

# Breaking Parity:

## Equilibrium Exchange Rates and Currency Premia

Mai Chi Dao, Pierre-Olivier Gourinchas, and Oleg Itskhoki

WP/25/153

*IMF Working Papers* describe research in progress by the author(s) and are published to elicit comments and to encourage debate.

The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

**2025  
AUG**



**IMF Working Paper**  
Research Department

**Breaking Parity: Equilibrium Exchange Rates and Currency Premia\***

**Prepared by Mai Chi Dao, Pierre-Olivier Gourinchas, and Oleg Itskhoki**

Authorized for distribution by Pierre-Olivier Gourinchas  
Month 2025

**IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate.** The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

**ABSTRACT:** We offer a unifying empirical model of covered and uncovered currency premia, interest rates and spot and forward exchange rates, both in the cross section and time series of currencies. We find that the rich empirical patterns are in line with a partial equilibrium model of the currency market, where hedged and unhedged currency is supplied by intermediary banks subject to value-at-risk balance-sheet constraints, emphasizing the frictional nature of equilibrium currency premia and exchange rate dynamics. In the cross section, the excess supply of local-currency savings is the key determinant of low relative interest rates, negative covered and uncovered currency premia, cheap forward dollars; and vice versa. In the time series, covered currency premia change infrequently and in concert across currencies, driven by aggregate financial market conditions. In contrast, uncovered currency premia move frequently in response to currency-specific demand shocks, which we capture with the dynamics of net currency futures positions of dealer banks. Sharp exchange rate depreciations in response to negative shifts in currency demand are followed by small persistent predictable appreciations that generate future positive expected currency returns necessary to ensure intermediation of currency demand shocks, irrespective of their financial or macroeconomic origin. Changes in net futures positions of dealer banks account for most of the variation in the spot exchange rate for every currency.

JEL Classification Numbers:	F30, F31, F32, G12, G15
Keywords:	exchange rates; uncovered interest parity; covered interest parity; currency markets; futures market; intermediation frictions
Author's E-Mail Address:	<a href="mailto:mdao@imf.org">mdao@imf.org</a> , <a href="mailto:pgourinchas@imf.org">pgourinchas@imf.org</a> , <a href="mailto:itskhoki@fas.harvard.edu">itskhoki@fas.harvard.edu</a> ;

\* We are grateful to Philippe van der Beck, John Campbell, Xavier Gabaix, Şebnem Kalemli-Özcan, Hanno Lustig, Hélène Rey, Vania Stavrakeva, Jeremy Stein, and Moto Yogo for comments and to seminar participants at the 2024 AEA meetings, 2nd Jackson Hole IFM conference, BSE Summer Forum, Brown, LBS and HBS. Da Hoang provided excellent research assistance.

# 1 Introduction

We address a fundamental question in international macroeconomics: what drives the exchange rate? The well-documented lack of strong and robust contemporaneous comovements between exchange rates and aggregate macroeconomic and financial variables suggests that exploration of the determination of exchange rates should extend beyond the standard macro-financial environment (Meese and Rogoff, 1983). From a micro perspective, exchange rates are prices that equilibrate demand and supply in currency markets (Evans and Lyons, 2002). In contrast to the weak link with aggregate macro variables, exchange rates correlate strongly with deviations from Covered and Uncovered Interest Parity (CIP and UIP, respectively) conditions. Since these parity wedges play an important role in intermediating currency demand and supply, we should therefore be able to trace movements in equilibrium exchange rates and associated parity wedges to shifts in demand and supply in currency markets, regardless of whether these shifts are driven by fundamental or non-fundamental “animal spirit” shocks. We do so by offering a unifying empirical theory that explains the joint dynamics of UIP and CIP deviations across currencies, as well as of the spot and forward exchange rates.

To guide our analysis, we introduce a simple partial equilibrium model of the currency market. At the center of the model are global intermediary banks with their affiliated broker-dealer branches that step in to clear the dollar-local currency market, absorbing residual net demand for spot and derivatives. Banks are subject to value-at-risk-type balance-sheet constraints and require equilibrium compensation for intermediating net positions. This takes the form of UIP and CIP premia, with the former compensating for currency-risk exposure and the latter for swapping hedged returns across currencies. Given interest rate differentials, spot and forward exchange rates adjust to deliver the required premia for the currency market to clear. We show that the data align closely with the predictions of our model in both the cross section of currencies and the time series for individual currencies.

In the cross section, countries with an excess supply of local-currency savings feature low local-currency interest rates and negative UIP and CIP premia. The logic is as follows. First, a persistent excess net supply of local currency savings depresses local-currency interest rates. This compels investors to fund at this low rate to seek higher returns in foreign currency (FX, via US dollar). Part of the associated FX (dollar) exposure is then sold on the currency market to intermediaries, via forwards and swaps. In the absence of a drift in the exchange rate, the equilibrium expected UIP is negative, equal to the differential between the local and the dollar interest rates. Moreover, intermediaries will only accept to buy dollars forward if these are cheap enough to forego the higher dollar interest rates, i.e. if the CIP premium is negative. In the data, this situation corresponds to *funding currencies* such as the Japanese yen, Swiss franc, and to a lesser extent the euro and the British pound.

The reverse situation applies in countries with relatively scarce local-currency savings relative to local-currency investments. These countries feature high local-currency interest rates, positive UIP and CIP premia and expensive forward dollars. The logic is similar. First, a persistently low net

supply of local-currency savings implies high local-currency interest rates. This compels investors to fund in the US dollar and seek higher returns in local currency. Part of the associated local-currency exposure is then sold back to intermediaries, via forwards and swaps. In the absence of a drift in the exchange rate, the equilibrium expected UIP is positive and equal to the differential between the local-currency and the dollar interest rate. Moreover, intermediaries will only accept to sell dollars forward if these are sufficiently expensive to forego the higher local currency interest rate, i.e. the CIP premium is positive. This is characteristic of *investment*, *commodity* and *emerging-market currencies* (e.g., Australian and New Zealand dollars, Mexican peso, and to a lesser extent Canadian dollar).

The time-series patterns of currency premia are more nuanced. *Covered* currency premia change in concert across currencies. Most of this variation is captured by a common component related to global financial market conditions. Funding currencies with a positive local-currency savings gap see a widening of their negative CIP premia when global financial conditions tighten, while investment (and especially emerging) currencies experience an increase in their positive CIP premia. In other words, forward dollars become cheaper for funding currencies and more expensive for investment currencies when global financial conditions tighten. Additionally, there are periods of increased demand for the US dollar when CIP premia increase for all currencies, funding and investment alike. Nonetheless, CIP premia are generally stable month-to-month outside periods of global financial and dollar stress, and there is no time-series comovement between CIP and UIP premia for individual currencies after absorbing time fixed effects.

In contrast, *uncovered* currency premia move strongly in response to currency-specific demand shocks which have no discernible effect on CIP deviations. We capture these shocks with the change in net currency futures positions of dealer banks, reflecting the need to clear excess demand in a specific currency market.<sup>1</sup> This currency-specific variable explains a large portion of variation in both expected and realized UIP premia in our panel of currencies. Expected UIP premia are two orders of magnitude more variable than the corresponding CIP premia. Like CIP premia, UIP premia also respond to aggregate shocks in the broader financial markets, but these global forces account for only a small portion of the overall variation in UIP deviations, which are currency-specific.

We further show that currency-specific shocks do not affect the interest rate differential or the forward premium, but instead result in large and persistent swings in both spot and forward exchange rates. Changes in the currency futures positions of dealer banks account for the bulk of variation in spot exchange rates for all currencies with available data and result in long half-lives of many months, and hence predictable currency returns. Figure 1 showcases the tight relationship between realized changes in the spot pound and euro exchange rates (vis-à-vis the US dollar) and changes in the respective futures positions of dealer banks.<sup>2</sup> These results align closely with

<sup>1</sup>Futures positions offer an easily measurable portion of the currency market, which is likely highly correlated with both the spot and over-the-counter forward currency markets, as we argue below.

<sup>2</sup>Similar patterns hold for other currencies, as we show in Appendix Figures A9–A10, while Appendix Figures A3 and A11–A12 show the fit for the levels of exchange rates.

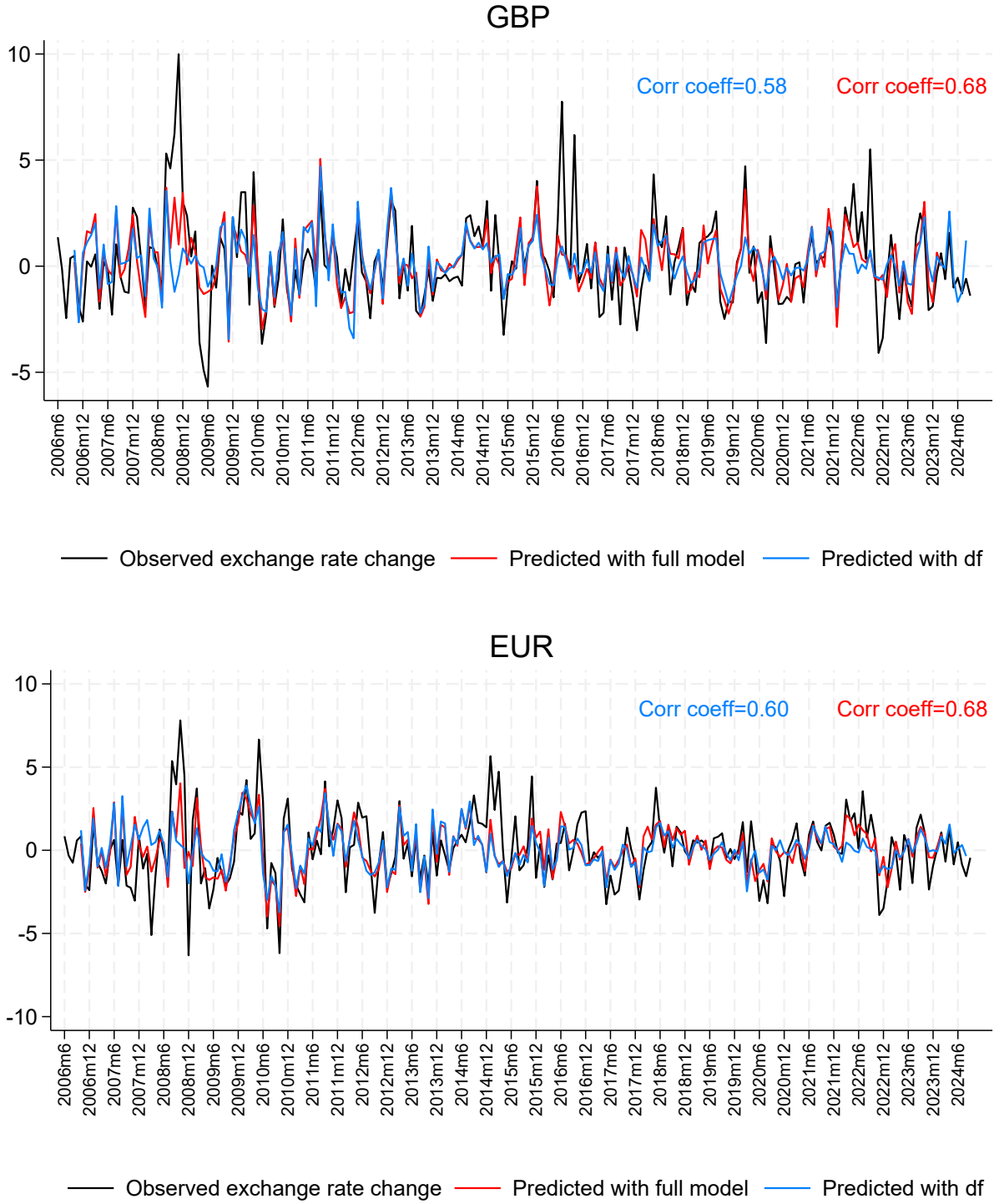


Figure 1: Realized changes in nominal exchange rates and their fitted values

Note: The figures plot the realization of the log monthly changes in the spot exchange rates for the euro and the British pound along with the fitted values from an empirical model using only the currency futures positions of dealer banks, as well as the full model with other covariates of the exchange rates (based on Table 6).

the predictions of our model of frictional currency intermediation, where shifts in currency demand must be met by expanding positions of dealer banks and a widening UIP premium to compensate the bank-holding company. While the local-currency interest rate differential and the forward premium equilibrate the currency market in the cross-section, it is the volatile and persistent fluctuations in the spot and forward exchange rates that allow for the adjustment of currency premia necessary to equilibrate the currency market in response to shocks.

We find robustly predictable currency returns in the time series conditional on the changes in dealer positions. Specifically, investors with open currency positions before the shock experience an abrupt large negative return, while investors that take the currency position in response to the shock collect a smaller but persistent positive expected return. This is reminiscent of the result in [Brunnermeier, Nagel, and Pedersen \(2009\)](#), with the difference that the positive returns after the shock reflect the predictable movement in the exchange rate, rather than the interest rate differential. It is seemingly at odds with the stylized fact that the panel of currency returns largely reflects the cross-section of interest rate differentials and features little time-series predictability (see e.g. [Hassan and Mano, 2018](#)). This fact, however, is still true in our data when not conditioned on currency-specific demand shocks captured by the futures positions of dealer banks. Both currency-specific dealer bank positions and spot exchange rates are volatile, persistent, and only weakly correlated with changes in aggregate macro and financial variables, including interest rate differentials.

This leaves open the question of which shocks are driving the exchange rate. Futures positions of dealer banks may or may not proxy for specific primitive shocks — macroeconomic or financial.<sup>3</sup> They instead identify the resulting variation in net currency demand that must be met by intermediaries at an equilibrium currency premium. Spot and forward exchange rates move to ensure the equilibrium premia that allow the currency market to clear. In addition to fundamental volatility, the exchange rate features “excess” volatility due to frictional intermediation. This explains not only the lack of a robust correlation between the exchange rate and fundamentals, but also the large gap in the exchange rate volatility relative to macro variables ([Itskhoki and Mukhin, 2021, 2025a](#)).

The main goal of our paper is to document and explain the joint statistical properties of currency premia and exchange rates in a panel of major currencies in both advanced and emerging markets. The novelty of our empirical work is in reconciling the salient patterns of the joint distribution of UIP and CIP deviations and the spot and forward exchange rates, both in the cross-section of currencies and in the time series. In doing so, we impose few theoretical or structural restrictions and, instead, show that the rich empirical patterns that we document are in line with the predictions of a simple partial-equilibrium model of the currency market.

**Related literature** Our paper follows the tradition of the pioneering study by [Evans and Lyons \(2002\)](#), who first established a strong connection between currency trading and exchange rates.

---

<sup>3</sup>We find preliminary evidence that capital inflows into investment-currency bonds and dollar asset purchases by funding-currency investors correlate with both dealer net futures positions and individual exchange rates. However, these macro capital flows lack the robust correlation property that we document is inherent to the net dealer positions.

However, instead of using order flows to infer the likely shifts in currency demand, we use the actual currency positions taken by intermediaries, as suggested by the recent theoretical literature on frictional intermediation (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021, 2025a). We differ from the related literature that focuses on identifying exogenous shifts in currency demand and supply, including Camanho, Hau, and Rey (2022), Beltran and He (2023), Bräuer and Hau (2024), Barbiero, Bräuning, Joaquim, and Stein (2024), in that our goal is not to identify an exogenous currency demand shock or currency supply elasticity, but rather to capture in a reduced-form way the bulk of the variation in currency premia and exchange rates. We accomplish this by exploiting the remarkable explanatory power of the dealer banks’ net FX futures position variable as a proxy for shifts in currency demand. This approach also sets our work apart from the growing literature on estimating structural currency and asset demand following the important work of Kojen and Yogo (2020).

Our work also connects to multiple literatures exploring the macroeconomic and financial determinants of exchange rates and currency premia. The vast literature that attempts to establish the macroeconomic determinants of the exchange rate includes Meese and Rogoff (1983), Gourinchas and Rey (2007), Engel, Mark, and West (2008), Stavrageva and Tang (2024) and Engel and Wu (2024).<sup>4</sup> A related literature establishing the connection between exchange rates and macro-financial variables includes Lustig, Roussanov, and Verdelhan (2011), Corte, Riddiough, and Sarno (2016), Jiang, Krishnamurthy, and Lustig (2021), Lilley, Maggiori, Neiman, and Schreger (2022).<sup>5</sup> We adopt from this literature the macro-finance variables that have proved to be most correlated with movements in exchange rates, and show how they can be mapped into shifts in intermediated currency supply and demand.

We also build on the growing empirical literature documenting interest rate parity deviations. Deviations from UIP have been extensively studied for decades by the theoretical and empirical literature following Fama (1984) as surveyed in Engel (2014), including Lustig and Verdelhan (2011), Hassan and Mano (2018), Kalemli-Özcan and Varela (2021), and more recently as a transmission mechanism for bond demand shocks across countries in Gourinchas, Ray, and Vayanos (2025). Unlike UIP, the covered interest parity largely held for G10 currencies up until the Global Financial Crisis (GFC). Since then, the deviation from CIP became sizable and persistent across all G10 currencies versus the dollar, as reviewed by Du and Schreger (2022). The leading explanation for CIP deviations centers around the post-GFC tightening of bank regulation which constrains the expansion of intermediaries’ balance sheets (Du, Tepper, and Verdelhan, 2018) and divergent dollar funding costs of international banks (Rime, Schrimpf, and Syrstad, 2022). More generally, factors driving demand for

---

<sup>4</sup>One possibility emphasized in this literature is that exchange rates are driven by expectations and news shocks about future macro-fundamentals (see also Ilzetzi, Reinhart, and Rogoff, 2020; Chahrour, Cormun, De Leo, Guerron-Quintana, and Valchev, 2021; Kekre and Lenel, 2024; Itskhoki and Mukhin, 2025b). In frictional currency markets, such news shocks can trigger shifts in currency demand and hence affect the contemporaneous currency premia and the exchange rate in a way consistent with our findings.

<sup>5</sup>Another related literature explores the connection between exchanger rates and asset prices includes Hau and Rey (2006), Engel (2016), Chernov and Creal (2023) and Chernov, Haddad, and Itskhoki (2024).

dollar funding and hedging interact with these supply-side intermediation frictions in determining the CIP premium, both in advanced (Ivashina, Scharfstein, and Stein, 2015; Liao and Zhang, 2025) and emerging economies (Dao and Gourinchas, 2025).

The vast majority of the literature has studied either the deviation from UIP or CIP in isolation, while our conceptual framework offers an understanding of their joint determination and the resulting implications for exchange rate dynamics. A paper which also studies both wedges is Greenwood, Hanson, Stein, and Sunderam (2020), who highlight shocks to currency-specific long-term bond supply as a source for correlated UIP and CIP deviations. De Leo, Keller, and Zou (2024) show how carry trade inflows into emerging markets subject to capital controls can also cause a co-movement between UIP and CIP deviation. Bacchetta, Benhima, and Berthold (2025) consider the cost of FX interventions in a model of safe-haven countries where both CIP and UIP deviations are present. Consistent with our results, they argue that CIP and UIP deviations can be simultaneously negative for these ‘funding’ countries (in our notation). There is growing evidence that determinants of these wedges correlate with the exchange rate, with the underlying shocks ranging from preferences for asset convenience to any shock that shifts currency demand requiring frictional intermediation. The shared testable implication of many such theories is that variables affecting intermediaries’ balance sheets should, in turn, affect equilibrium parity wedges and hence the exchange rate. Therefore, instead of committing to a particular source of shocks to these parity wedges, we offer a framework that describes their joint determination under a general type of shock, and one that is consistent with statistical properties of these wedges across a broad set of currencies for which the data is available.

## 2 Model of Currency Intermediation

We first describe the problem of an individual global intermediary bank. We then describe the industry equilibrium in which spot, forward and swap FX markets clear, determining the spot and forward exchange rates and the resulting equilibrium UIP and CIP premia.

### 2.1 Global bank (intermediary)

We describe the problem of a given bank  $i$  with initial net worth  $W_{it}^*$ . All variables with  $*$  are expressed in US dollars. We focus on a given currency  $k$  market against the dollar, considered in isolation for now. We omit indicators  $i$  and  $k$  in this section and bring them back below when we consider the industry equilibrium.

**Balance sheet** Table 1 defines the balance sheet variables of the bank and the associated returns. The liability side consists of the net worth  $W_t^*$  and external funding  $D_t^*$ , which we assume is in dollars. The associated external funding cost on the interbank dollar market is  $R_t^*$ . The asset side of the balance sheet consists of dollar reserves  $B_t^* \geq 0$  that pay  $\underline{R}_t^*$ , risky investments  $H_t^* \geq 0$  with ex-post realized dollar return  $\tilde{R}_{t+1}^*$  and local-currency (LC) assets (net of any LC borrowing)

Table 1: International Bank: the Balance Sheet

Assets			Liabilities
$B_t^* \geq 0 : \underline{R}_t^*$	\$ reserves	net worth	$W_t^* :$
$H_t^* \geq 0 : \tilde{R}_{t+1}^*$	\$ risky investment	borrowing in \$	$D_t^* : R_t^*$
$A_t^* : R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$	LC investment (\$ value)		
-----			
Off balance sheet (zero-wealth positions)			
$F_t^* : \frac{R_t \mathcal{E}_t}{\mathcal{F}_t} \left( \frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1 \right)$	currency forward		
$S_t^* : R_t^* - R_t \frac{\mathcal{E}_t}{S_t}$	currency swap		

$A_t^*$  with a local-currency return  $R_t$ . This converts into an ex-post dollar return  $R_t \mathcal{E}_t / \mathcal{E}_{t+1}$  where  $\mathcal{E}_t$  is the spot exchange rate defined as the local-currency price of the dollar such that an increase in  $\mathcal{E}_t$  denotes a depreciation of the local currency, or an appreciation of the dollar.

As a matter of accounting, the two sides of the balance sheets are equated:

$$B_t^* + H_t^* + A_t^* = W_t^* + D_t^*. \quad (1)$$

We measure the size of the balance sheet with the magnitude of the risky investments  $H_t^*$ , leaving out reserves  $B_t^*$  and the dollar and LC funding variables  $A_t^*$  and  $D_t^*$ . Note that  $A_t^*$  and  $D_t^*$  can take both positive and negative values, with e.g.  $A_t^* < 0$  corresponding to a net LC liability.<sup>6</sup>

In addition to the on-balance-sheet operations, Table 1 describes possible off-balance sheet operations. The bank can sell currency forwards and futures. We refer to the combined position  $F_t^*$  as just forwards for brevity. When  $F_t^* > 0$ , the bank sells dollars forward (in exchange for LC) at the forward rate  $\mathcal{F}_t$ . Conversely, when  $F_t^* < 0$ , the bank buys dollars and sells LC forward. We normalize  $F_t^*$  to denote a commitment to buy  $R_t \mathcal{E}_t F_t^*$  units of local currency in exchange for  $R_t \mathcal{E}_t F_t^* / \mathcal{F}_t$  dollars at  $t + 1$ . The  $t + 1$  dollar payout on this zero-capital position is, therefore, given by  $(1/\mathcal{E}_{t+1} - 1/\mathcal{F}_t) R_t \mathcal{E}_t F_t^* = (\mathcal{F}_t/\mathcal{E}_{t+1} - 1) R_t \mathcal{E}_t F_t^* / \mathcal{F}_t$ . In other words, at  $t + 1$ , one dollar must be exchanged for  $\mathcal{F}_t$  units of local currency – with a dollar value of  $\mathcal{F}_t/\mathcal{E}_{t+1}$  – per each effective unit of the forward position  $R_t \mathcal{E}_t F_t^* / \mathcal{F}_t$  taken at  $t$ .<sup>7</sup>

Finally, the bank can also sell dollar swaps, defined as simultaneous spot and forward transactions, with the forward leg at the swap rate  $S_t$ . We refer to the swap position as  $S_t^*$ . When  $S_t^* > 0$ , the bank exchanges  $\mathcal{E}_t$  units of local currency (with a spot value of one dollar) for one dollar at  $t$ , with the obligation to receive back  $R_t \mathcal{E}_t$  units of local currency at  $t + 1$  in exchange for  $R_t \frac{\mathcal{E}_t}{S_t}$  dollars.

<sup>6</sup>Our analysis generalizes to the case where LC assets and liabilities pay a differential return, and the size of the balance sheet is defined as  $Y_t^* := H_t^* + [A_t^*]^+ + [-D_t^*]^+$  with  $[x]^+ \equiv \max\{x, 0\} > 0$ .

<sup>7</sup>As we will shortly see, the forward position of  $\frac{R_t \mathcal{E}_t}{\mathcal{F}_t} F_t^*$  dollars translates into a currency-risk exposure equal to  $F_t^*$ . Our definition of  $F_t^*$  is without loss of generality, as  $\frac{R_t \mathcal{E}_t}{\mathcal{F}_t} F_t^*$  scales proportionally with  $F_t^*$  and hence it is just a redefinition of units. The logic in this scaling is that one dollar invested in a euro asset pays  $R_t \mathcal{E}_t$  euros at  $t + 1$  which then are converted back to dollars at the forward rate  $\mathcal{F}_t$ , thus characterizing exposure on one dollar invested at  $t$ .

Per unit of a swap position  $S_t^*$ , the financial payout at  $t + 1$  is  $R_t^*$  dollars in exchange for  $R_t \mathcal{E}_t$  units of local currency converted to dollars at the swap exchange rate  $\mathcal{S}_t$ . That is, the total payout on the off-balance sheet swap position  $S_t^*$  is  $(R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}) S_t^*$ .<sup>8</sup> The position  $S_t^*$  can be negative or positive. Note that swaps result in no additional currency risk exposure since all payoffs are pre-determined in dollars. Appendix Figure A1 illustrates cash flows for both on-balance-sheet and off-balance-sheet asset holdings.

**Bank net worth and currency exposure** We have now described all on and off balance sheet positions of the bank at  $t$  and the associated payoffs at  $t + 1$ . This allows us to describe the bank's period  $t + 1$  net worth by aggregating the payoffs on its different positions:

$$W_{t+1}^* = \underline{R}_t^* B_t^* + \tilde{R}_{t+1}^* H_t^* + R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} A_t^* - R_t^* D_t^* + R_t \frac{\mathcal{E}_t}{\mathcal{F}_t} \left( \frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1 \right) F_t^* + \left( R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t} \right) S_t^*.$$

We conjecture and prove below that forward and swap exchange rates must be equal in equilibrium,  $\mathcal{S}_t = \mathcal{F}_t$ , as swaps can be engineered using a carry and a forward. Combining the expression for  $W_{t+1}^*$  with the balance sheet (1) at  $t$  and rearranging terms yields the dynamic equation for net worth:

**Lemma 1** *Assuming  $\mathcal{S}_t = \mathcal{F}_t$ , the net worth evolution of the bank can be written as follows:*

$$W_{t+1}^* = R_t^* (W_t^* - H_t^* - B_t^*) + \underline{R}_t^* B_t^* + \tilde{R}_{t+1}^* H_t^* + CIP_t \cdot X_t^* + UIP_{t+1} \cdot Z_t^*, \quad (2)$$

where  $X_t^* \equiv F_t^* + S_t^*$  is the off-balance-sheet exposure of the bank and  $Z_t^* \equiv A_t^* + F_t^*$  is the currency-risk exposure of the bank. The (realized) UIP and CIP premia are given by:

$$UIP_{t+1} \equiv R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - R_t^* \quad \text{and} \quad CIP_t \equiv R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}. \quad (3)$$

**Proof:** We use the balance sheet identity (1) to express out  $D_t^*$  in the evolution of net worth. We then isolate the two exposures  $X_t^*$  and  $Z_t^*$  using their definitions, and collect the remaining term as  $R_t \mathcal{E}_t \left( \frac{1}{\mathcal{F}_t} - \frac{1}{\mathcal{S}_t} \right) S_t^*$ , which is equal to zero when  $\mathcal{S}_t = \mathcal{F}_t$ . ■

The currency positions of the bank are summarized in the two exposure variables – the currency risk exposure  $Z_t^* = A_t^* + F_t^*$  and the off-balance-sheet exposure  $X_t^* = F_t^* + S_t^*$ . Formally, observe that  $\frac{\partial(W_{t+1}^*/W_t^*)}{\partial(\mathcal{E}_t/\mathcal{E}_{t+1})} = R_t \frac{Z_t^*}{W_t^*}$ , hence the pass-through of exchange rate volatility into net worth volatility is proportional to the exchange rate exposure  $Z_t^*$ . The compensation for the two exposures are the

<sup>8</sup>By construction, receiving one dollar in exchange for  $\mathcal{E}_t$  units of local currency reduces both  $A_t^*$  (LC net assets) and  $D_t^*$  (dollar net liabilities) by one period- $t$  dollar without changing the size of the balance sheet  $Y_t^*$ . The payout on this change in the positions is  $R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$  in dollars. This is combined with  $R_t \mathcal{E}_t$  units of LC that are received in exchange for  $R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}$  dollars at  $t + 1$  according to the swap contract. Combining together, the total payoff on a unit of  $S_t^*$  position is then  $R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} + R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t} = R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}$ , as given in the text. As with forwards, the exact scaling of units of swap contracts is without loss of generality, and we define  $S_t^*$  this way as it will shortly emerge as the relevant measure of the off-balance-sheet exposure.

realized UIP and CIP premia, respectively. Note that they are defined in “reverse” directions in (3): we measure the currency exposure by the risk of the LC depreciation (an increase in  $\mathcal{E}_{t+1}$ ) and the off-balance-sheet exposure as the cost of foregoing LC return  $R_t$  relative to dollar return  $R_t^*$ . A forward position  $F_t^*$  affects both exposures  $X_t^*$  and  $Z_t^*$  simultaneously, and hence the payout on forwards collects both UIP and CIP premia. In contrast, swap position  $S_t^*$  does not result in exchange rate risk exposure and hence carries only the CIP premium.<sup>9</sup>

**Balance sheet constraints** Denote  $\Theta_{t+1}$  a stochastic discount factor that prices returns with a general property that  $\mathbb{E}_t \Theta_{t+1} = 1/R_t^*$ . This stochastic discount factor may arise from the discount factor of the representative household or the owner of the bank. Note that a non-stochastic discount factor,  $\Theta_{t+1} \equiv 1/R_t^*$  is admissible, and corresponds to a risk-neutral bank. The bank maximizes the present discounted net worth  $\mathbb{E}_t \Theta_{t+1} W_{t+1}^*$  subject to a balance sheet constraint.

The balance sheet constraint, in turn, requires the bank to set aside dollar reserves  $B_t^*$  that generally earn a lower return  $\underline{R}_t^* < R_t^*$ , and increasingly more reserves with various exposures of the bank — namely, the size of its balance sheet  $H_t^*$ , the off-balance-sheet exposure  $X_t^*$ , and the currency-risk exposure  $Z_t^*$ . Formally, we write the balance sheet constraint as:

$$B_t^* \geq a_t H_t^* + b_t |Z_t^*| + \delta |X_t^*|, \quad (4)$$

where

$$a_t \equiv \frac{\alpha}{2} \frac{H_t^*}{W_t^*} \quad \text{and} \quad b_t \equiv \frac{\gamma \sigma_t}{2} \frac{|Z_t^*|}{W_t^*}. \quad (5)$$

with  $\sigma_t^2 \equiv R_t^2 \cdot \text{var}_t(\mathcal{E}_t/\mathcal{E}_{t+1})$  and  $\alpha, \gamma, \delta > 0$ . These coefficients reflect regulation and value-at-risk considerations, and can differ by currency, policy regime or time period.

