Europe given their universal business model, which includes European broker-dealers as part of the European banking group (Cerutti, Claessens and Ratnovski, 2017).

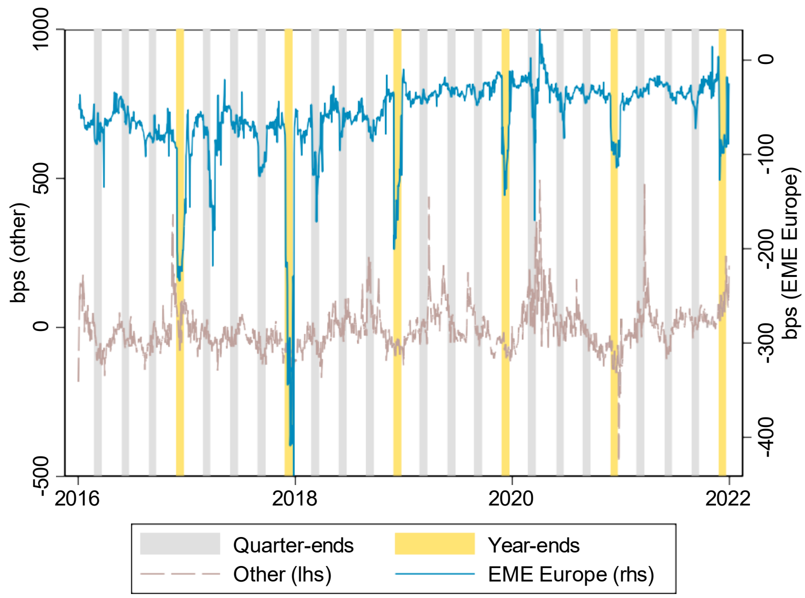
During year-ends, regulatory pressures on the liquidity of money market become much more pervasive. As highlighted by Cerutti, Obstfeld and Zhou (2021), the capital surcharge for globally systemically important banks (GSIBs), introduced on January 1, 2016, has a notably strong effect in driving three-month benchmark CIP deviations in the fourth quarter, when U.S. and euro area regulators evaluate GSIB balance sheets. Our event-study methodology – which follows the one for AEs in Cerutti, Obstfeld and Zhou (2021) – gives an idea of the marginal impact of the regulations at times when the regulatory constraints are more binding. Figure 4 shows the estimated coefficients when we regress daily 3-month offshore / NDF CIP deviations on a set of dummies indicating the dates before and after the day when 3-month forward contracts begin to settle at the start of next year (these contracts are usually priced at end-September each year).[17] Before the GSIB regulation went into place, the 3-month bases for EME European currencies, AE currencies and other deliverable EM currencies experience little to no action during these dates. For non-Eastern European EM NDFs, estimated coefficients before year-end dates are large yet statistically insignificant (panel (c)). After 2016 however, we observe a downward jump of the AE basis by 13 basis points on average (panel (b)). In panel (a), we find that the average response of CIP deviations (23 bps) is stronger in the case of Eastern European currencies, nearly twice the amount of G10 currencies. Little to no action is observed for other EM currencies. It follows that the regulatory constraints facing global FX dealers are especially binding for emerging markets, with arbitraging capital retreating from EM markets by more than their AE counterparts.

4 Global factors and CIP deviations: On-shore and off-shore disconnect

Following the discussion in the previous section, we set out to investigate the sensitivity of CIP deviations to global factors capturing variations in the risk-taking capacity of global financial intermediaries. In doing so, we make an important distinction between off-shore and on-shore bases. We attribute the potential heterogeneous responses to FX market segmentation and costly financial intermediation, as in Du (2019) and Liao and Zhang (2020). Through panel regressions, we find that offshore CIP deviations respond positively to a decline in the balance sheet capacity of key EM currency dealers, while onshore CIP deviations have the opposite response, suggesting a significant disconnect. Consistent with a limited risk-bearing capacity explanation, we further show that the response of CIP deviations to global factors is most pronounced in those that involve

[17] These regressions also include currency fixed effects. In Figure 4, we report 95% confidence inter- vals based on heteroskedasticity-robust standard errors as the number of clusters to compute clustered standard errors are very small.

Figure 3: Quarter-end dynamics for 1-month CIP deviations



Note: Figure 3 plots average 1-month offshore / NDF CIP deviations from 2016 to 2022 for two distinct currency groups. The blue solid line (rhs) plots average basis for EME European currencies (CZK, HUF, PLN, RUB). The red dashed line (lhs) plots averages over all other EM currencies.

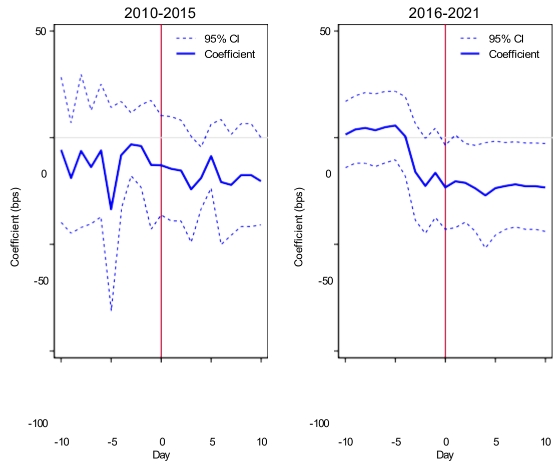
off-shore forward. In a final step, echoing our discussion in Section 2, we also use our regression framework to show that country-specific default risk is unlikely to be a significant driver of short-term CIP deviations in emerging markets.

4.1 Theoretical underpinnings and hypotheses: Basis sensitivity, costly financial intermediation, and segmented markets

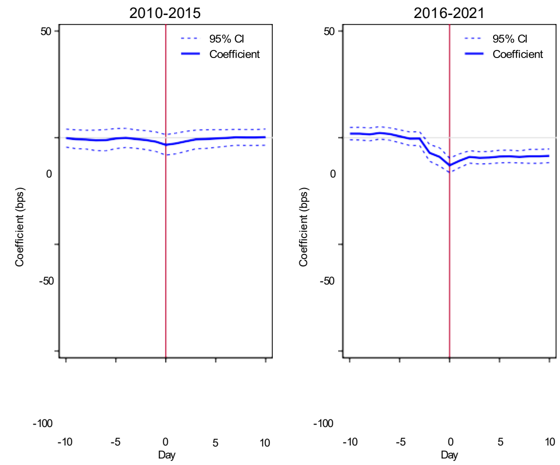
Empirical literature on CIP deviations in advanced economies has established a close relationship between CIP deviations and the risk-bearing capacity of intermediaries (Avdjiev, Du, Koch and Shin, 2019; Augustin, Chernov, Schmid and Song, 2020; Liao and Zhang, 2020; Cerutti, Obstfeld and Zhou, 2021). For advanced economies, CIP deviations are enlarged when the broad dollar index appreciates, or global financial intermediaries' intermediary leverage ratio (He, Kelly and Manela, 2017) tightens.

To extend the analysis to emerging market currencies, we need to take into account the important distinction between on-shore and off-shore bases. The potential existence of two segmented markets, one for international investors of EM assets, and one for domestic players with limited amount of arbitrage in between could effectively lead to very different responses of CIP deviations to global shocks.

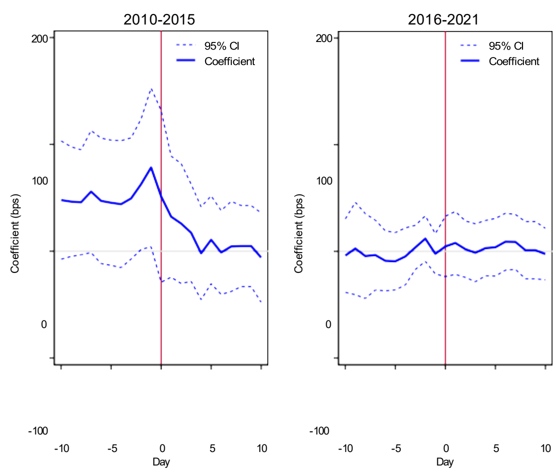
Figure 4: Year-end dynamics of 3-month basis, by groups of currencies



