# Breaking Parity:
## Equilibrium exchange rates and currency premia

Mai Chi Dao
IMF

Pierre-Olivier Gourinchas
UC Berkeley and IMF

Oleg Itskhoki
Harvard

March 19, 2025

PRELIMINARY — DOWNLOAD MOST RECENT DRAFT HERE:
https://itskhoki.com/papers/BreakingParity.pdf

**Abstract**

We propose a partial equilibrium model of frictional currency intermediation to derive an empirical framework that explains the joint behavior of interest rates, currency premia and spot and forward exchange rates, both in the cross section of currencies and in the time series for individual currencies. 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, *expensive* currency forwards; and *vice versa*. In the time series, *covered* currency premia change in concert, driven by aggregate financial market conditions. In contrast, *uncovered* currency premia move frequently in response to *idiosyncratic* currency demand shocks which we capture with the dynamics of net currency futures positions of dealer banks. Sharp spot exchange rate movements accommodate the equilibrium dynamics of predictable currency returns necessary to ensure intermediation of currency demand shocks, irrespective of their financial or macroeconomic origin. Changes in the net currency futures positions of dealer banks account for most of the variation in the spot exchange rate for every currency.

# 1 Introduction

We start with a fundamental question in international macro: what drives the exchange rate? The lack of a strong and robust contemporaneous comovement of exchange rates with aggregate macroeconomic and financial variables suggests that the exploration of exchange rate determination should extend beyond the standard macro-financial environment. From a micro perspective, exchange rates are prices that equilibrate demand and supply in the currency markets. 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) conditions, emphasizing the important role these wedges play in intermediating currency demand and supply. One should therefore be able to trace movements in the equilibrium exchange rates and associated parity wedges to shifts in demand and supply in currency markets, irrespective of whether these shifts are driven by fundamental or non-fundamental "animal spirit" shocks. This is exactly what we do in this paper, offering a unifying empirical theory that explains the joint dynamics of UIP and CIP deviations across currencies, as well as spot and forward exchange rate variation.

To guide our analysis, we set up a model of partial equilibrium in the currency market. At the center of the model are dealer banks that step in to clear the market when there remains net demand for currency at given equilibrium prices. The dealer banks are subject to value-at-risk-type balance sheet constraints and hence provide frictional intermediation in the currency market. In other words, they require currency premia for intermediating various positions: absorbing currency risk is compensated with UIP deviations, while swapping currency returns is compensated with CIP deviations. Given interest rate differentials, spot and forward exchange rates adjust to ensure the equilibrium currency premia that allow the dealer banks to clear the currency market. We show that the data aligns closely with the prediction of the model both in the cross section of currencies and in the time series for individual currencies.

In the cross section, countries with excess supply of local-currency savings feature low interest rates and negative UIP and CIP premia, with dollars being cheap on the forward market (relative to spot). These premia compensate dealer banks for their exposure to currency risk to clear the gap between local-currency savings and investment, as well as for supplying dollar swaps and holding dollar forwards.[1] In the data, this situation corresponds to funding currencies such as Japanese yen, Swiss franc, and to a lesser extent the euro and the British pound. The reverse situation applies in countries with excess demand for local-currency investment relative to supply of local-currency savings, with high local-currency interest rates, positive UIP and CIP premia, and expensive for-

[1]Excess supply of local-currency savings drives down the long-run local-currency interest rate and compels investors to fund at this low rate and seek higher return on investment in foreign currency (US dollar). Part of this FX exposure is then sold on the currency market to intermediaries, including by means of swaps and forwards. This results in a UIP premium on foreign currency (dollar) equal in equilibrium to the interest rate differential, as well as a CIP premium for foregoing higher FX return and making forward dollars cheap. The reverse is the case in countries with relatively scarce local-currency savings and high local-currency interest rates, and hence high local currency premia. Additionally, in such countries, funding at low FX (dollar) rates creates hedging demand which makes forward dollars more expensive.

ward dollars. This is characteristic of investment, commodity and EM currencies (e.g., Canadian, Australian and New Zealand dollars, Mexican peso).

In the time series, covered currency premia change in concert across currencies. Most of this variation is captured by a common component related to the 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 Dollar funding conditions tighten.

In contrast, uncovered currency premia move strongly in response to *idiosyncratic* currency demand shocks, which have no discernable effect on the CIP deviations. We capture these shocks with the change in the net currency futures positions of dealer banks, reflecting the need to clear excess demand in a particular currency market.[2] This currency-specific variable explains a large portion of variation in both expected and realized UIP premia in the panel of currencies. Consequently, 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 currency and financial markets that shift currency supply, but these global forces only account for a small portion of the larger overall variation in the UIP deviations.

We further show that most of the 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. The changes in the currency futures positions of the dealer banks account for the bulk of the variation in spot exchange rates for all currencies for which we have data, and result in long half-lives of many months and predictable currency returns. Figure 1 illustrates the tight relationship between realized changes in the spot pound and euro exchange rates (vis-à-vis the US dollar) and the changes in the respective futures positions of dealer banks.[3] These results align closely with 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.

We find robustly predictable currency returns in the time series conditional on the changes in the 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 reflects the predictable movement in the exchange rate, rather than the interest rate differential. It is also 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. Has-

[2]Futures positions offer an easily measurable portion of the currency market, which is likely highly correlated with both spot exchange rate and over-the-counter currency forward markets.

[3]Same patterns hold for other currencies, as we show in Appendix Figures A8–A9, while Appendix Figures A2 and A10–A11 show the fit for the levels of exchange rates.