The nature of this balance sheet constraint is straightforward: the more exposure, the greater the associated risk, and hence the greater are the required reserves. The constraint is binding because holding reserves is costly when  $\underline{R}_t^* < R_t^*$ . More risky investment  $H_t^* > 0$  and more exposure to the currency risk  $|Z_t^*|$  require increasingly higher reserves. This is the value-at-risk logic: each additional unit of exposure increases the contribution to net worth volatility in proportion to  $H_t^*/W_t^*$  and  $\sigma_t |Z_t^*|/W_t^*$ , respectively, where  $\sigma_t$  is the standard deviation of the carry return (realized UIP premium). Correspondingly,  $\alpha$  and  $\gamma$  reflect the risk weights of the bank’s positions.

The reserve requirement associated with the non-stochastic off-balance-sheet exposure  $X_t^*$  is different. The risk associated with such position is not in the volatility of returns, but in the counterparty risk, and thus does not scale up with the size of the position, assuming each bank is small relative to the market. Therefore, the associated value-at-risk increases linearly with exposure  $|X_t^*|$

---

<sup>9</sup>Conventional wisdom often considers that banks do not carry significant exposure to foreign exchange risk due to prudential regulation and internal risk management, though actual data on this has been scant. Research using newly available supervisory data provides visibility into the opaque off-balance-sheet derivative exposure, showing that combining all spot and derivative positions at the bank-holding level, large entities in the US and Europe still have substantial unhedged FX positions  $Z_t^*$  (see Moskowitz, Ross, Ross, and Vasudevan, 2024; Abbassi and Bräuning, 2021).

rather than being convex in it, in contrast with  $|Z_t^*|$ .<sup>10</sup> Due to linearity of the constraint in  $|X_t^*|$ , we additionally assume that  $|X_t^*| \leq \bar{X}^*$  for some  $\bar{X}^*$ .

The bank solves the following portfolio problem:

$$\max_{B_t^* \geq 0, H_t^* \geq 0, X_t^*, Z_t^*} \mathbb{E}_t \Theta_{t+1} W_{t+1}^* \quad \text{subject to (2), (4)-(5) and } |X_t^*| \leq \bar{X}^*. \quad (6)$$

We denote with  $\mu_t/R_t^*$  the Lagrange multiplier on the balance sheet constraint (4). We assume the bank takes returns  $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$  and exchange rates  $\{\mathcal{E}_t, \mathcal{F}_t\}$  as given, and make the following assumption which ensures that the balance sheet constraint is binding and  $H_t^* > 0$ :

**Assumption 1**  $\underline{R}_t^* < R_t^*$  and  $\mathbb{E}_t[\Theta_{t+1} \tilde{R}_{t+1}^*] > 1$ .

We prove the following characterization of the optimal portfolio positions for the bank (see Appendix B):

**Proposition 1** *Under Assumption 1, we have  $\mu_t = R_t^* - \underline{R}_t^* > 0$  and the balance sheet constraint of the bank is binding. Furthermore, (a) the swap exchange rate equals the forward exchange rate,  $\mathcal{S}_t = \mathcal{F}_t$ ; and (b) the supply schedules for spot and forward currency are given by:*

$$\overline{UIP}_t = \gamma \mu_t \sigma_t \frac{Z_t^*}{W_t^*} \quad \text{and} \quad CIP_t = \delta \mu_t \cdot \text{sign}(X_t^*) \quad \text{for } |X_t^*| \leq \bar{X}^*, \quad (7)$$

where  $\overline{UIP}_t \equiv \mathbb{E}_t[\frac{\Theta_{t+1}}{\mathbb{E}_t \Theta_{t+1}} UIP_{t+1}]$  is the expected UIP premium and  $\text{sign}(x)$  is a step function from  $-1$  to  $+1$  at  $x = 0$ . Thus,  $X_t^* = \bar{X}^* \cdot \text{sign}(CIP_t)$  when  $|CIP_t| > \delta \mu_t$  and  $X_t^* = 0$  when  $|CIP_t| < \delta \mu_t$ .

When the balance sheet constraint is binding, the shadow cost of expanding exposure which requires a one unit (dollar) increase in reserves  $B_t^*$  (be it  $H_t^*$ ,  $X_t^*$  or  $Z_t^*$ ), is equal to  $\mu_t = R_t^* - \underline{R}_t^*$ , and hence the bank will only take on such exposure if it is sufficiently compensated. Since the off-balance-sheet exposure  $X_t^*$  carries only the counterparty risk, the reserves need only to change proportionally with  $|X_t^*|$ . As a result, the associated CIP premium is constant per unit of the position but has the same sign as  $X_t^*$ . That is, CIP must be a step function from  $-\delta \mu_t$  to  $+\delta \mu_t$  at  $X_t^* = 0$ . If CIP is smaller in absolute value, the bank will not take any position ( $X_t^* = 0$ ) and if CIP is larger in absolute value, the bank will take the largest position possible ( $|X_t^*| = \bar{X}^*$ ) of the same sign as the CIP deviation.

In contrast, risky exposures  $H_t^*$  and  $Z_t^*$  carry the volatility risk of the underlying asset, and therefore required reserves  $B_t^*$  are convex in these exposures. A leveraged risky position comes not only at the risk of losing its value, but also with the price risk of the underlying asset. For example, the impact of exchange rate volatility on the bank's net worth  $W_{t+1}^*$  is proportional to  $\sigma_t Z_t^*$ . As a result, the associated UIP premium is linear in  $\sigma_t Z_t^*/W_t^*$ .

<sup>10</sup>Intuitively, the risk of  $X_t^*$  is a drift linked to counterparty default, while the risk of  $Z_t^*$  is a diffusion linked to the value of the underlying asset price. More generally, we could consider a class of reserve-requirement functions  $\frac{1}{1+\epsilon}(|\cdot|/W_t^*)^\epsilon$  for different types of exposure. The prediction of our theory, that we contrast later with the data, is that  $\epsilon \approx 0$  for riskless off-balance-sheet exposure and  $\epsilon \approx 1$  for risky exposures, consistent with the value-at-risk logic.

Finally, note that the currency-risk exposure  $Z_t^*$  is associated with both local currency investment  $A_t^*$  and with forward positions  $F_t^*$ . Both must carry an expected UIP premium  $\overline{UIP}_t$  for the bank to take them on the margin. We express the expected UIP premium as:

$$\overline{UIP}_t \equiv R_t \frac{\mathcal{E}_t}{\widehat{\mathcal{E}}_t} - R_t^*, \quad \text{where} \quad \widehat{\mathcal{E}}_t = \left( \mathbb{E}_t \left[ \frac{\Theta_{t+1}}{\mathbb{E}_t \Theta_{t+1}} \mathcal{E}_{t+1}^{-1} \right] \right)^{-1}, \quad (8)$$

that is,  $\widehat{\mathcal{E}}_t$  is the risk-neutral expectation of the future spot exchange rate. The forward position  $F_t^*$  additionally creates an off-balance-sheet exposure similar to that of a swap position  $S_t^*$ , and both must be compensated on the margin by the CIP premium  $CIP_t$ . Thus, an  $F_t^*$  position of the bank is compensated in expectation with both premia,  $\overline{UIP}_t + CIP_t = R_t \mathcal{E}_t (1/\widehat{\mathcal{E}}_t - 1/\mathcal{F}_t)$ .

## 2.2 Currency market equilibrium

Taking as given the path of interest rates and asset returns,  $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$ , we now focus on the partial equilibrium in the currency market and solve for the two exchange rates: the spot exchange rate  $\mathcal{E}_t$  and the forward exchange rate  $\mathcal{F}_t$  as a function of the market demand for unhedged and hedged currency exposure. The two exchange rates correspond to the two equilibrium premia reflected in the expected  $\overline{UIP}_t$  deviation and the  $CIP_t$  deviation. Note that  $\overline{UIP}_t$  depends on both the current spot exchange rate  $\mathcal{E}_t$  and the expectation of the future exchange rate  $\mathcal{E}_{t+1}$ , or more precisely  $\widehat{\mathcal{E}}_t$  defined in equation (8). Assuming all banks face the same UIP and CIP deviations allows for aggregation of positions under equilibrium prices.<sup>11</sup>

We first derive the currency supply schedules. Individual bank  $i$  supplies currency according to conditions (7), where  $\mu_t = R_t^* - \underline{R}_t^*$  and  $\sigma_t^2 = R_t^2 \text{var}_t(\mathcal{E}_t/\mathcal{E}_{t+1})$  are market variables common across banks,  $(\gamma_{it}, \delta_{it})$  vary exogenously across banks (and possibly time), and  $\{Z_{it}^*, X_{it}^*, W_{it}^*\}$  are bank-level endogenous variables, where  $Z_{it}^* = A_{it}^* + F_{it}^*$  and  $X_{it}^* = F_{it}^* + S_{it}^*$ , as defined above in Lemma 1. We further denote with  $\bar{\delta}_t$  the balance sheet constraint parameter  $\delta_{it}$  for the marginal bank supplying forwards and swaps.<sup>12</sup> We still focus on a given currency  $k$  market and hence still suppress the currency index.

We denote with  $\mathbb{Z}_t^*$  and  $\mathbb{X}_t^*$  the aggregate demand to sell currency risk and to buy currency forwards and swaps, respectively. For brevity and with a slight abuse of language, we refer to the two as the unhedged and hedged currency demand, respectively. We have  $\mathbb{Z}_t^* \equiv \mathbb{A}_t^* + \mathbb{F}_t^*$  and  $\mathbb{X}_t^* \equiv \mathbb{F}_t^* + \mathbb{S}_t^*$ , where  $\mathbb{F}_t^*$  is the demand to buy dollar forwards,  $\mathbb{S}_t^*$  is the demand to swap dollars for local currency, and  $\mathbb{A}_t^*$  is the excess demand for local currency investment over the supply of local-currency savings. In each case, the intermediary banks take the reverse positions, in line with

<sup>11</sup>The two significant assumptions here are that exchange rate expectations, as summarized by  $\widehat{\mathcal{E}}_t$ , are common across banks, and that  $\mathcal{F}_t$  is common across banks (since forward market is over the counter).

<sup>12</sup>Formally, in a given period  $t$ , assume a distribution of  $\{\delta_{it}\}$  across banks  $i$ . All banks with  $\delta_{it} < \bar{\delta}_t$  are active in the off-balance-sheet currency market, while all banks with  $\delta_{it} > \bar{\delta}_t$  are not. See Appendix B.

our definitions of  $(A_{it}^*, F_{it}^*, S_{it}^*)$  above. Market clearing requires:

$$\mathbb{Z}_t^* = \sum_i (A_{it}^* + F_{it}^*) \quad \text{and} \quad \mathbb{X}_t^* = \sum_i (F_{it}^* + S_{it}^*), \quad (9)$$

that is, the aggregate demand for currency is met by the intermediary banks' supply.

Combining market clearing equation (9) with the optimal supply schedules of the intermediary banks (7) results in the following equilibrium characterization (see Appendix B):

**Proposition 2** *The equilibrium expected UIP and CIP premia as a function of aggregate unhedged and hedged currency demand  $\mathbb{Z}_t^*$  and  $\mathbb{X}_t^*$  are given, respectively, by:*

$$\overline{UIP}_t \equiv R_t \frac{\mathcal{E}_t}{\bar{\mathcal{E}}_t} - R_t^* = \bar{\gamma}_t \mu_t \sigma_t \cdot \frac{\mathbb{Z}_t^*}{\mathbb{W}_t^*}, \quad (10)$$

$$CIP_t \equiv R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t} = \bar{\delta}_t \mu_t \cdot \text{sign}(\mathbb{X}_t^*), \quad (11)$$

where  $\mu_t = R_t^* - \underline{R}_t^*$ ,  $\mathbb{W}_t^* \equiv \sum_i W_{it}^*$  is the aggregate net worth of the dealer banks,  $\bar{\gamma}_t \equiv \left( \sum_i \frac{W_{it}^* / \gamma_{it}}{\mathbb{W}_t^*} \right)^{-1}$  is the hyperbolic weighted average of  $\gamma_{it}$ , and  $\bar{\delta}_t = \delta_{it}$  is the tightness of the balance sheet constraint of the marginal (indifferent) bank supplying forwards.

Proposition 2 emphasizes both the key similarities and the key differences between the equilibrium UIP and CIP premia. Both UIP and CIP premia expand in periods of large financial spreads as captured by  $\mu_t = R_t^* - \underline{R}_t^*$  due to the overall tightened funding constraints. UIP and CIP premia have the sign of the respective aggregate demand — namely, the aggregate demand for spot and forward dollars  $\mathbb{Z}_t^* = \mathbb{A}_t^* + \mathbb{F}_t^*$  determines the sign of the UIP, while the aggregate demand for dollar forwards and swaps  $\mathbb{X}_t^* = \mathbb{F}_t^* + \mathbb{S}_t^*$  determines the sign of CIP.<sup>13</sup> Finally, the UIP and CIP depend on the distribution of the banks' balance sheet constraint parameters  $\{\gamma_{it}, \delta_{it}\}$  summarized by  $(\bar{\gamma}_t, \bar{\delta}_t)$ , with a shift upward (first order stochastic dominance) in these distributions increasing the equilibrium premia.

The main difference between UIP and CIP premia is that the UIP premium increases monotonically in the size of the aggregate demand for currency spot and forward exposure relative to the aggregate net worth of the dealer banks,  $\mathbb{Z}_t^* / \mathbb{W}_t^*$ , while the size of the CIP deviation depends only on the aggregate financial conditions  $\bar{\delta}_t \mu_t$  and the *direction* of the forward and swap demand  $\mathbb{X}_t^*$ . This is a stark testable implication, illustrated in Figure 2, that we bring to the data.<sup>14</sup> Furthermore, conditions (10)–(11) apply both in levels and in changes, and thus characterize both the average (steady state) signs and levels of the currency premia, as well as their dynamics in response to shocks, of-

<sup>13</sup>Demand for forwards from the market can be for hedging, funding or speculating. We do not need to take a stance on the motive. The propositions only require that dealer banks accommodate the net demand for forwards.

<sup>14</sup>The difference is potentially not as stark in levels, as  $\bar{\delta}_t$  may be increasing in  $\mathbb{X}_t^* / \mathbb{W}_t^*$  as an increase in this aggregate demand variable may require more banks to become active, increasing  $\delta_{it}$  of the marginal bank. Nonetheless, for local changes, we assume and later verify in the data that  $\bar{\delta}_t$  does not change with month-to-month variation in demand, absent major shocks.

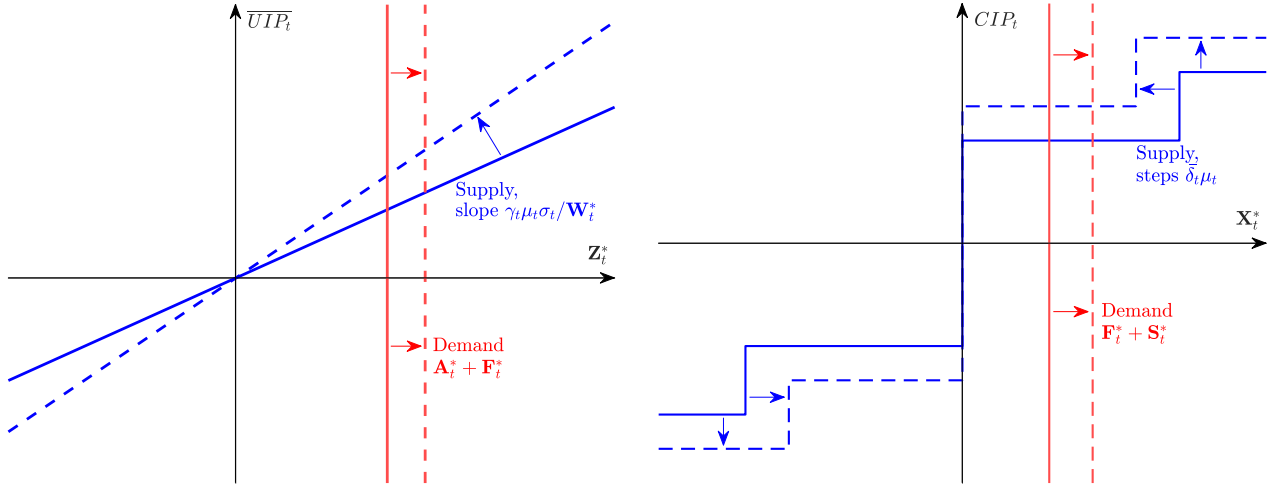


Figure 2: Currency market equilibrium: currency risk and currency swaps

Note: The figure illustrates currency market equilibrium described in Proposition 2, with shifts in currency demand and supply: changes in  $\bar{\gamma}_t \mu_t \sigma_t / \mathbb{W}_t^*$  rotate (change the elasticity) of the spot (risky) currency supply schedule in the left panel, while changes in  $\bar{\delta}_t \mu_t$  changes the step function of the swap (hedged) currency supply in the right panel, while changes in  $Z_t^*$  and  $X_t^*$  reflect movements along the respective currency supply schedules.

fering a menu of testable implications. In particular, we expect the UIP premium to respond to currency demand shocks with an elasticity  $\bar{\gamma}_t \mu_t \sigma_t / \mathbb{W}_t^*$ , while we expect the CIP premium to shift only with aggregate market conditions captured by  $\bar{\delta}_t \mu_t$  without responding to local currency demand shocks. Conditions (10)–(11) also characterize the response of the spot and forward exchange rates  $\mathcal{E}_t$  and  $\mathcal{F}_t$  to currency demand shocks, providing additional empirical relationships that we estimate in the data.<sup>15</sup>

We close this section with a short discussion of demand and supply in the currency market. We separate shocks to currency demand captured by  $(Z_t^*, X_t^*)$  from shifts of the currency supply curves characterized in Proposition 1. Proposition 2 characterizes the equilibrium adjustment in currency premia in response to any shifts in currency demand, as intermediary banks move along their supply curves in (7). However, the role of intermediaries can be played by any agent in the economy to the extent their currency supply responds to UIP and CIP premia according to equation (7).<sup>16</sup> For concreteness, consider the equilibrium UIP premium condition. The slope of the aggregate currency supply curve is given by:

$$\bar{\gamma}_t \mu_t \sigma_t / \mathbb{W}_t^* = \mu_t \sigma_t \left( \sum_i W_{it}^* / \gamma_{it} \right)^{-1},$$

where the aggregation is across all financial institutions that respond elastically to changes in the UIP premium. Greater aggregate intermediary net worth or more slack in balance-sheet constraints make the market more elastic and reduce the pass-through from currency demand shocks into the UIP premium, and vice versa.

<sup>15</sup>Note that the levels of exchange rates are determined by other equilibrium forces left outside our partial equilibrium model, in particular, by the equilibrium in the goods market and the country's inter-temporal budget constraint (see [Itskhoki and Mukhin, 2021](#)).

<sup>16</sup>In fact, positions of any investor in the economy can simultaneously feature a shifter (demand) and a slope (supply).

## 2.3 Testable implications

We now make use of Proposition 2 to summarize the empirical implications of our theory for the long run and the short run — that is, for the cross section of currency premia and for the dynamic response of currency premia and exchange rates to shocks. We bring back the currency index  $k$  and rewrite the currency supply schedules in (10) and (11) as:

$$\overline{UIP}_{kt} \equiv R_{kt} \frac{\mathcal{E}_{kt}}{\hat{\mathcal{E}}_{kt}} - R_t^* = \mu_t \bar{\gamma}_{kt} \sigma_{kt} \cdot \frac{\mathbb{Z}_{kt}^*}{\mathbb{W}_{kt}^*}, \quad (12)$$

$$CIP_{kt} \equiv R_t^* - R_{kt} \frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} = \mu_t \bar{\delta}_{kt} \cdot \text{sign}(\mathbb{X}_{kt}^*), \quad (13)$$

where the tightness of the balance-sheet constraint  $\mu_t$  is common across currencies (see Proposition 1), while all other variables are, in general, currency specific and hence may vary in the cross section of currencies. Note that  $\mathcal{E}_{kt}$  ( $\mathcal{F}_{kt}$ ) is the spot (forward) exchange rate of currency  $k$  in units of currency  $k$  for one dollar,  $\hat{\mathcal{E}}_{kt}$  is the (risk-neutral) expectation of the future currency  $k$  spot exchange rate (defined in (8)),  $R_{kt}$  is the local currency  $k$  interest rate, and  $R_t^*$  is the dollar interest rate. Finally,  $\mathbb{X}_{kt}^*$  and  $\mathbb{Z}_{kt}^*$  are demand shifters for (“risky” and “hedged”) exposure to currency  $k$  that are intermediated by banks in equilibrium (see Figure 2).

Currency supply conditions (12) and (13) apply both in the cross section and the time series. We now explore the implications for each case separately.

### 2.3.1 Cross section of currencies

A fundamental difference between countries is the supply of local-currency savings relative to the demand for local-currency investment. We summarize the aggregate *gap* between local-currency funding and savings with  $\mathbb{A}_{kt}^*$  which measures the extent of local-currency investment that needs to be covered with foreign-currency funding. Specifically,  $\mathbb{A}_{kt}^* > 0$  corresponds to countries with excess demand for local-currency funding or insufficient supply of local-currency savings. Conversely,  $\mathbb{A}_{kt}^* < 0$  corresponds to countries with excess supply of local-currency savings, and hence a need to convert local-currency funding into dollar investments. In terms of our simple model,  $\mathbb{A}_{kt}^*$  is one source of currency demand that global banks need to intermediate by taking local-currency exposure.

For our theoretical analysis, instead of specifying a full structural general equilibrium model, we make the following two assumption which we verify empirically in the next section:

**Assumption 2** *In the long-run equilibrium, the nominal exchange rate does not systematically drift, that is, the unconditional expectation of the currency  $k$  depreciation is  $\mathbb{E}\{\mathcal{E}_{kt}/\mathcal{E}_{k,t+1}\} \approx 1$ .*

This is simply a martingale assumption on the nominal exchange rate. It can be readily generalized to an environment with drift due to systematic inflation differentials, which are effectively absent

in our sample of developed countries between 2000 and 2020.<sup>17</sup> It is meant to emphasize that the expected currency returns in the cross section are not due to expected movements in the exchange rate, but due to differences in the nominal (or real) interest rates, in line with the data.

**Assumption 3** *Currencies  $k$  with systematic local-currency funding gaps  $\mathbb{A}_{kt}^* > 0$  feature (a) high local-currency interest rates  $R_{kt} > R_t^*$ , (b) excess demand for forward dollars  $\mathbb{F}_{kt}^* > 0$  and (c) excess demand for local-currency swaps  $\mathbb{S}_{kt}^* > 0$ ; and vice versa.*

Countries with a local-currency funding gap ( $\mathbb{A}_{kt}^* > 0$ ) have insufficient local funds to satisfy local-currency investment. This pushes up the local-currency interest rate and attracts foreign capital. Conversely, countries with excess supply of local-currency funding ( $\mathbb{A}_{kt}^* < 0$ ) feature low local-currency interest rates and capital outflows. Investors follow the interest rate differentials and generate demand for swaps as they seek high return investments without exposure to the currency risk. Formally, the interest rate differentials are a source of demand for high interest-rate currency swaps — i.e., local-currency swaps ( $\mathbb{S}_{kt}^* > 0$ ) in the former case and dollar swaps ( $\mathbb{S}_{kt}^* < 0$ ) in the latter case. Similarly, investing in the high interest rate currency creates demand to buy dollars forward ( $\mathbb{F}_{kt}^* > 0$ ) in the former case and sell dollars forward ( $\mathbb{F}_{kt}^* < 0$ ) in the latter case. Furthermore, expensive local-currency funding,  $R_{kt} > R_t^*$ , compels firms to raise capital in dollars and hedge their balance sheet by buying dollars forward. These are the forces behind assumption 3. Recent papers that analyze comprehensive supervisory data for FX derivatives holdings by global banks largely validate these assumptions.<sup>18</sup>

**Proposition 3** *Under Assumption 2 and 3: (a) currencies with excess demand for local-currency investment feature high local-currency interest rates, positive UIP and CIP premia, and expensive forward dollars ( $\mathcal{F}_{kt} < \mathcal{E}_{kt}$ ); (b) currencies with excess supply of local-currency savings features low local-currency interest rates, negative UIP and CIP premia, and cheap forward dollars ( $\mathcal{F}_{kt} > \mathcal{E}_{kt}$ ).*

First, note that by Assumption 2 the unconditional expectations of the UIP premium is given by the local-currency interest rate differential:

$$\mathbb{E}\{\overline{UIP}_{kt}\} = \mathbb{E}\{R_{kt} - R_t^*\}. \quad (14)$$

If the exchange rate does not have a long-run drift, the long-run UIP premium is the reflection of the local-currency interest rate differential. By Proposition 2, this interest differential must equal

<sup>17</sup>In the case of persistent differences in inflation rates across countries, the assumption can easily be amended to  $\mathbb{E}\{\mathcal{E}_{kt}/\mathcal{E}_{k,t+1}\} \approx (1 + \pi^*)/(1 + \pi)$  where  $\pi$  and  $\pi^*$  denote respectively the local and US average inflation rates.

<sup>18</sup>Using daily supervisory reports covering FX positions of all large US banks, Moskowitz, Ross, Ross, and Vasudevan (2024) document bank-level net FX swap positions, i.e. the counterpart to  $\mathbb{S}_{kt}^*$  in our model, that are most negative and largest for the JPY (−\$5.4bn daily average) and most positive and largest for the AUD (\$1.3bn daily average), among the six major currencies reported. In addition, using regulatory data covering the universe of FX derivative transactions in the UK, Hacıoğlu-Hoke, Ostry, Rey, Rousset Planat, Stavlakeva, and Tang (2024) document that the net FX exposure through all forward, futures and swap contracts of the dealer bank sector, i.e. the counterpart to  $\mathbb{X}_{kt}^*$  in our model, is negative and large for EUR positions and negative but smaller for GBP positions. These facts are in line with the signs and magnitudes of the local-currency gaps by country that we document below in Table 2.

the compensation collected by the intermediary banks for their persistent currency-risk exposure reflected in  $\mathbb{Z}_{kt}^* = \mathbb{A}_{kt}^* + \mathbb{F}_{kt}^*$ , which is positive for countries with scarce local-currency funding ( $\mathbb{A}_{kt}^* > 0$ ) and high interest rates, and vice versa.

The local-currency funding gap similarly determines the off-balance sheet exposure,  $\mathbb{X}_{kt}^* = \mathbb{F}_{kt}^* + \mathbb{S}_{kt}^*$ , which by Assumption 3 is positive for countries with scarce local-currency funding ( $\mathbb{A}_{kt}^* > 0$ ), and vice versa. By Proposition 2, the associated intermediation requires a positive CIP premium:

$$CIP_{kt} = R_t^* - R_{kt} \frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} > 0 \quad \Rightarrow \quad \frac{\mathcal{F}_{kt}}{\mathcal{E}_{kt}} > \frac{R_{kt}}{R_t^*} > 1, \quad (15)$$

despite the high local-currency interest rate. Forward dollars are expensive in countries with a local-currency funding gap  $\mathbb{A}_{kt}^* > 0$ , a cross-sectional version of the forward premium puzzle. Note how conditions (14) and (15) differ from the frictionless benchmark in which the interest rate differential  $R_{kt}/R_t^*$  equals both the forward premium  $\mathcal{F}_{kt}/\mathcal{E}_{kt}$  and the expected (risk-neutral) currency depreciation.

Conversely, for countries with excess local-currency savings ( $\mathbb{A}_{kt}^* < 0$ ), the off-balance sheet exposure  $\mathbb{X}_{kt}^*$  is negative, which requires a negative CIP premium,  $CIP_{kt} < 0$ , and hence  $\mathcal{F}_{kt}/\mathcal{E}_{kt} < R_{kt}/R_t^* < 1$ . Forward dollars are cheap for currencies with excess local-currency savings. In both cases, the equilibrium forward rate compensates the intermediary banks with an appropriate CIP premium for their swap positions over and above the interest rate gap between the two currencies.

### 2.3.2 Dynamics of currency premia and exchange rates

The predictions of our modeling framework, as summarized in currency supply schedules (12)–(13), also have implications for currency premia dynamics:

1. Consider a small local-currency demand shock  $df_{kt}^*$  such that  $df_{kt}^* > 0$  corresponds to sales of local currency and purchases of dollars, whether spot or forward, with  $d\mathbb{Z}_{kt}^*/df_{kt}^* > 0$  and  $d\mathbb{X}_{kt}^*/df_{kt}^* > 0$ . These result in shifts along currency supply schedules such that:

$$d\overline{UIP}_{kt}/df_{kt}^* > 0 \quad \text{and} \quad dCIP_{kt}/df_{kt}^* = 0, \quad (16)$$

The CIP remains unchanged provided the change in  $df_{kt}^*$  is small enough not to affect the identity of the marginal bank leaving  $\bar{\delta}_{kt}$  unchanged in Proposition 2.<sup>19</sup>

2. Aggregate shocks to the (shadow) cost of intermediation  $d\mu_t > 0$  increase both UIP and CIP premia in absolute values:

$$d|\overline{UIP}_{kt}|/d\mu_t > 0 \quad \text{and} \quad d|CIP_{kt}|/d\mu_t > 0. \quad (17)$$

---

<sup>19</sup>Large aggregate shifts in currency demand may affect  $CIP_{kt}$  via changes in  $\bar{\delta}_{kt}$  when market clearing requires participation of additional intermediary banks with tighter constraints.

That is, both UIP and CIP premia must become more positive for investment currencies with  $\mathbb{A}_{kt}^* > 0$  that feature  $\mathbb{Z}_{kt}^* > 0$  and  $\mathbb{X}_{kt}^* > 0$ , and conversely must become more negative for funding currencies with  $\mathbb{A}_{kt}^*, \mathbb{Z}_{kt}^*, \mathbb{X}_{kt}^* < 0$ , corresponding to spanning out of both currency premia. Furthermore, since the UIP premium is increasing in the local-currency funding gap  $\mathbb{A}_{kt}^*$ , the impact of financial shocks  $\mu_t$  on the UIP premium is increasing in  $\mathbb{A}_{kt}^*$ , offering another testable implication which we write as follows:

$$d\overline{UIP}_{kt}/d\mu_t \propto \mathbb{A}_{kt}^*. \quad (18)$$

The same comparative dynamics as in (17) applies to shocks to  $\bar{\gamma}_{kt}/\mathbb{W}_{kt}^*$  for UIP premia and to shocks to  $\bar{\delta}_{kt}$  for CIP premia, both proxying for shocks to supply of currency intermediation.<sup>20</sup>

### 3 Empirical Results

We now turn to data to test the key empirical predictions resulting from Section 2. We first describe the data used to test these predictions, including the construction of UIP and CIP deviations, the data on FX dealers' futures position, and various measures of broad financing constraints. We then document, in turn, the cross-sectional and the dynamic properties of currency premia and exchange rates.

#### 3.1 Data

**UIP and CIP premia** Our sample consists of currencies for which we have empirical proxies for changes in intermediaries' net forward position. These are the G7+ advanced economies and 4 emerging market currencies.<sup>21</sup> To construct UIP and CIP premia with respect to the US dollar at monthly frequency for our sample currencies, we choose the horizon to be 3 months, which is the maturity with the most liquid forward markets and over which professional survey exchange rate forecasts are readily available. We follow the literature (Kalemli-Özcan and Varela, 2021) and use the monthly 3-month ahead exchange rate forecasts from Consensus Forecast surveys (Consensus Economics). For the interest rate component of the parities we also follow the literature and use 3-month money market interest rates or interbank deposit rates, depending on availability. Spot and forward exchange rates are taken as monthly averages of daily values. Further details on underlying data series and their descriptions are reported in Appendix Table A1.