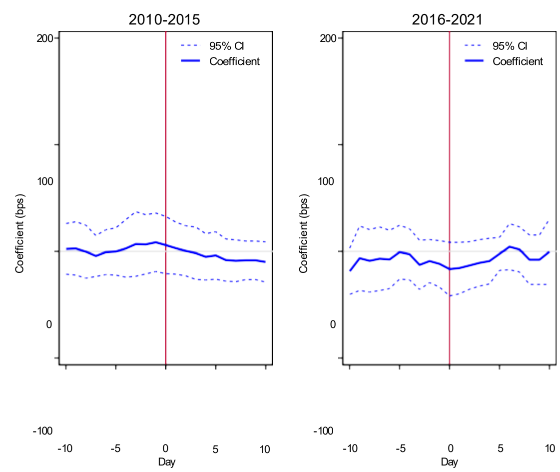
(a) EME European currencies



(b) AE currencies



(c) Other EM currencies: non-deliverable



(d) Other EM currencies: deliverable

Note: Figure 4 plots reports event-study coefficients on the panel of G10 three-month Libor bases against the U.S. dollar. The offshore/NDF CIP deviations are projected on a set of dummy variables indicating days around the start and end of the time window in which a three-month forward's settlement date is of a different year than its maturity date. Day 0 typically refers to two days before the end of September. The left-hand-side plot of each panel plots the coefficients estimated over the 2010-2015 sample, when G-SIB regulation were not in place. The right-hand-side plot reports the corresponding coefficients after regulations were enacted from 2016 to 2021. The EME European currencies we consider are CZK, HUF, RUB, PLN (Panel (a)). The advanced economy currencies (Panel (b)) are G10 currencies. Panel (c) and panel (d) look at other EM currencies (non-deliverable and deliverable, respectively). We report 95% confidence interval based on heteroskedasticity-robust standard error (due to a small number of clusters)

To illustrate this point, consider the costly intermediation model of Liao and Zhang (2020). In the theory, net creditors with a positive external investment position (such as institutions in non-U.S. advanced economies such as Japan) hedge their currency position from investing in dollar-denominated assets by selling dollar forward. In times of financial stress, swap dealers with a limited risk-bearing capacity require a lower price of the forward dollar to absorb the demand pressure in supplying local currency forward. This leads to the local currency being overvalued in the forward market relative to the spot market, after adjusting for interest rate differentials – a more negative CIP deviations (see (2)). The logic is similar for countries with a negative external position.

In the context of emerging market economies, typically an international net debtor when we exclude reserve accumulation, the international investor introduced in Sec- tion 2 funds herself in dollars, converts the dollar to local currency to purchases local-currency assets and demands currency hedges from FX swap dealers located off-shore. Consider a rise in *global* risk aversion directly affecting the intermediation capacity of FX swap dealers, who supply dollar forward to the investor. While the spot exchange rate appreciates due to usual risk-on/risk-off reasons, the price of the dollar in the for- ward market rises by even more, as FX swap dealers would require a higher spread (i.e., more expensive forward dollar) to be willing to intermediate the hedging demand of the investor. Meanwhile, hedging demand may also respond to global risk-off shocks, as previously unhedged carry traders exploiting pure UIP deviation may decide to protect the downside and eliminate some exchange rate uncertainty by demanding dollar forward. Both forces lead to an overreaction of local currency depreciation in the forward market relative to that in the spot market. Using the notation of (2), a larger $f - s$ leads to a *positive* change in off-shore CIP deviations.

With perfect arbitrage in the spot and forward market, pressures in the off-shore market would transmit perfectly to the on-shore market, resulting in the same response of on-shore CIP deviations to global risk aversion shocks. However, for a number of EM currencies, significant limits to arbitrage exist, with numerous restrictions imposed on domestic FX intermediation, as Sections 2 and 3 document. Derivative markets are especially subject to position limits and participation constraints, which effectively segment the markets for FX swaps. On-shore FX dealers, usually domestic banks, are less directly affected by global risk-off shocks, thus reducing intermediation capacity by less. Instead of overreacting and depreciating by a larger amount, forward local currency may *underreact* relative to its response in the spot market. Per (2), the on-shore basis would be less sensitive to global financial shocks. A *negative* response of the on-shore basis would also be possible. Our first hypothesis to be tested empirically can be stated as follows:

Hypothesis 1. *The sensitivity of CIP deviations computed using onshore forward exchange rates to global factors is smaller than their counterparts computed using offshore forward exchange rates.*

In the data, significant wedges between on-shore and off-shore CIP deviations exist. For a group of eight currencies whose wedge is considerably large (BRL, CNY, IDR, INR, MYR, PHP, THB, TWD), Figure 5 plots the evolution of off-shore minus on-shore

CIP deviations. During normal times, the spread fluctuates around zero. In times of economic stress, the spread becomes positive, driven by an over-depreciation of local currency in the off-shore forward market relative to the on-shore market, in line with the theory.[18] Figure 6 zooms in on two recent global risk-off episodes, the Taper Tantrum of 2013 (Panel (a)) and the onset of COVID-19 pandemic in early 2020 (Panel (b)). In these episodes, the difference amounts to 300-400 basis points.

Guided by the theory on the financial determinants of exchange rate (Gabaix and Maggiori, 2015; Liao and Zhang, 2020, among others), we also expect that the difference in the sensitivity of *offshore* CIP deviations to global factors depends on the degree of segmentation in the forward market. International banks are often the dominant counterparties for non-deliverable FX forward through its market-making role (Lipscomb, 2005). In recent periods, they face increasing hedging demand from international mutual funds' investment in local-currency bond markets.[19] On the other hand, both onshore and offshore participants could share risk for currencies with an integrated forward market. This results in a steeper supply curve for hedging services for currencies with segmented markets, effectively amplifying the response of offshore CIP deviations for these currencies when global risk-aversion tightens.[20]

Hypothesis 2. *The sensitivity of offshore CIP deviations to global risk factors for currencies with segmented FX markets is stronger compared to their counterparts with integrated FX markets.*

4.2 Regression evidence

To understand the macro-financial correlates of CIP deviations for both on-shore and off-shore bases and test our hypotheses on the offshore-onshore disconnect, we run panel regressions of 3-month CIP deviations on a set of global macro-financial factors. We alleviate the concern of potential non-stationarity using monthly differences throughout our regression specifications, following Cerutti, Obstfeld and Zhou (2021).

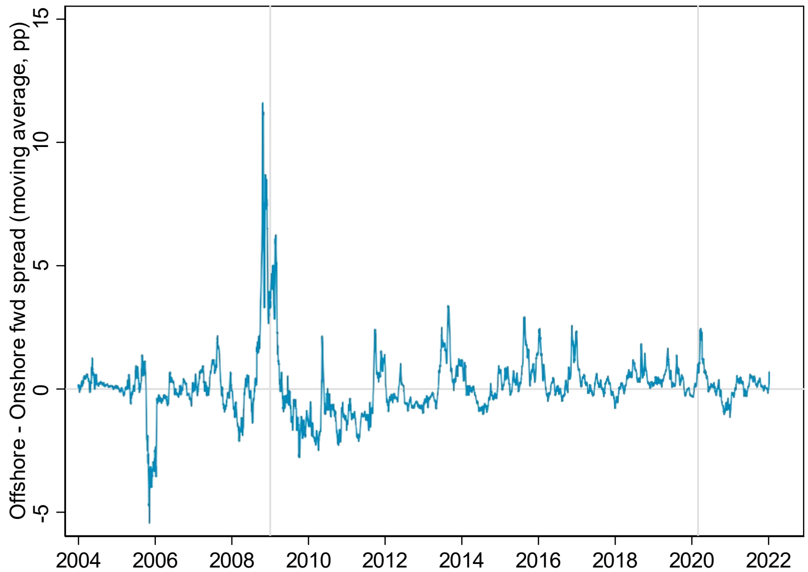
We discuss the choice of variables in our baseline specification in more details. Detailed descriptions of regressors and summary statistics are reported in Appendix Table

[18]Note that we use the same interest rate and spot exchange rate throughout to compute off-shore and on-shore CIP deviations for each currency.

[19]The increase in overall trading of emerging market currencies is largely driven by a shift in hedging demand from bank and insurance companies to international asset managers (Caballero, Maurin, Wooldridge and Xia, 2022). For capital inflows to emerging markets after countries' inclusion in international equity and bond indices, see Raddatz, Schmukler and Williams (2017). For international mutual funds' currency hedging practices, see Sialm and Zhu (2021).

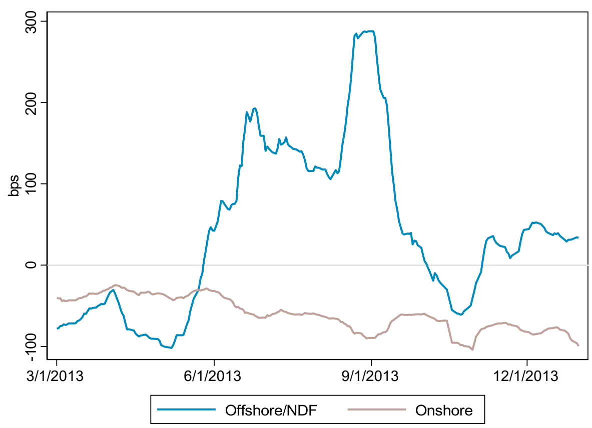
[20]Krogstrup and Tille (2018) attributes the heterogeneous sensitivity of foreign currency capital flows to global risk factors to intermediaries' ex-ante currency exposure.