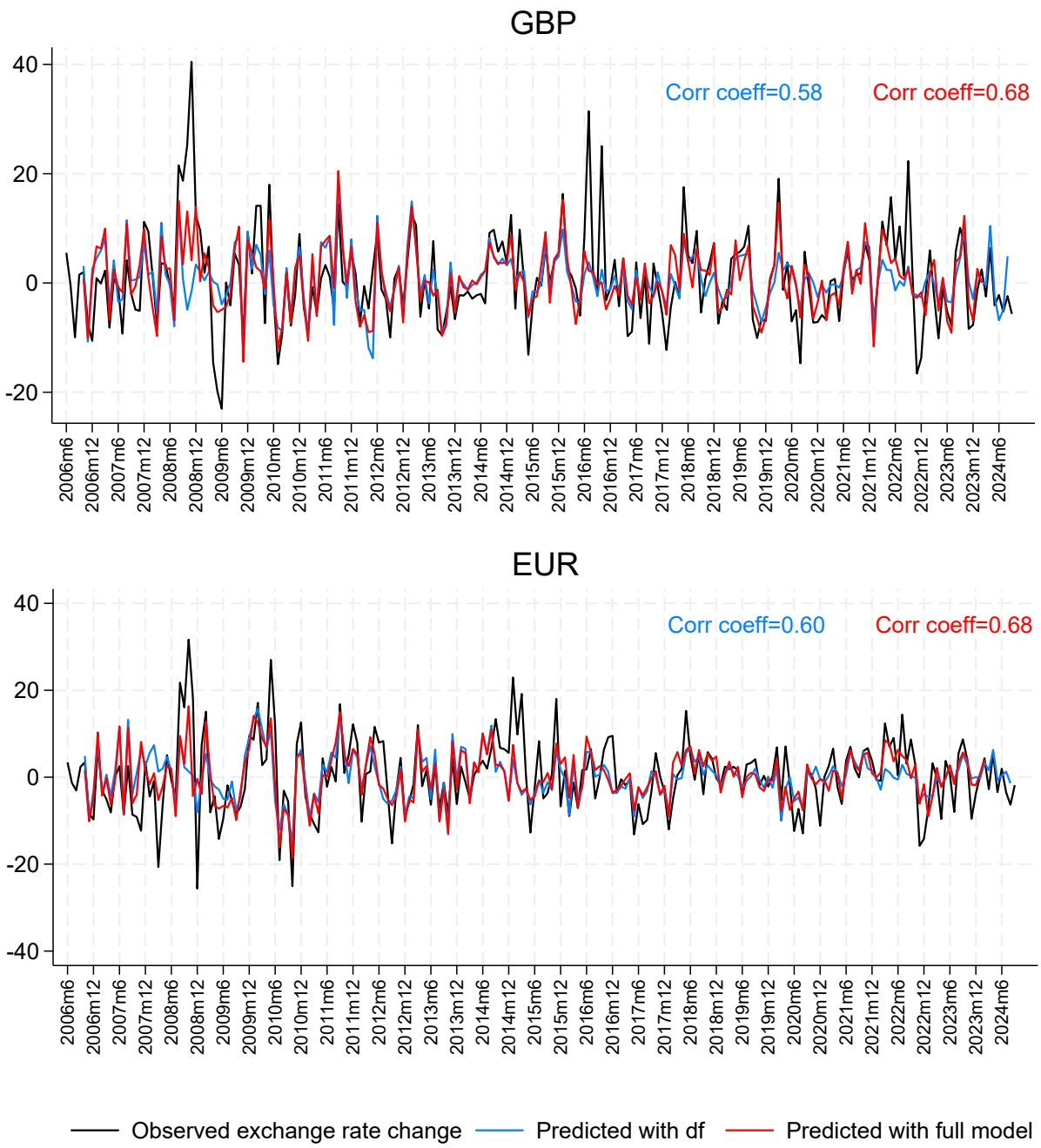



Figure 1: Realized changes in nominal exchange rates and their fitted values

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).

san and Mano, 2018). This fact is still true in our data when not conditioned on currency-specific demand shocks that we capture with the futures positions of dealer banks. Both currency-specific dealer bank positions and spot exchange rates are volatile, persistent, and largely uncorrelated with changes in aggregate macro and financial variables, including interest rate differentials.

So what are the shocks driving the exchange rate? Futures positions of dealer banks may or may not proxy for specific primitive shocks — macroeconomic or financial. They instead identify

the resulting variation in currency demand that must be met by intermediaries at an equilibrium currency premium. Spot and forward exchange rates move, in a large part, 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, 2025).

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. The novelty of our empirical work largely arises from bringing together and reconciling salient patterns for the joint distribution of UIP and CIP deviations, the variation in spot and forward exchange rates, in the cross-section as well as time-series, and for both advanced and emerging market currencies. Moreover, we are the first to introduce the remarkable explanatory power of a publicly-available variable on the futures positions of dealer banks which alone accounts for a large share of exchange rates variation.

Additionally, we show that the richness of empirical patterns that we observe in the data is fully in line with a simple partial-equilibrium model of frictional intermediation in the currency market. 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.

This partial equilibrium framework is, of course, insufficient for counterfactual and policy analysis. For example, one may want to ask what the properties of the equilibrium exchange rate would be in response to the same fundamental shocks but in an environment with frictionless intermediation where UIP (and CIP) holds. Furthermore, frictional intermediation suggests a rationale for policy interventions that lean against currency demand shocks by (partially or fully) eliminating currency premia and stabilizing the exchange rate. Conducting such optimal policy analysis requires a fully-specified general equilibrium model.[4] 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.