<sup>20</sup>According to the model, changes in  $\bar{\gamma}_{kt}/\mathbb{W}_{kt}^*$  reflect time variation in the FX risk weight and intermediary's net worth while changes in  $\bar{\delta}_{kt}$  reflect shifts in the marginal intermediary's off-balance-sheet constraint. In practice, we expect these shifts to be highly correlated with the global financial and dollar cycles.

<sup>21</sup>The G7+ currencies are: Japanese Yen (JPY), Swiss Franc (CHF), Euro (EUR), British Pound (GBP), Canadian Dollar (CAD), Australian Dollar (AUS) in addition to the US dollar (USD) used as the base, plus New Zealand Dollar (NZD). The EM currencies are Mexican Peso (MXN), Brazilian Real (BRL), South African Rand (ZAR) and Russian Ruble (RUB).

Following the definitions of UIP and CIP premia in (3) and (8), where one-period ahead is 3 months, we measure the CIP premium, the realized UIP premium, and the survey-expected UIP premium as follows:

$$\begin{aligned} CIP_{kt} &= -(r_{kt} - r_t^{US}) + 4 \cdot \log(\mathcal{F}_{kt}/\mathcal{E}_{kt}), \\ UIP_{k,t+3} &= (r_{kt} - r_t^{US}) - 4 \cdot \log(\mathcal{E}_{k,t+3}/\mathcal{E}_{kt}), \\ \widehat{UIP}_{kt} &= (r_{kt} - r_t^{US}) - 4 \cdot \log(\widehat{\mathcal{E}}_{kt}/\mathcal{E}_{kt}), \end{aligned} \tag{19}$$

where  $r_{kt}$  is the net 3-month money market or deposit interest rate for currency  $k$ ,  $r_t^{US}$  is the corresponding US dollar interest rate, both annualized;  $\mathcal{E}_{kt}$  is the spot exchange rate in month  $t$  (in units of local currency  $k$  per US dollar),  $\mathcal{F}_{kt}$  is the 3-month outright forward exchange rate quoted in  $t$ , and  $\widehat{\mathcal{E}}_{kt}$  is the 3-month ahead consensus survey exchange rate forecast at  $t$ .<sup>22</sup> Thus, the final term in each equation in (19) measures an annualized depreciation rate — forward, realized, and forecasted, respectively. Note that, as in the theory, the direction of the CIP premium is measured “in reverse” to conform with the conventional basis definition.<sup>23</sup>

Appendix Figures A4 plots the UIP and CIP premia for G7+ currencies and MXN (as a typical EM for which we have the best data). Several stylized facts stand out: the UIP premium is several orders of magnitude larger than the CIP premium, both in level and in changes, especially for G7+ currencies. Among the G7+, the average monthly change in the expected UIP premium is 4.8 percent (480 bps) on average (in either direction), while it is only 4 basis points for the CIP premium. The UIP and CIP for MXN is more volatile than for G7+ currencies. Appendix Figure A6 further decomposes UIP and CIP premia into the interest differential versus the expected relevant exchange rate adjustment components, and in both cases most of the time-series volatility comes from the exchange rates and very little from the dynamics of interest rates.

**Dealer banks’ net FX futures position** We observe the net futures position of FX dealer banks in various currencies vis-à-vis the US dollar, from the CFTC’s *Traders in Financial Futures* (TFF) weekly report. The TFF report provides a weekly breakdown of the aggregate net long/short futures positions of every major currency traded on the Chicago Mercantile Exchange (CME) into the underlying positions of four institutional categories of large traders: Dealer/Intermediary, Asset Manager, Leveraged Funds, and Other (e.g., corporate treasurers and smaller banks). The first category is conventionally called the “sell side”, while the other categories represent the “buy side”. Such *sell-side* entities on FX futures markets are primarily represented by broker-dealer arms of major global banks such as Goldman Sachs, JP Morgan, Deutsche Bank, etc.<sup>24</sup>

<sup>22</sup>Note that we proxy the risk-neutral exchange rate expectation  $\widehat{\mathcal{E}}_{kt}$  defined in (8) using the survey exchange rate forecast in the data. We also use the realized UIP premium as an unbiased noisy proxy for the expected UIP premium in the tradition of Fama (1984) regression.

<sup>23</sup>As we have daily quotes for the outright forward rates as opposed to only monthly survey forecast, we are able to compute the CIP premium at higher frequency (weekly and daily) than the UIP premium (monthly).

<sup>24</sup>See the full list at <https://www.cmegroup.com/markets/fx/fx-futures-and-options-block-and-ofr-providers.html>.

The TFF complements and disaggregates the more well-known *Commitment of Traders Report* (COT) from the CFTC, which splits reportable futures positions instead according to two main trading motives: commercial (hedging) and non-commercial (speculative) traders. This breakdown is inherently uncertain, as a given trader can take position in the futures market for either hedging, speculating or market making on different occasions and across different organizational units within a firm. Instead, the TFF data that we use only relies on the position breakdown by trader type, irrespective of their trading motive.<sup>25</sup>

Although the CME is the largest FX futures market worldwide, the futures market itself makes up only a small share of the total FX derivative trade. A much larger volume of FX trade occurs through FX swaps and forwards. In recent years, however, trading volumes in CME-listed FX futures have grown significantly, especially for G7 currencies, becoming a major venue for FX price discovery.<sup>26</sup>

We scale the dealers’ net futures position by the size of the market measured by the total amount of open interest on the CME for a given currency:

$$f_{kt}^* = 100 \cdot \frac{\text{Dealer Net Position}_{kt}}{\frac{1}{12} \sum_{j=0}^{11} \text{Open Interest}_{k,t-j}}. \quad (20)$$

where the net position in the numerator is the difference between all dealers’ long and short positions and the open interest in the denominator is the sum of all long positions of every trader on the exchange (as each long position has a short position to clear). Dealer net positions are aggregated among the large dealers (around a dozen large banks for each currency who make up the Dealer/Intermediary classification) and measured in number of standardized contracts. The scaling in (20) makes our measure *unitless* (% of the market), eliminating a potential source of mechanical correlation with the exchange rate. We take the 12-month moving average of monthly open interest contracts in the denominator to capture the slow-moving trend growth in the market size. All empirical results hold if using a different horizon for the moving average or just the month-specific open interest, as most of the variation in  $\Delta f_{kt}^*$  comes from the net position in the numerator.

A positive value for  $f_{kt}^*$  means that dealer banks are long in the FX currency future and short the US dollar future, accommodating the opposite position of the market (composed, in turn, primarily of asset managers/institutional investors and hedge funds). Appendix Figure A5 plots the dealer net futures position by G7 currency. While we see that positions do co-move in tandem to some extent, likely driven by common shifts in dollar demand and other global factors, there is substantial currency-specific variation in net futures positions.

<sup>25</sup>A number of studies have used the non-commercial futures position in the COT report as a measure of speculative positioning in FX markets (see e.g. Brunnermeier, Nagel, and Pedersen, 2009; Tornell and Yuan, 2012; Hong and Yogo, 2012). Stavrageva and Tang (2020) note that the ‘Dealer/Intermediary’ category of the TFF closely maps, though is not identical to the legacy reports’ ‘commercial’ category.

<sup>26</sup>The 2022 BIS Triennial Survey reports that the average daily trading volume across all FX derivatives was \$5.4 trillion in April 2022 (compared to \$2 trillion in spot trading volume), of which \$3.8 trillion was in short-maturity FX swaps. Outright forwards made up \$1.2 trillion and exchange traded FX futures and options added around \$0.3 trillion to that total. The US dollar was on one side of around 90 percent of all FX trades. As of 2022, trading in FX futures overtook spot volumes traded on traditional primary electronic broker venues (see BIS, 2024).

Appendix Table A2 reports some summary statistics for the monthly change in dealer’s net futures position,  $\Delta f_{kt}^*$ , for all the currencies reported in the TFF. For the G7+ currencies the TFF reports go back to June 2006, providing us with 218 monthly observations per currency.<sup>27</sup> The monthly changes in dealer positions are large in absolute value: dealer banks are the key market makers and one standard deviation change in their net positions amounts to nearly 20 percent of the total futures market size for each currency. Furthermore, dealer banks change positions in either direction over time, from being short to long in any given currency against the dollar, and vice versa.

**Slope of the currency supply** Besides shifts in dealer banks’ currency positions (20), our model results also assign a potentially important role for variables that control the slope of the currency supply schedules in Proposition 2. These are variables that measure the marginal cost of dollar funding  $\mu_t$ , the net worth of dealer banks  $\mathbb{W}_t^*$ , the expected exchange rate volatility  $\sigma_{kt}^2$ , or the liquidity constraint parameters  $\bar{\gamma}_{kt}$  and  $\bar{\delta}_{kt}$ . In practice, empirical measures of these slope variables tend to be correlated. Higher dollar funding costs are often associated with more global risk aversion, larger implied volatility, lower bank net worth, and lower associated intermediation capacity (see e.g. Miranda-Agrippino and Rey, 2022; Avdjiev, Du, Koch, and Shin, 2019). The sample correlation matrix in Appendix Table A3 between common measures of these global financial cycle variables confirm the strong co-movement among them. These measures include the global financial cycle factor from Miranda-Agrippino and Rey (2022), the equity implied volatility index VIX, the intermediary net worth from He, Kelly, and Manela (2017), and the broad dollar index (i.e., the trade-weighted US dollar exchange rate from the Federal Reserve Board). We explore all of them in our empirical tests but rely on the VIX as our baseline proxy for  $\mu_t$  in the model due to its high-frequency availability and prior evidence of strong correlation with the global financial cycle (Rey, 2013).

### 3.2 Cross section of currency premia

We start our analysis with the cross-section of interest rate parity deviations. Table 2 ranks currencies in our sample by the average local-currency interest rate differential relative to the dollar,  $\bar{R}_k - \bar{R}^*$ , reported in column 2.<sup>28</sup> The Japanese yen and Swiss franc, as well as the Euro, feature lower average interest rates relative to the dollar, while other currencies have a higher average interest rate, especially commodity currencies — Australian and New Zealand dollars — and emerging market currencies, the latter countries reflecting in part both inflation and default risks in addition to currency risk.

<sup>27</sup>The Mexican Peso (MXN) is the only emerging market currency for which we have traders’ futures position from the TFF for the same sample period, and where trading activity and market depth are comparable to major G7 currencies. The TFF also reports futures position in the Brazilian Real (BRL) and the Russian Ruble (RUB) since April 2012, and for the South African Rand (ZAR) since May 2015 (albeit with numerous gaps and much lower trading volumes).

<sup>28</sup>The interest rate differentials are constructed using 3-month money market rates for most currencies. Whenever complete and comparable series for 3-month money market rates are not available throughout the sample period, we use 3-month deposit rates instead. See Table A1 for details.

Table 2: Currency premia by dollar funding gap (averages and standard deviations)

	(1) Funding gap, $\bar{A}_{kt}^*$	(2) Interest rate gap, $R_{kt} - R_t^*$	(3) Carry return $UIP_{k,t+1}$	(4) Survey UIP premium $\widehat{UIP}_{kt}$	(5) CIP premium $CIP_{kt}$
<u>Funding and Balanced</u>					
JPY	−31.53 (7.51)	−1.78 (1.71)	−7.07 (19.58)	−2.13 (9.42)	−0.22 (0.17)
CHF	−50.36 (23.51)	−1.39 (1.19)	−2.76 (18.10)	−3.12 (10.13)	−0.21 (0.21)
EUR	−2.61 (5.60)	−0.39 (1.32)	−0.60 (19.49)	−1.07 (9.74)	−0.20 (0.25)
GBP	−1.10 (5.64)	0.51 (1.26)	1.31 (18.18)	−1.48 (7.94)	−0.11 (0.17)
<u>Investment/Commodity</u>					
CAD	11.02 (6.30)	0.18 (0.75)	1.38 (15.92)	0.06 (7.30)	−0.05 (0.14)
AUD	24.12 (6.13)	2.02 (1.66)	9.02 (25.47)	−0.14 (12.63)	0.04 (0.17)
NZD	17.64 (8.19)	2.31 (1.55)	10.99 (24.94)	−1.98 (13.33)	0.09 (0.20)
<u>Emerging</u>					
MXN	3.83 (3.29)	4.69 (1.36)	14.58 (23.59)	4.07 (8.54)	−0.02 (0.69)
ZAR	1.87 (9.13)	5.71 (2.07)	18.71 (34.82)	2.18 (16.50)	0.40 (0.40)
RUB	−15.12 (9.36)	6.47 (4.41)	21.30 (33.80)	6.52 (9.62)	0.04 (3.09)
BRL	8.88 (8.11)	10.32 (3.33)	29.80 (34.46)	9.10 (12.20)	−1.42 (3.06)

Notes: The entries in the table are averages (standard deviations) of the respective country variables over sample period of January 2000 to December 2020 (shorter for MXN, RUB and BRL due to data availability for local-currency interest rates and exchange rate surveys).

Recall from Section 2.3 that the average local-currency funding gap  $\bar{A}_k^*$  summarizes the gap between local-currency investment needs and supply of savings and pins down the sign and magnitudes of UIP and CIP premia in steady state (Proposition 3). A country with a positive gap  $\bar{A}_k^* > 0$  needs foreign-currency funding to cover local-currency investment. Assuming this foreign-currency funding is mostly in US dollar, we can measure it as the negative of the external dollar asset gap, where the latter is defined as the difference between external dollar-debt assets and liabilities in percent of domestic GDP of a country.<sup>29</sup> We henceforth refer to this local-currency funding gap as the *funding gap*. Column 1 of Table 2 reports the average funding gap  $\bar{A}_k^*$ . There is a clear positive

<sup>29</sup>These data, constructed by Benetrix, Gautam, Juvenal, and Schmitz (2019) and updated by Allen and Juvenal (2024), are part of a comprehensive decomposition of external balance sheets across countries by major currencies, done at the annual frequency and available from 1990 to 2020. We focus on debt positions (as opposed to equity) as these require intermediation through currency markets and are subject to currency risk that requires partial hedging.

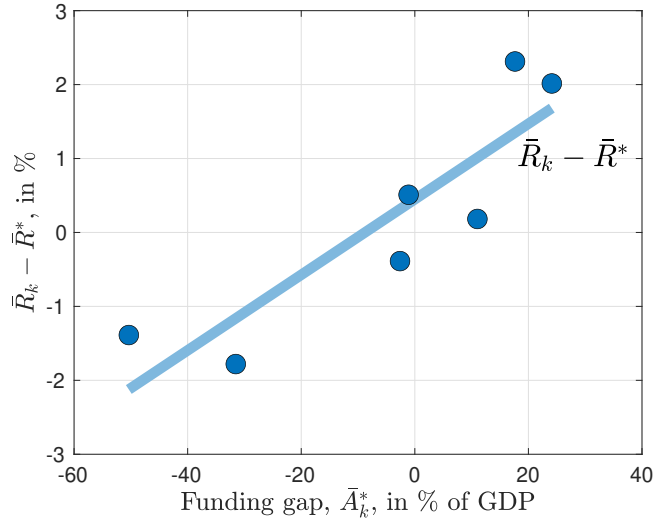


Figure 3: Cross section of average interest rate differentials against the funding gap

Note: The figure plots the local-currency interest rate differential  $\bar{R}_k - \bar{R}^*$  in % against the local-currency funding gap  $\bar{A}_k^*$  defined in the text; all variables are time-series averages for G7+ currencies.

correlation between the average funding gap  $\bar{A}_k^*$  and the average interest rate differential  $\bar{R}_k - \bar{R}^*$ . Currencies with a large funding gap feature high local-currency interest rates, and vice versa. We illustrate this pattern in Figure 3 for G7+ currencies and in Appendix Figure A7 for all currencies.

Countries with a positive funding gap and positive interest rate differentials feature positive average currency returns (average realized UIP deviations,  $\overline{UIP}_{k,+1}$ ), positive average expected survey-based UIP deviations ( $\widehat{UIP}_k$ ) and positive average CIP deviations ( $\overline{CIP}_k$ ), and vice versa, as we report in columns 3–5 of Table 2. The larger the average interest rate differential,  $\bar{R}_k - \bar{R}^*$ , the larger the UIP and CIP deviations. We illustrate these patterns in the two panels of Figure 4, both for G7+ currencies and for select EM currencies.<sup>30</sup>

Expected UIP deviations are large on the order of 200 basis points (2%) annualized and with a standard deviation over time an order of magnitude larger (10% annualized, reported in brackets in Table 2). In fact, average survey UIP deviations  $\widehat{UIP}_k$  line up closely to the 45°-line with the average interest rate differential,  $\bar{R}_k - \bar{R}^*$ , as depicted in the left panel of Figure 4. The average realized currency returns (UIP deviations)  $\overline{UIP}_{k,+1}$  are considerably larger – about five-fold – yet still exhibit a strong positive association with both expected UIP deviations and the average interest rate differential.

In contrast, CIP deviations on average are an order of magnitude smaller (20 basis points, or 0.2%, annualized, or less) and have a standard deviation over time of about the same magnitude (20 basis points). Note that the standard deviation can be considerably larger for EM currencies, and the conventional CIP deviations are measured less reliably for these currencies (see Dao and Gourinchas, 2025). Nonetheless, there is still a strong positive association between average CIP

<sup>30</sup>The average realized currency return is off the charts for Brazil (hence we do not show it in the left panel), and CIP deviations are too volatile for Brazil and Russia (hence we do not show them in the right panel). All numbers are reported in Table 2 and plotted in Appendix Figure A8.

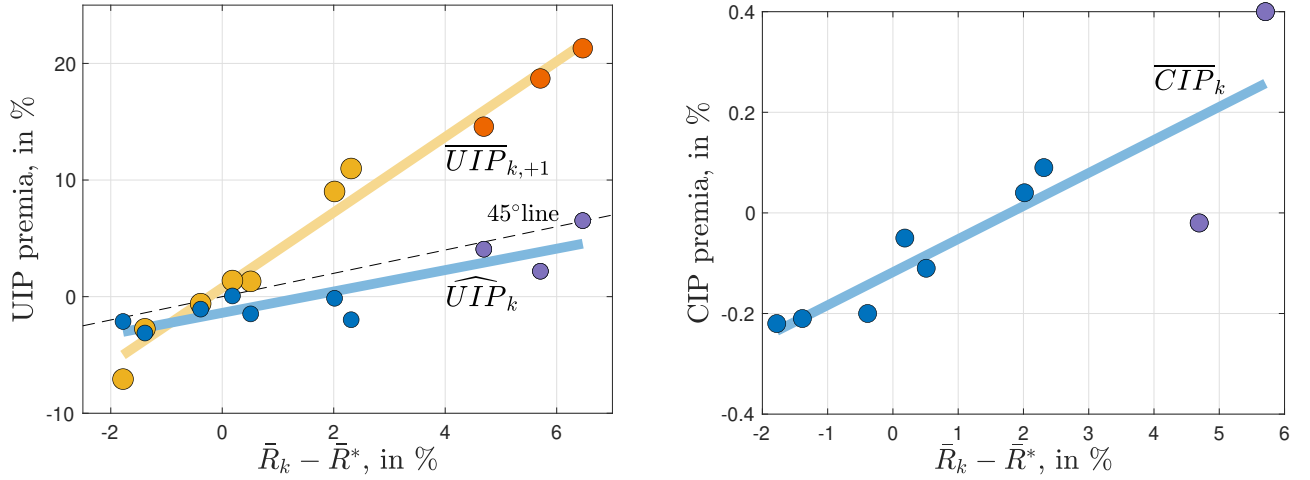


Figure 4: Cross section of the average UIP and CIP deviations against the interest rate differential

Note:  $\widehat{UIP}_k$  is the average expected (survey-based) UIP deviation and  $\overline{UIP}_{k,+1}$  is the average realized currency return. Currency premia and interest rate differentials are reported in %. The left panel shows results for G7+ currencies (blue and yellow dots) and MXN, ZAR and RUB (purple and orange dots); the right panel drops RUB due to highly volatile CIP wedge (see Table 2 and Appendix Figure A8).

deviations, average UIP deviations and the average interest rate differential, as illustrated in the right panel of Figure 4 and in Appendix Figure A8.

**Classification of currencies** Table 2 splits currencies in our sample into three groups. The first group contains Japanese yen (JPY) and Swiss franc (CHF) as *funding* currencies featuring a large negative funding gap (i.e., excess supply of local-currency savings) and Euro (EUR) and Great British pound (GBP) as *balanced* currencies featuring a more balanced supply of local-currency savings and small funding gaps. JPY and CHF have the lowest local-currency interest rates and the most pronounced negative UIP and CIP deviations. GBP and especially EUR behave, in our sample, in a similar way to funding currencies with negative CIP deviations and somewhat less pronounced negative UIP deviations and smaller interest rate gaps.

The other two groups contain Canadian, Australian and New Zealand dollars (CAD, AUD, NZD) as *investment/commodity* currencies featuring an excess demand for local-currency investment relative to the supply of local-currency savings and all *emerging market* currencies. Both groups feature high local-currency interest rates and generally positive UIP and CIP deviations. For investment currencies, the CIP deviations are typically small and UIP deviations occasionally flip sign. Over time, CAD becomes more of a balanced currency like EUR and GBP and, to a lesser extent, the same is true of AUD. NZD, however, remains a robust proxy for EM-currency premia among the G7+ currencies.

**Properties of the long-run equilibrium** The observations described above are in line with the theoretical predictions of Section 2.3 as summarized in Proposition 3. Funding currencies feature excess supply of local-currency savings ( $\mathbb{A}_k^* < 0$ ) and, vice versa, investment currencies feature an excess supply of local-currency investment ( $\mathbb{A}_k^* > 0$ ). This results in negative average interest rate

differentials in the former and positive average interest rate differential in the latter. The associated currency risk commands an expected UIP premium which is approximately equal to the interest rate differential. This prediction holds well in our sample for the expected survey-based UIP deviation that lines up closely with the average interest rate differential. In the long run the local-currency interest rate differential compensates for the currency-risk exposure arising from the currency’s average funding gap, acting as a limit on interest rate equalization across countries.

Investment in high-interest-rate currencies also creates demand to (partially) sell these currencies forward and eliminate the associated currency risk.<sup>31</sup> For funding currencies, this means selling dollars forward. For intermediaries to demand these forward dollars, they must be sufficiently cheap, i.e., the CIP premium must be negative: the forward premium must be smaller than the interest rate differential. Conversely, for investment currencies this means buying dollars forward. For intermediaries to supply these forward dollars, they must be sufficiently expensive, i.e., the CIP premium must be positive: the forward premium must exceed the interest rate differential. This results in a positive cross-sectional association between CIP deviations, UIP deviations, and local-currency interest rate differentials. As predicted in the theory Section 2.3, this is the reflection of the *forward premium puzzle* in the cross section: the forward premium does not predict an expected depreciation and instead ensures the required equilibrium CIP premium by more than offsetting the interest rate differential.<sup>32</sup>

### 3.3 Dynamics of currency premia

Having established the cross-sectional patterns of currency risk premia, we now turn to characterizing their dynamic properties.

**Empirical strategy** Guided by our theoretical framework, we estimate an equilibrium relationship between currency premia and exchange rate positions absorbed by intermediary banks. In our dynamic panel of currencies, we estimate the following distributed lag specification for various measures of currency premia  $v_{kt}$ :

$$\Delta v_{kt} = \theta_k + \theta_t + \sum_{j=0,1,2} \beta_j \Delta f_{k,t-j}^* + \gamma \Delta w_{kt} + \rho v_{k,t-1} + \epsilon_{kt}^v, \quad (21)$$

where  $\theta_k$  and  $\theta_t$  are currency and time fixed effects and  $w_{kt}$  are currency specific controls. For  $v_{kt}$ , we adopt the tri-monthly (quarterly) UIP premium  $\widehat{\Delta UIP}_{kt}$  using survey expectations of the future exchange rate, the ex post realized tri-monthly UIP deviation  $UIP_{kt,t+3}$ , and the tri-monthly CIP

<sup>31</sup>Hedging of FX risk is in many instances required by regulation or internal risk management, especially for banks and institutional investors (see [Du and Huber, 2024](#)).

<sup>32</sup>While our results here, as summarized in Figures 3–4, focused mostly on G7+ currencies, Appendix Figures A7–A8 extend the results to a broader sample with other advanced economies (G10+ currencies) and 15 emerging-market currencies using the purified measure of CIP from [Dao and Gourinchas \(2025\)](#).

premium  $CIP_{kt}$ , all annualized and expressed in log points, as defined in (19). In some specifications, we drop time fixed effects  $\theta_t$  and include aggregate time-series controls such as VIX and other variables that proxy for the overall financial conditions. The time interval is a month.

The key right-hand-side variable in our projection (21) is the currency-specific demand shifter as captured by the position of dealer banks relative to the size of the currency market,  $\Delta f_{kt}^*$ , defined in equation (20). An increase in  $f_{kt}^*$  implies that the dealer banks absorb currency  $k$  futures and sell dollars forward, and hence the rest of the currency  $k$  market demands dollars forward. This variable exhibits very persistent dynamics in the panel of currencies which we capture with the following estimated time-series process:

$$\Delta f_{kt}^* = \theta_k + \theta_t - \underset{[4.50]}{0.130} \cdot f_{k,t-1}^* + \underset{[5.20]}{0.183} \cdot \Delta f_{k,t-1}^* - \underset{[3.83]}{0.119} \cdot \Delta f_{k,t-2}^* + \epsilon_{kt}^f, \quad (22)$$

with  $|t|$ -stats reported in brackets, and with the standard deviation of innovation equal to 15.6.<sup>33</sup> We depict the impulse response of  $f_{kt}^*$  to its standardized innovation in the first panel of Figure 8 below, which shows a considerable amount of persistence with eventual mean reversion and a half-life of 6 months. The stationarity of  $f_{kt}^*$  is implied by the times-series process in (22), but would otherwise be hard to establish at conventional levels of statistical confidence, as we further discuss below.

Combining together our statistical model in (21) and (22), we are estimating the responses of currency premia  $v_{kt}$  projected on  $f_{kt}^*$  innovations, capturing shifts in currency demand, and controlling for shifters of currency supply  $w_{kt}$ . This specification emerges as the empirical *reduced-form* counterpart of the equilibrium UIP and CIP conditions (12) and (13). Appendix C provides a detailed exposition of our identification argument which we summarize here. The underlying assumption is that  $\Delta f_{kt}^*$  is an effective proxy for changes in the overall forward positions  $\Delta \mathbb{F}_{kt}^*$  of the intermediary bank sector, and hence in its hedged and unhedged currency exposure,  $\Delta \mathbb{X}_{kt}^*$  and  $\Delta \mathbb{Z}_{kt}^*$ . We can write an unobservable first-stage projection for  $\Delta \mathbb{Z}_{kt}^*$  as:

$$\Delta \mathbb{Z}_{kt}^* = \alpha_k + \eta_k \Delta f_{kt}^* + u_{kt}, \quad (23)$$

and similarly for  $\Delta \mathbb{X}_{kt}^*$ . This first stage must feature  $\eta_k > 0$  and a significant  $R^2$  for the implementable reduced-form specification (21) to have explanatory power, which we show is strongly the case in the data.

Intuitively, changes in the “Dealer/Intermediary” net position in a currency’s futures,  $\Delta f_{kt}^*$ , contain an important signal for the overall demand shift for that currency in the wider FX derivative and spot markets, which is ultimately intermediated by consolidated global banks. An increase in  $f_{kt}^*$  reflects a demand shock to buy dollars and sell currency  $k$  forward, i.e., an increase in  $\mathbb{F}_{kt}^*$  that forms part of both unhedged and hedged currency demand,  $\mathbb{Z}_{kt}^*$  and  $\mathbb{X}_{kt}^*$  in (12)–(13). This requires

<sup>33</sup>Some of the variation in  $\Delta f_{kt}^*$  is absorbed into time fixed effects, reflecting correlated multi-currency shocks. The time-series process for  $\Delta f_{kt}^*$  without absorbing time fixed effects is virtually the same, but with a larger standard deviation of innovation equal to 19.1. We check that additional lags in (22) are insignificant.

a greater supply of currency by intermediary banks that charge the respective currency premia, according to Proposition 2. Note that dealer banks typically pass on their excess net exposure to their affiliated parent banks via the OTC market to maintain a hedged balance sheet as required by regulation (see Appendix Figure A2). Therefore, the levels of  $f_{kt}^*$  can be systematically different from the levels of  $\mathbb{Z}_{kt}^*$  and  $\mathbb{X}_{kt}^*$ , but all we require is that  $\Delta f_{kt}^*$  systematically correlates with  $\Delta \mathbb{F}_{kt}^*$ , and hence with  $\Delta \mathbb{Z}_{kt}^*$  and  $\Delta \mathbb{X}_{kt}^*$ .<sup>34</sup>

Given the unobserved first stage (23), our specification (21) projects currency premia (i.e., prices) on the proxy for innovations in the currency exposure of global banks (i.e., quantities). This is, of course, not a structural equation and cannot be used to infer structural supply elasticities. However, as we show in Appendix C, when regression (21) features a high  $R^2$ , our proxy  $\Delta f_{kt}^*$  for intermediary sector currency exposure must be capturing well the overall shifts in currency  $k$  demand that shape equilibrium currency premia. These innovations are not specific proxies for structural currency demand shocks — such as macroeconomic news or financial shocks. Instead, they isolate the equilibrium comovement between currency exposure of intermediaries and market premia, which are related via currency supply schedules in Propositions 2.

**Dynamics of currency premia** We start with the pooled sample of G7+ currencies and report the results in Table 3 for survey-expected UIP premium, realized UIP premium, and CIP premium. We find a strong contemporaneous response and ensuing mean reversion for both survey-expected and realized UIP premia, and no response of the CIP premium to the shock to dealer positions in the futures market  $\Delta f_{kt}^*$ . These results are consistent with Proposition 2. The effect on the UIP premium is large and statistically significant (with  $t$ -stats of 12 or more). A one standard deviation innovation in  $\Delta f_{kt}^*$  (equal to 15.6) is associated with a nearly 300 basis point increase in both UIP premia (or 400 basis points if time fixed effects are not absorbed). Interestingly, the expected survey UIP provides a very accurate prediction for the realized UIP deviation in projection on the dealer positions shock, and for this reason in what follows we focus on the survey-based measure of the UIP premium.

The explained variation of survey UIP premium is  $R^2 = 0.466$  before including time fixed effects and increases to  $R^2 = 0.705$  after including time fixed effects. In contrast, most variation in CIP premia in the panel of currencies is absorbed by time fixed effects. While UIP premia are two orders of magnitude more volatile (recall standard deviations in Table 2), the CIP premia exhibit more persistence and are driven by aggregate (rather than currency-specific) shocks. This is again in

<sup>34</sup>The specific assumptions behind this argument are as follows. First, futures and forwards are highly substitutable instruments, hence, shifts in demand for futures likely correlate with broad shifts in currency demand. While we observe positions of dealer banks, who are market makers and are known to have largely hedged FX positions, changes in futures positions of dealer banks are informative of the shifts in the broad currency exposure of international intermediary banks via the OTC forward market. This is because any net position of the broker-dealer subsidiary ultimately is intermediated by the consolidated bank, which prices funding costs across currencies and allocates positions across affiliated entities (see Rime, Schrimpf, and Syrstad, 2022). Second, international intermediary banks do not fully offset their OTC forward exposure in the spot market and/or the swap market. Specifically, their spot exposure is slower moving reflecting the evolution of the macroeconomic local-currency savings gaps, while swap exposure tends to correlate positively with the forward exposure (see Correa, Du, and Liao, 2020; Moskowitz, Ross, Ross, and Vasudevan, 2024, and Appendix C).