Figure 5: Offshore-onshore CIP deviation spread (pp)

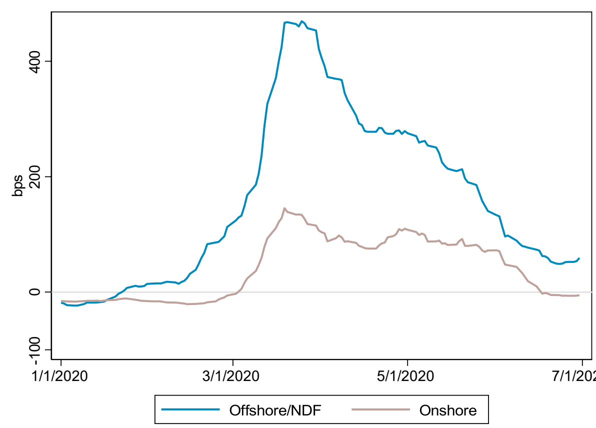


Note: Average off-shore minus on-shore 3-month CIP deviations for BRL, CNY, IDR, INR, MYR, PHP, THB and TWD. Gray vertical lines refer to the Great Financial Crisis and the COVID-19 crisis.

Figure 6: Average CIP deviations during global risk-off episodes: Currencies with segmented FX forward markets



(a) Taper Tantrum



(b) COVID-19

Note: Average off-shore and on-shore 3-month CIP deviations for BRL, CNY, IDR, INR, MYR, PHP, THB and TWD. Individual series are first smoothed using 10-day moving averages before taken cross-sectional averages.

A3. Guided by the theory of costly financial intermediation established in the previous section, we compute the largest emerging market currency dealer banks' leverage ratios and construct an aggregate dealer leverage factor, in the spirit of He, Kelly and Manela

(2017).[21] Euromoney's annual FX survey has been reporting the market share of FX dealer banks for EM currencies since 2015. For all dealer banks appearing with top-ten market shares in at least one wave of survey, we obtain their key financial indicators from Bloomberg and compute the intermediary leverage ratio, as the inverse of capital ratio defined as

$$ICR_{i,t} = \frac{\text{Market equity}_{it}}{\text{Market equity}_{it} + \text{Book debt}_{it}}$$

where book debt is computed by subtracting total common equity from total assets. A high intermediary leverage ratio, in particular, corresponds to a low intermediary capital ratio, so that the dealer leverage is countercyclical. The bank-specific ratio is aggregated using equal weights. An increase in the dealer leverage factor captures declining risk-bearing capacities of the largest EM currency dealers. We provide the list of dealer banks in Appendix Table A2.[22]

Among other currency-specific correlates, following Cerutti, Obstfeld and Zhou (2021) and Krohn and Sushko (2022), we also use normalized bid-ask spread of FX forwards to gauge the impact of market liquidity on the basis. The forward market liquidity measure is defined as

$$10000 \times \frac{F_t^{ask} - F_t^{bid}}{F_t^{mid}}$$

where F denotes the level of forward exchange rate, and $F_t^{mid} = (F_t^{ask} + F_t^{bid})/2$ is the mid price. We also include 3-month nominal money market interest rate differential to account for hedging demand imbalances induced by shifts in the funding cost / relative attractiveness of investment in EM currencies versus the USD.[23]

We also consider other global factors. Avdjiev, Du, Koch and Shin (2019), among

[21] Huang, Ranaldo, Schrimpf and Somogyi (2022) study the role of constrained dealers in supplying liquidity in the FX market by considering a similar dealer leverage measure. The He, Kelly and Manela (2017) primary dealer leverage ratio measure is a powerful predictor of CIP deviations for advanced economy currencies (Augustin, Chernov, Schmid and Song, 2020; Cerutti, Obstfeld and Zhou, 2021).

[22] The survey results can be accessed at https://www.euromoney.com/surveys/foreign-exchange-survey. The use of top-ten dealers in each survey is without loss of generality, as the offshore FX market is significantly concentrated. According to the 2022 Euromoney FX survey, the top 20 FX dealer banks of EM currencies account for nearly 90% of the total market. Appendix Figure A5 shows that our dealer leverage measure strongly comoves with He, Kelly and Manela (2017) primary dealer leverage ratio.

[23] See the discussion in Cerutti, Obstfeld and Zhou (2021). The inclusion of nominal interest rate differentials in the regressions is also justified by the fact that, if $x_{t,t+n} \neq 0$, a regression of forward premium $(f - s)$ onto the interest rate differential yields a coefficient generally not equal to 1. Subtracting from both sides of the equation leads to a mechanical relationship between the basis and the interest rate differentials.

others, demonstrate the close comovement between the broad dollar index and CIP deviations for advanced economy (G10) currencies. Cerutti, Obstfeld and Zhou (2021) further show that a single principal component of nominal effective exchange rates of safe-haven currencies (USD, JPY, CHF) are powerful correlates of G10 CIP deviations. An increase in the common factor (appreciation of the safe haven currency) leads to a widening of the basis, suggesting that global risk aversion may be the underlying drivers of both the dollar and the basis. We therefore also include the safe-haven currency common factor, as well as the residuals from projecting the broad dollar onto the common factor, to understand if flight to safety captures additional dimensions of EM CIP deviation dynamics beyond intermediary risk-bearing capacity. Appendix Figure A5 plots the evolution of the common factor and the residual.

We conduct our regression exercise using monthly averages of financial variables. We winsorize the CIP deviations and FX liquidity measure at 1% and 99% tails to alle- viate the concern for outliers. We include currency fixed effects in our panel regressions and report two-way clustered standard errors by time and currency.[24] Table 2 reports our findings. Panel (a) focuses on our baseline measure of intermediary leverage as the global factor. Across sample periods and on-shore / off-shore basis, a rise in the U.S. interest rate relative to the EM country leads to an increase in the basis. The forward- market bid-ask spread is associated with positive coefficients throughout the specifica- tions. Interpreted through the lens of financial intermediation, these positive coefficients capture the effect of financial tightening – a relative increase of the U.S. interest rate enlarges the opportunity costs of swap dealers to engage in intermediation activities, while an increase in the bid-ask spread reflects these players' reluctance to supply liquidity. For our key explanatory variable – FX dealer leverage ratio, columns (1) and (2) indicate a strong correlation between a tightening intermediary leverage constraint and a more positive offshore CIP deviations. A one percentage point increase in the leverage ratio corresponds to 1.1 basis points increase in the off-shore basis for the entire sample, and 0.9 basis points for the post-crisis sample.[25]

The sign of the correlation between CIP deviations and FX dealer leverage is consistent with the limited risk-bear capacity theory we outlined. To understand this, we first compare our results with G-10 currencies. An important distinction is that while EMs are in general net debtors, most AEs are net creditors in their international investment

[24]We conduct a number of robustness checks. Appendix Table A5 reports results based on 1-month CIP deviations. In Appendix Table A6, we report results from the same specifications but generated using CIP deviations constructed with 3-month USD Libor rate.

[25]In untabulated robustness exercise, we find that the significant correlation between dealer leverage and CIP deviations is not sensitive to excluding the sample after 2020 marked by the COVID-19 disruption.

positions. For G-10 currencies, a tightening of FX dealer and/or primary dealer leverage is associated with a *negative* response of CIP deviations (see Avdjiev, Du, Koch and Shin (2019); Cerutti, Obstfeld and Zhou (2021) and Appendix Table A4). During risk-off episodes, offshore CIP deviations tend to jump "up" for emerging market currencies, but spike "down" for advanced economy currencies.

For further verification of our hypotheses, we focus on the post-2010 sample in order to take advantage of better data availability for all currencies. The effect of a reduced risk-bearing capacity of global intermediaries displays a strong pattern of disconnect between on-shore and off-shore bases. In line with our hypothesis 1, for currencies with significant segmented markets, columns (5) and (6) show that a one percentage point increase in the leverage ratio corresponds to a 1.35 basis point increase in the off-shore basis, but only a 0.38 basis point (and a statistically insignificant) increase in the on-shore basis. Table 2 also shows that the sensitivity of the bases to interest rate differentials and FX market liquidity also exhibits some degrees of disconnect.

To verify hypothesis 2, we compare columns (3) and (5). Column (3) suggests that for currencies with an integrated FX market, a one percentage point increase in the leverage ratio corresponds to 0.61 basis point increase in the off-shore basis, statistically significant at the 5% level. In relative terms, the effect is more than 50 percent smaller than that for the segmented currency group. Column (4) reports estimates for offshore CIP deviations, excluding currencies with a large non-deliverable forward market (CLP, COP, PEN). The level and statistical significance of coefficients is comparable to those in column (3).

Panel (b) of Table 2 reports panel regressions adding safe-haven common factor and residuals.[26] Although the leverage ratio and the common factor is closely correlated (with a correlation of 0.4 in their monthly differences), the inclusion of an additional proxy for global risk aversion does not substantially affect the estimated relationship be- tween leverage and the bases (as shown in columns (1) and (2)), as well as the disconnect between off-shore and on-shore bases. Column (5) and (6) suggests that although the safe-haven factor and residuals are highly significant and positive in the case of off-shore basis, on-shore basis has statistically insignificant responses to both the appreciation of the safe-haven currencies and to shifts in the component orthogonal to the common factor capturing flight to safety. Finally, comparing columns (3), (4) and (5), it is clear that as in the case of FX dealer leverage, currencies with a segmented FX forward market have more sensitive CIP deviations to safe-haven currency movements compared to their integrated counterparts

[26]The coefficient for the common factor and the residuals does not have a straightforward interpretation, as principal components are invariant to a scaling factor.