**Related literature** TO BE COMPLETED

1. Evans and Lyons (2002) other papers with order flow and more recent literature coming back to this JKL, BBStein...
2. Macro shocks and exchange rates
3. Financial variables and exchange rates
4. Intermediation models of FX
5. UIP and CIP literature

[4]See Fanelli and Straub (2021); Cavallino (2019); Basu, Boz, Gopinath, Roch, and Unsal (2020) and Itskhoki and Mukhin (2023).

Of course, the data features abundant evidence on interest rate parity deviations. Deviations from UIP have been extensively studied for decades by the theoretical and empirical literature (Fama, 1984). *Expand on UIP here.*

Unlike the uncovered interest parity, the covered interest parity largely held in the data for G-10 currencies up until the Global Financial Crisis (GFC). While prior violations of CIP did occur for brief episodes and for specific currency pairs (Taylor, 1989), it was not until 2007 and afterwards that the deviation from CIP became sizeable and persistent across essentially all advaced economy currencies versus the dollar. What started as a temporary symptom of dollar funding stress during the acute financial crisis turned into a permanent feature of the offshore dollar market until today (see review by Du and Schreger, 2021).

The leading explanation for CIP deviations, at least in advanced economies, centers around the post-GFC tightening of bank regulation which constrains the riskless expansion of intermediaries' balance sheets for arbitrage trade and market making (Du, Tepper, and Verdelhan, 2018). Empirical evidence at detailed dealer and contract-level data have corroborated this supply-side channel (Cenedese, della Corte and Wang, 2021). In addition, factors driving demand for dollar funding and hedging interact with these supply-side frictions in endogenously determining the CIP premium (Ivashina, Scharfstein, and Stein (2015); Liao and Zhang (2020); Abbassi and Bräuning, 2020; Barbiero et al. 2024).

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 implication for exchange rate dynamics. A paper which also studies both wedges is that by Greenwood, Hanson, Stein, and Sunderam (2020), which highlights 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 the UIP and CIP deviation. There is growing evidence that determinants of either wedge directly correlate with the exchange rate (Jiang, Krishnamurthy, and Lustig, 2021; Evans and Lyons, 2002, earlier work). The underlying shocks to these wedges can be preference shocks for assets (convenience yields), or any other shock to currency demand mediated by frictional intermediation (Jeanne and Rose, 2002; Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021). A directly testable implication is that variables which affect balance sheet quantities of intermediaries should in turn affect equilibrium parity wedges and exchange rates. Instead of comitting to a particular source of shock to these parity wedges, we offer a general framework that describes their joint determination under any type of shock, and which is consistent with statistical properties of these wedges and their components across a broad set of currencies.

# 2 Model of Currency Intermediation

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

## 2.1 International dealer bank (intermediary)

We focus on a problem of a given bank $i$ with initial net worth $W_{it}^*$. All variables with $*$ are expressed in dollars. We focus on a give currency $k$ market (against the dollar), effectively assuming for now segmentation of currency markets. 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. As a matter of accounting, gross assets equal gross liabilities, with net worth $W_t^*$ being the gap between external assets and liabilities:

$$B_t^* + H_t^* + A_t^* = W_t^* + D_t^*. \tag{1}$$

We denote with $D_t^*$ the external funding of the bank, which we assumed is in dollars. The external funding cost on the interbank dollar market is $R_t^*$.

On the asset side, $B_t^* \geq 0$ are dollar reserves that pay $\underline{R}_t^*$ and $H_t^* \geq 0$ are risky investment with ex-post dollar return $\tilde{R}_{t+1}^*$. $A_t^*$ are local-currency (LC) net assets, that is LC lending net of LC borrowing. LC net assets pay a return $R_t$ in local currency, which converted to dollars gives the ex-post realized return of $R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$. $\mathcal{E}_t$ is the spot exchange rate in units of local currency for one dollar: an increase is $\mathcal{E}_t$ denotes LC depreciation, or dollar appreciation.

We measure the size of the balance sheet using the asset side as:

$$Y_t^* = B_t^* + H_t^*, \tag{2}$$

where $Y_t^*$ combine together reserves and risky assets, while leaves out 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, in which case e.g. $A_t^* < 0$ corresponds to a net LC liability.[5]

In addition to the on-balance-sheet operations, the bank sells currency forwards $F_t^*$. When $F_t^* > 0$, the bank sells dollars forward (buys LC forward) at the forward (exchange) rate $\mathcal{F}_t$. Conversely, when $F_t^* < 0$, the banks buys forwards, i.e. buys dollars forward and sells local currency. Specifically, we normalize $F_t^*$ to mean that the bank commits to buy $(R_t \mathcal{E}_t) \cdot F_t^*$ units of local currency for $\frac{R_t \mathcal{E}_t}{\mathcal{F}_t} \cdot F_t^*$ dollars at $t+1$. The $t+1$ dollar payout on this zero-capital position is, therefore,

[5] In the appendix, we generalize our analysis to the case where LC assets and liabilities pay a differential return, and the size of the balance sheet is defined as $Y_t^* := B_t^* + H_t^* + \left[A_t^*\right]^+ + \left[-D_t^*\right]^+$ with $\left[x\right]^+ \equiv \max\{x, 0\} > 0$.