Table 3: UIP and CIP premia in the G7+ panel of currencies

Dep. var $\Delta v_{kt}$ :	$\Delta \widehat{UIP}_{kt}$		$\Delta UIP_{kt,t+3}$		$\Delta CIP_{kt}$	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta f_{kt}^*$	0.203*** [16.61]	0.171*** [15.35]	0.226*** [12.15]	0.189*** [11.83]	-0.0000 [0.01]	-0.0000 [0.06]
$\Delta f_{k,t-1}^*$	-0.059*** [5.03]	-0.053*** [5.31]	0.000 [0.02]	-0.002 [0.13]	-0.0004 [1.57]	0.0002 [1.07]
$\Delta CIP_{kt}$	-6.753*** [3.33]	0.491 [0.15]	-11.660*** [3.19]	-2.432 [0.95]		
$\Delta \widehat{UIP}_{kt}$					-0.0018** [2.82]	0.0002 [0.19]
$v_{k,t-1}$	-0.462*** [10.57]	-0.499*** [9.26]	-0.144*** [5.48]	-0.193*** [7.11]	-0.264*** [8.01]	-0.272*** [4.64]
Observations	1, 512	1, 512	1, 498	1, 498	1, 512	1, 512
# currency FE	7	7	7	7	7	7
Time FE		✓		✓		✓
Within $R^2$	0.466	0.705	0.238	0.630	0.148	0.545

Note: Estimated specification (21) with and without time fixed effects;  $|t|$ -stats in brackets are computed using Driscoll-Kraay standard error that are robust to heteroscedasticity, autocorrelation up to 12 lags and cross-panel correlation in the residuals. All regressions additionally include  $\Delta f_{k,t-2}^*$  that in all cases are estimated to be close to zero and insignificant. \*\*\* (\*\* and \*) denotes statistical significance at the 1-percent (5-percent and 10-percent) level.

line with Proposition 2, which suggests that changes in CIP should come not from idiosyncratic currency flows, but from broader financial conditions captured by  $(\bar{\gamma}_k \mu_t, \bar{\delta}_k \mu_t)$ . Indeed, most of the  $CIP_{kt}$  variation in the panel is captured by common shocks across all currencies.

Table 3 also reveals that, despite the lack of CIP response to dealer positions, there is a negative comovement between UIP and CIP premia at monthly frequency.<sup>35</sup> Note that this contrasts with the positive comovement between the two premia apparent in the cross-section of currencies in Table 2 and Figure 4. Recall from the definitions in (3) that the two premia are measured “in reverse”, with the positive UIP premium coming with a high expected (or realized) return on currency  $k$ , while the positive CIP premium comes from a relative low *covered* returned on currency  $k$ . The former premium comes with the exposure to currency  $k$  depreciation risk, while the latter is the premium for giving up the currency  $k$  expected return when currency risk is hedged. This explains the positive comovement between the two premia in the cross section.

In the time-series, in contrast, the periods of unusually high currency  $k$  UIP premia are also periods of unusually high hedged return on currency  $k$ , and vice versa. We investigate the source of this negative comovement further below, but note here that it fully disappears when time fixed effects are included in the specification in Table 3. With time fixed effects, there is no longer any

<sup>35</sup>Quantitative, however, CIP premia moves roughly 1-to-2 orders of magnitude less: a hundred basis points increase in the survey UIP premium comoves with a reduction in the CIP premium of only 0.2 basis points. Conversely, using UIP regressions, 10 basis point increase in the CIP premium is associated with a 68 basis points reduction in the survey UIP premium and a 117 basis points reduction in the realized UIP premium.

Table 4: Decomposition of UIP and CIP premia responses

Dep. var:	(1) $\widehat{\Delta UIP}_{kt}$	(2) $\Delta CIP_{kt}$	(3) $4 \cdot \Delta \log \mathcal{E}_{kt}$	(4) $4 \cdot \Delta \log \mathcal{F}_{kt}$	(5) $4 \cdot \Delta \log \widehat{\mathcal{E}}_{kt}$	(6) $\Delta \log(R_{kt}/R_t^*)$
$\Delta f_{kt}^*$	0.171*** [15.47]	0.0000 [0.34]	0.227*** [23.18]	0.225*** [22.87]	0.055*** [7.77]	-0.0005** [2.64]
$\Delta f_{k,t-1}^*$	-0.052*** [5.38]	0.0003 [1.39]	-0.048** [3.04]	-0.048** [3.10]	0.004 [0.23]	-0.0004 [1.26]
Observations	1,512	1,512	1,512	1,512	1,512	1,512
# currency FE	7	7	7	7	7	7
Time FE	✓	✓	✓	✓	✓	✓
Within $R^2$	0.705	0.545	0.690	0.690	0.767	0.672

Note: The table decomposes the responses of survey UIP and CIP premia into their individual components: spot and forward exchange rates, 3-month-ahead survey exchange rate expectations, tri-monthly interest rate differential; all variables are annualized (multiplied by 4) to be consistent with definitions of UIP and CIP premia. All regressions are in monthly changes and additionally include  $\Delta f_{k,t-2}^*$  (always insignificant) and  $\widehat{UIP}_{k,t-1}$  and  $CIP_{k,t-1}$  to account for mean reversion, but do not include  $\Delta CIP_{kt}$  or  $\widehat{\Delta UIP}_{kt}$  as regressors (in contrast with columns 2 and 6 of Table 3).  $|t|$ -stats in brackets are computed using Driscoll-Kraay standard errors that are robust to heteroscedasticity, autocorrelation up to 12 lags and cross-panel correlation; stars denote statistical significance as above.

significant time-series comovement between currency-specific CIP and UIP premia. In other words, the time-series comovement between UIP and CIP is not currency specific, but instead is driven by broad financial and currency market conditions.

**Decomposition of currency premia** Table 4 provides the decomposition of the UIP and CIP premia responses into their individual components: spot and forward exchange rates, survey exchange rate expectations (3-month ahead), and tri-monthly interest rate differentials. Column (1) and (2) of Table 4 reproduce approximately columns (2) and (6) of Table 3.<sup>36</sup> By construction, we have an exact decomposition such that the coefficients satisfy the following aggregation by columns: (1) = (3) - (5) + (6) and (2) = (4) - (3) - (6).

Recall that the change in the dealers currency position  $\Delta f_{kt}^*$  is associated with a large and significant effect on the UIP premium, but not on the CIP premium. We now can trace it to the individual components of these premia. Both premia share the interest rate differential, which effectively remains unchanged with a movement in  $\Delta f_{kt}^*$  (or, more precisely, declines by less than 1 basis point in response to a one standard deviation increase in  $\Delta f_{kt}^*$ ). In contrast, both spot and forward exchange rates depreciate very strongly with an increase in  $\Delta f_{kt}^*$  (by 350 basis points when annualized) and perfectly in-sync, explaining the lack of any change in the CIP premium. The movement in spot exchange rate is stronger than the response of the UIP premium (by 270 basis points) as the survey expected exchange rate 3 months ahead also depreciates but by a considerably smaller amount.

<sup>36</sup>The slight difference of the specifications is the exclusion of  $\Delta CIP_{kt}$  or  $\widehat{\Delta UIP}_{kt}$  as regressors (which were insignificantly different from zero in Table 3) and the inclusion of both  $\widehat{UIP}_{k,t-1}$  and  $CIP_{k,t-1}$  as controls in each specification to allow for exact decomposition.

To summarize, much of the movement in UIP premium comes from the on-impact change in the spot exchange rate, and not from the interest rate. This is in contrast with the cross-sectional pattern documented in Table 2 and Figure 4) where the survey UIP premium reflects the interest rate differential nearly one-to-one (cf. Hassan and Mano, 2018). Furthermore, the absence of the dynamic response of the CIP premium is not due to a lack of the exchange rate adjustment, but instead due to synchronized spot and forward depreciations that fully offset each other keeping CIP premium stable (and generally non-zero, as described in Table 2).

**Currency premia for individual currencies** In Table 5, we zoom in on the responses of survey UIP and CIP premia for individual currencies. In doing so, we also incorporate controls for broad financial and currency market conditions. We use log changes in the VIX as the proxy for global financial cycle (overall financial market conditions) and log changes in the broad dollar index as proxy for the global dollar cycle. We focus on the G7+ currencies (which we had in our panel specification) plus MXN, and report results for other EM currencies with sparser data in Appendix Table A4.

We make the following observations about the response of UIP and CIP premia in panels A and B of Table 5, respectively. First, the effects of dealers' position  $\Delta f_{kt}^*$  on expected UIP premia are remarkably consistent across currencies, including EM currencies. The  $t$ -stats on  $\Delta f_{kt}^*$  vary from 5 to 8 for G7+ currencies even when we control for the changes in the broad dollar index and VIX. Dealer positions together with the broad dollar and the VIX explain between 53% and 67% of the variation in currency-specific UIP premia. This is quite a remarkable fit given the large amount of seemingly idiosyncratic variations in UIP deviations.

In stark contrast, the variation in the dealers' futures positions,  $\Delta f_{kt}^*$ , is robustly irrelevant for the variation of CIP premia, with rather precisely estimated coefficients of zero for every currency.<sup>37</sup> However, VIX and, especially, the broad dollar co-move significantly with CIP premia for most currencies. Still, these variables, together with the lagged level of the CIP premium, explain only about 20% of the variation in currency-specific CIP premia (contrast with the high  $R^2$  in Table 3 in the panel with time fixed).

These observations are in line with the predictions of our model as illustrated in Figure 2. Typical month-to-month shifts in currency demand are translated into corresponding changes in UIP premia required for intermediation by global banks, due to movements up (or down) along their 'unhedged' currency supply schedule in the left panel of the figure. At the same time, there are no such effects on CIP premia, which remain stable despite movements in UIP, as local month-to-month demand shifts are accommodated along the same flat portion (step) of the 'hedged' currency supply schedule in the right panel of the figure.

Our second observation from Table 5 is that the co-movement with VIX is clearly differentiated

<sup>37</sup> At higher frequency, using weekly data, we find some statistically significant association between dealers' positions  $\Delta f_{kt}^*$  and  $\Delta CIP_{kt}$ , but these effects are small both quantitatively and statistically (in terms of  $R^2$ ); see Appendix Table A8.

Table 5: CIP and survey UIP premia for individual currencies

	(1) JPY	(2) CHF	(3) EUR	(4) GBP	(5) CAD	(6) AUD	(7) NZD	(8) MXN
Panel A: Dependent variable $\Delta \widehat{UIP}_{kt}$								
$\Delta f_{kt}^*$	0.191*** [8.07]	0.113*** [5.05]	0.252*** [5.33]	0.153*** [6.49]	0.107*** [6.71]	0.162*** [5.46]	0.166*** [8.19]	0.075*** [3.55]
$\Delta \log VIX_t$	-0.103*** [3.21]	-0.068** [2.06]	-0.017 [1.19]	0.048** [2.17]	0.079*** [6.41]	0.154*** [5.32]	0.117*** [6.19]	0.089*** [2.77]
$\Delta \log \mathcal{E}_t^{USD}$	1.506*** [4.04]	1.827*** [4.84]	2.119*** [9.71]	1.446** [3.99]	1.804*** [5.84]	1.410** [3.51]	1.687*** [3.74]	1.917*** [4.02]
Panel B: Dependent variable $\Delta CIP_{kt}$								
$\Delta f_{kt}^*$	-0.0004 [0.93]	0.0004 [0.86]	-0.0006 [0.67]	0.0003 [0.74]	0.0008 [1.59]	0.0000 [0.14]	0.0001 [0.25]	-0.0011 [0.59]
$\Delta \log VIX_t$	-0.0015*** [2.79]	-0.0014* [1.95]	-0.0012** [2.23]	-0.0004 [1.00]	0.0001 [0.32]	0.0006 [0.81]	0.0009* [1.86]	0.0005 [0.27]
$\Delta \log \mathcal{E}_t^{USD}$	-0.0228** [2.16]	-0.0158 [1.31]	-0.0250** [2.26]	-0.0192** [2.00]	-0.0199*** [3.71]	-0.0240*** [4.02]	0.0002 [0.02]	0.0735* [1.82]
Observations	216	216	216	216	216	216	216	216
$R^2$ for $\Delta \widehat{UIP}_{kt}$	0.560	0.539	0.623	0.570	0.671	0.629	0.568	0.529
$R^2$ for $\Delta CIP_{kt}$	0.293	0.270	0.265	0.165	0.287	0.197	0.237	0.198

Note: Regressions extend specification in columns (1) and (5) of Table 3 and run them for individual currencies additionally including controls for the change in the broad dollar index and in the log VIX. All regressions include two lags of  $\Delta f_{kt}^*$  and the lagged level of the dependent variable, as well as controls for either  $\Delta CIP_{kt}$  or  $\Delta \widehat{UIP}_{kt}$ , as in Table 3, omitted for brevity.  $|t|$ -stats in brackets are computed using Newey-West standard errors robust to residual autocorrelation of up to 12 lags; stars denote statistical significance as above.

across currencies — with funding currencies (JPY, CHF and to a lesser extent EUR) experiencing a reduction in UIP and become more negative, while all other currencies (investment and EMs, and to a lesser extent GBP) see an increase in their positive UIP premia with higher VIX. To be more precise, we find that the estimated impact of VIX on UIP premium varies continuously from negative to positive as we go from the largest negative funding gaps (JPY and CHF) to the largest positive funding gaps (AUD and NZD, as well as MXN), with highly significant estimates in each case but the EUR, where the effect happens to be close to a precise zero (as expected for a currency with *balanced* local-currency funding). For CIP premia, the pattern of comovement with the VIX is similar to that of UIP premia: increases in VIX tend to make CIP premia more negative for funding currencies and more positive for investment, commodity and EM currencies.<sup>38</sup>

These patterns are again consistent with the prediction of the theory. Changes in the broad financial conditions affect supply schedules in the currency market, which in turn is reflected in both UIP and CIP premia (the effect of  $\mu_t$  in Proposition 2). The widening of both UIP and CIP premia across currencies in response to the tightening of general financial conditions, as proxied by VIX,

<sup>38</sup>In other words, with higher VIX, forward dollars become even cheaper relative to spot dollars for the funding currencies and even more expensive relative to spot dollar for investment currencies (recall the discussion of the forward premium following Table 2 in the end of Section 3.2).

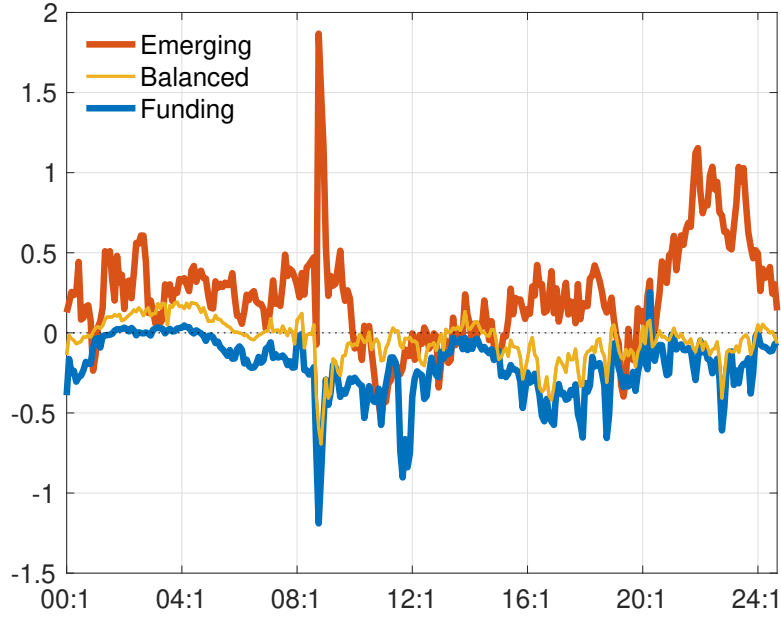


Figure 5: CIP premia by currency bins

Note: Monthly dynamics of CIP deviations for three bins of currencies: ‘funding’ bin is the average of JPY, CHF, EUR; ‘emerging’ bin is the average of NZD, MXN, ZAR; ‘balanced’ bin is the average of GBP, CAD, AUD.

is consistent with the theoretical prediction summarized in (17). Furthermore, theory predicts that this differential impact of the global financial cycle on currency premia stems from countries’ local-currency savings-investment imbalance as captured by the funding gap  $\bar{A}_k^*$ , recall (18). Signs and magnitudes of the long-run currency premia are shaped by  $\bar{A}_k^*$  (Table 2), and they expand proportionally when financial conditions tighten. We further confirm this prediction in Appendix Tables A6 and A7 where we interact  $\bar{A}_k^*$  with VIX and a variety of other proxies for broad financial conditions (namely, global FX dealer wealth, global financial cycle factor, and short-term dollar funding spreads), and show that these interaction terms have an important predictive effect for the response of both currency premia in a G7+ panel.

Finally, unlike with VIX, the co-movement of UIP premia with the broad dollar are remarkably similar across currencies — with the broad dollar appreciation associated with increasing UIP premia (i.e., UIP premia becoming more positive or less negative) for every currency. Similarly, the broad dollar tends to comove strongly and negatively with CIP premia for most G7+ currencies, with the exception of NZD (as well as MXN). Interestingly, the negative comovement between UIP and CIP premia for individual currencies, which we observed in Table 3, effectively disappears once we control for the broad dollar and the VIX.<sup>39</sup> Broad dollar appreciations likely capture both general shifts in demand towards the dollar (like the common component of all  $\Delta f_{kt}^*$ , but additionally via shifts in demand for dollar swaps, see Ivashina, Scharfstein, and Stein, 2015), as well as the general tightening of financial conditions (like an increase in VIX), which complicates the interpretation of the response to this shock.

<sup>39</sup>The two premia still comove negatively only for CHF and the effects are statistically negligible for other G7+ currencies, while the comovement is weakly positive for MXN. These results are omitted from Table 5 for brevity.

To conclude, unlike UIP, CIP premia do not feature significant month-to-month variation idiosyncratic to shifting demand for individual currencies. Instead, CIP premia feature pronounced and persistent lower-frequency movements associated with the global financial (and dollar) cycle. Figure 5 provides an effective summary of much of the monthly CIP dynamics in the panel of currencies. It averages CIP deviations for JPY, CHF and EUR to form the ‘funding’ bin and those for NZD, MXN and ZAR to form the ‘emerging’ bin. The remaining G7 currencies (GBP, CAD, AUD) form the ‘balanced’ bin. The figure reveals a very stark pattern: CIP premia for funding currencies are negative and small most of the time, but occasionally spike downwards during global cycles. CIP premia for emerging markets are a mirror image of this with larger positive CIP deviations and more volatile spikes upwards. The balanced currencies are in between, with their CIP premia close to zero in normal times and occasionally spiking downwards together with funding currencies, and this comovement with funding currencies intensifies towards the end of our sample. Since emerging MXN and ZAR were not in our pooled G7+ panel in Table 3, this explains why time fixed effects have such a high explanatory power in the panel of G7+ CIP premia, where only NZD systematically breaks ranks.

### 3.4 Exchange rate dynamics

The previous section established that the relationship between dealer positions and currency premia is supported by the contemporaneous adjustment in exchange rates, with the spot and forward exchange rates responding in lock-step (Table 4). We now focus on the dynamic relationship between dealer positions and spot exchange rates. We first illustrate the robust relationship across currencies between  $\Delta f_{kt}^*$  and  $\Delta \log \mathcal{E}_{kt}$  using a scatter plot in Figure 6. The raw pooled correlation is 0.6 for G7+ currencies and highly statistically significant.

We unpack this correlation further by estimating the following dynamic projection for individual currencies (including MXN):

$$\Delta \log \mathcal{E}_{kt} = \theta_k + \sum_{j=0,1,2,3} \Delta f_{k,t-j}^* + \gamma_k \Delta w_{kt} + \rho_k \log \mathcal{E}_{k,t-1} + \epsilon_{kt}^e, \quad (24)$$

where  $w_{kt}$  include conventional variables used in exchange rate regressions including the interest rate differential  $i_{kt} - i_t^*$ , the Treasury basis, and the VIX. The Treasury basis is computed as the difference between the 12-month US Treasury yield and the average of 12-month Treasury yields in G10 currencies swapped into dollar using the corresponding 12-month forward exchange rate. We use this variable in the exchange rate regressions instead of the broad dollar to capture shocks to dollar safe asset demand but avoid the mechanical correlation due to major currencies’ weights in the broad dollar index. We also report the results in the panel of G7+ currencies with and without time fixed effects.<sup>40</sup>

<sup>40</sup>We obtain consistent results for emerging market currencies, reported in Appendix Table A5, even though their FX futures markets are shallower and data on dealer futures positions sparser.

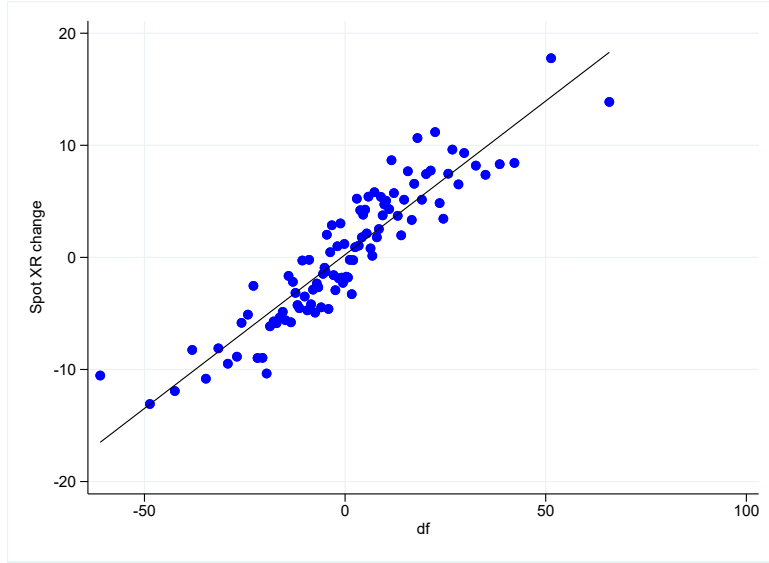


Figure 6: Dealer positions and exchange rate changes: scatter plot of  $\Delta \log \mathcal{E}_{kt}$  against  $\Delta f_{kt}^*$

Note: The figure is a raw scatter plot of exchange rate changes  $\Delta \log \mathcal{E}_{kt}$  against changes in dealer positions  $\Delta f_{kt}^*$  with all G7+ currencies pooled together and all currency-months observations binned into 100 bins based on realizations of  $\Delta f_{kt}^*$  and the corresponding  $\Delta \log \mathcal{E}_{kt}$  averaged within every bin producing the dots in the plot.

We report the results in Table 6. There is a strong contemporaneous response of the spot exchange rate to the dealer position shock for every currency, with  $t$ -stats around 10 and ranging from 4.0 for MXN and 7.6 for GBP at the lower end to 12.6 for CHF and 15.9 for NZD at the higher end. An increase in dealers' currency  $k$  position, representing a shift in the market demand away from currency  $k$  towards the dollar, is associated with a quantitatively strong contemporaneous depreciation of currency  $k$ . The magnitudes of the coefficients are remarkably consistent across currencies. For a one standard deviation innovation in individual  $\Delta f_{kt}^*$ , currency  $k$  depreciates by around 1.3%, ranging from 0.9% for MXN and CAD to 1.3% for JPY and CHF and 1.6% for NZD. After absorbing time fixed effects in a panel of G7+ currencies, a one standard deviation innovation to dealer currency positions is associated with a 0.9% depreciation of the currency against the dollar.

Furthermore, these exchange rate movements are very persistent, exhibiting virtually no exogenous mean reversion as reflected in  $\hat{\rho}_k \approx 0$  estimates on the lagged exchange rate for all  $k$  in Table 6. All mean reversion in the exchange rate response comes from mean reversion in the dealer positions. Recall that our estimated specification (22) implies a half-life of 5 or 6 months for a shock to  $f_{kt}^*$ , and a corresponding half-life of 6 or 8 months for the exchange rate in the panel of G7+ currencies, for the specification with or without time fixed effects, respectively. For individual currencies, the half-lives vary from 6 to 13 months across currencies, and it is  $\infty$  for GBP (see the last line in Table 6).<sup>41</sup>

The statistical model (24), as estimated in Table 6, accounts for 45 to 60% of the variation in spot exchange rate changes for individual currencies, as well as in the pooled panel (and 70% with time fixed). The combined explained variation is due to the dealer positions as well as the more

<sup>41</sup>Note that specification (22) imposes stationarity. An alternative specification in changes implies no mean reversion in  $f_{kt}^*$  and, therefore, no mean reversion in the exchange rate.

Table 6: Spot Exchange Rates

Dep.var: $\Delta \log \mathcal{E}_{kt}$	JPY (1)	CHF (2)	EUR (3)	GBP (4)	CAD (5)	AUD (6)	NZD (7)	MXN (8)	G7+ Panel	
									(9)	(10)
$\Delta f_{kt}^*$	0.071*** [9.04]	0.061*** [12.65]	0.103*** [9.71]	0.060*** [7.63]	0.050*** [11.63]	0.062*** [11.79]	0.069*** [15.87]	0.045*** [4.00]	0.068*** [26.81]	0.056*** [26.48]
$\Delta f_{k,t-1}^*$	0.006 [0.97]	-0.005 [1.17]	0.007 [0.98]	-0.005 [1.16]	-0.003 [0.54]	0.004 [0.55]	-0.002 [0.46]	0.006 [0.86]	-0.002 [0.50]	-0.006 [1.54]
$\Delta f_{k,t-2}^*$	0.015** [2.21]	0.018*** [5.11]	0.027*** [4.35]	0.004 [0.90]	0.003 [0.73]	0.008 [1.04]	0.015*** [2.71]	0.010 [1.65]	0.013*** [4.61]	0.010*** [3.94]
$\Delta(i_{kt} - i_t^*)$	-1.739** [2.31]	-0.004 [0.00]	-2.906*** [3.14]	-2.875*** [3.95]	-2.942*** [3.72]	-3.793*** [3.60]	-2.908*** [4.46]	-1.362 [1.59]	-2.563*** [4.40]	-2.887** [2.09]
$\Delta T\text{-basis}_t$	0.851 [1.00]	-1.802* [1.90]	-1.533 [1.55]	-1.052 [1.31]	-2.591*** [2.78]	-3.104*** [3.24]	-2.089** [2.03]	-3.336*** [2.43]	-1.608*** [2.91]	
$\Delta \log VIX_t$	-0.014* [1.68]	-0.004 [0.44]	-0.006 [0.72]	0.001 [0.18]	0.010* [1.86]	0.034*** [4.07]	0.019** [2.17]	0.034** [2.40]	0.005 [0.97]	
$\Delta \log W_t^*$	0.011 [0.44]	-0.030 [1.64]	-0.074*** [5.31]	-0.098*** [3.26]	-0.086*** [4.17]	-0.084*** [3.16]	-0.104*** [2.82]	-0.115*** [2.81]	-0.067*** [3.79]	
$\log \mathcal{E}_{k,t-1}$	0.007 [0.84]	-0.017 [1.58]	0.017 [1.50]	-0.002 [0.17]	-0.002 [0.18]	0.004 [0.39]	-0.004 [0.36]	-0.005 [0.66]	-0.001 [0.09]	-0.009 [1.27]
Observations	209	209	209	209	209	209	209	209	1,463	1,463
# currency FE									7	7
Time FE										✓
$R^2$	0.450	0.436	0.473	0.485	0.592	0.606	0.607	0.444	0.464	0.700
Due to $\Delta f_{kt}^*$ :										
share of $R^2$	0.812	0.890	0.686	0.636	0.515	0.416	0.628	0.352	0.776	0.602
std of innovation (%)	1.32	1.30	1.16	1.09	0.93	1.23	1.61	0.91	1.29	0.87
half-life (months)	8	6	∞	6	6	13	6	7	8	6

Note: Dependent variable is the monthly log change in the nominal exchange rate versus the dollar.  $|t|$ -stats in brackets of columns 1–8 computed using Newey–West standard errors robust to residual autocorrelation up to 12 lags;  $|t|$ -stats in columns 9–10 computed using Driscoll–Kraay standard errors, robust to heteroscedasticity, autocorrelation up to 12 lags, and cross-panel correlation in the residuals.

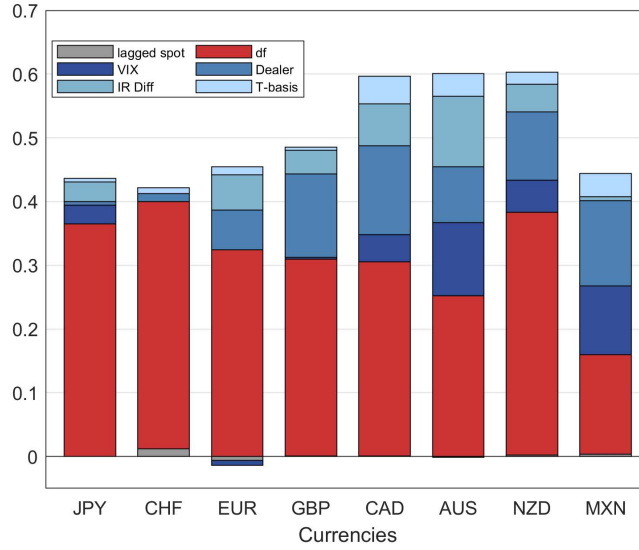


Figure 7: Exchange rate regressions (24): contributions to  $R^2$  by regressor

Note: Bars show the decomposition of  $R^2$  of regressions in Table 6 into the respective contributions of individual regressors by currency (see text and footnote 42).

conventional variables that correlate with the exchange rate. Changes in the interest rate differential have a strong association with exchange rate appreciations for all currencies but CHF and MXN.

The Treasury basis has a negative effect on exchange rates — a reduction in the basis captures increased demand for dollar safe assets and associated depreciation of other currencies — which increases in magnitude and significance as we move from funding toward investment currencies (from left to right in Table 6). This is consistent with the results in the literature (see [Jiang, Krishnamurthy, and Lustig, 2021](#)) and implies that a global shift in demand towards dollar safe assets depreciates investment currencies more than funding ones. The VIX, in turn, has a weakly appreciating impact on funding currencies, while the impact turns to a depreciating one for commodity and investment currencies. This is consistent with the corresponding results for the UIP discussed above, which also showed a differential impact of financial conditions on currency premia in proportion with their funding gap. Controlling for changes in log dealer wealth, another proxy for intermediation capacity, also has strong association with exchange rates: a decrease in dealer wealth is associated with depreciation of all currencies except for the funding currencies CHF and JPY.

Despite these statistical associations with conventional macro-finance variables, the dealer position maintains a large and independent contribution to the fit of the statistical model, explaining the majority of variation in the exchange rate. Table 6 reports the share of total  $R^2$  due to this variable alone, which ranges from 35% and 42% for MXN and AUD, to 64% and 69% for GBP and EUR, to 81% and 89% for JPY and CHF. For all currencies but MXN and AUD, changes in dealer positions account for the majority of explained variation even when taking into account the possible correlation between right-hand side variables. We show the full variance decomposition of the model

$R^2$  in Figure 7.<sup>42</sup> The robust relationship between dealer positions and exchange rate movements across currencies and the large share of the explained variance together account for the tight fit in the scatter plot in Figure 6 above.