Table 2: EM CIP deviations and global factors

Panel (a): Baseline panel regressions

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.231*	0.164**	0.098	0.093	0.350***	0.212**
	(0.122)	(0.072)	(0.081)	(0.088)	(0.095)	(0.078)
Δ log dealer leverage	1.076***	0.912***	0.610**	0.630**	1.348**	0.379
	(0.344)	(0.261)	(0.218)	(0.254)	(0.428)	(0.292)
Δ fwd bid-ask	0.872*	0.828**	0.442	0.451	1.631*	0.185
	(0.438)	(0.321)	(0.267)	(0.325)	(0.779)	(0.285)
Observations	4,128	2,706	1,637	1,110	1,069	1,087
R-squared	0.069	0.042	0.036	0.043	0.061	0.057
Country FE	✓	✓	✓	✓	✓	✓

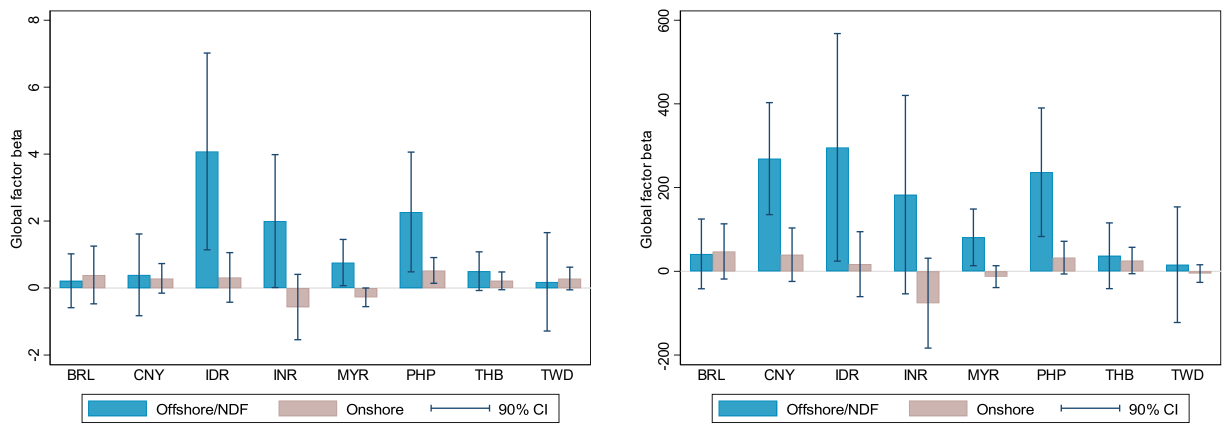
Panel (b): Add safe haven dollar factor

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.211*	0.156**	0.096	0.093	0.317***	0.210**
	(0.113)	(0.065)	(0.080)	(0.088)	(0.050)	(0.076)
Δ log dealer leverage	0.654**	0.599**	0.491*	0.547*	0.734*	0.341
	(0.290)	(0.235)	(0.241)	(0.272)	(0.360)	(0.268)
Δ fwd bid-ask	0.786*	0.698**	0.392	0.390	1.368*	0.177
	(0.421)	(0.276)	(0.243)	(0.292)	(0.628)	(0.278)
safe haven common factor	71.086**	40.409*	17.656	12.608	78.277*	4.363
	(28.614)	(20.225)	(17.769)	(19.050)	(35.639)	(20.453)
safe haven residual	8.291***	10.710***	3.614	2.757	21.325**	1.398
	(2.819)	(3.257)	(2.599)	(2.645)	(6.199)	(2.366)
Observations	4,128	2,706	1,637	1,110	1,069	1,087
R-squared	0.093	0.070	0.044	0.048	0.121	0.059
Country FE	✓	✓	✓	✓	✓	✓

Note: Monthly regressions of first differences. The dependent variable is changes in the 3-month CIP deviations (offshore/NDF for columns (1)-(4) in both panels, and onshore for column (5)), based on USD A2/P2 commercial paper interest rate. The independent variables include changes in the (nominal) USD A2/P2 commercial paper rate–local nominal money market rate differential, log of aggregate EM currency FX dealer leverage ratio, and forward bid-ask spread normalized by mid price of forward exchange rate. In Panel (b), the safe haven common factor is the first principal component of nominal effective exchange rate of safe-haven currencies (USD, CHF, JPY), and the residual refers to estimated error term after projecting the dollar nominal effective exchange rate onto the common factor, following Cerutti, Obstfeld and Zhou (2021). Columns (1) and (2) report regression results for all currencies from 2002 to 2021 (column (1)) and from 2010 to 2021 (column (2)). In columns (3) to (6), we focus on the 2010-2021 subperiod, and divide the sample into two groups. Group I include currencies with little FX forward market segmentation across border, as well as non-deliverable currencies with a small offshore-onshore forward spread based on available data (CLP, COP, KRW, PEN, who are further dropped in column (4)). Group II refers to currencies with substantial FX forward market segmentation (BRL, CNY, IDR, INR, MYR, PHP, THB). The CIP deviations and forward market liquidity measure are winsorized at 1% and 99%. Two-way clustered standard errors by currency and time are reported. *** p<0.01, ** p<0.05, * p<0.1.

Figure 7 corroborates the evidence on on-shore / off-shore disconnect, using time-series regressions on individual currencies in the subgroup considered in column (5) and (6) of Table 2. Consistent with the results from panel regressions, offshore bases respond positively to both a tightening of leverage and an appreciation of the common component of safe-haven currencies. On the other hand, on-shore basis are typically associated with zero-to-negative coefficients.

Figure 7: Global factor-β (2010-2021) for currencies with forward-market segmentation



(a) Log FX dealer leverage **(b)** Safe-haven currency common factor

Note: Time-series β of monthly change of on-shore (red) and off-shore/NDF (blue) 3-month CIP deviations on monthly change in log of aggregate EM currency FX dealer leverage ratio (Panel (a)) or safe-haven currency common factor (Panel (b), constructed following Cerutti, Obstfeld and Zhou (2021)), in a regression that also controls for interest rate differential and forward bid-ask spread. Error bands correspond to 90% confidence interval with Newey-West standard errors with 12 lags. The CIP deviations are winsorized at 1% and 99%.

4.3 CIP deviations and country-specific correlates

Country-specific factors could affect the dynamics of CIP deviations as well as our estimate of the global factors' importance. Although the issue of counterparty default in short-term CIP deviations is unlikely to be of significant concern, as we discuss in Section 2, sovereign default risk tends to co-move with currency risk and a surge in country risk could spill over to the currency market, both onshore and offshore. The absence of comovement between onshore CIP deviations and global factors may also reflect the role of EM central banks intervening in FX spot and forward markets or accumulating FX reserves to stabilize the spot exchange rate.

While the intuitive linkage between country-specific factors and CIP deviations may be clear, the signs of these correlations are unclear. To the extent that a rise in sovereign risk induces a flight to safety from EM by international investors and affects the forward premium through the unwinding of currency hedges, and FX interventions could have an impact on both the forward and the spot market, the relative movement between forward and spot exchange rate and thus the direction of deviations rom CIP could be ambiguous. We thus take an agnostic approach and focus on whether the correlations are statistically significant, without taking a stand on the interpretation. For sovereign risk, we obtain 5-year USD sovereign credit default swap spread from Markit. As mentioned in Section 2, CDS spreads of EM sovereigns exhibit strong co-movement under the influence of a global factor. We extract the first principal component of the spread from the countries for which we have data, and include the residuals in our regressions. For the sizes of FX intervention, we use the monthly broad measure (as percentages of GDP) provided by Adler, Mano, Chang and Shao (2021), recording accumulation of FX reserves as positive and selling of foreign-currency reserves as a negative intervention. As FX intervention could arise endogenously as a response to market conditions, we include the measure lagged by a month into our regressions.

Table 3, Panel (a) reports the regression results on the role of sovereign default risk.[27] Consistent with the observation of Lipscomb (2005), we find weak evidence indicating that sovereign risk is a significant correlate of short-term CIP deviations. While, the 5-year CDS spread (residualized by the first principal component, as prescribed by Longstaff, Pan, Pedersen and Singleton (2011)) is significant at 5% level for offshore CIP deviations after 2010, the statistical significance does not survive when we move to specific currency groups.[28]

In Panel (b), we also find relative weak evidence supporting the linkage between CIP deviations and (lagged) FX intervention. For most sample cuts, the coefficient es- timates are mostly positive. Intervention in the FX market by selling foreign currencies is associated with a more negative, yet insignificant CIP deviation.[29] We observe more interesting correlations for the group of currencies with segmented forward markets. Consistent with the intuition that FX intervention is primarily carried out in on-shore markets, a one percentage point increase in the size of foreign-currency asset purchase (as a fraction of GDP) is associated with a 3.6 basis point decline in on-shore CIP deviations, potentially explained by the expectation of future reversal of intervention target

[27]For robustness, we also produce a table with the same specification, but using CIP deviations constructed with 3-month USD Libor rate. See panel (b) of Table A6.