Table 1: International Bank: the Balance Sheet

| Assets | | | Liabilities |
|---|---|---|---|
| $B_t^* \geq 0 : \underline{R}_t^*$ | \$ reserves | net worth | $W_t^* :$ ROE |
| $H_t^* \geq 0 : \tilde{R}_{t+1}^*$ | \$ risky investment | borrowing in \$ | $D_t^* : R_t^*$ |
| $A_t^* : R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$ | € 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 | | |
| $S_t^* : R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}$ | currency swap | | |

given by $\left(\frac{R_t \mathcal{E}_t}{\mathcal{E}_{t+1}} - \frac{R_t \mathcal{E}_t}{\mathcal{F}_t}\right) F_t^* = \left(\frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1\right) \frac{R_t \mathcal{E}_t}{\mathcal{F}_t} F_t^*$. 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 $\frac{R_t \mathcal{E}_t}{\mathcal{F}_t} F_t^*$ taken at $t$. 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 $F_t^*$.[6]

Finally, the bank also sells dollar swaps. Per unit of a zero-capital 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 $\left(R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}\right) S_t^*$. The position $S_t^*$ can be negative or positive. 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 $R_t \frac{\mathcal{E}_t}{\mathcal{S}_t}$ dollars.[7] As with forwards, the exact scaling of units of contracts is without loss of generality, and we define it this way as $S_t^*$ will shortly emerge as the relevant measure of the off-balance-sheet exposure. Note that swaps change neither the size of the balance sheet of the bank, nor result in any currency risk exposure since all payoffs are pre-determined in dollars. Appendix Figure A1 illustrate cash flows for both on-balance-sheet and off-balance-sheet asset holdings.

**Evolution of net worth** 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

[6] 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 $t$.

[7] 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.

by aggregating the payoffs on its different positions:

$$W^*_{t+1} = \underline{R}^*_t B^*_t + \tilde{R}^*_{t+1} H^*_t + R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} A^*_t - R^*_t D^*_t + R_t \frac{\mathcal{E}_t}{\mathcal{F}_t} \left( \frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1 \right) F^*_t + \left( R^*_t - R_t \frac{\mathcal{E}_t}{\mathcal{S}_t} \right) S^*_t.$$

Combining this expression for $W^*_{t+1}$ with the balance sheet at $t$ in (1) and rearranging terms yields the dynamic equation for net worth:

**Lemma 1** *The net worth evolution of the bank can be written as follows:*

$$W^*_{t+1} = R^*_t (W^*_t - Y^*_t) + \underline{R}^*_t B^*_t + \tilde{R}^*_{t+1} H^*_t + CIP_t \cdot X^*_t + UIP_{t+1} \cdot Z^*_t + R_t \Big( \frac{\mathcal{E}_t}{\mathcal{F}_t} - \frac{\mathcal{E}_t}{\mathcal{S}_t} \Big) S^*_t, \quad (3)$$

*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, and the (realized) UIP and CIP premia are given by:*

$$UIP_{t+1} \equiv R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - R^*_t \qquad \textit{and} \qquad CIP_t \equiv R^*_t - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}. \quad (4)$$

**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 in $S^*_t$. Finally, we use the definition of the size of the balance sheet (2) to combine $H^*_t + B^*_t = Y^*_t$. ■

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 the exchange rate volatility into the net worth volatility is proportional to the exchange rate exposure $Z^*_t$. The compensation for the two exposures are the realized UIP and CIP premia (deviations), respectively. Note that they are defined in "reverse" directions in (4): we measure the currency exposure by the risk of the dollar appreciation and 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 (by construction). In contrast, swap position $S^*_t$ does not result in exchange rate risk exposure and hence carries only the CIP premium.

**Balance sheet constraints** The bank maximizes the discounted net worth $\mathbb{E}_t \Theta_{t+1} W^*_{t+1}$ subject to a balance sheet constraint. A generally stochastic discount factor $\Theta_{t+1}$ has the property that $\mathbb{E}_t \Theta_{t+1} = 1/R^*_t$, and it may arise form 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 it corresponds to a risk-neutral bank.

The balance sheet constraint, in turn, requires 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 $Y_t^*$, the off-balance-sheet exposure $X_t^*$, and the currency-risk exposure $Z_t^*$. Formally, we write the balance sheet constraint as:

$$B_t^* \geq a_t[Y_t^* - B_t^*]^+ + b_t|Z_t^*| + \delta|X_t^*|, \tag{5}$$

where

$$a_t \equiv \frac{\alpha}{2}\frac{|Y_t^* - B_t^*|}{W_t^*} \qquad \text{and} \qquad b_t \equiv \frac{\gamma\sigma_t}{2}\frac{|Z_t^*|}{W_t^*}. \tag{6}$$

with $\sigma_t^2 \equiv R_t^2 \cdot \text{var}_t\big(\mathcal{E}_t/\mathcal{E}_{t+1}\big)$ and $\alpha, \gamma, \delta > 0$. These coefficients reflect regulation and value-at-risk considerations, and they can differ by currency or by policy regime (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 $H_t^* = Y_t^* - B_t^* > 0$ and more exposure to the currency risk $Z_t^*$ require increasingly higher reserves. This is the value-at-risk logic: each next unit of exposure increases the contribution to net worth volatility in proportion with $H_t^*/W_t^*$ 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 hence it does not scale up with the size of the position (assuming the bank is small relative to the market). Therefore, the proportional value at risk is not increasing in the size of the exposure $|X_t^*|$, and hence the reserve requirement scales proportionally with $|X_t^*|$, rather than being convex in $X_t^*$, in contrast with $Z_t^*$.[8] Due to linearity of the constraint for $X_t$, we additionally assume that $|X_t| \leq \bar{X}^*$ for some large $\bar{X}^*$.