To further illustrate the fit of our statistical model (24), we plot the predicted components of the changes and cumulated levels for each exchange rates. The results for EUR and GBP are reported in Figures 1 in the introduction (and in Appendix Figure A3 in levels), while results for all other currencies are reported in Appendix Figures A9–A12. The figures plot the fit of the full model and the partial fit due to dealer positions only. The figures also report the resulting correlations between exchange rates with their predicted components (in changes and in levels, respectively). The high quality of the fit is apparent from observing the plots and confirmed in high correlation coefficients. In particular, the correlation in changes between exchange rates and their predicted component based on the dealer positions alone are around 0.6 for most currency (with the exception of MXN for which it is 0.5). These correlations for the full model are around 0.7. The fit in levels is equally strong, but it can be misleading for a model with near-non-stationary variables, and this is why one should focus only on the fit in changes.

**Impulse responses and currency returns** We focused so far on the contemporaneous comovement between the dealers’ futures positions, currency premia and exchange rate changes. To complete our description of the dynamics of currency premia and exchange rates, we now turn to describing the estimated impulse responses conditional on a shock to the dealers’ futures position. As before, this does not assume that changes in the dealers’ positions are exogenous; instead we interpret our results as describing the dynamic statistical properties of currency premia and exchange rates conditional on a standardized shock to the evolution of endogenous dealer positions, that is,  $\mathbb{E}_t\{\Delta \log \mathcal{E}_{k,t+j} | \Delta f_{kt}^*\}$  according to the estimated statistical model (22)–(24).<sup>43</sup>

Figure 8 plots the estimated impulse response to a one standard deviation innovation in the dealers’ futures position  $f_{kt}^*$  at  $t$  for the dealers’ position evolution itself (in levels and in changes,  $f_{k,t+j}^*$  and  $\Delta f_{k,t+j}^*$ ) in the left panel and for the corresponding log exchange rate against the dollar (also in levels and in changes,  $\log \mathcal{E}_{k,t+j}$  and  $\Delta \log \mathcal{E}_{k,t+j}$ ) in the right panel. We use the point estimates from the panel specification for G7+ currencies with time fixed effects, as reported in (22) and in column 10 of Table 6.

We find a persistent impulse response to the dealers’ position innovation, with half lives of 5 months and 6 months respectively for the dealers’ position and the exchange rate, respectively. On

<sup>42</sup>This  $R^2$  decomposition is based on the following covariance decomposition for any regression  $y_t = \hat{\beta}x_t + \hat{\gamma}z_t + \hat{\epsilon}_t$ :

$$\frac{\text{cov}(\hat{\beta}x_t, y_t)}{\text{var}(y_t)} + \frac{\text{cov}(\hat{\gamma}z_t, y_t)}{\text{var}(y_t)} = 1 - \frac{\text{var}(\hat{\epsilon}_t)}{\text{var}(y_t)} = R^2.$$

Note that this decomposition accommodates possible correlation between regressors  $x_t$  and  $z_t$  and does not depend on the sequence of inclusion of variables, but may result in a negative contribution of certain regressors to the  $R^2$ .

<sup>43</sup>Formally, we trace out the predicted dynamic paths of  $f_{k,t+j}^*$ ,  $\log \mathcal{E}_{k,t+j}$  and other variables for  $j \geq 0$  when the innovation to  $f_{kt}^*$  is equal to its one standard deviation, i.e.,  $\epsilon_{kt}^f = \sigma_{fk} = \text{std}(\epsilon_{kt}^f)$  in (22).

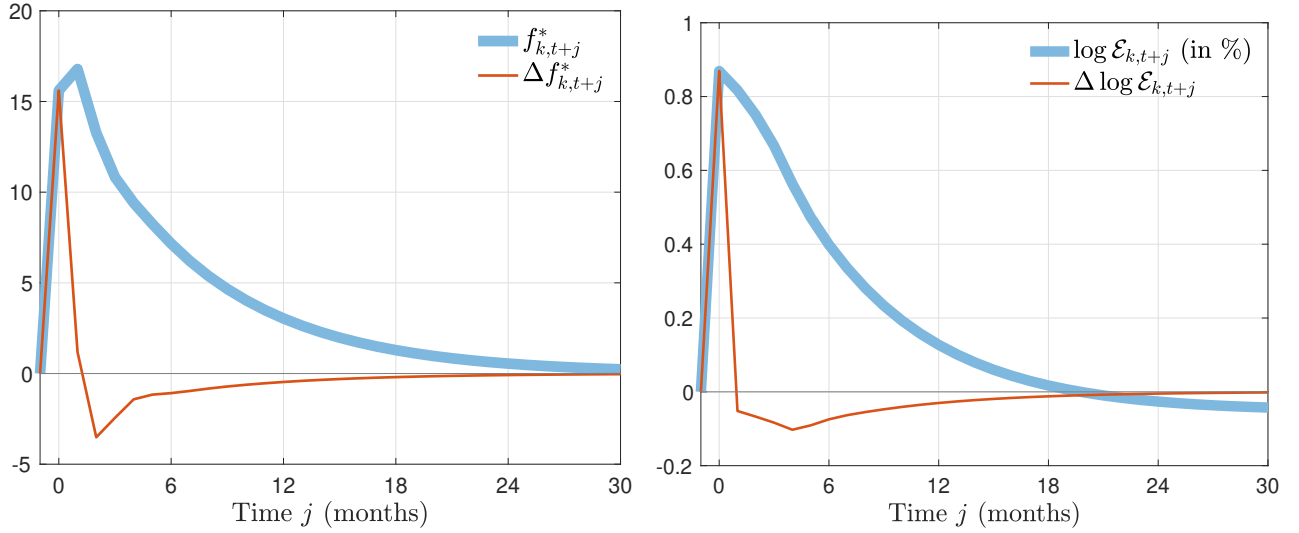


Figure 8: Impulse response to an innovation to  $\Delta f_{kt}^*$

Note: Impulse responses are constructed for a one standard-deviation innovation to  $f_{kt}^*$  using point estimates from the pooled panel specification with time fixed effects for G7+ currencies, as reported in (22) and in column 10 of Table 6.

impact of a one standard innovation to  $f_{kt}^*$ , a typical exchange rate depreciates by 0.87% (87 log basis points) and then gradually appreciates over the following two years, by an average of 6 log basis points monthly over the first 12 months. The distinctive feature of this impulse response is that the large unexpected devaluation on impact is followed by a sequence of predictable small appreciations (compare with the theoretical impulse response in [Itskhoki and Mukhin, 2021](#)). Appendix Figure A13 plots alternative impulse responses for the specification without time fixed effects, in which case the exchange rate responds by 1.29% on impact and then mean reverts with a longer half life of 8 months.<sup>44</sup>

Finally, we turn to the impulse responses for currency premia and interest rates, and evaluate the predictable path of currency returns conditional on an innovation to dealers' position  $f_{kt}^*$ . Note that this cannot be done directly using currency premia regressions in Tables 3-5 as the time change to currency premia defined in (19) does not correspond to the impulse response of currency returns. Instead, we need to decompose currency premia into their individual components, construct their respective projections on the innovation to  $f_{kt}^*$ , and then assemble it back into an impulse response for currency returns. For example, for realized currency returns,  $UIP_{kt,t+3} = (r_{kt} - r_t^{US}) - 4 \cdot \log(\mathcal{E}_{k,t+3}/\mathcal{E}_{kt})$ , we use local projections for  $\Delta(r_{kt} - r_t^{US})$  and  $\Delta \log \mathcal{E}_{kt}$  to construct the path of  $\partial UIP_{k,t+j,t+3+j}/\partial f_{kt}^*$  for  $j \geq -3$ . Similarly, we construct the predicted path of CIP returns.

We find that a one standard deviation innovation to  $\Delta f_{kt}^*$  is associated with virtually no change in the covered interest rate premium  $CIP_{k,t+j}$  and no change in the interest rates differential  $r_{k,t+j} - r_{t+j}^{US}$ , at any horizon  $j \geq 0$ . The estimated effects are of the order of magnitude of one

<sup>44</sup>Appendix Figure A14 shows impulse responses for individual currencies. Appendix Figure A15 plots impulse responses for the specification which does *not* force mean reversion in specification (22) by omitting the lagged level control  $f_{k,t-1}^*$ , in which case  $f_{kt}^*$  has an impulse response close to a random walk and the exchange rate mean reverts very slowly with virtually an infinite half live (despite the continued inclusion of lagged  $\log \mathcal{E}_{k,t-1}$  into (24)).

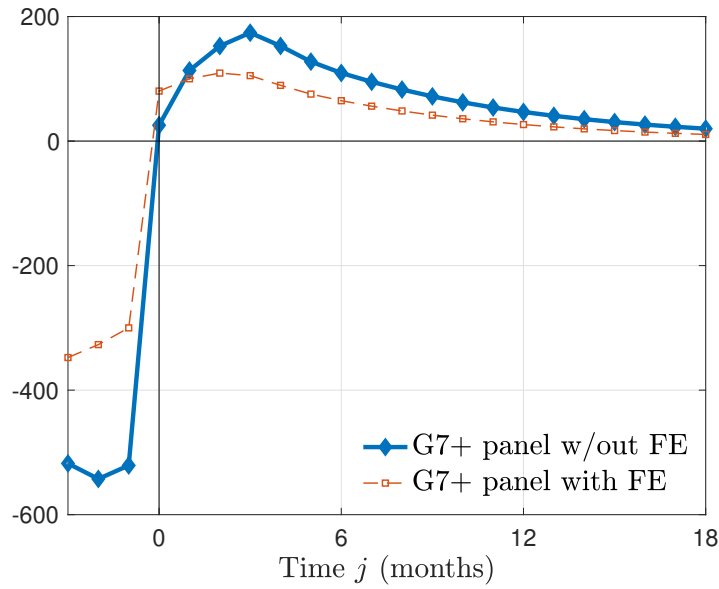


Figure 9: Currency returns (basis points) around the innovation to  $f_{kt}^*$

Note: The figure plots the impulse response to uncovered currency returns at  $t + j$  conditional on a one standard deviation innovation to dealers' futures positions  $f_{kt}^*$  at  $t$ . That is, the outcome variable is the realized (for  $j \leq 0$ ) and predicted (for  $j > 0$ ) returns on a 3-month zero-capital carry trade at  $t + j$ , which is long currency  $k$  and short US dollar, per dollar of gross exposure. The units on  $y$ -axis are annualized basis points, i.e., 200 corresponds to 2% extra return.

tenth of a basis point for both variables in a panel of G7+ currencies, with or without time fixed effects, as shown in Appendix Figure A16.

In contrast to the covered premium and the interest rate differential, the uncovered currency returns respond sharply to innovations in the dealers' futures positions. Figure 9 plots the realized (for  $j \leq 0$ ) and expected (for  $j > 0$ ) currency returns at  $t + j$  conditional on a one standard innovation to the dealers' position  $f_{kt}^*$  at  $t$ , in a panel of G7+ currencies. We focus on predicted returns in the specification without time fixed effects as this reflects the actual financial returns to the entire currency position, but we display for comparison the alternative estimates from the specification that absorbs time fixed effects.

We find that a one standard deviation positive innovation in  $f_{kt}^*$  in month  $t$  is associated with a very large negative return on currency  $k$  for positions open before  $t$ , that is, for  $j < 0$ . Specifically, these negative returns are as large as 540 basis point (5.4%) annualized loss on a three-month position. In other words, one such standard monthly shock during the three-month tenure of the contract instantaneously destroys value (net worth) equal to 1.3% of the net currency exposure, in line with the magnitude of a standard predicted devaluation reported in Table 6. This is akin to the currency crashes described in Brunnermeier, Nagel, and Pedersen (2009), but focusing on routine monthly events rather than large crisis episodes. In a reversal, the currency  $k$  returns on positions taken after the innovations in  $f_{kt}^*$ , for  $j > 0$ , are (expected to be) positive and collected over a longer period of time: up to 175 basis points (1.75%) annualized in the first quarter and over 100 basis points on average over the full year.

Essentially the entire currency return described above is driven by the predictable movement in the spot exchange rate, as follows from the impulse responses of the interest rate (effectively zero) and the exchange rate described above. An essential feature of the exchange rate impulse response is the predictable gradual appreciation of currency  $k$  over the following year following a sharp depreciation on impact. The sharp depreciation is what creates both the value loss on impact of the shock (the “steamroller”) and the generally high underlying volatility for currency trading, as this depreciation is unanticipated. The gradual predictable appreciation is what gives the intermediary bank the expected return, but with a modest Sharpe ratio given the risk (the “pennies” that they collect in front of a steamroller).<sup>45</sup> Indeed, this situation describes an equilibrium exchange rate response that supports positive expected currency returns for intermediary banks subject to a “no-good-deal” bound on the carry trade Sharpe ratio (see [Chernov, Haddad, and Itskhoki, 2024](#)). Less surprise volatility in the exchange rate would make the currency trade too appealing for broader groups of investors, while less predictable mean reversion in the exchange rate would make it not sufficiently attractive for intermediaries to absorb the currency risk. Our proxy for currency demand shocks,  $\Delta f_{kt}^*$ , and its statistical properties allows to rationalize both the surprise variation in the exchange rate on impact of the shock and the intertemporal profile of predictable currency returns following the shock.

## 4 Discussion and conclusion

In this paper, we provide a description of joint statistical properties of currency premia (covered and uncovered), interest rates and exchange rates (spot and forwards), both in the cross section of currencies and in their dynamic panel. We find that the rich empirical patterns are rationalized by a simple partial equilibrium model of the currency market, where hedged and unhedged currency supply is ensured by intermediary banks subject to value-at-risk balance-sheet constraints, emphasizing the frictional nature of equilibrium currency premia and exchange rate dynamics. We conclude the paper by summarizing the salient features of the currency market equilibrium that emerge from our analysis.

In the cross section, local-currency interest rate differentials and covered and uncovered currency premia are a reflection of the local-currency funding gap of the country, which in turn reflects whether the country is a net supplier of savings or a net destination for investment from the rest of the world. Funding currencies of countries with an excess supply of local-currency savings, like Japan and Switzerland, feature: (i) low local-currency interest rates, (ii) negative UIP premia that reflect the interest rate differential, and (iii) negative CIP premia which reflect cheap forward (relative to spot) dollars. The opposite is true for investment, commodity and emerging-market currencies

---

<sup>45</sup>Note that these are significant predictable future exchange rate appreciations at  $t + j$  given the innovation to  $f_{kt}^*$  observed at  $t$ , in a stark contrast to essentially no predictable currency movements when projected on a shock to the interest rate differential at  $t$  in a panel of currencies (see e.g. [Hassan and Mano, 2018](#)).

of countries with insufficient local-currency savings which require international (dollar) funding to finance domestic investment.

Intuitively, excess supply of local savings puts downward pressure on the local-currency interest rates and compels domestic investors to search for yield abroad, with an associated demand to sell dollars forward, making them cheap relative to spot dollars and resulting in a negative CIP deviation. This premium is collected by intermediary banks to compensate them for hedged swapping of higher foreign-currency returns for lower local-currency returns. In turn, the interest rate differential translates one-for-one into the long-run UIP premium charged by intermediary banks for holding the currency risk as a result of both spot and forward exposures. Therefore, it is the currency risk that stands in the way of international equalization of local-currency interest rates, and the interest rate gap acts as the premium for currency risk exposure, which explains the entire magnitude of UIP deviations in the cross section. In turn, forward premium (or discount) more than offsets the interest rate differential to compensate intermediary banks supplying currency swaps. Thus, forward premium has no predictive properties for the future spot exchange rate, consistent with the empirical forward premium puzzle.

In the time-series, CIP and UIP premia have entirely different dynamic properties. While UIP premia vary at high frequency in response to currency-specific shocks tightly correlated with dealer banks' currency futures positions, CIP premia stay stable in response to these shocks and instead change relatively infrequently with aggregate financial conditions. When broader financial market conditions tighten, as for example with a spike in VIX, CIP premia widen – becoming more positive for investment currencies and more negative for funding currencies.

Unlike for CIP premia, time fixed effects and aggregate financial conditions explain only a small portion of variation in UIP premia, which respond most strongly to shifts in currency-specific demand as proxied by dealer banks' futures positions. We show that it is the dynamics of the spot exchange rate that ensures the response of both expected UIP premium and the ex post currency returns, while the interest rate differential does not respond to shifts in currency demand.<sup>46</sup> An increase in dealer banks' futures position in currency  $k$  is strongly correlated with a contemporaneous depreciation of currency  $k$  against the dollar, driving a significant financial loss for those exposed to this currency before the shock. In contrast, intermediaries that take currency  $k$  position in response to the shock obtain predictable positive expected returns, albeit with a modest Sharpe ratio due to the high volatility of the exchange rate (that is, “collecting pennies in front of a steamroller”).

These dynamics of currency returns are ensured by a times-series process for exchange rates that features persistent innovations and long half-lives, yet with a small predictable mean reversion over a period of multiple quarters. This emphasizes the frictional nature of exchange rate fluctuations that ensure both predictable returns (UIP deviations) and large unpredictable innovations that tightly bound the Sharpe ratio of currency carry trades. Lower predictable returns would be incon-

---

<sup>46</sup>Forward exchange rates respond in lock-step with spot exchange rates, keeping CIP premium stable in response to shifts in currency demand. Only when aggregate financial condition tighten, forward dollars become cheaper (more expensive) relative to spot dollars for funding (investment) currencies.

sistent with frictional intermediation of the currency risk which requires an equilibrium premium, while lower volatility would violate a “no-good-deal” bound for currency trading. Even if underlying shocks are fundamental macroeconomic shocks, capital flows and changing currency positions associated with these shocks require intermediation in the currency market, which in turn leads to a volatile near-random-walk process for the exchange rate, consistent with exchange rate disconnect.<sup>47</sup> Hence, a model with the same set of fundamental shocks but frictionless intermediation with uncovered parity holding must result in very different equilibrium exchange rate dynamics.

We also note the very different implication for the path of currency returns when we project them on the shocks to currency dealer positions as opposed to the shock to interest rates. Changes in interest rates have a very weak predictive power for future exchange rate depreciations with a nearly zero  $R^2$  in the Fama regression. In other words, conditional on the interest rate differential, most of the currency returns is the interest rate differential itself, in the panel of currencies. In contrast, conditional on the shock to currency demand, changes in currency returns come entirely from the predictable dynamic path of the exchange rate, while interest rates do not respond. Interestingly, this offers a real-time way (at a weekly or monthly frequency) to measure expected UIP deviations which emerge in concert with the shifts in currency futures positions of dealer banks. Alternative measures of the frictional UIP premium are notoriously difficult given the unobservable exchange rate expectations involved in the construction of this variable at high frequency.

A number of open questions, both positive and normative, remain for future work. For example, what is the allocation of currency risk exposure among the various participants of the financial markets and the nature of shifts in their currency demand? Although we model the intermediary sector as a global bank with affiliated dealer, our framework extends to intermediation by any agent with a stable currency supply schedule in response to the UIP premium. Similarly, our framework does not rely on a distinction between hedgers and speculators as often assumed in the literature, since each agent can act on either motive and the equilibrium UIP is the result of the interaction between shifts in currency demand and supply (see Appendix C). Another question to explore is the connection between dealer banks’ futures positions and other financial and macroeconomic variables, with the goal of resolving exchange rate disconnect.

Turning to policy, a question of keen interest concerns the rationale and relevant target for official FX interventions and other exchange rate policy tools. The frictional intermediation that we emphasize suggests a rationale for policy interventions that lean against currency demand shocks by (partially or fully) eliminating currency premia and stabilizing the exchange rate. Stabilizing the UIP premium amounts to accommodating or dampening currency-specific demand shocks, and as a result largely stabilizing the spot exchange rate. In contrast, stabilizing the CIP premium means leaning against the global financial and dollar cycles in the currency market, and by doing so, stabilizing the forward premium without eliminating fluctuations in the spot exchange rate. A combi-

---

<sup>47</sup>While we find strong correlation of exchange rate with futures positions of dealer banks, the correlation with capital flows is significantly weaker as they are not perfectly correlated with the resulting currency exposure that needs to be absorbed by the financial intermediary sector.

nation of these wedges can therefore serve as operational targets for the policy maker, depending on which type of shock needs to be managed, as illustrated by the case for ‘basis control’ in [Gourinchas \(2022\)](#). Of course, conducting such optimal policy analysis requires a fully-specified general equilibrium model.<sup>48</sup> Our paper provides important guidance towards such analysis by articulating which model elements are critical to account for the joint empirical patterns of exchange rates and currency premia.

---

<sup>48</sup>See [Fanelli and Straub \(2021\)](#); [Cavallino \(2019\)](#); [Basu, Boz, Gopinath, Roch, and Unsal \(2020\)](#) and [Itskhoki and Mukhin \(2023\)](#).

## References

- ABBASSI, P., AND F. BRÄUNING (2021): “Demand effects in the FX forward market: Micro evidence from banks’ dollar hedging,” *The Review of Financial Studies*, 34(9), 4177–4215.
- ALLEN, C., AND L. JUVENAL (2024): “The Role of Currencies in External Balance Sheets,” IMF Working Paper No. 2024.
- AVDJIEV, S., W. DU, C. KOCH, AND H. S. SHIN (2019): “The Dollar, Bank Leverage, and Deviations from Covered Interest Parity,” *American Economic Review: Insights*, 1(2), 193–208.
- BACCHETTA, P., K. BENHIMA, AND B. BERTHOLD (2025): “Foreign exchange intervention with UIP and CIP deviations,” *Swiss Finance Institute Research Paper*, (23-71).
- BARBIERO, O., F. BRÄUNING, G. JOAQUIM, AND H. STEIN (2024): “Dealer risk limits and currency returns,” Working paper no. 24-11, Federal Reserve Bank of Boston.
- BASU, S. S., E. BOZ, G. GOPINATH, F. ROCH, AND F. D. UNSAL (2020): “A Conceptual Model for the Integrated Policy Framework,” IMF Working Papers No. 2020/121.
- BELTRAN, P., AND C. HE (2023): “Inelastic Financial Markets and Foreign Exchange Interventions,” [working paper](#).
- BENETRIX, A., D. GAUTAM, L. JUVENAL, AND M. SCHMITZ (2019): “Cross-Border Currency Exposures,” IMF Working Paper No. 2019/299.
- BIS (2024): “FX Markets and FX Interventions,” Bank for International Settlements, Markets Committee Papers, March 2024.
- BRÄUER, L., AND H. HAU (2024): “Can Time-Varying Currency Risk Hedging Explain Exchange Rates?,” SFI Research Paper No. 22-77.
- BRUNNERMEIER, M. K., S. NAGEL, AND L. H. PEDERSEN (2009): “Carry Trades and Currency Crashes,” in *NBER Macroeconomics Annual 2008, Volume 23*, pp. 313–347.
- CAMANHO, N., H. HAU, AND H. REY (2022): “Global portfolio rebalancing and exchange rates,” *The Review of Financial Studies*, 35(11), 5228–5274.
- CAVALLINO, P. (2019): “Capital Flows and Foreign Exchange Intervention,” *American Economic Journal: Macroeconomics*, 11(2), 127–70.
- CHAHROUR, R., V. CORMUN, P. DE LEO, P. GUERRON-QUINTANA, AND R. VALCHEV (2021): “Exchange Rate Disconnect Redux,” Boston College Working Papers in Economics No. 1041.
- CHERNOV, M., AND D. CREAL (2023): “International yield curves and currency puzzles,” *The Journal of Finance*, 78(1), 209–245.
- CHERNOV, M., V. HADDAD, AND O. ITSKHOKI (2024): “What do Financial Markets say about the Exchange Rate?,” NBER Working Paper No. 32436.
- CORREA, R., W. DU, AND G. Y. LIAO (2020): “U.S. banks and global liquidity,” Working paper no. w27491, National Bureau of Economic Research.
- CORTE, P. D., S. J. RIDDIOUGH, AND L. SARNO (2016): “Currency premia and global imbalances,” *The Review of Financial Studies*, 29(8), 2161–2193.
- DAO, M. C., AND P.-O. GOURINCHAS (2025): “Covered Interest Parity Deviations in Emerging Markets: Measurement and Drivers,” IMF Working Paper No. 2025/057.
- DE LEO, P., L. KELLER, AND D. ZOU (2024): “Speculation, Forward Exchange Demand, and CIP Deviations in Emerging Economies,” Research papers, The Wharton School.
- DU, W., AND A. W. HUBER (2024): “Dollar Asset Holdings and Hedging Around the Globe,” working paper.
- DU, W., AND J. SCHREGER (2022): “CIP deviations, the dollar, and frictions in international capital markets,” in *Handbook of International Economics*, vol. 6, pp. 147–197. Elsevier.
- DU, W., A. TEPPER, AND A. VERDELHAN (2018): “Deviations from Covered Interest Rate Parity,” *The Journal of*

- Finance*, 73(3), 915–957.
- ENGEL, C. (2014): “Exchange Rates and Interest Parity,” in *Handbook of International Economics*, ed. by G. Gopinath, E. Helpman, and K. S. Rogoff, vol. 4, pp. 453–522. Elsevier.
- (2016): “Exchange Rates, Interest Rates, and the Risk Premium,” *American Economic Review*, 106(2), 436–474.
- ENGEL, C., N. C. MARK, AND K. D. WEST (2008): “Exchange Rate Models Are Not As Bad As You Think,” in *NBER Macroeconomics Annual 2007, Volume 22*, pp. 381–441.
- ENGEL, C., AND S. P. WU (2024): “Exchange Rate Models are Better than You Think, and Why They Didn’t Work in the Old Days,” NBER Working Paper No. 32808.
- EVANS, M. D. D., AND R. K. LYONS (2002): “Order Flow and Exchange Rate Dynamics,” *Journal of Political Economy*, 110(1), 170–180.
- FAMA, E. F. (1984): “Forward and spot exchange rates,” *Journal of Monetary Economics*, 14(3), 319–338.
- FANELLI, S., AND L. STRAUB (2021): “A Theory of Foreign Exchange Interventions,” *The Review of Economic Studies*, 88(6), 2857–85.
- GABAIX, X., AND M. MAGGIORI (2015): “International Liquidity and Exchange Rate Dynamics,” *The Quarterly Journal of Economics*, 130(3), 1369–1420.
- GOURINCHAS, P.-O. (2022): “International Macroeconomics: From the Great Financial Crisis to COVID-19, and Beyond,” *IMF Economic Review*, 70(1), 1–34.
- GOURINCHAS, P.-O., W. RAY, AND D. VAYANOS (2025): “A preferred-habitat model of term premia, exchange rates, and monetary policy spillovers,” *American Economic Review*, forthcoming.
- GOURINCHAS, P.-O., AND H. REY (2007): “International Financial Adjustment,” *Journal of Political Economy*, 115(4), 665–703.
- GREENWOOD, R., S. G. HANSON, J. C. STEIN, AND A. SUNDERAM (2020): “A Quantity-Driven Theory of Term Premia and Exchange Rates,” Discussion paper, National Bureau of Economic Research.
- HACIOĞLU-HOKE, S., D. OSTRY, H. REY, A. ROUSSET PLANAT, V. STAVRAKEVA, AND J. TANG (2024): “Topography of the FX derivatives market: a view from London,” Staff working paper no. 1,103, Bank of England.
- HASSAN, T. A., AND R. C. MANO (2018): “Forward and Spot Exchange Rates in a Multi-Currency World,” *The Quarterly Journal of Economics*, 134(1), 397–450.
- HAU, H., AND H. REY (2006): “Exchange Rates, Equity Prices, and Capital Flows,” *Review of Financial Studies*, 19(1), 273–317.
- HE, Z., B. KELLY, AND A. MANELA (2017): “Intermediary asset pricing: New evidence from many asset classes,” *Journal of Financial Economics*, 126(1), 1–35.
- HONG, H., AND M. YOGO (2012): “What does futures market interest tell us about the macroeconomy and asset prices?,” *Journal of Financial Economics*, 105(3), 473–490.
- ILZETZKI, E., C. M. REINHART, AND K. S. ROGOFF (2020): “Will the Secular Decline in Exchange Rate and Inflation Volatility Survive COVID-19?,” *Brookings Papers on Economic Activity*, pp. 279–316.
- ITSKHOKI, O., AND D. MUKHIN (2021): “Exchange Rate Disconnect in General Equilibrium,” *Journal of Political Economy*, 129(8), 2183–2232.
- (2023): “Optimal Exchange Rate Policy,” NBER Working Paper No. 31933.
- (2025a): “Mussa Puzzle Redux,” *Econometrica*, 93(1), 1–39.
- (2025b): “What Drives the Exchange Rate?,” *IMF Economic Review*, 73(1), 86–117.
- IVASHINA, V., D. SCHARFSTEIN, AND J. STEIN (2015): “Dollar Funding and the Lending Behavior of Global Banks,” *The Quarterly Journal of Economics*, 130(3), 1241–1281.
- JIANG, Z., A. KRISHNAMURTHY, AND H. N. LUSTIG (2021): “Foreign Safe Asset Demand and the Dollar Exchange Rate,” *The Journal of Finance*, 76(3), 1049–1089.

- KALEMLI-ÖZCAN, S., AND L. VARELA (2021): “Five Facts about the UIP Premium,” NBER Working Paper No. 28923.
- KEKRE, R., AND M. LENEL (2024): “Exchange Rates, Natural Rates, and the Price of Risk,” NBER Working Paper No. 32976.
- KOIJEN, R. S. J., AND M. YOGO (2020): “Exchange Rates and Asset Prices in a Global Demand System,” NBER Working Papers No. 27342.
- LIAO, G., AND T. ZHANG (2025): “The Hedging Channel of Exchange Rate Determination,” *Review of Financial Studies*, 38, 1–38.
- LILLEY, A., M. MAGGIORI, B. NEIMAN, AND J. SCHREGER (2022): “Exchange Rate Reconnect,” *The Review of Economics and Statistics*, 104(4), 845–55.
- LUSTIG, H., N. ROUSSANOV, AND A. VERDELHAN (2011): “Common Risk Factors in Currency Markets,” *The Review of Financial Studies*, 24(11), 3731–77.
- LUSTIG, H. N., AND A. VERDELHAN (2011): “The Cross-Section of Foreign Currency Risk Premia and Consumption Growth Risk: Reply,” *American Economic Review*, 101(7), 3477–3500.
- MEESE, R., AND K. S. ROGOFF (1983): “Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?,” *Journal of International Economics*, 14(1), 3–24.
- MIRANDA-AGRIPPINO, S., AND H. REY (2022): “The Global Financial Cycle,” in *Handbook of International Economics: International Macroeconomics, Volume 6*, ed. by G. Gopinath, E. Helpman, and K. Rogoff, vol. 6 of *Handbook of International Economics*, pp. 1–43. Elsevier.
- MOSKOWITZ, T. J., C. P. ROSS, S. Y. ROSS, AND K. VASUDEVAN (2024): “Quantities and Covered-Interest Parity,” Working paper no. w32707, National Bureau of Economic Research.
- REY, H. (2013): “Dilemma not trilemma: the global financial cycle and monetary policy independence,” *Jackson Hole Symposium Proceedings*.
- RIME, D., A. SCHRIMPF, AND O. SYRSTAD (2022): “Covered interest parity arbitrage,” *The Review of Financial Studies*, 35(11), 5185–5227.
- STAVRAKEVA, V., AND J. TANG (2020): “Deviations from fire and exchange rates: A GE theory of supply and demand,” *working paper*.
- (2024): “A Fundamental Connection: Exchange Rates and Macroeconomic Expectations,” *The Review of Economics and Statistics*, pp. 1–49.
- TORNELL, A., AND C. YUAN (2012): “Speculation and hedging in the currency futures markets: Are they informative to the spot exchange rates,” *Journal of Futures Markets*, 32(2), 122–151.