[28]In untabulated results, we find little association between CIP deviations and rating downgrades to sovereign bond by international rating agencies.

[29]While we do not find systematic evidence in favor of a significant role of FX intevention, CIP deviations do widen during country-specific episodes of temporary currency pegs (see Amador, Bianchi, Bocola and Perri (2019) for a theoretical discussion). In Figure A4 of the Appendix, we show that the Czech National Bank, by accumulating FX reserves to maintain an exchange rate floor of the Czech Republic Kruna against the Euro from late 2013 to early 2017, induces a substantial widening of short-term CIP deviations. This is likely due to expectations of future de-peg, as forward Kruna is consistently more expensive than spot Kruna, inducing a negative forward premium.

(such as an exchange rate floor). For the same set of currencies, on the other hand, the correlation of offshore CIP deviations with FX intervention has the opposite sign (albeit insignificant at 10% level), suggesting potential barriers to policy transmission.

Table 3: CIP deviations and EM-specific correlates

Panel (a): Country default risk: Residualized CDS spread

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.223*	0.186***	0.141	0.146	0.327***	0.192*
	(0.122)	(0.063)	(0.086)	(0.096)	(0.075)	(0.082)
Δ log dealer leverage	0.632*	0.593**	0.501*	0.525*	0.795	0.363
	(0.308)	(0.245)	(0.242)	(0.274)	(0.489)	(0.243)
Δ fwd bid-ask	0.844*	0.587**	0.291	0.290	1.272	0.196
	(0.439)	(0.254)	(0.180)	(0.209)	(0.659)	(0.266)
safe haven common factor	69.404**	37.994*	13.996	5.057	91.786*	14.722
	(29.286)	(20.012)	(16.956)	(17.507)	(41.191)	(17.821)
safe haven residual	7.551**	9.772***	3.730	2.875	21.955**	2.413
	(2.754)	(3.313)	(2.535)	(2.519)	(7.607)	(2.521)
Δ 5y residualized cds spread	0.179	0.482**	0.471	0.515	0.608	-0.065
	(0.113)	(0.221)	(0.299)	(0.351)	(0.589)	(0.159)
Observations	3,660	2,439	1,637	1,110	802	809
R-squared	0.098	0.076	0.064	0.082	0.132	0.077
Country FE	✓	✓	✓	✓	✓	✓

Panel (b): Lagged FX intervention

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.211*	0.155**	0.096	0.092	0.305***	0.215**
	(0.114)	(0.065)	(0.080)	(0.088)	(0.055)	(0.073)
Δ log dealer leverage	0.652**	0.588**	0.485*	0.534*	0.729*	0.344
	(0.289)	(0.234)	(0.241)	(0.271)	(0.367)	(0.263)
Δ fwd bid-ask	0.785*	0.704**	0.395	0.390	1.375*	0.181
	(0.421)	(0.278)	(0.247)	(0.295)	(0.627)	(0.273)
safe haven common factor	71.282**	42.667*	18.795	14.870	80.605*	3.251
	(28.437)	(20.396)	(17.955)	(19.520)	(35.897)	(20.386)
safe haven residual	8.300***	10.945***	3.688	2.937	22.145**	1.082
	(2.846)	(3.336)	(2.613)	(2.713)	(6.568)	(2.349)
FXI	0.173	3.426	1.224	1.870	9.758	-3.642*
	(1.226)	(2.070)	(1.476)	(1.892)	(6.046)	(1.547)
Observations	4,126	2,706	1,637	1,110	1,069	1,087
R-squared	0.093	0.071	0.044	0.049	0.126	0.063
Country FE	✓	✓	✓	✓	✓	✓

Note: Monthly regressions of first differences. The dependent variable is changes in the 3-month CIP deviations (offshore/NDF for columns (1)-(4) in both panels, and onshore for column (5)). In Panel (a), 5-year residualized CDS spread refers to the projection error estimated from regressing 5-year dollar-denominated CDS spread of each EM country (source: Markit) onto the first principal component of all CDS spreads in our sample. In Panel (b), "FXI" is to the size of foreign exchange intervention compiled by Adler, Mano, Chang and Shao (2021). A positive FXI corresponds to intervention by accumulating FX reserves, and vice versa. The FXI variable is lagged by one month. The CIP deviations are winsorized at 1% and 99%. In Panel (a), TWD is dropped for lack of data on sovereign CDS spread. Two-way clustered standard errors by currency and time are reported. *** p<0.01, ** p<0.05, * p<0.1.

5 Discussion and policy implications

With the development of onshore FX markets and foreign participation in domestic financial systems, understanding the dynamics of short-term CIP deviations in emerging markets has increasingly important implications for macro stabilization policies. Interpreted through the lens of Equation (3), a negative CIP deviation reflects the cost advantage, on a hedged basis, of dollar-denominated funding relative to local-currency borrowing. Our systematic analysis of short-term CIP deviations reveals that there is an incentive to take advantage of the negative bases for most currencies in our sample. Yet during periods of heightened global risk sentiments and reduced intermediation capacities of global banks, a spike in the basis poses significant challenges for EM borrowers to roll over liabilities, and for international currency investors to continuously hedge the currency risk.

Gourinchas (2022), in his Mundell-Fleming lecture, proposes that central banks could engage in "basis control" – targeting the level of short-term CIP deviations in an environment with foreign-currency funding frictions. In normal times, the authority would steer the basis higher to prevent private agents from overborrowing cheap foreign funding. During domestic recessions, on the other hand, CIP deviations would be kept low in order to bolster the borrowing capacity and stimulate output. Our analysis suggests two types of policy instruments to implement this target in emerging markets economies that are particularly vulnerable to the global financial cycle and the global dollar cycle.[30] Preemptive capital flow management and macroprudential policies, including constraints on participation in FX forward markets, could reduce the onshore market's sensitivity to movements in risk sentiments and thus dampen the pressure on the external finance premia (Das, Gopinath and Kalemli-Özcan, 2021). Meanwhile, segmentation on the forward markets provides central banks with wider policy space to lean against the wind – counteract depreciation pressure by intervening in the *forward* market to provide downside protection to domestic dollar borrowers. By entering into forward contracts with domestic borrowers that commit to buy U.S. dollar forward at a high price, the central bank effectively serves as an insurance provider and sets a ceiling on CIP deviations by offering cheaper currency hedges. The non-deliverable nature of the forward market in many emerging markets makes it likely that such operations would be cost-effective and would pose little threat to the stability of foreign exchange reserves.[31]

[30] For the pervasive impact of a strong dollar on emerging markets, see Obstfeld and Zhou (2022).

[31] Such interventions are in similar spirit to the dollar swap line operations conducted by central banks in the advanced economies. To see why the cost of intervening in the NDF market would likely be small, note that ex ante, the cost of intervention is the gap between the forward rate and the expected exchange rate

While a segmented FX market could dampen the transmission of global risk-off shocks to onshore markets across the financial cycle, our analysis suggests a subtle tradeoff that policymakers need to navigate when imposing such constraints, especially during periods of financial stress. It is well understood that imposing an implicit tax on currency hedges discourages foreign participation in local-currency markets. Moreover, in markets where key providers of hedging services, such as global banks, face greater difficulty sharing risks with onshore market participants, tightening risk-absorbing capacities of global financial intermediaries could amplify the sensitivity of offshore CIP deviations to global factors. What's more, market segmentation precludes onshore intervention measures from fully stabilizing the expectations of offshore investors. The resulting surge in hedging costs may lead to destabilizing capital outflows. For ex- ample, as shown by Schmittmann and Chua (2020), when hedging costs using NDFs become very expensive, this can lead international investors to liquidate local currency bond holdings.[32] For a small set of EM firms able to access offshore bond markets for financing or carry trade purposes (Bruno and Shin, 2017), they are nonetheless exposed to large swings in the offshore FX market. The offshore/onshore forward spread, as a sign of the risk-shifting capacity of global financial intermediaries, should receive more attention by policymakers in countries with segmented FX markets and non-resident investors in domestic markets.

In practice, EM central banks have adopted different strategies to regulate onshore FX markets. Concerned by the spillover effect of offshore NDF markets, Malaysia has been maintaining a strictly prohibition on domestic banks' offshore NDF positions since 2016, while India, citing the tradeoff outlined above, has allowed onshore banks to par- ticipate in the NDF market since 2020.[33] Meanwhile, intervention activities in the FX forward market have picked up. Gonzalez, Khametshin, Peydró and Polo (2019) show that Brazil's intervention in the domestic NDF market during and after Taper Tantrum successfully mitigated the currency risk faced by Brazilian banks and dampened the negative real effect. Similar efforts have been observed for a number of Asian currencies

at settlement. The central bank incurs ex-post loss if the realized depreciation is such that the prevailing spot exchange rate at settlement is higher than the agreed-upon forward exchange rate, and receives a transfer otherwise. To the extent that the intervention efforts of the central bank may stabilize exchange rate expectations, such operations could be profitable both ex ante and ex post. Sandri (2020) provides evidence on the profitability of Central Bank of Brazil's FX swap operations.