The bank solves the following portfolio problem:

$$\max_{B_t^* \geq 0, H_t^* \geq 0, X_t^*, Y_t^*, Z_t^*, S_t^*} \mathbb{E}_t \Theta_{t+1} W_{t+1}^* \quad \text{subject to (3) and (5)–(6)}, \tag{7}$$

and given the definitions of exposures $(X_t^*, Y_t^*, Z_t^*)$. We denote with $\mu_t/R_t^*$ the Lagrange multiplier on the balance sheet constraint (5). We assume the bank takes returns $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$ and exchange rates $\{\mathcal{E}_t, \mathcal{F}_t, \mathcal{S}_t\}$ as given. We 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):

[8] Intuitively, the risk of $X_t^*$ is a drift (of counterparty default), while the risk of $Z_t^*$ is a diffusion (of the underlying asset price). More generally, we could consider a class of reserve-requirement functions $\frac{1}{1+\epsilon}\big(|\cdot|/W_t^*\big)^\epsilon$ 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.

**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:*

$$\overline{UIP}_t = \gamma \mu_t \sigma_t \frac{Z_t^*}{W_t^*} \qquad \text{and} \qquad CIP_t = \delta \mu_t \cdot \text{sign}(X_t^*) \tag{8}$$

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

When the balance sheet constraint is binding, the shadow cost of expanding exposure (whether it is $X_t^*$, $Y_t^*$ or $Z_t^*$) which requires a one unit (dollar) increase in reserves $B_t^*$, is equal to $\mu_t = R_t^* - \underline{R}_t^*$, and hence the bank will only do it 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 $Y_t^*$ and $Z_t^*$ carry the volatility risk of the underlying asset (risky investment and currency risk, respectively), and therefore required reserves $B_t^*$ are convex (quadratic) in these exposures. A leveraged risky position comes not only at the risk of losing its value (which is zero for the off-balance-sheet currency exposure coming from forwards $F_t^*$), but also with the price risk of the underlying asset. For example, the exchange rate volatility $\sigma_t^2$ is associated with an affect on the bank's net worth $W_{t+1}^*$ which is proportional to $\sigma_t Z_t^*$. As a result, the associated UIP premium is increasing in $\sigma_t Z_t^*/W_t^*$ as the required reserves $B_t^*$ scale with $(Z_t^*)^2$.[9]

Finally, note that the currency-risk exposure $Z_t^*$ is associated with both local currency investment $A_t^*$ and with forward positions $F_t^*$, that 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:

$$\overline{UIP}_t \equiv R_t \frac{\mathcal{E}_t}{\widehat{\mathcal{E}}_t} - R_t^*, \qquad \text{where} \qquad \widehat{\mathcal{E}}_t = \left(\mathbb{E}_t\left[\frac{\Theta_{t+1}}{\mathbb{E}_t\Theta_{t+1}} \mathcal{E}_{t+1}^{-1}\right]\right)^{-1} \tag{9}$$

that is, $\widehat{\mathcal{E}}_t$ is the risk-neutral expectation of the future spot exchange rate. The forward position $F_t^*$ additionally carries 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:

$$\overline{UIP}_t + CIP_t = R_t \frac{\mathcal{E}_t}{\widehat{\mathcal{E}}_t} - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}.$$

[9] A similar argument applied to a leveraged positive-value risky position $H_t^*$ when $Y_t^* > W_t^*$. Our results for UIP and CIP premia do not depend on how required reserves $B_t^*$ scale with the size of the risky balance sheet $Y_t^*$ as long as they are associated with a balance sheet (shadow) cost of holding additional reserves.

Lastly, holding the magnitudes of the two currency exposures, $X_t^*$ and $Z_t^*$, the swaps are perfectly substitutable with forwards, and therefore the forward and swap exchange rates must be equalized, $\mathcal{S}_t = \mathcal{F}_t$. In what follows, we refer to both as the forward exchange rate.

## 2.2 Currency market equilibrium

We focus on the partial equilibrium in the currency market. Given Proposition 1, $\mathcal{S}_t \equiv \mathcal{F}_t$, and we have two exchange rates to solve for — the spot exchange rate $\mathcal{E}_t$ and the forward exchange rate $\mathcal{F}_t$. We take as given the path of interest rates and asset returns $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$. The two exchange rates correspond to the two equilibrium premia — 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 (9). Assuming all banks face the same UIP and CIP deviations allows for aggregation of positions using observed prices.[10]

We first derive the market currency supply schedules. Individual bank $i$ supplies currency according to conditions (8), where $\mu_t = R_t^* - \underline{R}_t^*$ and $\sigma_t^2 = R_t^2 \mathrm{var}_t\big(\mathcal{E}_t/\mathcal{E}_{t+1}\big)$ 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 we 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.[11] 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, we refer to the two as the spot and forward 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 our definitions of $(A_{it}^*, F_{it}^*, S_{it}^*)$ above. The market clearing requires:

$$\mathbb{Z}_t^* = \sum_i (A_{it}^* + F_{it}^*) \qquad \text{and} \qquad \mathbb{X}_t^* = \sum_i (F_{it}^* + S_{it}^*), \tag{10}$$

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

Combining market clearing (10) with the optimal supply schedules of the intermediary dealer banks (8) results in the following equilibrium characterization (see Appendix B):

[10] The two significant assumptions here is 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).

[11] Formally, in a given period $t$, assume a distribution of $\{\delta_{it}\}$ across banks $i$, and 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.