## A Additional Tables and Figures

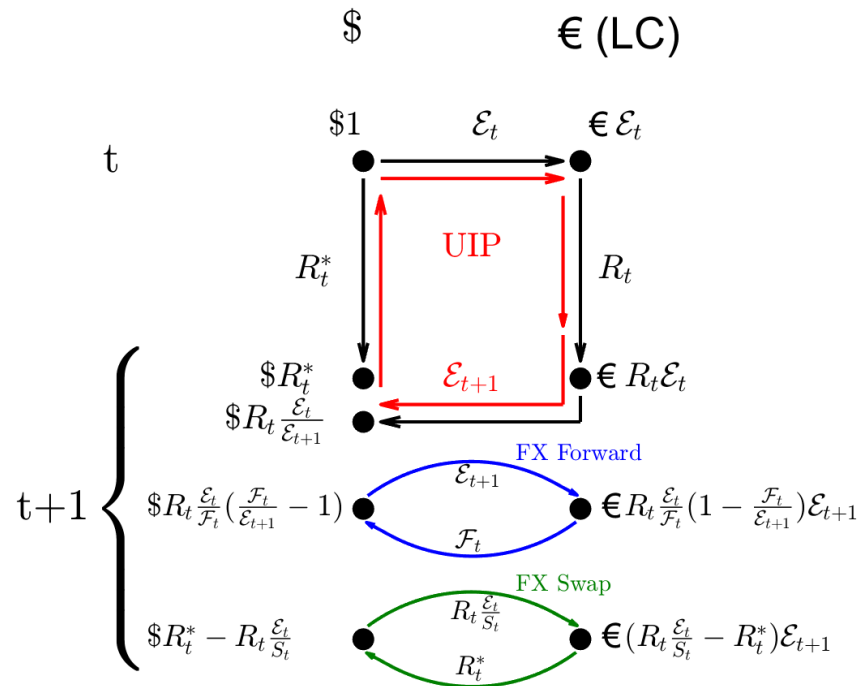


Figure A1: Illustration for balance sheet in Table 1: possible currency trades

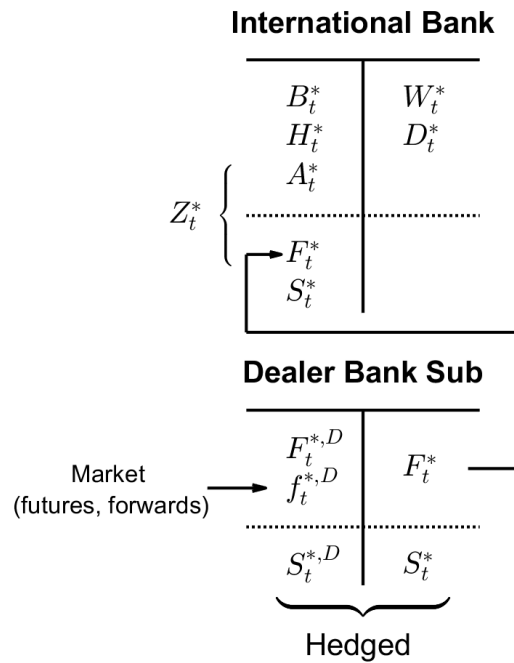


Figure A2: Illustration of international intermediary bank and its dealer subsidiary: FX exposure passthrough

Table A1: Interest rates and forward rates: tickers and descriptions

Currency	Ticker (3M)	Description (3M)
<b>Interest Rates</b>		
USD	USD3MFSR=X	US Dollar 3 Month ICE LIBOR
JPY	JPY3MD=	Japanese Yen 3 Month deposit
CHF	CHF3MD=	Swiss Franc 3 Month deposit
EUR	EURIBOR3MD=	Euro 3 Month EURIBOR
GBP	GBP3MFSR=X	UK Pound Sterling 3 Month ICE LIBOR
CAD	CA3MBAFIX=	Canadian Dollar 3 Month Interest Rate Fixing
AUD	AUD3MD=	Australian Dollar 3Month deposit
NZD	NZD3MD=	New Zealand Dollar 3Month deposit
MXN	MXTIE3M=RR	Mexican Peso 3 Month TIE Interbank Rate
BRL	BRRED90D=CBBR	BRL 90D Discount Rate
ZAR	JIBAR3M=	South African Rand 3 Month JIBAR
RUB	RUB3MD=	Russian Rubel 3 Month deposit
<b>Forward Rates/Premia</b>		
USD	USD3MV=	US DOLLAR/US DOLLAR 3 MONTH FX FORWARD OUTRIGHT
JPY	JPY3MV=	US DOLLAR/JAPANESE YEN 3 MONTH FX FORWARD OUTRIGHT
CHF	CHF3MV=	US DOLLAR/SWISS FRANC 3 MONTH FX FORWARD OUTRIGHT
EUR	EUR3MV=	EURO/US DOLLAR 3 MONTH FX FORWARD OUTRIGHT
GBP	GBP3MV=	UK POUND STERLING/US DOLLAR 3 MONTH FX FORWARD OUTRIGHT
CAD	CAD3MV=	US DOLLAR/CANADIAN DOLLAR 3 MONTH FX FORWARD OUTRIGHT
AUD	AUD3MV=	AUSTRALIAN DOLLAR/US DOLLAR 3 MONTH FX FORWARD OUTRIGHT
NZD	NZD3MV=	NEW ZEALAND DOLLAR/US DOLLAR 3 MONTH FX FORWARD OUTRIGHT
MXN	MXN3MV=	US DOLLAR/MEXICAN PESO 3 MONTH FX FORWARD OUTRIGHT

Source: Refinitiv/LSEG. Interest rate day count and forward point quoting conventions differ by currency and period. The USD 3-month LIBOR rate is replaced by the synthetic LIBOR rate by the ICE Benchmark Administration after July 2023, following cessation of the official Dollar LIBOR panel rate publication, until September 30 2024. This synthetic rate is calculated using the 3-month SOFR reference rate and a spread reflecting large banks' credit risk and liquidity conditions. The synthetic LIBOR rate represents a consistent extension of the historical LIBOR rate to facilitate the settlement of legacy contracts, as required by the UK Financial Conduct Authority (FCA). A similar transition requirement and synthetic LIBOR rate methodology applies to the GBP 3-Month ICE LIBOR rate starting after December 2021 until March 2024 (using the 3-month SONIA reference rate).

Table A2: Summary statistics for monthly changes in dealer net futures positions  $\Delta f_{kt}^*$ 

Currency	Obs	Mean	Std. dev.	Min	p25	Median	p75	Max
JPY	218	0.00	19.5	-52.8	-11.4	-0.3	11.0	76.8
CHF	218	0.16	22.6	-99.6	-12.6	-0.8	10.6	65.4
EUR	218	0.01	11.5	-32.6	-7.0	-0.6	6.2	30.4
GBP	218	0.19	19.4	-55.7	-12.4	-0.5	12.0	62.6
CAD	218	0.64	19.7	-68.7	-12.1	0.3	14.0	46.4
AUS	218	0.27	21.3	-62.7	-12.8	-0.7	15.0	64.1
NZD	218	0.32	24.9	-54.4	-16.4	0.2	16.7	67.4
MXN	218	-0.26	21.3	-65.3	-11.6	-0.6	11.1	99.9
RUB	155	-0.34	10.8	-36.7	-5.0	-1.2	5.5	45.2
BRL	152	0.59	30.1	-89.4	-15.7	3.8	17.9	102.7
ZAR	99	-1.21	21.7	-88.0	-8.8	-0.1	9.7	59.0

Notes: Table shows summary statistics for the monthly change in net (long) futures position of FX dealers in percent of 12-month moving average open interest by currency. Sample period: June 2006 to August 2024. Source: CFTC TFF Report (weekly reports aggregated to monthly frequency).

Table A3: Pairwise correlation coefficients for global financial conditions

	$\Delta \log \text{VIX}_t$	$\Delta \log \overline{\mathcal{E}_t^{USD}}$	$\Delta GFCy_t$	$\Delta \log \mathbb{W}_t^*$	$\Delta \text{T-basis}_t$
$\Delta \log \text{VIX}_t$					
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	0.3719*				
$\Delta GFCy_t$	-0.6150*	-0.6159*			
$\Delta \log \mathbb{W}_t^*$	-0.5122*	-0.4206*	0.6821*		
$\Delta \text{T-basis}_t$	-0.1960*	-0.2087*	0.2065*	0.1135*	
$\Delta(\text{EFFR}_t - \text{IORB}_t)$	0.0057	-0.1121*	0.0662*	0.1507*	0.3506*

Note: Entries show monthly pairwise correlation coefficients. \* indicate statistical significance at 5 percent.  $\overline{\mathcal{E}_t^{USD}}$  is the Broad Dollar Index.  $\log \mathbb{W}_t^*$  is the log capital ratio of global intermediaries from He et al. (2017).  $\text{T-basis}_t$  is the 12-month Treasury basis as defined in JKL.  $GFCy$  is the global financial cycle factor from Miranda-Aggreggipino and Rey (2022).  $\text{EFFR} - \text{IORB}$  is the spread between effective federal funds rate and the interest on reserve balances.

Table A4: UIP for Emerging Market currencies

Dep var:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\widehat{\Delta UIP}_{kt}$	EM panel						
	Baseline	Time FE	USD & VIX	MXN	ZAR	RUB	BRL
$\Delta f_{kt}^*$	0.139*** [5.91]	0.096*** [2.93]	0.075*** [3.88]	0.075*** [3.55]	0.029 [0.56]	0.140** [2.26]	0.035** [2.14]
$\Delta f_{k,t-1}^*$	-0.064** [2.37]	-0.042 [1.06]	-0.053** [2.26]	-0.052** [2.32]	0.011 [0.25]	-0.041 [0.34]	-0.008 [0.22]
$\Delta CIP_{kt}$	0.463 [0.33]	-1.251** [2.08]	-0.341 [0.36]	-2.558*** [3.79]	0.155 [0.04]	-1.858*** [4.62]	-3.639* [1.67]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$			2.477*** [5.46]	1.917*** [4.02]	6.414*** [7.14]	1.999** [2.07]	2.491*** [3.35]
$\Delta \log VIX_t$			0.075*** [2.76]	0.089*** [2.77]	0.052 [0.95]	0.114** [2.56]	0.078 [1.62]
$\widehat{UIP}_{k,t-1}$	-0.366*** [6.40]	-0.431*** [5.12]	-0.379*** [5.77]	-0.351*** [4.54]	-0.569*** [9.00]	-0.456*** [5.74]	-0.477*** [5.96]
Observations	556	556	556	216	88	151	101
# currency FE	4	4	4				
Time FE		✓					
Within $R^2$	0.280	0.748	0.442	0.529	0.589	0.433	0.396

Note: Regression specification and variable definitions follow Table 3, applied to monthly spot exchange rate changes of Emerging Market currencies with available data on dealer futures positions from the CFTC's TFF database. All regressions additionally include  $\Delta f_{k,t-2}^*$  that in all cases are estimated to be close to zero and insignificant. \*\*\* (\*\* and \*) denotes statistical significance at the 1-percent (5-percent and 10-percent) level.

Table A5: Spot exchange rate regressions for EM currencies

Dep. Var: $\Delta \log \mathcal{E}_{kt}$	MXN	RUB	BRL	ZAR	EM Panel	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta f_{kt}^*$	0.045*** [4.00]	0.056** [2.19]	0.026*** [2.86]	0.049*** [2.90]	0.044*** [4.55]	0.032*** [3.74]
$\Delta f_{k,t-1}^*$	0.006 [0.86]	0.022 [0.72]	0.003 [0.28]	-0.007 [0.37]	0.003 [0.47]	-0.004 [0.45]
$\Delta f_{k,t-2}^*$	0.010 [1.65]	0.005 [0.28]	0.019* [1.86]	0.001 [0.050]	0.007 [1.59]	0.008 [1.46]
$\Delta(i_{kt} - i_t^*)$	-1.362 [1.59]	1.974*** [21.08]	1.990** [2.45]	-3.445 [1.28]	1.863*** [7.49]	1.970*** [12.85]
$\Delta T\text{-basis}_t$	-3.336** [2.43]	-2.053 [0.63]	1.573 [0.38]	-4.891** [2.02]	-2.481 [1.16]	
$\Delta \log \text{VIX}_t$	0.034** [2.40]	0.049** [2.12]	0.042 [1.29]	-0.003 [0.08]	0.038** [2.15]	
$\Delta \log \mathbb{W}_t^*$	-0.115*** [2.81]	-0.105*** [3.54]	-0.061 [0.74]	-0.216** [2.49]	-0.084** [2.38]	
$\Delta \log \mathcal{E}_{k,t-1}$	-0.005 [0.66]	-0.001 [0.17]	-0.016** [2.32]	-0.030 [0.98]	-0.006 [0.99]	-0.013 [1.13]
Observations	209	149	134	78	570	588
# Currency FE					4	4
Time FE						✓
Within $R^2$	0.444	0.598	0.209	0.328	0.374	0.798

Notes: Regression specification and variable definitions follow Table 6, applied to monthly spot exchange rate changes of EM currencies with available data on dealer futures positions from the CFTC's TFF database. |t|-stats computed using Newey West standard errors in columns 1-4 and Driscoll-Kraay autocorrelation and heteroskedasticity robust standard errors in column 5 shown in brackets. \*\*\*, \*\*, \* denote statistical significance at the 1, 5 and 10 percent level respectively.

Table A6: UIP panel regressions with alternative measures of  $\mu$ 

Dep. var: $\widehat{UIP}_{k,t}$	(1) $\mu = VIX$	(2) $\mu = -DealerW$	(3) $\mu = -GFCy$	(4) $\mu = -GFCy$	(5) $\mu = EFFR - IORB$	(6) $\mu = EFFR - IORB$	(7) $\mu = EFFR - IORB$
$\Delta f_{kt}^*$	0.163*** [11.88]	0.169*** [13.14]	0.165*** [12.49]	0.175*** [13.10]	0.172*** [12.65]	0.161*** [12.52]	0.155*** [11.68]
$\Delta f_{k,t-1}^*$	-0.044*** [3.76]	-0.044*** [3.68]	-0.043*** [3.51]	-0.041*** [3.12]	-0.040*** [2.91]	-0.045*** [3.31]	-0.042*** [2.99]
$\Delta f_{k,t-2}^*$	0.011 [1.03]	0.013 [1.17]	0.012 [1.17]	0.022** [2.02]	0.020* [1.94]	0.017 [1.38]	0.016* [1.69]
$\Delta \log \mathcal{E}_t^{USD}$	1.468*** [9.63]	1.413*** [9.13]	1.363*** [9.13]	1.258*** [6.67]	1.256*** [6.39]	1.818*** [8.95]	1.586*** [7.15]
$\Delta \log VIX_t$	0.050*** [3.28]		0.035** [2.21]		0.007 [0.36]		0.057*** [3.59]
$\Delta \log VIX_t \times \bar{A}_{kt}^*$	0.002*** [5.08]		0.002*** [3.56]		0.001* [1.76]		0.002*** [5.10]
$\Delta \mu_t$		0.134*** [2.75]	0.084* [1.89]	3.651** [2.44]	3.394* [1.73]	4.532 [1.04]	3.856 [1.19]
$\Delta \mu_t \times \bar{A}_{kt}^*$		0.006*** [6.42]	0.002* [1.76]	0.205*** [5.57]	0.135*** [3.32]	0.372 [1.45]	0.315** [2.02]
$\bar{A}_{kt}^*$	0.022 [1.00]	0.023 [1.02]	0.022 [0.98]	0.036 [1.53]	0.037 [1.55]	0.009 [0.39]	0.010 [0.43]
Observations	1,204	1,204	1,204	1,064	1,064	1,022	1,022
# currency FE	7	7	7	7	7	7	7
Within R2	0.570	0.562	0.574	0.577	0.581	0.535	0.567

Notes: Panel regressions for G7 currencies with survey-based UIP change as the dependent variable and using alternative measures of  $\mu_t$  (marginal cost of Dollar funding): baseline VIX index, the inverse of log Dealer leverage ratio ( $-DealerW$ ), the negative of the (pro-cyclical) Global Financial Cycle index ( $-GFCy$ ) from Miranda-Agrippino and Rey and the spread between effective federal funds rate and the interest on reserve balance rate ( $EFFR - IORB$ ). Measures of  $\mu$  are interacted with the currency-specific local-currency funding gap  $\bar{A}_{kt}^*$ , which equals external dollar-debt liabilities minus external dollar-debt assets in percent of GDP, and changes *only* at the annual frequency.  $\Delta CIP_{k,t}$  and lagged UIP level  $\widehat{UIP}_{k,t-1}$  are included in all columns but not reported. Currency fixed effects included in all regressions. |t|-stats computed using Driscoll-Kraay autocorrelation and heteroskedasticity robust standard errors shown in brackets.

Table A7: CIP panel regressions with dollar gap interaction and alternative measures of  $\mu$ 

Dep. var: $\Delta CIP_{kt}$	(1) $\mu = VIX$	(2) $\mu = -DealerW$	(3) $\mu = -GFCy$	(4) $\mu = -GFCy$	(5) $\mu = EFFR - IORB$	(6) $\mu = EFFR - IORB$	(7) $\mu = EFFR - IORB$
$\Delta f_{kt}^*$	0.0003 [0.79]	0.0004 [1.00]	0.0003 [0.88]	0.0005 [1.57]	0.0005 [1.53]	-0.0000 [0.17]	-0.0001 [-0.36]
$\Delta f_{k,t-1}^*$	-0.0002 [0.74]	-0.0002 [0.80]	-0.0001 [0.73]	-0.0002 [0.73]	-0.0002 [0.72]	-0.0001 [0.32]	-0.0001 [0.40]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	-0.0189** [2.37]	-0.0233** [2.30]	-0.0217** [2.36]	-0.0189*** [3.31]	-0.0192*** [3.33]	-0.0096* [1.78]	-0.0082 [1.62]
$\Delta \log VIX_t$	-0.0002 [0.44]		-0.0005 [1.29]		-0.0002 [0.59]		-0.0000 [0.05]
$\Delta \log VIX_t \times \bar{A}_{kt}^*$	0.00002*** [2.67]		0.0000 [1.55]		0.0001 [0.47]		0.00002** [2.55]
$\Delta \mu_t$		0.0013 [1.33]	0.0019* [1.69]	-0.0398 [1.20]	-0.0305 [1.12]	0.164*** [2.97]	0.168*** [3.05]
$\Delta \mu_t \times \bar{A}_{kt}^*$		0.0001** [2.52]	0.0000 [0.91]	0.0017* [1.85]	0.0015 [1.59]	0.0095** [2.33]	0.0092*** [2.77]
$\bar{A}_{kt}^*$	-0.0001 [0.22]	-0.0001 [0.22]	-0.0001 [0.24]	-0.0001 [0.11]	-0.0000 [0.097]	-0.0002 [0.37]	-0.0002 [0.35]
Observations	1,204	1,204	1,204	1,064	1,064	1,022	1,022
# currency FE	7	7	7	7	7	7	7
Within R2	0.193	0.192	0.199	0.213	0.214	0.217	0.224

Notes: Panel regressions for G7 currencies with CIP change as dependent variables and using alternative measures of  $\mu_t$  (marginal cost of Dollar funding): baseline VIX index, the inverse of log Dealer leverage ratio ( $-DealerW$ ), the negative of the (pro-cyclical) Global Financial Cycle ( $-GFCy$ ) index from Miranda-Agrippino and Rey and the spread between effective federal funds rate and the interest on reserve balance rate ( $EFFR - IORB$ ). Measures of  $\mu$  are interacted with the local-currency funding gap  $\bar{A}_{kt}^*$ , which equals external dollar-debt liabilities minus external dollar-debt assets in percent of GDP, and changes *only* at the annual frequency. A constant term,  $\Delta UIP_{k,t}$  and lagged CIP level  $CIP_{k,t-1}$  included in all columns but not reported. Currency fixed effects included in all regressions. |t|-stats computed using Driscoll-Kraay autocorrelation and heteroskedasticity robust standard errors shown in brackets.

Table A8: Weekly CIP panel

Dep. var: $\Delta CIP_{k,t}$	G7+ panel		EM panel	
	(1)	(2)	(3)	(4)
$CIP_{k,t-1}$	-0.090*** [6.27]	-0.061*** [5.31]	-0.085*** [2.93]	-0.134** [2.14]
$\Delta f_{kt}^*$	0.0002** [2.56]	0.0003** [2.50]	0.001** [1.99]	-0.001 [0.38]
$\Delta f_{k,t-1}^*$	0.000 [0.47]	-0.000 [0.26]	-0.001 [1.31]	-0.000 [0.22]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	-0.012** [3.12]		0.052*** [3.67]	
$\Delta \log VIX_t$	-0.0004*** [3.99]		0.001 [1.52]	
Observations	6,328	6,328	2,292	2,292
Within $R^2$	0.060	0.575	0.051	0.452
# currency FE	7	7	4	4
Time FE		✓		✓

Notes: Panel regressions for G-7 and EM currencies with weekly CIP change as dependent variable and weekly change in FX futures dealer position as main explanatory variable. EM Panels include the same four EM currencies as in Table A5. All regressions additionally include  $\Delta f_{t-2}^*$  that in all cases are estimated to be close to zero and insignificant. Currency fixed effects included in all regressions and time fixed effects included in columns (2) and (4). |t|-statistics computed using Driscoll-Kraay autocorrelation and heteroskedasticity robust standard errors shown in brackets.

\*\*\*, \*\*, \* denote statistical significance at the 1, 5 and 10 percent level respectively.

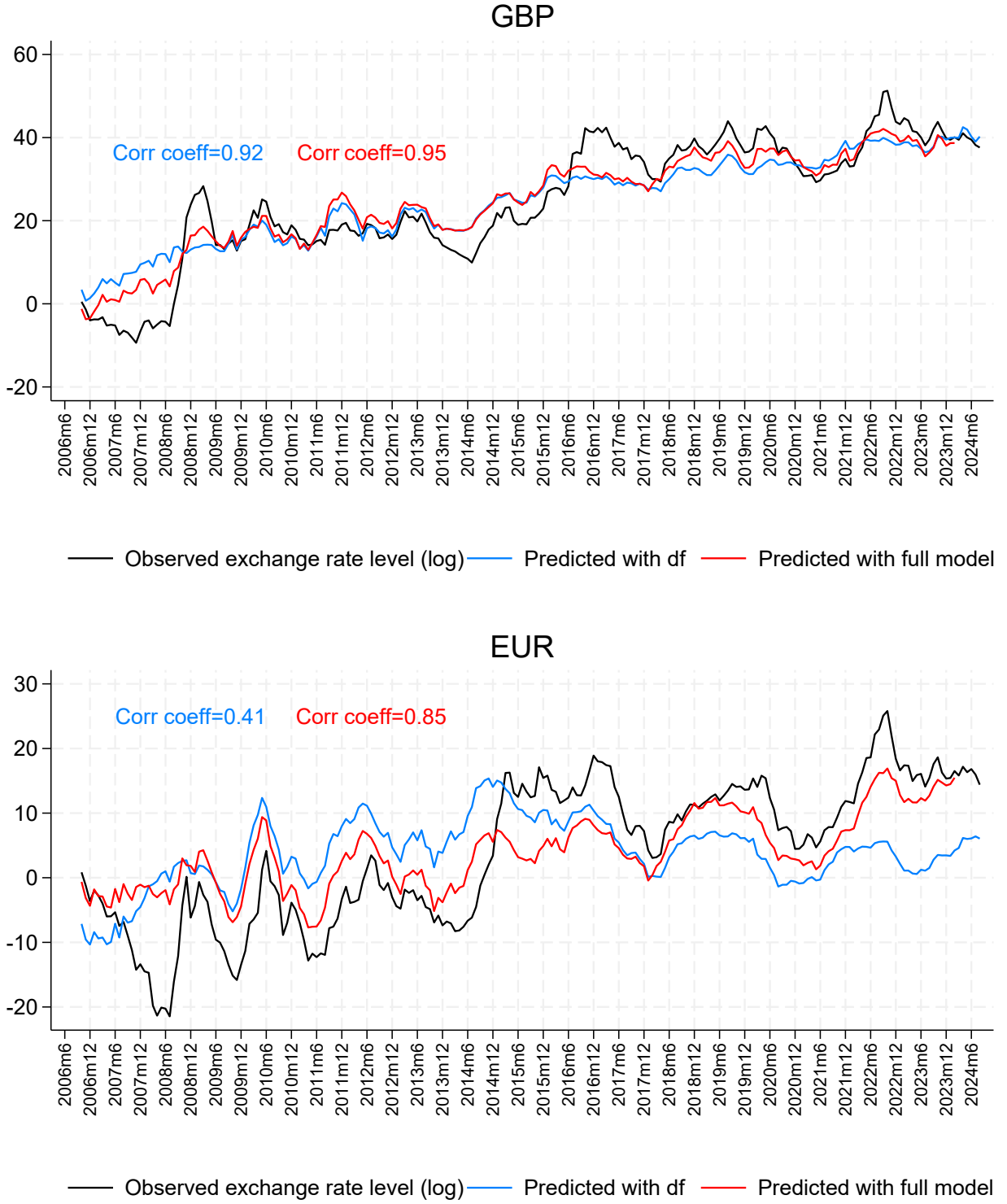
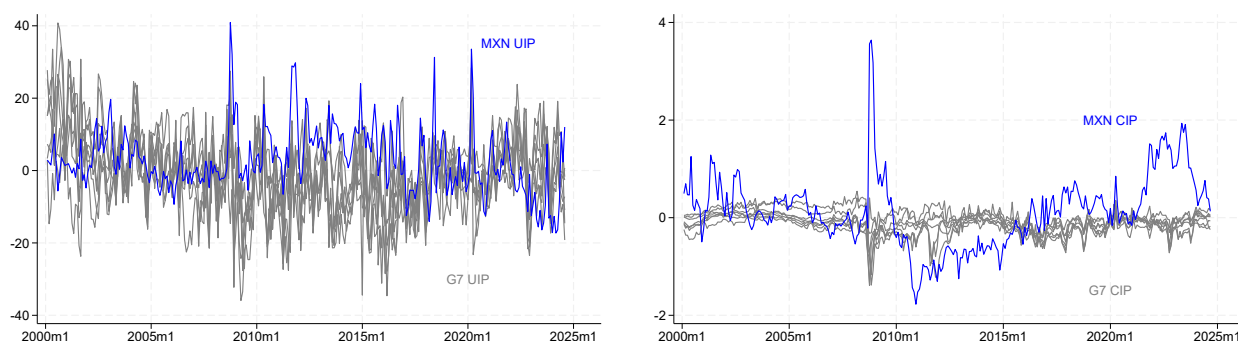


Figure A3: Realizations of  $\log \mathcal{E}_{kt}$  and its fitted values

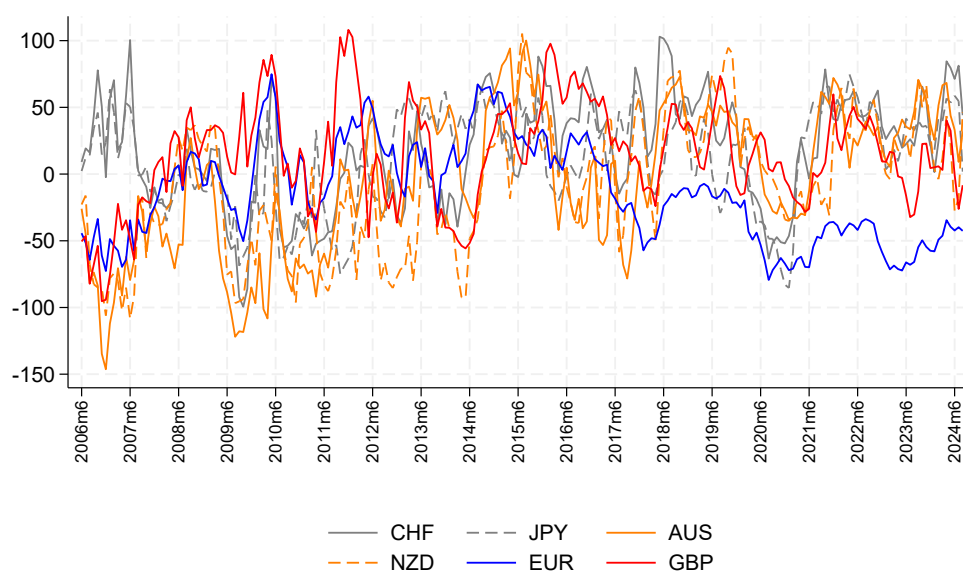
Note: The figures plot the realization of the log of the spot exchange rates  $\log \mathcal{E}_{kt}$  for the euro and the British pound along with the cumulated fitted values from an empirical model of  $\Delta \log \mathcal{E}_{kt}$  using only the currency futures positions of dealer banks  $\Delta f_{kt}^*$ , as well as the full model with other covariates of the exchange rate (based on Table 6).

Figure A4: Time series of survey UIP and CIP premia: G7 and MXN



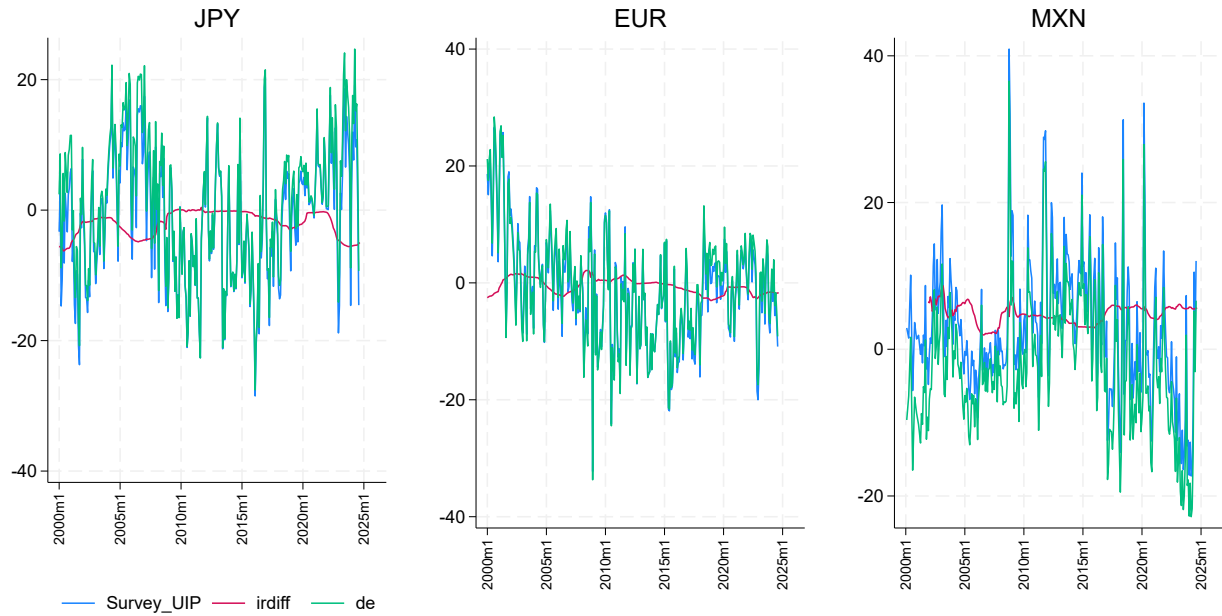
Notes: Left figure plots the 3-month survey UIP premium for G7 currencies (gray) and Mexican Peso (blue), in percent annualized. Right figure plots the 3-month CIP premium for G7 currencies (gray) and Mexican peso (blue), in percent annualized. Source: Bloomberg, Refinitiv, IMF IFS, Consensus Economics.