[32]This point has received attention from policymakers in Asia-Pacific EMs. See Bank for International Settlements (2022).

[33]See Schmittmann and Chua (2020) for more information on Asian countries' policy approaches to NDF market integration, and Reserve Bank of India (2019, 2020) for arguments in favor of opening up the onshore market.

in the recent dollar appreciation cycle.[34] Evaluating the macroeconomic impact and welfare benefits of capital flow management measures and FX intervention in the currency forward markets should be high in policymakers' agenda for future research.

[34]Also see Domanski, Kohlscheen and Moreno (2016) for a general discussion, and Jermann, Wei and Yue (2022) for China's intervention in the offshore CNH market.

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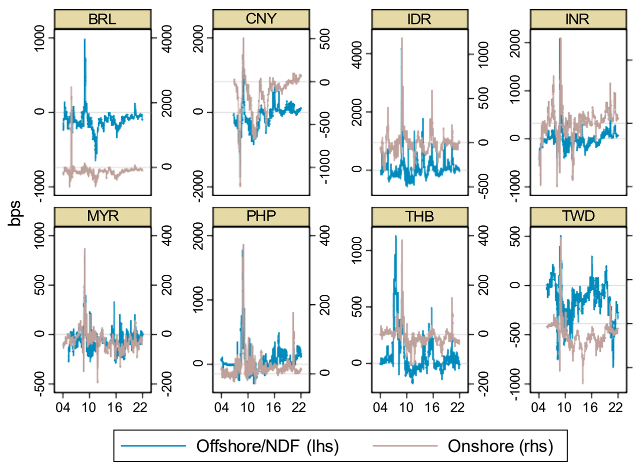
Appendix

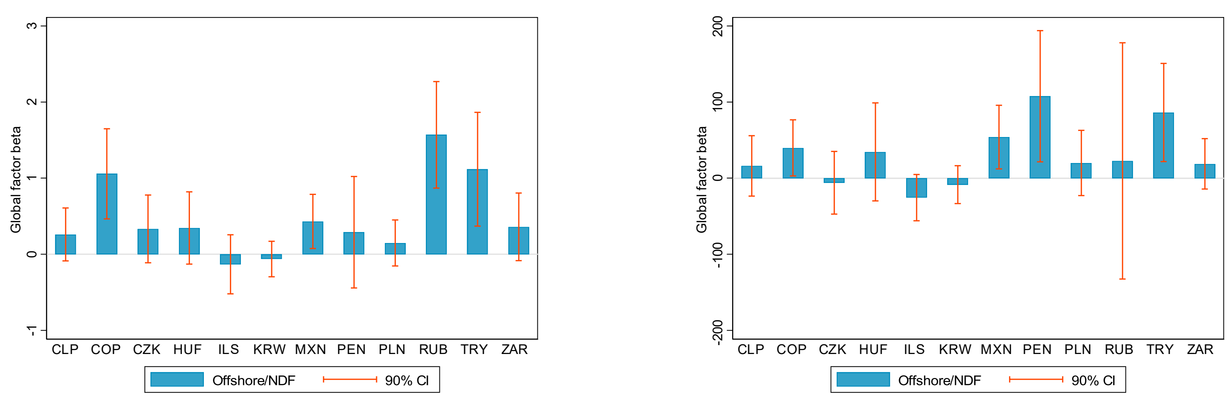
A Data sources, additional figures and tables

Figure A1: Currencies with segmented FX forward markets: On-shore / offshore 3-month CIP deviations (2004-2021)



Note: Daily onshore (red) and offshore (blue) 3-month CIP deviations for BRL, CNY, IDR, INR, MYR, PHP, THB and TWD. Gray horizontal lines refer to zero levels.

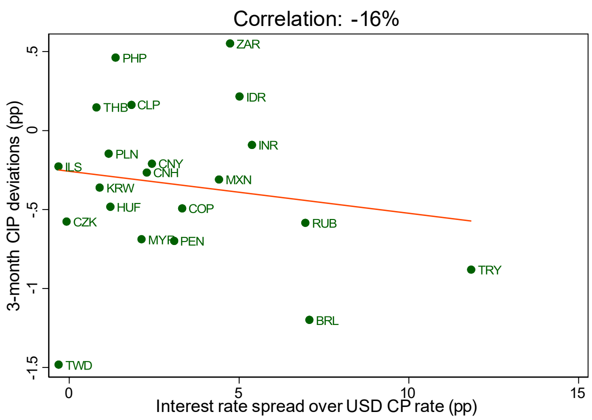
Figure A2: Global factor-β (2010-2021) for 3-month offshore CIP deviations of other EM currencies



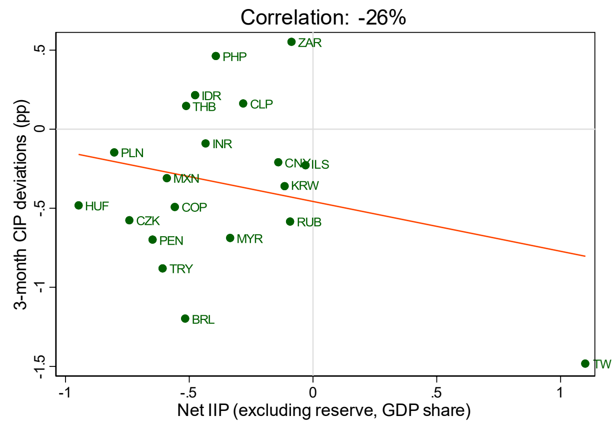
(a) Log FX dealer leverage **(b)** Safe-haven currency common factor

Note: Time-series β of monthly change of off-shore/NDF 3-month CIP deviations on monthly changes in log FX dealer leverage ratio (Panel (a)) or safe-haven currency common factor (Panel (b), constructed following Cerutti, Obstfeld and Zhou (2021)), in a regression that also controls for interest rate differential and forward bid-ask spread. Error bands correspond to 90% confidence interval with Newey-West standard errors with 12 lags. The CIP deviations are winsorized at 1% and 99%.

Figure A3: CIP deviations and macro correlates across countries (2010-2021), with TWD



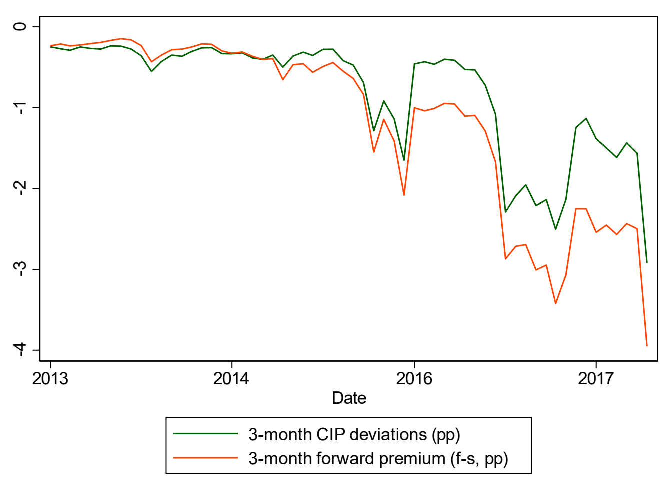
(a1) Interest rate differential: EM, with TWD



(b1) Net IIP (minus reserves) to GDP ratio: EM, with TWD

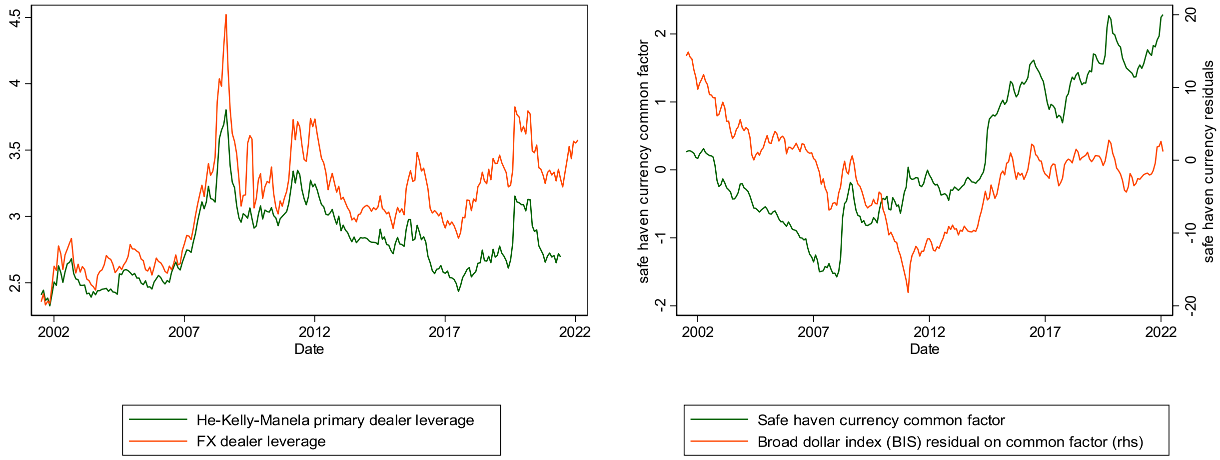
Note: Figure 2 plots time-series averages of benchmark 3-month CIP deviations against key macro-financial aggregates of emerg- ing markets and advanced economies. The benchmark 3-month CIP deviations are offshore quotes or quotes on non-deliverable forwards. Interest rate spread for emerging market currencies is calculated by taking the difference between 3-month money market rate and 3-month US A2/P2 commercial paper rate. For advanced economies, dollar interest rate is Libor rate. Net international investment position (IIP) are annual observations from the Milesi-Ferretti and Lane (2017) dataset, updated to 2021 (link: https://www.brookings.edu/research/the-external-wealth-of-nations-database/). We subtract reserves from the aggregate international investment position for each country. Sample period: 2010-2021. The daily deviations from CIP are winsorized at 1% and 99% before being aggregated for the graphs.