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

$$\overline{UIP}_t \equiv R_t \frac{\mathcal{E}_t}{\widehat{\mathcal{E}}_{t+1}} - R_t^* = \bar{\gamma}_t \mu_t \sigma_t \cdot \frac{\mathbb{Z}_t^*}{\mathbb{W}_t^*}, \tag{11}$$

$$CIP_t \equiv R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t} = \bar{\delta}_t \mu_t \cdot \text{sign}(\mathbb{X}_t^*), \tag{12}$$

*where $\mu_t = R_t^* - \underline{R}_t^*$, $\mathbb{W}_t^* \equiv \sum_i W_{it}^*$ is the aggregate dealer bank net worth, $\bar{\gamma}_t \equiv \left(\sum_i \frac{W_{it}^*/\gamma_{it}}{\mathbb{W}_t^*}\right)^{-1}$ is the hyperbolic weighted average of $\gamma_{it}$, and $\bar{\delta}_t = \delta_{it}$ 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 high financial premia 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 dollar funding and hedging $\mathbb{Z}_t^* = \mathbb{A}_t^* + \mathbb{F}_t^*$ 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.[12] 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 dollars funding and hedging 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 conditions 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.[13] Furthermore, conditions (11)–(12) 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, offering 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 the CIP premium to only shift with aggregate market conditions captured by $\bar{\delta}_t \mu_t$ without responding to local currency demand shocks. Finally, conditions (11)–(12) 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.[14]

We close this section with the discussion of demand and supply in the currency market. We separate shocks to currency demand captured by $(\mathbb{Z}_t^*, \mathbb{X}_t^*)$ and shifts of the currency supply curves

[12] 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.

[13] 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, in local changes, it is reasonable to assume that $\bar{\delta}_t$ does not very with month-to-month variation in demand absent major shocks.

[14] 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).

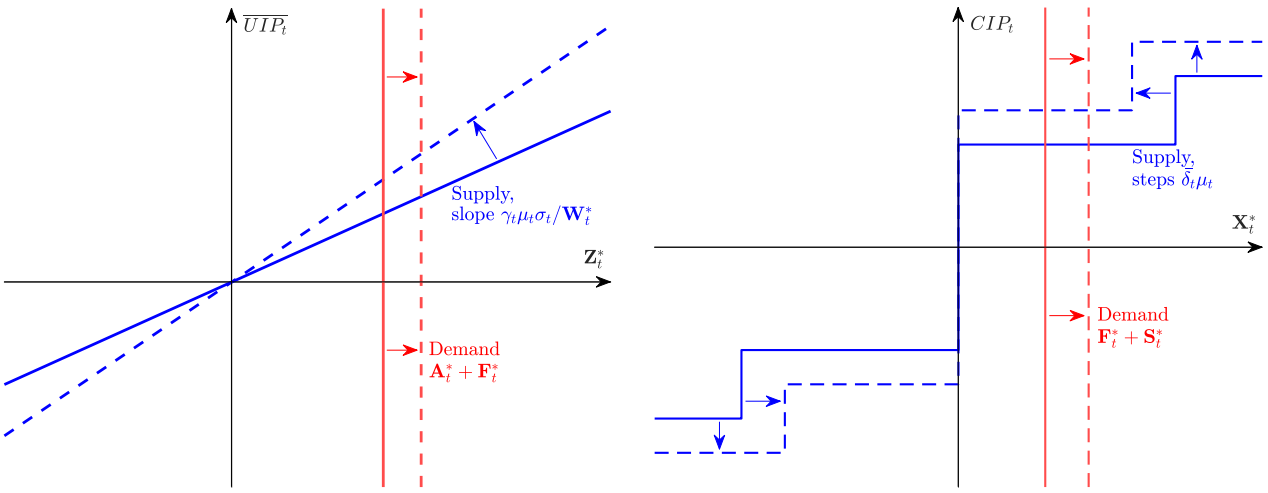



Figure 2: Currency market equilibrium: currency risk and currency swaps

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 $\mathbb{Z}_t^*$ and $\mathbb{X}_t^*$ reflect movements along the respective currency supply schedules.

characterized in Proposition 1. Proposition 2 then characterizes the equilibrium adjustment in currency premia associated with the shifts in currency demand that must be satisfied by intermediary dealer banks that move along their supply curves (8). Note that the role of intermediaries can be played by any agents in the economy to the extent their currency positions respond to UIP and CIP premia.[15] For concreteness, consider the UIP premium: the slope of the aggregate currency supply curve is given by:

$$\bar{\gamma}_t\mu_t\sigma_t/\mathbb{W}_t^* = \mu_t\sigma_t\Big(\sum\nolimits_i W_{it}^*/\gamma_{it}\Big)^{-1},$$

where the aggregation is across all agents who respond with their currency positions to the UIP premium. Thus, shifts in currency demand $\mathbb{Z}_t^*$ are met with an adjustment in the equilibrium UIP premium with an aggregate slope coefficient $\bar{\gamma}_t\mu_t\sigma_t/\mathbb{W}_t^*$. Greater aggregate net worth in intermediation 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.

## 2.3 Testable implications and empirical specification

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

[15] In fact, positions of any agent in the economy can simultaneously feature a shifter (demand) and a slope (supply).

rewrite the currency supply schedules in (11) and (12) as:

$$\overline{UIP}_{kt} \equiv R_{kt}\frac{\mathcal{E}_{kt}}{\widehat{\mathcal{E}}_{k,t+1}} - R_t^* = \mu_t \bar{\gamma}_{kt}\sigma_{kt} \cdot \frac{\mathbb{Z}_{kt}^*}{\mathbb{W}_{kt}^*}, \tag{13}$$

$$CIP_{kt} \equiv R_t^* - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} = \mu_t \bar{\delta}_{kt} \cdot \text{sign}(\mathbb{X}_{kt}^*), \tag{14}$$

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, $\hat{\mathcal{E}}_{k,t+1}$ is the expectation of the future currency $k$ spot exchange rate, $R_{kt}$ 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 currency $k$ ("risky" and "hedged") that is intermediated by the dealer banks in equilibrium (see Figure 2).