Figure A5: Dealers net futures position by G7 currency

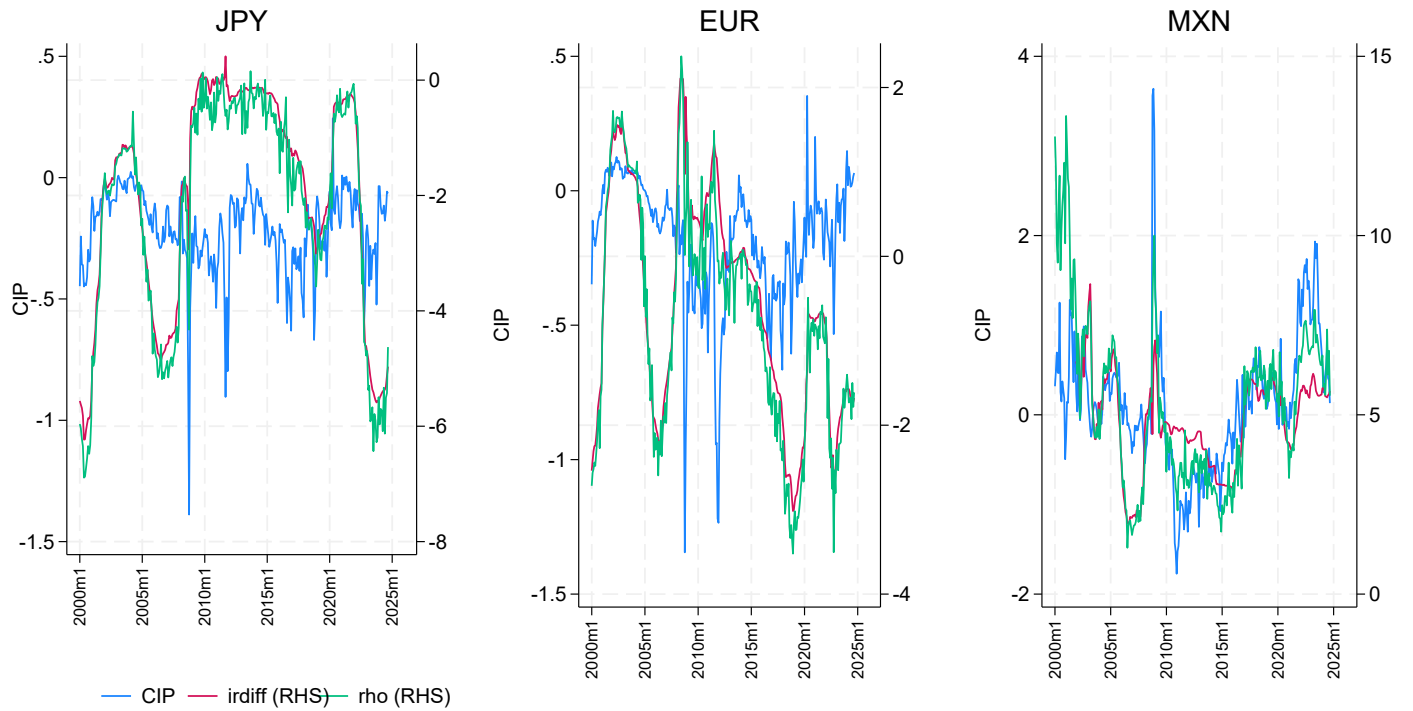


Notes: The figure plots the time series for net futures positions of dealer banks on the Chicago Mercantile Exchange by currency, in percent of 12-month moving average total open positions in each currency. Data are monthly averages of weekly numbers. Source: CFTC Traders in Financial Futures (TFF) Weekly Reports.

Figure A6: UIP and CIP decomposition



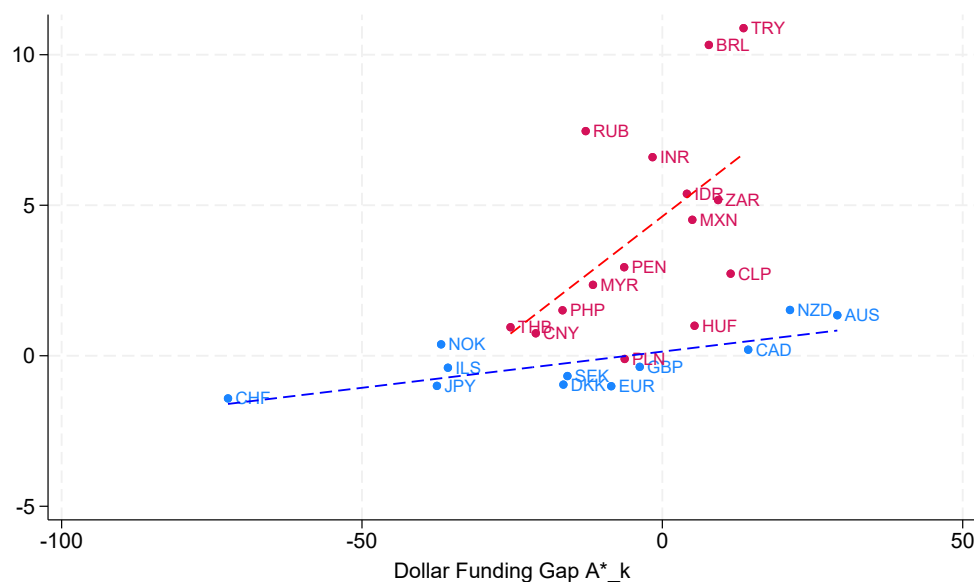
(a) UIP decomposition for JPY, EUR, MXN.



(b) CIP decomposition for JPY, EUR, MXN.

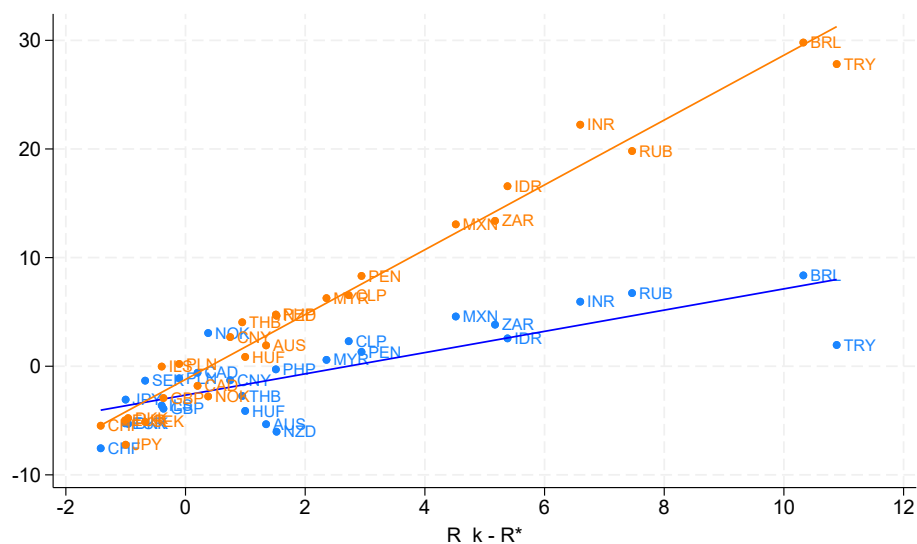
Notes: Panel (a) shows the decomposition of the survey UIP premium into the local currency vs. dollar interest rate differential (irdiff) and expected appreciation (de). Panel (b) decomposes the CIP premium into the interest differential (irdiff) and forward premium (rho).

Figure A7: Cross section of average interest rate differentials (in %) against the average funding gap (advanced economies and emerging markets currencies)

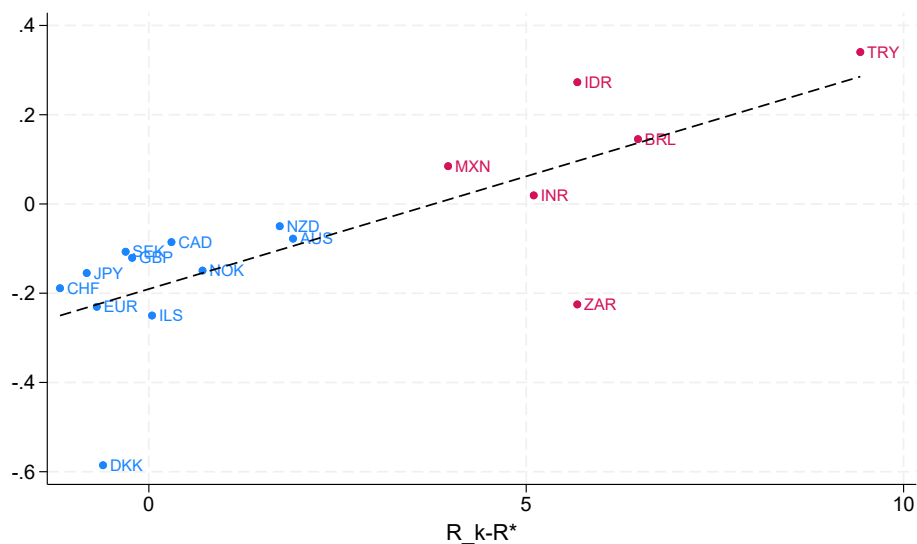


Notes: This figure generalizes Figure 3 in the main text to a broader set of advanced economies and emerging market currencies, illustrating group-specific slopes for the scatter plot of the average local-currency funding gap and interest rate differential vis-à-vis the dollar (red for EM, blue for AE currencies). All variables are averaged over Jan 2012- Dec 2020 monthly observations. The local-currency funding gap is the dollar external debt liability net of dollar external asset position in percent of domestic GDP.

Figure A8: Cross section of the average UIP and CIP deviations (in %) against the average interest rate differential



(a) Survey (blue) and realized (orange) 3-month UIP deviations against 3-month IR differential



(b) 12-month CIP deviation and IR differential, purified CIP for EM currencies (red).

Notes: This figure generalizes Figure 4 in the main text to a broader set of advanced economies and emerging market currencies. All variables are averaged over Jan 2012- Dec 2020 monthly observations. Purified CIP deviations and purified interest rate differentials for EM currencies in panel (b) are calculated using supranational bond yields according to [Dao and Gourinchas \(2025\)](#). To match the tenor of the purified CIP deviations, panel (b) plots the 12-month CIP deviation against the 12-month risk-free interest rate differential for all currencies.

Figure A9: Realizations of  $\Delta \log \mathcal{E}_{kt}$  and its fitted values for individual currencies

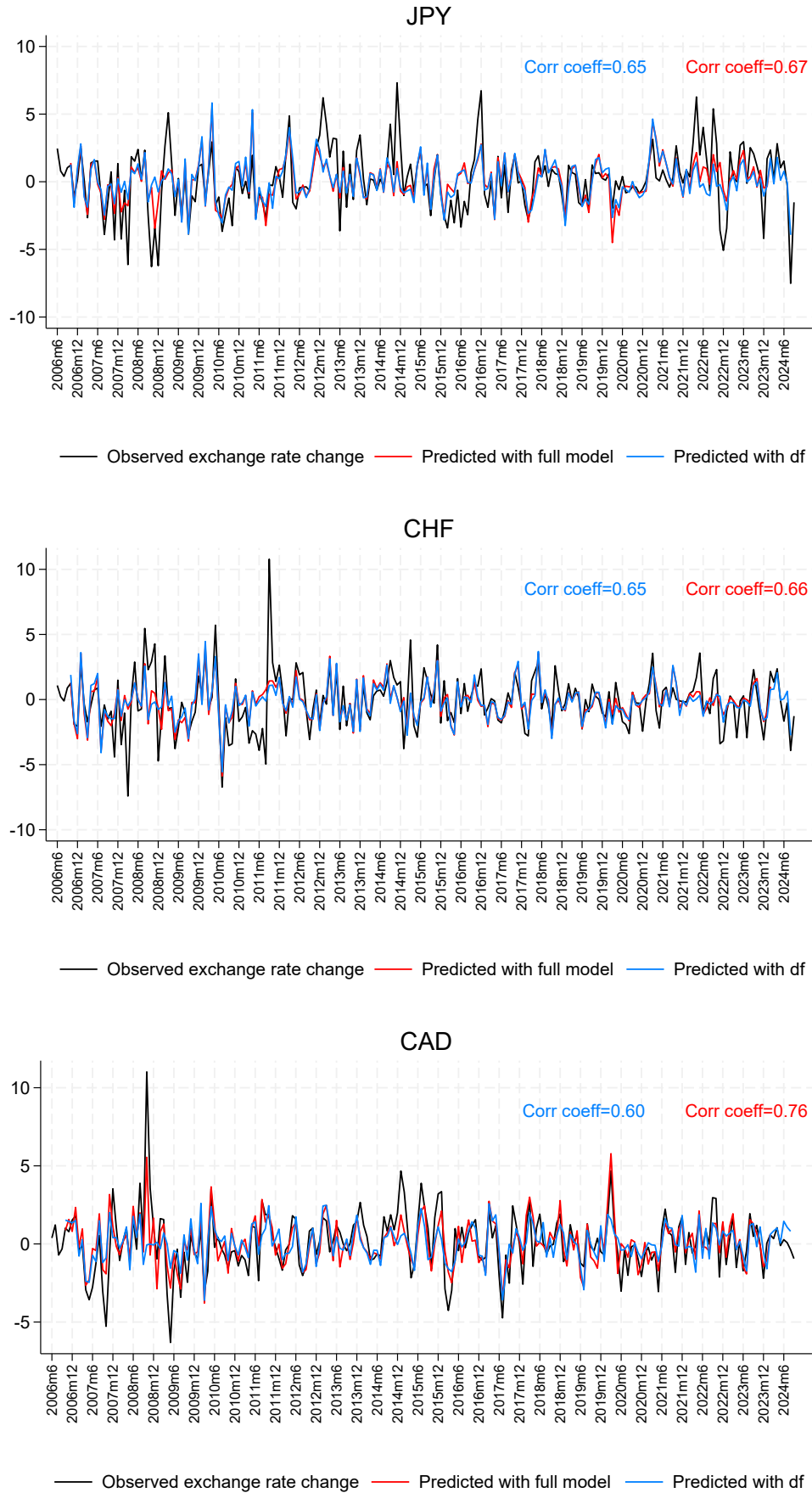


Figure A10: Realizations of  $\Delta \log \mathcal{E}_{kt}$  and its fitted values for individual currencies(continued)

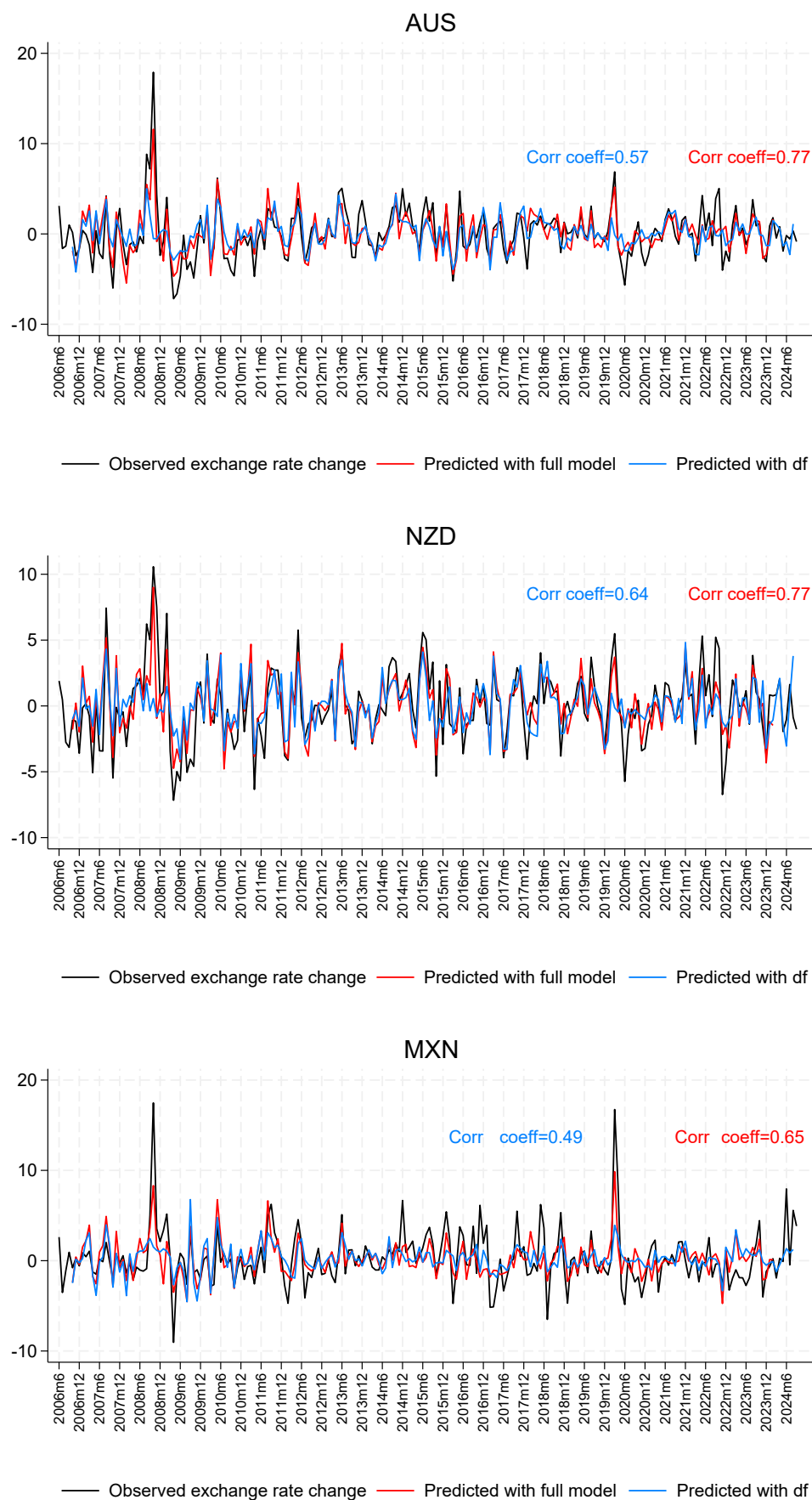


Figure A11: Realizations of  $\log \mathcal{E}_{kt}$  and its fitted values for individual currencies

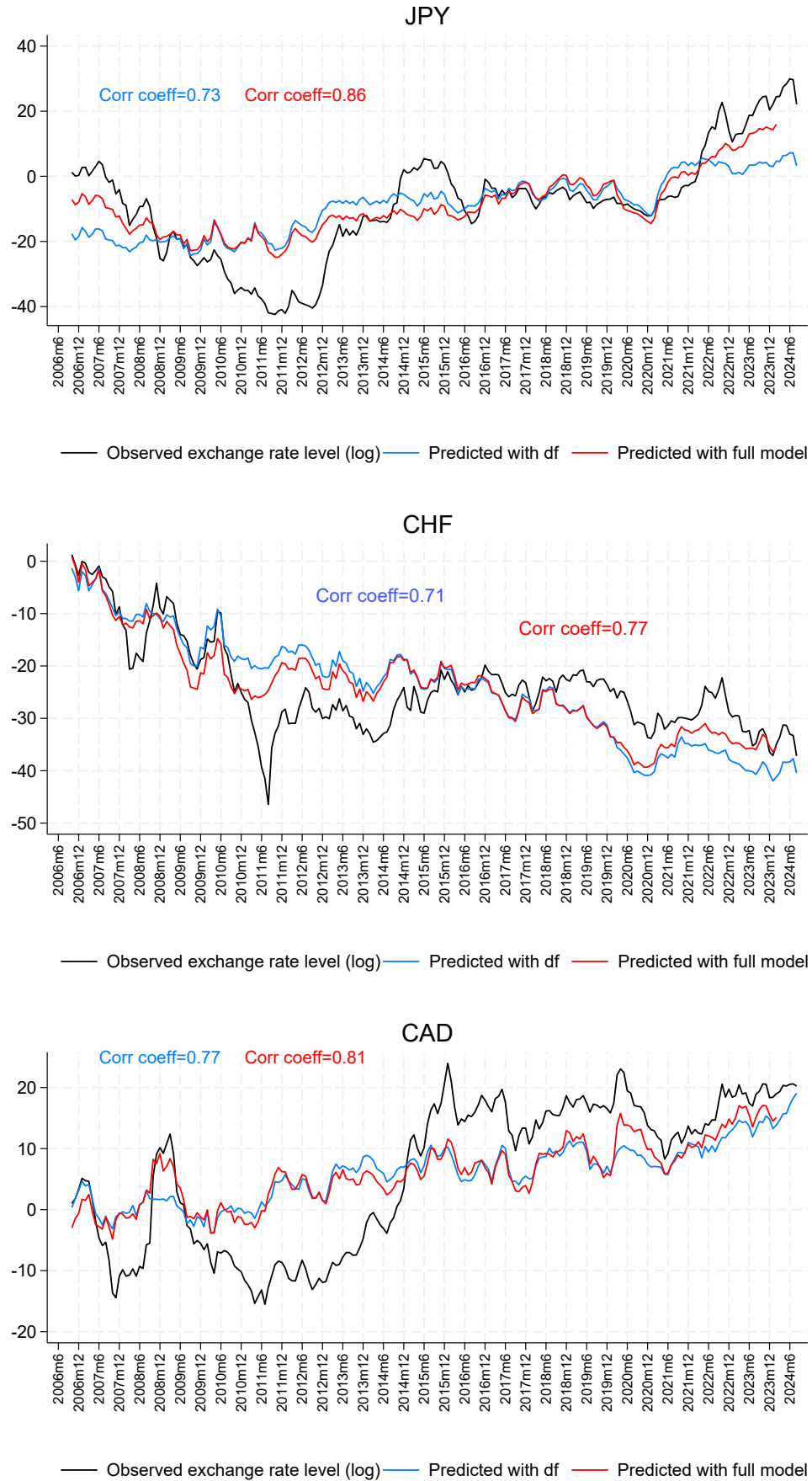
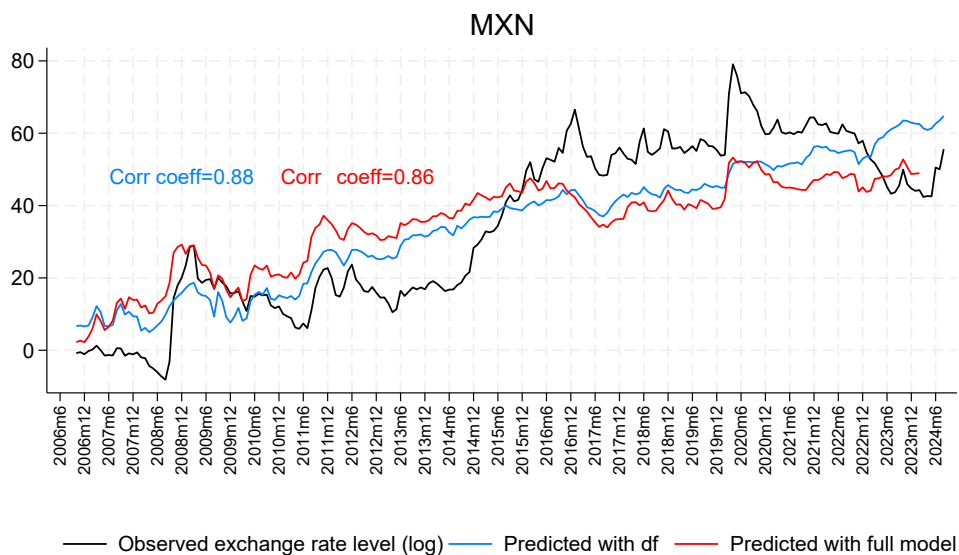
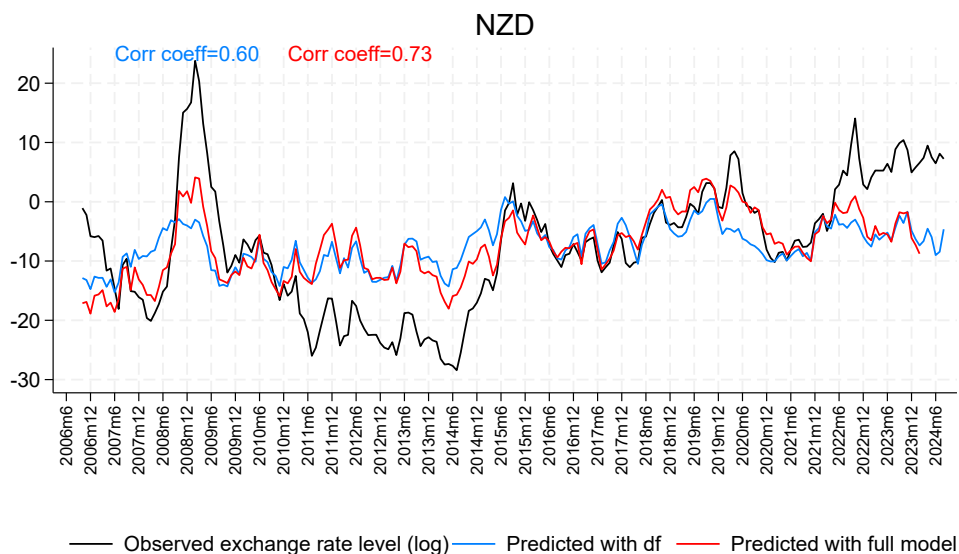
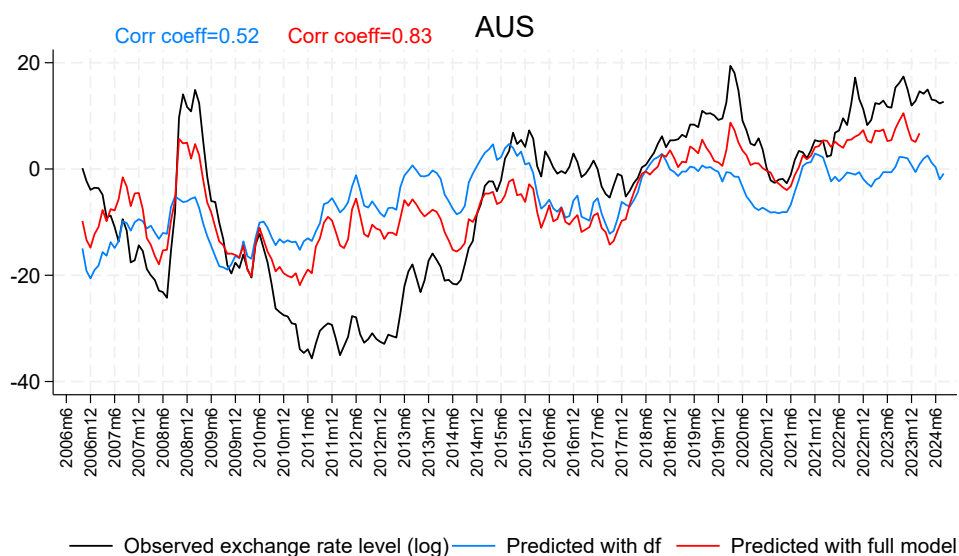


Figure A12: Realizations of  $\log \mathcal{E}_{kt}$  and its fitted values for individual currencies (continued)



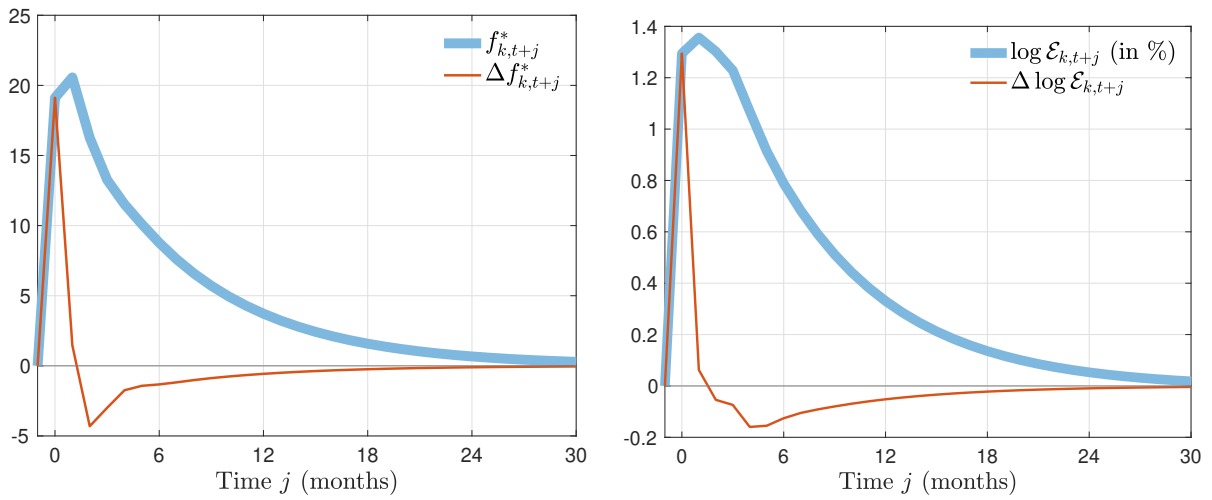


Figure A13: Impulse response to an innovation to  $\Delta f_{kt}^*$ : no time fixed effect

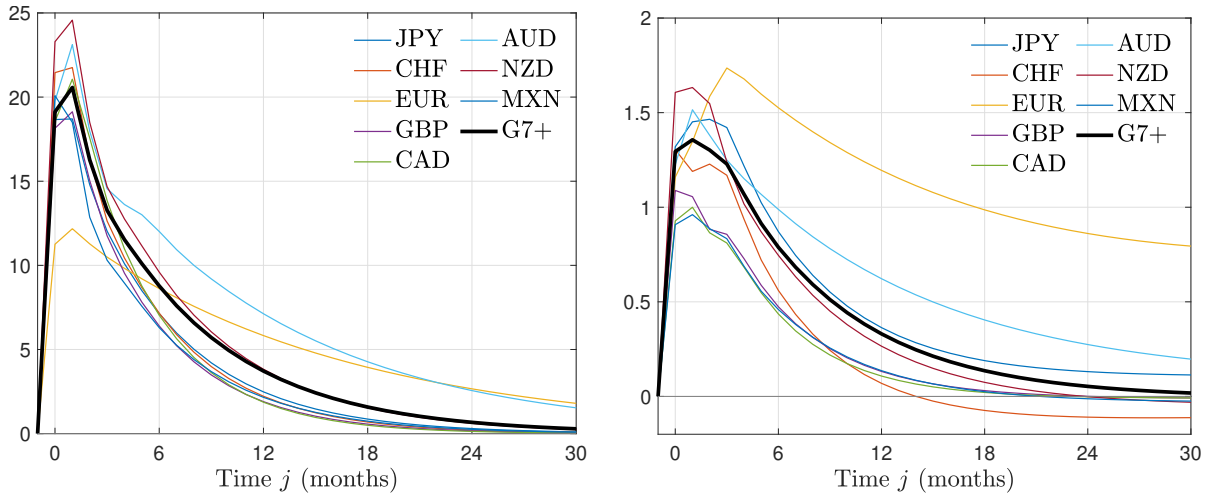


Figure A14: Impulse response to an innovation to  $\Delta f_{kt}^*$ : individual currencies

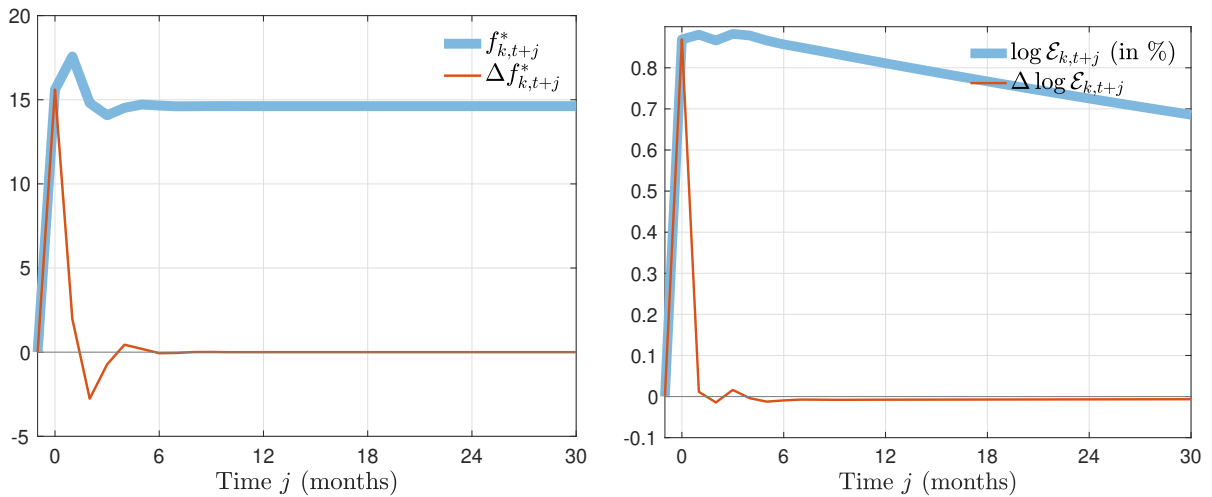


Figure A15: Impulse response to an innovation to  $\Delta f_{kt}^*$ : no mean reversion in (22)

Note: Top row plots impulse responses for the pooled G7+ panel specification *without* time fixed effects. Middle row plots impulse responses for individual currencies (black lines are for the G7+ panels without time fixed effects, as in the top row). Bottom row plots impulse responses for the G7+ panel with time fixed effects, but without lagged level  $f_{k,t-1}^*$  in specification (22) for  $\Delta f_{kt}^*$ . See Figure 8 for comparison with the baseline panel specification with time fixed effects.