Figure A4: Czech Kruna: 3-month CIP deviations and forward premia during period of exchange rate floor (2013-2017)



Note: Figure A4 plots the 3-month CIP deviations and forward premia for CZK. The exchange rate floor against EUR lasted from 11/07/2013 to 04/06/2017. The forward premium is computed as the difference between log 3-month forward exchange rate and log spot exchange rate, both in units of Kruna per USD.

Figure A5: Evolution of key global factors



(a) Log intermediary leverage

(b) Safe haven currency common factor

Note: Panel (a) plots the monthly evolution of intermediary leverage ratio used in the regressions in Section 4. He-Kelly-Manela primary dealer leverage refers to the He, Kelly and Manela (2017) leverage ratio computed from a set of designated treasury market primary dealers. FX dealer leverage refers to the measure constructed in this paper from a set of FX dealer banks of EM currencies with the largest market share according to Euromoney annual FX survey. Panel (b) plots the safe haven currency common factor used in Cerutti, Obstfeld and Zhou (2021) and the safe haven residuals for USD. The safe haven currency common factor is the first principal component of nominal effective exchange rate for USD, CHF, JPY. The residuals are obtained by regressing the USD nominal effective exchange rate on the common factor.

Table A1: Data sources and tickers – 3-month CIP deviations

				Domestic interest rate	
Country/Region	**Currency**	**Off-shore / NDF**	**On-shore**	Definition	Ticker
Brazil	BRL	BCN3M Curncy	BCO3M Curncy	DI-PRE	PREDI90 Index
					BRDPR3M (after June 2020)
Chile	CLP	CHN3M Curncy	CHO3M Curncy	CAMARA OIS	CHSWPC Curncy
China	CNY	CCN3M Curncy	CCO3M Curncy	Interbank	SHIF3M Index
Colombia	COP	CLN3M Curncy	CLP3M Curncy	DTF	DTF RATE Index
Czech Republic	CZK	CZK3M Curncy		Interbank	PRIB03M Index
Hungary	HUF	HUF3M Curncy		Interbank	BUBOR03M Index
Indonesia	IDR	IHN3M Curncy	IHO3M Curncy	Interbank	JIIN3M Index
Israel	ILS	ILS3M Curncy		Interbank	TELBOR03 Index
India	INR	IRN3M Curncy	IRO3M Curncy	OIS	*INROS3M*
South Korea	KRW	*KRW3M=*	KWO3M Curncy	Interbank	KRBO3M Index
Mexico	MXN	MXN3M Curncy		Interbank (TIIE)	*MXTIIE3M=RR*
Malaysia	MYR	MRN3M Curncy	*MYR3M=MY*	Interbank	KLIB3M Index
Peru	PEN	PSN3M Curncy		Interbank	PRBOPRB3 Index
Philippines	PHP	PPN3M Curncy	PPO3M Curncy	Interbank	PREF3MO Index
		PHP3MNDF= (after 11/4/2016)			
Poland	PLN	PLN3M Curncy		Interbank	WIBR3M Index
Russia	RUB	RUB3M Curncy		Interbank	MOSKP3 Index
Thailand	THB	THB3M Curncy	TBO3M Curncy	Interbank	BOFX3M Index
Turkey	TRY	TRY3M Curncy		Interbank	TRLIB3M Index
Taiwan	TWD	NTN3M Curncy	NTO3M Curncy	Interbank	TAIBOR3M Index
South Africa	ZAR	ZAR3M Curncy		Interbank	JIBA3M Index

Note: Tickers in italicized fonts are from Datastream/Refinitiv.

Table A2: Data sources and tickers – FX dealer leverage

Name	Bloomberg ticker
BNP Paribas	BNP FP Equity
Barclays	BARC LN Equity
Bank of America	BAC US Equity
Citigroup	C US Equity
Credit Suisse	CSGN SW Equity
Deutsche Bank	DBK GR Equity
Goldman Sachs	GS US Equity
HSBC	HSBA LN Equity
JP Morgan	JPM US Equity
Morgan Stanley	MS US Equity
Societe Generale	GLE FP Equity
Standard Chartered	STAN LN Equity
State Street	STT US Equity
UBS	UBSG SW Equity

Note: The list of FX dealer banks used to compute aggregate EM currency FX dealer leverage ratio. These banks are selected from the Euromoney FX survey as the largest market participants (excluding non-banks) in dealing EM currencies since 2015.

Table A3: Regressions: Summary statistics

Panel (a): Global factors

Variable	Obs	Mean	Std. Dev.	Min	Max	P50
log FX dealer leverage ratio	240	3.097	.389	2.332	4.521	3.08
safe haven currency common factor	240	.153	.963	-1.577	2.266	-.172
safe haven residual	240	-1.997	6.288	-18.194	14.847	-1.505

Panel (b): Country-specific regressors

Variable	Obs	Mean	Std. Dev.	Min	Max	P50
3-month offshore CIP deviations (bps)	4368	-28.144	130.112	-537.634	646.177	-20.942
3-month onshore CIP deviations (bps)	2056	-39.599	93.264	-553.043	280.301	-22.853
$r^{US} - r$ (%)	4500	-3.596	4.599	-47.379	4.505	-2.785
offshore fwd bid-ask	4546	25.864	18.715	5.165	156.905	21.023
onshore fwd bid-ask	4397	22.905	17.512	3.262	144.808	18.414
5y residualized cds spread (bps)	4158	-8.228	135.216	-804.393	2642.105	-8.558
FXI (% GDP)	4798	.135	.853	-7.89	10.82	.05

Panel (c): Variable descriptions

Name	Definition
Global factors:	
FX dealer leverage ratio	(Market equity + book debt)/Market equity for largest FX dealers for EM currencies
Safe haven common factor	First principal component of nominal effective exchange rate for USD, CHF, JPY
USD safe haven residuals	Residuals from projecting USD nominal effective exchange rate on safe haven common factor
Country-specific factors:	
FXI	Adler, Mano, Chang and Shao (2021) measure of FX intervention (spot+forward). +: reserve accumulation. Unit: percent GDP.
Forward bid-ask	FX Forward market liquidity: 10000×(ask - bid)/mid.
Residualized CDS spread	Residuals from regressing 5-year USD CDS spread on the first principal component of CDS spread series for all countries in the regression sample. Source: Markit.

Note: This table reports summary statistics and variable descriptions for key regressors introduced in Section 4. The sample runs from 2002M1 to 2021M12. CDS spread data is missing for Taiwan. CIP deviations and liquidity (bid-ask) is winsorized at 1% and 99% tails. The forward market liquidity measure is defined as 10000×(ask forward exchange rate−bid forward exchange rate)/mid forward exchange rate.

Table A4: G10 currency CIP deviations (IBOR) and intermediary leverage factor

Panel (a): He, Kelly and Manela (2017) primary dealer leverage

	(1)	(2)	(3)	(4)
			drop AUD/NZD	drop AUD/NZD
	02-21	10-21	02-21	10-21
VARIABLES	Δ Libor basis	Δ Libor basis	Δ Libor basis	Δ Libor basis
$\Delta(r^{US} - r)$	-4.635	-11.659	-3.619	-11.149
	(2.658)	(7.869)	(2.846)	(10.178)
Δ log primary dealer leverage	-0.094	-0.201**	-0.127*	-0.233**
	(0.061)	(0.083)	(0.063)	(0.095)
Δ fwd bid-ask	-0.458	-0.290	-0.622	-0.327
	(0.398)	(0.472)	(0.471)	(0.551)
Observations	2,242	1,344	1,813	1,077
R-squared	0.020	0.047	0.023	0.049
Country FE	✓	✓	✓	✓

Panel (b): FX dealer leverage

	(1)	(2)	(3)	(4)
			drop AUD/NZD	drop AUD/NZD
	02-21	10-21	02-21	10-21
VARIABLES	Δ Libor basis	Δ Libor basis	Δ Libor basis	Δ Libor basis
$\Delta(r^{US} - r)$	-4.879*	-11.922	-3.984	-11.580
	(2.615)	(7.815)	(2.774)	(10.081)
Δ log fx dealer leverage	-0.074	-0.132*	-0.088	-0.145*
	(0.046)	(0.062)	(0.052)	(0.073)
Δ fwd bid-ask	-0.445	-0.307	-0.621	-0.367
	(0.395)	(0.482)	(0.465)	(0.566)
Observations	2,242	1,344	1,813	1,077
R-squared	0.023	0.050	0.026	0.050
Country FE	✓	✓	✓	✓