Currency supply conditions (13) and (14) apply both in the long-run equilibrium and for short-run dynamics. We now explore the implications for each case separately.

### 2.3.1 Cross section of currencies (in the long run)

A fundamental difference between countries is the supply of local-currency savings relative to the demand for local-currency investment. We summarize the relative demand for funding and supply of savings in local currency by the *currency gap* variables $\mathbb{A}_{kt}^*$, which measures the local currency gap (or the negative of the dollar gap). Specifically, $\mathbb{A}_{kt}^* > 0$ corresponds to countries with excess demand for local-currency funding (or insufficient supply of local-currency savings), and hence a negative dollar gap — the need to convert dollar funding into local-currency funding. Conversely, $\mathbb{A}_{kt}^* < 0$ corresponds to countries with excess supply of local-currency savings, and hence a positive dollar gap — the need to convert local-currency funding into dollar investments.[16]

For our theoretical analysis 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 $\mathbb{E}\{\mathcal{E}_{kt}/\mathcal{E}_{k,t+1}\} \approx 1$.*

**Assumption 3** *Currencies $k$ with a systematic local-currency funding gap $\mathbb{A}_{kt}^* > 0$ 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 excess supply of local-currency funding ($\mathbb{A}_{kt}^* < 0$) feature low local-currency interest rates, while countries with excess demand for local-currency investment ($\mathbb{A}_{kt}^* > 0$) feature

[16] Note that $\mathbb{A}_{kt}^*$ is one source of currency demand that the dealer banks need to intermediate by taking currency exposure to equilibrate the imbalanced demand and supply of local-currency funding.

high local-currency interest rates. The interest rates differentials are a source of demand for high interest-rate currency swaps — i.e., dollar swaps ($\mathbb{S}^*_{kt} < 0$) in the former case and local-currency swaps ($\mathbb{S}^*_{kt} > 0$) in the latter case. In other words, investors seek high-return investment without exposure to the currency risk. Similarly, investing in the high interest rate currency creates demand to sell dollars forwards ($\mathbb{F}^*_{kt} < 0$) in the former case and buy 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.

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

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

$$\mathbb{E}\{\overline{UIP}_{kt}\} = \mathbb{E}\{R_{kt} - R^*_t\}. \tag{15}$$

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 the compensation collected by the dealer 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 (i.e., $\mathbb{A}^*_{kt} > 0$) and high interest rates, and vice versa.

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 also 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 in the former case:

$$CIP_{kt} = R^*_t - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} > 0 \qquad \Rightarrow \qquad \frac{\mathcal{F}_{kt}}{\mathcal{E}_{kt}} > \frac{R_{kt}}{R^*_t} > 1, \tag{16}$$

despite the high local-currency interest rate. This is why we say that the 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. This equilibrium forward rate compensates the dealer banks with an appropriate CIP premium for their swap positions to give up the high local-currency rate of return.[17]

[17]The reverse is, of course, also true with $CIP_{kt} < 0$ and hence $\mathcal{F}_{kt}/\mathcal{E}_{kt} < R_{kt}/R^*_t < 1$, i.e., cheap forward dollars for currencies with excess local-currency savings.

### 2.3.2 Short-run dynamics of currency premia and exchange rates

Our dynamic analysis is motivated by the shocks to currency demand and supply as illustrated in Figure 2. The predictions of our modeling framework are also summarized in currency supply schedules (13)–(14) and have the following implications:

1. Local-currency demand shocks $\mathrm{d}f^*_{kt}$ that shift the dealer bank positions $\mathrm{d}\mathbb{Z}^*_{kt}/\mathrm{d}f^*_{kt} > 0$ and $\mathrm{d}\mathbb{X}^*_{kt}/\mathrm{d}f^*_{kt} > 0$ result in shifts along currency supply schedules such that:[18]

$$\mathrm{d}\,\overline{UIP}_{kt}/\mathrm{d}f^*_{kt} > 0 \qquad \text{and} \qquad \mathrm{d}\,CIP_{kt}/\mathrm{d}f^*_{kt} = 0, \tag{17}$$

   provided that the change in $\mathrm{d}f^*_{kt}$ is small enough to affect the identity of the marginal bank and thus $\bar{\delta}_{kt}$ remains unchanged in Proposition 2. That is, the equilibrium remains on the same step in the right panel of Figure 2. Large aggregate shifts in currency demand may affect $CIP_{kt}$ via changes in $\bar{\delta}_{kt}$ when market clearing requires participation of additional currency desks.