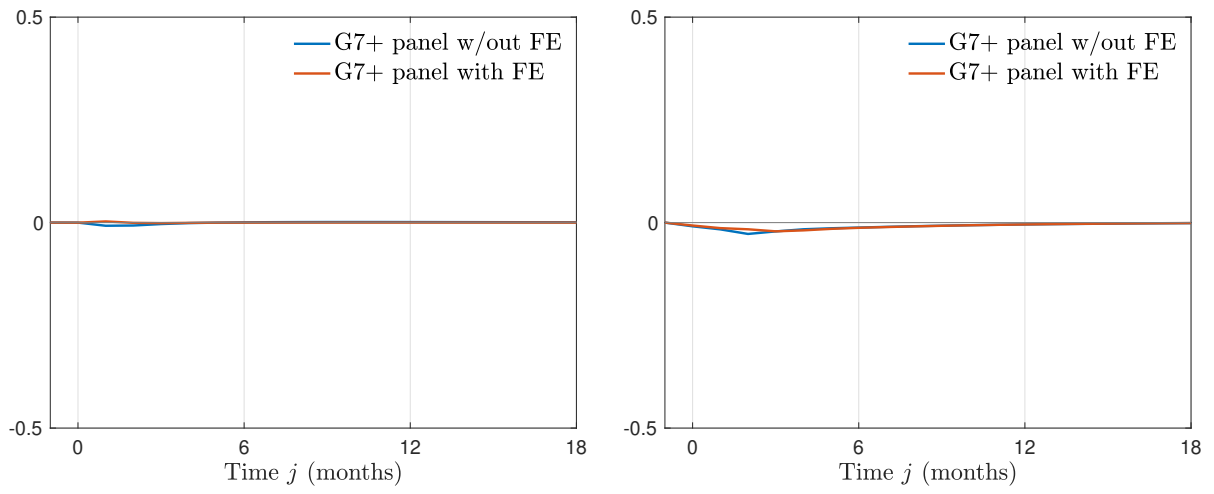


Figure A16: Impulse responses of  $CIP_{k,t+j}$  (left) and  $r_{k,t+j} - r_{t+j}^{US}$  (right) to a  $\Delta f_{kt}^*$  innovation

Note: Both panels are in basis points, that is, 0.5 on the  $y$ -axis is half a basis points (or 0.005%), annualized. See Figure 9 for the uncovered currency returns.

## B Proofs

**Proof of Proposition 1** Substitute the expression for net worth evolution (2) and simplify using  $\mathbb{E}_t \Theta_{t+1} = 1/R_t^*$ :

$$\begin{aligned} \mathbb{E}_t \Theta_{t+1} W_{t+1}^* &= (W_t^* - B_t^* - H_t^*) + \frac{R_t^*}{R_t^*} B_t^* + \mathbb{E}_t [\Theta_{t+1} \tilde{R}_{t+1}^*] H_t^* \\ &\quad + \frac{1}{R_t^*} CIP_t X_t^* + \mathbb{E}_t [\Theta_{t+1} UIP_{t+1}] Z_t^* + \frac{R_t}{R_t^*} \left( \frac{\mathcal{E}_t}{\mathcal{F}_t} - \frac{\mathcal{E}_t}{\mathcal{S}_t} \right) S_t^*, \end{aligned}$$

and we write the constraint with complementary slackness as:

$$\frac{\mu_t}{R_t^*} \left[ B_t^* - \frac{\alpha}{2} \frac{([H_t^*]^+)^2}{W_t^*} - \frac{\gamma \sigma_t}{2} \frac{(Z_t^*)^2}{W_t^*} - \delta |X_t^*| \right] = 0.$$

Combining the two expressions into a Lagrangian and taking the five optimality conditions with respect to  $\{B_t^* \geq 0, H_t^* \geq 0, X_t^*, Z_t^*, S_t^*\}$  yields:

$$\begin{aligned} \frac{\mu_t}{R_t^*} &\leq \frac{R_t^* - \underline{R}_t^*}{R_t^*}, \\ \mathbb{E}_t [\Theta_{t+1} \tilde{R}_{t+1}^*] - 1 &\leq \frac{\alpha \mu_t}{R_t^*} \frac{H_t^*}{W_t^*}, \\ \mathbb{E}_t [\Theta_{t+1} UIP_{t+1}] &= \frac{\gamma \mu_t \sigma_t}{R_t^*} \frac{Z_t^*}{W_t^*}, \\ \frac{1}{R_t^*} CIP_t &= \frac{\delta \mu_t}{R_t^*} \text{sign}(X_t^*), \\ \frac{R_t}{R_t^*} \left( \frac{\mathcal{E}_t}{\mathcal{F}_t} - \frac{\mathcal{E}_t}{\mathcal{S}_t} \right) &= 0, \end{aligned}$$

where  $\text{sign}(X_t^*) = \frac{\partial |X_t^*|}{\partial X_t^*}$  is a step function from  $-1$  to  $1$  at  $X_t^* = 0$ . The inequalities in the first two optimality conditions, which hold with complementary slackness with  $B_t^* \geq 0$  and  $H_t^* \geq 0$ , respectively, together with Assumption 1 imply  $H_t^* > 0$  and  $B_t^* > 0$ , and hence  $\mu_t = R_t^* - \underline{R}_t^* > 0$ . That is, the balance sheet constraint is binding and the size of the balance sheet exceeds reserves with positive risky investment  $H_t^*$  determined from the second optimality conditions which holds with equality. The last condition implies  $\mathcal{S}_t = \mathcal{F}_t$ . The two conditions to the last one characterize  $CIP_t$  and  $\overline{UIP}_t = R_t^* \mathbb{E}_t [\Theta_{t+1} UIP_{t+1}]$ , and result in the expressions in the proposition, given that  $R_t^* = 1/\mathbb{E}_t \Theta_{t+1}$ . ■

**Proof of Proposition 2** Condition (10) is the direct result of aggregation of individual bank positions  $Z_{it}^* = A_{it}^* + F_{it}^*$  in the optimality condition (7) after rearranging it as  $\overline{UIP}_t \cdot \frac{W_{it}^*}{W_t^*} = \mu_t \sigma_t \cdot Z_{it}^*$  and imposing market clearing  $\sum_i Z_{it}^* = \mathbb{Z}_t^*$  from (9). Bringing the resulting term  $\sum_i W_{it}^* \gamma_{it}^*/\gamma_{it}$  to the right-hand side yields (10), with  $\overline{UIP}_t$  defined in (8).

Condition (11) follows a similar logic with the difference that the optimality condition (7) does not specify the size of the optimal bank positions  $X_{it}^*$ , only their sign which coincides with the sign of the CIP deviation  $CIP_t$ . Formally, for all dealer banks  $i$  active in the forward and swap markets, we have:

$$\text{sign}(X_{it}^*) = \text{sign}(CIP_t) = \text{sign}(\mathbb{X}_t^*).$$

Note that there may be gross positive and negative demand for forwards and swaps, but the dealer banks only need to intermediate the net demand from the rest of the economy given by  $\mathbb{X}_t^* = \mathbb{F}_t^* + \mathbb{S}_t^*$ , which is the reason for the second equality above. We generalize the optimality condition (7) to be:

$$\delta_{it} \mu_t \leq |CIP_t|,$$

with strict inequality if the size of  $X_{it}^*$  is constrained and equality if it is not. This leaves three possibilities: (1) If banks are symmetric, with  $\delta_{it} = \bar{\delta}_t$  for all  $i$ , then in equilibrium  $\mathbb{X}_t^* = \sum_i X_{it}^*$  with individual positions  $X_{it}^*$  indeterminant as banks are indifferent who supplies forwards and swaps. Alternatively, if banks are heterogenous with a distribution  $\{\delta_{it}\}$ , then only the most unconstrained banks supply swaps such that: (2) either  $\bar{\delta}_t = \min_i \delta_{it}$  or (3)  $\bar{\delta}_t = \min\{\delta_{it} : X_{it}^* \text{ is unconstrained}\}$ . In the former case, only the most efficient banks (with lowest  $\delta_{it}$ ) serve the market. In the latter case, the most efficient banks are constrained and the marginal (indifferent) bank supplying swaps has  $\delta_{it} > \min_i \delta_{it}$ ; all banks with lower  $\delta_{it}$  are active in this market as well, and all banks with a higher  $\delta_{it}$  are inactive. In all three cases, by construction  $\bar{\delta}_t \mu_t = |CIP_t|$  and threfore (11) holds as  $\text{sign}(CIP_t) = \text{sign}(\mathbb{X}_t^*)$ . ■

## C Time-series Identification

This appendix lays out the identification argument behind the local projection regressions (21) and (22) in Section 3.3 and (24) in Section 3.4.

For simplicity, we consider the simple case where both  $f_{kt}^*$  and variables of interest  $v_{kt}$  (currency premia, exchange rates) follow exact random walks, so there is no need to include lags in the dynamic projections in changes and their contemporaneous correlations are sufficient. We then focus on the following specification:

$$\Delta v_{kt} = \theta_k + \theta_t + \beta \Delta f_{kt}^* + \gamma w_{kt} + \varepsilon_{kt}. \quad (\text{A1})$$

In our empirical projections we include lags to take care of the potential dynamic correlations. Furthermore, we focus first on the expected UIP premium, that is  $v_{kt} = \overline{UIP}_{kt}$ , and then discuss the generalization to various proxies for expected UIP, as well CIP premium and the exchange rate.

**Bivariate regression** We defined the set of agents active in the currency market as  $\mathcal{I}_k = \mathcal{I}_k^D \cup \mathcal{I}_k^N$ , where  $\mathcal{I}_k^D \cap \mathcal{I}_k^N = \emptyset$ , and  $\mathcal{I}_k^D$  is the subset of agents classified as dealers and  $\mathcal{I}_k^N$  is the subset of non-dealers (i.e., everyone else).  $Z_{it}^*$  denotes the currency  $k$  risk exposure of agent  $i \in \mathcal{I}_k$ . Therefore, market clearing requires

$$\sum_{i \in \mathcal{I}_k} Z_{it}^* = 0 \quad (\text{A2})$$

since the currency risk exposure is in zero net supply (in other words, a positive exposure of one agent must be a negative exposure of somebody else). The total volume in the currency  $k$  market is  $\mathbb{V}_{kt}^* \equiv \sum_{i \in \mathcal{I}_k} |Z_{it}^*| > 0$ , where the strict inequality implies that the market is active. We define the net exposure of all dealers as:

$$\mathbb{Z}_{kt}^D \equiv \sum_{i \in \mathcal{I}_k^D} Z_{it}^*, \quad (\text{A3})$$

which by market clearing implies that  $\sum_{i \in \mathcal{I}_k^N} Z_{it}^* = -\mathbb{Z}_{kt}^D$ . By dealers, denoted with  $D$  in this appendix, we understand the broad intermediary bank company that owns the dealer, as we explain in the text of the paper.

We make the following assumption: currency  $k$  exposure of any agent  $i \in \mathcal{I}_k$  at  $t$  can be represented as

$$Z_{it}^* = -\xi_{it} + \rho_i \cdot \overline{UIP}_{kt}, \quad \xi_{it} \perp \overline{UIP}_{kt}, \quad (\text{A4})$$

where  $\overline{UIP}_{kt}$  is the expected payout per unit of currency exposure (as in (2) in Lemma 1). Assumption (A4) states that the exposure of any agents can be decomposed into the position taken for the purposes of collecting the (expected) currency return and the residual shifter  $\xi_{it}$  that by construction is orthogonal to the expected currency return. More precisely, equation (A4) holds without loss of generality as a decomposition of the currency exposure into its projection component onto the expected premium and the projection residual. Note that it is useful to think of the projection component in (A4) as the currency supply portion of the position and the orthogonal shifter as the currency demand portion, with each agent's position containing both elements of currency supply (in response to the currency premium) and currency demand (orthogonal to the currency premium).

While we expect (A4) to hold for every agent in the market as a reduced-form representation of their position, for dealer banks' with positions characterized by Proposition 1, decomposition (A4) also has a structural interpretation. Rewrite optimality condition in (7) as  $Z_{it} = \rho_{it} \cdot \overline{UIP}_{kt}$  for any  $i \in \mathcal{I}_k^D$  and where  $\rho_{it} \equiv W_{it}^* / [\gamma_{it} \mu_t \sigma_{kt}]$ . Then we can take a Taylor expansion around the unconditional mean of the position,  $\bar{Z}_i = \bar{\rho}_i \cdot \mathbb{E} \overline{UIP}_{kt}$ , as:

$$dZ_{it} = -\xi_{it} + \bar{\rho}_i \cdot d\overline{UIP}_{kt}, \quad \text{where} \quad \xi_{it} \equiv \frac{\bar{Z}_i}{\bar{\rho}_i} \cdot d\rho_{it} = \bar{Z}_i \cdot d \log \rho_{it}. \quad (\text{A5})$$

Of course,  $d\rho_{it}$  does not have to be in general orthogonal with  $d\overline{UIP}_{kt}$ , but it can always be projected on  $d\overline{UIP}_{kt}$  with  $\xi_{it}$  then defined as the residual from this projection. Below we make use of the structural non-orthogonal expansion (A5) for dealers and the reduced form orthogonal expansion (A4) for non-dealers.

Given the expansion in (A4) and the market clearing condition (A2), we can characterize the equilibrium in the currency market as follows:

**Proposition A1** *The equilibrium expected UIP premium in the currency is equal to:*

$$\overline{UIP}_{kt} = \frac{1}{\varrho_k^D + \varrho_k^N} \cdot \Xi_{kt}, \quad \text{where} \quad \Xi_{kt} \equiv \xi_{kt}^D + \xi_{kt}^N = \sum_{i \in \mathcal{I}_k^D} \xi_{it} + \sum_{i \in \mathcal{I}_k^N} \xi_{it}$$

is the currency  $k$  demand shock and  $\varrho_k^J \equiv \sum_{i \in \mathcal{I}_k^J} \bar{\rho}_i$  for  $J \in \{D, N\}$ . The equilibrium net position of all dealers combined is given by:

$$\mathbb{Z}_{kt}^D = -\xi_{kt}^D + \varrho_k^D \cdot \overline{UIP}_{kt} = -\xi_{kt}^D + \frac{\varrho_k^D}{\varrho_k^D + \varrho_k^N} \Xi_{kt} = \frac{1}{\varrho_k^D + \varrho_k^N} (\varrho_k^D \xi_{kt}^N - \varrho_k^N \xi_{kt}^D).$$

**Proof:** Substitute (A4) into (A2) and aggregate using the definitions of  $\xi_{kt}^J$  and  $\varrho_k^J$  for  $J \in \{D, N\}$ . Substitute the resulting expressions into (A3) to obtain the characterization of  $\mathbb{Z}_{kt}^D$ . ■

The equilibrium UIP premium reflect the aggregate currency demand shock  $\Xi_{kt}$  with the pass-through of this shock proportional to the inverse of the slope of the aggregate currency  $k$  supply in the market,  $\varrho_k^D + \varrho_k^N$ . As emphasized above, each agent  $i$  acts as a source of both supply and demand in a zero-net-supply currency market.

Using the characterization in Proposition A1, we can now characterize what happens as an outcome of the regression of the (expected) UIP premium on the net position of all dealers, for currency  $k$ :

$$\overline{UIP}_{kt} = \alpha_D + \beta_D \mathbb{Z}_{kt}^D + \epsilon_{kt}^D. \quad (\text{A6})$$

For simplicity, we wrote the regression in levels, but in practice it is implemented in changes to allow for unit roots in  $\xi_{kt}^J$ . We are interested, in particular, in the  $R^2$  in this regression which we denote as  $R_D^2$ .

**Corollary A1** *The coefficient and  $R^2$  in the regression (A6) are equal to:*

$$\beta_D = \frac{1}{\varrho_k^D} \cdot \frac{\text{cov}(\xi_{kt}^N + \xi_{kt}^D, \xi_{kt}^N - \varrho_k^N / \varrho_k^D \cdot \xi_{kt}^D)}{\text{var}(\xi_{kt}^N - \varrho_k^N / \varrho_k^D \cdot \xi_{kt}^D)} \quad \text{and} \quad R_D^2 = \frac{\text{cov}(\xi_{kt}^N + \xi_{kt}^D, \xi_{kt}^N - \varrho_k^N / \varrho_k^D \cdot \xi_{kt}^D)^2}{\text{var}(\xi_{kt}^N + \xi_{kt}^D) \text{var}(\xi_{kt}^N - \varrho_k^N / \varrho_k^D \cdot \xi_{kt}^D)}.$$

When  $\text{var}(\xi_{kt}^D) / \text{var}(\xi_{kt}^N) \rightarrow 0$ , we have  $\beta_D \rightarrow 1 / \varrho_D$  and  $R_D^2 \rightarrow 1$ , provided  $\rho_k^D > 0$ .

**Proof:** This is a corollary of characterization in Proposition A1 after using the fact that  $\beta_D = \frac{\text{cov}(\overline{UIP}_{kt}, \mathbb{Z}_{kt}^D)}{\text{var}(\mathbb{Z}_{kt}^D)}$  and  $R_D^2 = \frac{\text{cov}(\overline{UIP}_{kt}, \mathbb{Z}_{kt}^D)^2}{\text{var}(\overline{UIP}_{kt}) \text{var}(\mathbb{Z}_{kt}^D)}$  as the square of the correlation coefficient. Substitution of the expressions for  $\overline{UIP}_{kt}$  and  $\mathbb{Z}_{kt}^D$  from Proposition A1 and simple algebraical manipulations yield the result. Notice that as

$\text{var}(\xi_{kt}^D)/\text{var}(\xi_{kt}^N) \rightarrow 0$  we must also have  $\text{cov}(\xi_{kt}^N, \xi_{kt}^D)/\text{var}(\xi_{kt}^N) = \text{corr}(\xi_{kt}^N, \xi_{kt}^D) \cdot (\text{var}(\xi_{kt}^D)/\text{var}(\xi_{kt}^N)) \rightarrow 0$ , which yields the characterization of  $\beta_D$  and  $R_D^2$  in the limit. ■

The corollary shows that the coefficient is generically biased, but remains of the “right” sign provided that

$$\text{cov}(\xi_{kt}^N + \xi_{kt}^D, \xi_{kt}^N - \varrho_k^N / \varrho_k^D \cdot \xi_{kt}^D) > 0 \quad \Leftrightarrow \quad \varrho_k^D \text{var}(\xi_{kt}^N) + (\varrho_k^D - \varrho_k^N) \text{cov}(\xi_{kt}^N, \xi_{kt}^D) > \varrho_k^N \text{cov}(\xi_{kt}^D).$$

Therefore, large  $\rho_k^D / \rho_k^N$  and large  $\text{var}(\xi_{kt}^N)/\text{var}(\xi_{kt}^D)$  ensure this is the case. Note that this means that, for dealers, more variation in their positions is due to movement along their supply curve and less due to shifts in their currency demand, relative to non-dealers. In the limit of,  $\text{var}(\xi_{kt}^N)/\text{var}(\xi_{kt}^D) \rightarrow 0$ , the dealers net positions become a perfect instrument for the demand shock in the currency market. Intuitively, this is the situation when the dealers mostly move along their currency supply with almost *no* shifts in this schedule due to  $\xi_{kt}^D$ , in relative terms to the size of  $\xi_{kt}^N$ , and hence their net position  $\mathbb{Z}_{kt}^D$  becomes a perfect instrument for the currency demand shock  $\Xi_{kt}$ . This is reflected in the full  $R_D^2 = 1$ . Note that the estimated coefficient in this case recovers the elasticity  $1/\varrho_k^D$ , but not the aggregate elasticity of the currency market,  $1/(\varrho_k^D + \varrho_k^N)$ , which is relevant in shaping the equilibrium UIP premium in Proposition A1.

Interestingly, another case with a full  $R_D^2 = 1$  is when the demand shocks for dealers and non-dealers are perfectly correlated,  $\xi_{kt}^D = \phi \xi_{kt}^N$ . However, the estimated coefficient in this case is biased away from  $1/\varrho_k^D$ , and equals  $\beta_D = \frac{1}{\varrho_k^D} \cdot \frac{1+\phi}{1-\phi\varrho_k^N/\varrho_k^D}$ , and hence the condition for the “right” sign is simply  $\varrho_k^D > \phi\varrho_k^N$ . Despite the bias, this case also provides a perfect instrument (or, more precisely, perfect proxy) for the currency demand shock  $\Xi_{kt} = \frac{1+\phi}{\varrho_k^D + \varrho_k^N} \xi_{kt}^N$  in the net dealers’ position  $\mathbb{Z}_{kt}^D = \frac{\varrho_k^D - \phi\varrho_k^N}{\varrho_k^D + \varrho_k^N} \xi_{kt}^N$ .

As a final example, consider the case where  $\varrho_k^N = 0$ , that is, when the net position of all non-dealers exhibits only demand shifts but no net currency supply, resulting in  $\mathbb{Z}_{kt}^D = \xi_{kt}^N$ . Note that the full currency demand shock is still given by  $\Xi_{kt} = \xi_{kt}^N + \xi_{kt}^D$ . Therefore, we have:

$$\beta_D = \frac{1}{\varrho_k^D} \cdot \left[ 1 + \text{corr}(\xi_{kt}^D, \xi_{kt}^N) \left( \frac{\text{var}(\xi_{kt}^D)}{\text{var}(\xi_{kt}^N)} \right)^2 \right] \quad \text{and} \quad R_D^2 = 1 - [1 - \text{corr}(\xi_{kt}^D, \xi_{kt}^N)]^2 \cdot \frac{\text{var}(\xi_{kt}^D)}{\text{var}(\xi_{kt}^N + \xi_{kt}^D)}.$$

This case reflects both results above, one with  $\text{corr}(\xi_{kt}^D, \xi_{kt}^N) \rightarrow 1$  and the other with  $\text{var}(\xi_{kt}^D)/\text{var}(\xi_{kt}^N) \rightarrow 0$ . In both case,  $R_D^2 \rightarrow 1$ , but the bias disappears only in the latter case.

More generally,  $R_D^2$  is the measure of the proximity of  $\mathbb{Z}_{kt}^D$  and  $\Xi_{kt}$ , that is, how close the net dealers’ position approximates the aggregate demand shock in the currency  $k$  market, irrespectively of the bias of the estimated coefficient  $\beta_D$ .

**Regression with controls** Consider now an alternative specification to (A6) which controls for  $\xi_{kt}^D = \sum_{i \in \mathcal{I}_k^D} \bar{Z}_i \cdot d \log \rho_{it}$ , as defined in (A5). This corresponds to the controls for  $\bar{\gamma}_{kt} \mu_t$  and  $\mathbb{W}_{kt}^D$  that we include in our empirical specifications. We then have:

$$\overline{UIP}_{kt} = \alpha_D + \beta_D \mathbb{Z}_{kt}^D + \gamma_D \xi_{kt}^D + \epsilon_{kt}^D, \quad (\text{A7})$$

where in practice the specification is again estimated in changes over time. The estimate  $\beta_D$  in this case is equivalent to the pairwise regression coefficient in the projection of the residualized  $\overline{UIP}_{kt}$  on the residualized  $\mathbb{Z}_{kt}^D$  after eliminating the variation associated with  $\xi_{kt}^D$ . We can use Proposition A1 and its corollary to show that this case corresponds to the situation with  $\text{var}(\xi_{kt}^D)/\text{var}(\xi_{kt}^N) = 0$  in the pairwise specification, and hence  $\beta_D = 1/\varrho_k^D$  and  $R_D^2 = 1$ .

**Empirical proxies** In the data, we cannot perfectly observe either  $\overline{UIP}_{kt}$  or  $\mathbb{Z}_{kt}^D$ . Indeed, we only have proxies for  $\overline{UIP}_{kt}$  using either the survey expectations ( $\widehat{\overline{UIP}}_{kt}$ ) or the realized currency returns ( $UIP_{kt,t+3}$ ). This naturally results in a lower  $R^2$  than could be obtained with a perfect proxy for the expected UIP premium.

Even a more significant challenge is that the combined net currency exposure of intermediary banks,  $\mathbb{Z}_{kt}^D$ , is unobservable. We construct a proxy for  $\mathbb{Z}_{kt}^D$  for the intermediary bank sector from the futures market positions  $f_{kt}^*$  of the affiliated dealer-bank arms of large international banks.<sup>1</sup> The identifying assumption here is that the demand pressure in the futures market, captured with  $\Delta f_{kt}^*$ , reflects shifts in the broader currency market shaping the overall exposure  $\Delta \mathbb{Z}_{kt}^D$  taken on by the intermediary bank sector that prices the currency risk. Formally, this corresponds to the unobservable “first-stage”:

$$\Delta \mathbb{Z}_{kt}^D = \alpha_k + \eta_k \Delta f_{kt}^* + u_{kt}^D, \quad (\text{A8})$$

which must have  $\eta_k > 0$  and a sufficiently high  $R^2$  for our implemented “reduced-form” specification that regresses  $\Delta \text{UIP}_{kt}$  on  $\Delta f_{kt}^*$  to have explanatory power.

Recall that the overall currency exposure of international intermediaries consists of spot exposure and forward exposure,  $\mathbb{Z}_{kt}^D = \mathbb{A}_{kt}^D + \mathbb{F}_{kt}^D$ , where the latter term aggregates the much larger exposure via OTC forwards and a smaller exposure via market futures. Since futures and forwards are highly substitutable instruments, it is natural to assume that shifts in the futures market are a tell-tale for a broader shift in forward currency demand including in the OTC forward market. This justified why  $\Delta f_{kt}^*$  may be a good proxy for the overall  $\Delta \mathbb{F}_{kt}^D$ . Finally, we assume that the net spot currency position  $\mathbb{A}_{kt}^D$  of intermediary banks is a slow-moving variable reflecting structural local-currency savings gap pinned down by fundamentals, as also documented in [Correa, Du, and Liao \(2020\)](#). Under this assumption, monthly changes  $\Delta f_{kt}^*$  remain a good proxy for the overall monthly changes in  $\Delta \mathbb{Z}_{kt}^D$ , while the currency fixed effect  $\alpha_k$  in (A8) absorbs the slower-moving currency-specific trends in the savings gap.<sup>2</sup>

**CIP regressions** The stark difference of the  $\Delta \text{CIP}_{kt}$  regressions on  $\Delta f_{kt}^*$  is that, unlike in the  $\Delta \widehat{\text{UIP}}_{kt}$  regressions with large  $t$ -statistics on estimated coefficients and large  $R^2$ , we find rather precisely estimated zero coefficients and near zero  $R^2$  due to variation in  $\Delta f_{kt}^*$ . Recall from Proposition 2 that instead of  $\mathbb{Z}_{kt}^D = \mathbb{A}_{kt}^D + \mathbb{F}_{kt}^D$ , the relevant variable for CIP premium is  $\mathbb{X}_{kt}^D = \mathbb{S}_{kt}^D + \mathbb{F}_{kt}^D$ , where  $\mathbb{S}_{kt}^D$  are the net swap positions of intermediary banks. Our empirical variable  $\Delta f_{kt}^*$  is the most direct proxy for  $\Delta \mathbb{F}_{kt}^D$ , and we find it to be a strong predictor of the UIP premium for every currency. Therefore, the absence of any correlation between  $\Delta f_{kt}^*$  and the CIP premium for every currency at the monthly frequency (with some detectable statistical effects at the weekly frequency) is strongly suggestive that the regression coefficient of  $\Delta \text{CIP}_{kt}$  on  $\Delta \mathbb{X}_{kt}^D$  is zero in the unobservable “second stage” specification (parallel to (A7)). The virtually implausible alternative is that the correlation between  $\Delta f_{kt}^*$  and  $\Delta \mathbb{X}_{kt}^D$  happens to be close zero for every currency. This requires that the movement in swap positions  $\Delta \mathbb{S}_{kt}$  nearly perfectly offset the movements in forward positions  $\Delta \mathbb{F}_{kt}^D$ , keeping  $\Delta \mathbb{X}_{kt}^D \approx 0$ , a knife-edge situation even for a single currency, let alone for every currency in the panel.<sup>3</sup> Therefore, we conclude that  $\beta_k^{\text{CIP}} = 0$  in (A1) for every  $k$  is the consequence of locally elastic supply of hedged dollars,  $\varrho_k^D \rightarrow \infty$  for CIP (in the notation of Proposition A1 applied to CIP instead of UIP).

**Decomposition of currency premia dynamics** Given the empirical definitions of currency premia in (19), we can decompose their estimated impulse responses from specifications in (A1) (and their generalizations (21) that permit for more dynamics) into the impulse response of individual components — the interest rate differential, the forward premium, the current and future (expected) spot exchange rate. The case of interest rates and forward premia is straightforward, as these variables only feature objects known at  $t$ . The decomposition of the currency premia requires additional care since the realized carry trade return features both the current and future exchange rate. Therefore, we construct the individual impulse response for the exchange rate, and then aggregate it into the currency premium component-by-component.

<sup>1</sup>Dealer-banks act as market makers and are known to have largely hedged FX positions by passing (offsetting) their currency exposure to their bank-holding companies, similar to the setup in [Rime, Schrimpf, and Syrstad \(2022\)](#).

<sup>2</sup>The identification strategy in equation (A8) remains valid even if  $\Delta f_{kt}^*$  and  $\Delta \mathbb{A}_{kt}^D$  are not correlated, as long as movements in  $\Delta \mathbb{A}_{kt}^D$  do not fully offset movements in  $\Delta \mathbb{F}_{kt}^D$  when projected on  $\Delta f_{kt}^*$ .

<sup>3</sup>Furthermore, [Moskowitz, Ross, Ross, and Vasudevan \(2024\)](#) show that swap and forward positions tend to be positively correlated over time at the bank-level in the US.



**PUBLICATIONS**