Note: Monthlly regressions of first differences. The dependent variable is changes in the 3-month CIP deviations for G-10 currencies. In Panel (a), the global factor considered is the He, Kelly and Manela (2017) primary dealer leverage ratio. In Panel (b), the global factor is equal-weighted FX dealer leverage ratio. Columns (1) and (2) focus on the entire set of G-10 currencies over the 2002 (2010)-2021 sample, and columns (3) and (4) drop AUD and NZD (currencies with a positive CIP deviations). The CIP deviations and forward market liquidity measure (fwd bid-ask) are winsorized at 1% and 99%. Two-way clustered standard errors by currency and time are reported. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: EM CIP deviations and global factors: 1-month tenor

Panel (a): FX dealer leverage

	(1)	(2)	(3)	(4)	(5)	(6)
			Group I: integrated	Group I: no NDF	Group II: segmented	Group II: segmented
	02-21	10-21	10-21	10-21	10-21	10-21
VARIABLES	Δ offshore	Δ offshore	Δ offshore	Δ offshore	Δ offshore	Δ onshore
$\Delta(r^{US} - r)$	0.154	0.049	0.034	0.032	0.050	0.198***
	(0.124)	(0.124)	(0.180)	(0.192)	(0.157)	(0.038)
Δ log dealer leverage	1.189***	0.933**	0.450*	0.398	1.697**	0.192
	(0.406)	(0.328)	(0.223)	(0.263)	(0.643)	(0.237)
Δ fwd bid-ask	1.695**	1.621*	0.915	1.358	3.714***	0.384
	(0.659)	(0.849)	(1.086)	(1.273)	(1.016)	(0.289)
Observations	3,888	2,630	1,558	1,142	1,072	1,110
R-squared	0.038	0.021	0.015	0.027	0.038	0.036
Country FE	✓	✓	✓	✓	✓	✓

Panel (b): Add dollar factors

	(1)	(2)	(3)	(4)	(5)	(6)
			Group I: integrated	Group I: no NDF	Group II: segmented	Group II: segmented
	02-21	10-21	10-21	10-21	10-21	10-21
VARIABLES	Δ offshore	Δ offshore	Δ offshore	Δ offshore	Δ offshore	Δ onshore
$\Delta(r^{US} - r)$	0.143	0.046	0.031	0.032	0.066	0.196***
	(0.119)	(0.121)	(0.179)	(0.192)	(0.155)	(0.040)
Δ log dealer leverage	0.796**	0.575*	0.296	0.370	1.039	0.218
	(0.371)	(0.305)	(0.230)	(0.289)	(0.654)	(0.194)
Δ fwd bid-ask	1.570**	1.413	0.834	1.323	3.239***	0.378
	(0.640)	(0.822)	(1.082)	(1.268)	(0.845)	(0.302)
safe haven common factor	50.303	37.987	17.566	-8.065	67.190	-17.112
	(35.191)	(34.093)	(19.991)	(18.013)	(70.916)	(20.779)
safe haven residual	10.663***	13.563***	5.595**	3.545	25.042**	2.412
	(3.635)	(4.272)	(2.382)	(2.280)	(8.229)	(1.721)
Observations	3,888	2,630	1,558	1,142	1,072	1,110
R-squared	0.051	0.038	0.021	0.029	0.069	0.039
Country FE	✓	✓	✓	✓	✓	✓

Note: Monthly regressions of first differences. The dependent variable is changes in the 1-month CIP deviations (offshore/NDF for columns (1)-(4) in both panels, and onshore for column (5)), based on USD A2/P2 commercial paper interest rate. The independent variables include changes in the (nominal) USD A2/P2 commercial paper rate–local nominal money market rate differential, log of aggregate EM currency FX dealer leverage ratio, and forward bid-ask spread normalized by mid price of forward exchange rate. In Panel (b), the safe haven common factor is the first principal component of nominal effective exchange rate of safe-haven currencies (USD, CHF, JPY), and the residual refers to estimated error term after projecting the dollar nominal effective exchange rate onto the common factor, following Cerutti, Obstfeld and Zhou (2021). Columns (1) and (2) report regression results for all currencies from 2002 to 2021 (column (1)) and from 2010 to 2021 (column (2)). In columns (3) to (6), we focus on the 2010-2021 subperiod, and divide the sample into two groups. Group I include currencies with little FX forward market segmentation across border, as well as non-deliverable currencies with a small offshore-onshore forward spread based on available data (CLP, COP, KRW, PEN, who are further dropped in column (4)). Group II refers to currencies with substantial FX forward market segmentation (BRL, CNY, IDR, INR, MYR, PHP, THB). The CIP deviations and forward market liquidity measure (fwd bid-ask) are winsorized at 1% and 99%. Two-way clustered standard errors by currency and time are reported. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: CIP deviations, global and country-specific factors: IBOR basis

Panel (a): Baseline panel regressions

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.127	0.138*	0.098	0.092	0.229**	0.150**
	(0.080)	(0.068)	(0.091)	(0.099)	(0.082)	(0.060)
Δ log dealer leverage	0.670**	0.434	-0.036	0.015	1.157*	-0.225*
	(0.251)	(0.263)	(0.127)	(0.147)	(0.584)	(0.106)
Δ fwd bid-ask	0.504	0.736*	0.208	0.188	1.835*	0.036
	(0.317)	(0.387)	(0.315)	(0.416)	(0.958)	(0.258)
Observations	4,205	2,780	1,682	1,142	1,098	1,108
R-squared	0.025	0.018	0.010	0.011	0.048	0.025
Country FE	✓	✓	✓	✓	✓	✓

Panel (b): Add safe haven dollar factor and residualized CDS spread

VARIABLES	(1) 02-21 Δ offshore	(2) 10-21 Δ offshore	(3) Group I: integrated 10-21 Δ offshore	(4) Group I: no NDF 10-21 Δ offshore	(5) Group II: segmented 10-21 Δ offshore	(6) Group II: segmented 10-21 Δ onshore
$\Delta(r^{US} - r)$	0.126	0.175**	0.145	0.146	0.258**	0.136
	(0.088)	(0.070)	(0.100)	(0.111)	(0.092)	(0.069)
Δ log dealer leverage	0.341	0.188	-0.052	-0.003	0.689	-0.181*
	(0.210)	(0.219)	(0.143)	(0.176)	(0.635)	(0.081)
Δ fwd bid-ask	0.486	0.527	0.103	0.092	1.434	0.060
	(0.308)	(0.327)	(0.211)	(0.273)	(0.797)	(0.257)
safe haven common factor	35.045	18.071	-2.611	-12.144	63.531*	-4.331
	(20.563)	(12.419)	(10.708)	(10.623)	(26.602)	(7.562)
safe haven residual	7.685**	9.359**	2.574	2.194	23.189**	1.553
	(2.889)	(3.718)	(1.894)	(2.007)	(8.780)	(2.261)
Δ 5y residualized cds spread	0.144	0.459*	0.479	0.517	0.555	-0.119
	(0.098)	(0.222)	(0.307)	(0.359)	(0.508)	(0.114)
Observations	3,729	2,505	1,682	1,142	823	827
R-squared	0.046	0.050	0.038	0.052	0.128	0.029
Country FE	✓	✓	✓	✓	✓	✓

Note: Monthly regressions of first differences. The dependent variable is changes in the Libor 3-month deviations from CIP (offshore/NDF for columns (1)-(4) in both panels, and onshore for column (5)). The independent variables include changes in the USD Libor rate–local money market rate differential, log FX dealer leverage ratio, and forward bid-ask spread normalized by mid price of forward exchange rate. In Panel (b), the safe haven common factor is the first principal component of nominal effective exchange rate of safe-haven currencies (USD, CHF, JPY), and the residual refers to estimated error term after projecting the dollar nominal effective exchange rate onto the common factor, following Cerutti, Obstfeld and Zhou (2021). 5-year residualized CDS spread refers to the projection error estimated from regressing 5-year dollar-denominated CDS spread of each EM country (source: Markit) onto the first principal component of all CDS spreads in our sample. Columns (1) and (2) report regression results for all currencies from 2002 to 2021 (column (1)) and from 2010 to 2021 (column (2)). In columns (3) to (5), we focus on the 2010-2021 subperiod, and divide the sample into two groups. Group I include currencies with little FX forward market segmentation across border, as well as non-deliverable currencies with a small offshore-onshore forward spread based on available data (CLP, COP, KRW, PEN). Group II refers to currencies with substantial FX forward market segmentation (BRL, CNY, IDR, INR, MYR, PHP, THB). The CIP deviations are winsorized at 1% and 99%. Two-way clustered standard errors by currency and time are reported. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.