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

$$\mathrm{d}\left|\overline{UIP}_{kt}\right|/\mathrm{d}\mu_t > 0 \qquad \text{and} \qquad \mathrm{d}\left|CIP_{kt}\right|/\mathrm{d}\mu_t > 0. \tag{18}$$

   That is, both UIP and CIP premia must become more negative for funding currencies with $\mathbb{A}^*_{kt} < 0$ that feature $\mathbb{Z}^*_{kt} < 0$ and $\mathbb{X}^*_{kt} < 0$, and conversely must become more positive for investment currencies with $\mathbb{A}^*_{kt}, \mathbb{Z}^*_{kt}, \mathbb{X}^*_{kt} > 0$ (recall Proposition 3). 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:

$$\mathrm{d}\overline{UIP}_{kt}/\mathrm{d}\mu_t \propto \bar{\mathbb{A}}^*_k. \tag{19}$$

   The same comparative dynamics as in (18) applies for shocks to $\bar{\gamma}_{kt}/\mathbb{W}^*_{kt}$ for UIP premia and for shocks to $\bar{\delta}_{kt}$ for CIP premia, both proxying for shocks to supply of currency intermediation.[19]

We translate these comparative statics predictions into dynamic regression specifications in the next section, where we project changes in currency premia and exchange rates on changes in the futures positions of dealer banks $\Delta f^*_{kt}$, as well as on proxies for changes in $\mu_t$ and $(\bar{\gamma}_t, \bar{\delta}_t, \mathbb{W}^*_t)$ interacted with the currency $k$ long-run local-currency funding gap $\bar{\mathbb{A}}^*_k$. This allows us to trace out the effects of currency demand and supply shocks on equilibrium currency premia, with the ultimate goal of characterizing the dynamic response of the exchange rate to various shocks.

[18] Note that $\mathrm{d}f^*_{kt} > 0$ corresponds to sales of local currency and purchases of dollars, whether spot or forward, and vice versa.

[19] 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.

# 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 dealers' net forward position. These are the G7+ advanced economies and 4 emerging market currencies.[20] 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 deposit rates, depending on availability. Spot and forward exchange rates are taken as monthly averages from daily values. Further details on underlying data series and their descriptions are reported in Appendix Table A1.

Following the definitions of UIP and CIP premia in (4) and (9), where one period ahead is 3 months, we measure in the data the CIP premium, the realized UIP premium, and the survey-expected UIP premium as follows:

$$\begin{aligned} CIP_{kt} &= -(r_{kt} - r_t^{US}) + 4 \cdot \log(\mathcal{F}_{kt}/\mathcal{E}_{kt}), \\ UIP_{k,t+3} &= \quad (r_{kt} - r_t^{US}) - 4 \cdot \log(\mathcal{E}_{k,t+3}/\mathcal{E}_{kt}), \\ \widehat{UIP}_{kt} &= \quad (r_{kt} - r_t^{US}) - 4 \cdot \log\big(\widehat{\mathcal{E}}_{kt}/\mathcal{E}_{kt}\big), \end{aligned} \tag{20}$$

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 $t$ (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 $t$.[21] Thus, the final term in each equation in (20) measures a depreciation rate — forward, realized, and forecasted, respectively —

[20] 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).

[21] Note that we proxy the risk-neutral exchange rate expectation $\widehat{\mathcal{E}}_{kt}$ defined in (9) 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.

and is multiplied by 4 to make it annualized. Note that, as in the theory, the direction of the CIP premium is measured "in reverse" to conform with the conventional basis definition.[22]

Appendix Figures A3 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 by 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 A5 further decomposes UIP and CIP premia into the interest differential versus the expected 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** A key variable throughout our empirical analysis is the net futures position of FX dealer banks in various currencies vis-à-vis the US dollar, taken 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 on the Chicago Mercantile Exchange (CME) into 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", in line with our categorization in the model.

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.[23]

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.[24]

[22] 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).

[23] 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). To the best of our knowledge, we are the first ones to use the TFF data split.

[24] The 2022 BIS Triennual 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).

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:

$$f^*_{kt} = 100 \cdot \frac{\text{Dealer Net Position}_{kt}}{\frac{1}{12}\sum_{j=0}^{11} \text{Open Interest}_{k,t-j}}. \tag{21}$$

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 (21) 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 A4 plots the dealer net futures position by currency for the G7. 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 a substantial currency-specific variation in net futures positions. Appendix Table A2 reports the 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.[25] 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.

We assume that the change in the "Dealer/Intermediary" net position in a currency's futures, $\Delta f^*_{kt}$, contains an important signal for the overall demand shift for that currency in the wider FX derivative and spot markets. In other words, even though the aggregate currency exposure of intermediaries, $\mathbb{F}^*_{kt}$, may be very different in absolute terms from $f^*_{kt}$, we assume and verify in the data that the *change* in the futures position is a proxy for the change in the overall demand in the currency market, due to e.g. shifting desire to sell the currency-specific risk and/or to take hedged

[25]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).

local-currency positions. We formalize this in Appendix C, where we model this relationship as:

$$\Delta \log \mathbb{F}^*_{kt} = \alpha_k + \delta_t + \eta_k \Delta f^*_{kt} + \epsilon_{kt}, \tag{22}$$

and use the measure of the fit in our empirical specifications below as a validation of a tight correlation between $\Delta f^*_{kt}$ and unobserved $\Delta \log \mathbb{F}^*_{kt}$.

**Slope of currency supply** Besides shifts in dealer banks' currency positions (21), 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 $\sigma^2_{kt}$, 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.[26] 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. In particular, commodity currencies — Australian and New Zealand dollars — and emerging market currencies feature significantly higher interest rates, for the latter countries reflecting in part both inflation and default risks in addition to currency risk.

Recall from Section 2.3 the currency gap variable $\bar{\mathbb{A}}^*_k$ which effectively summarizes the long-term demand for local currency investment relative to supply of savings, and pins down the sign of the UIP and CIP premium in steady state (Proposition 3). We measure this currency gap by the negative of the external dollar gap, defined as the difference between the external dollar-debt assets

[26]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.

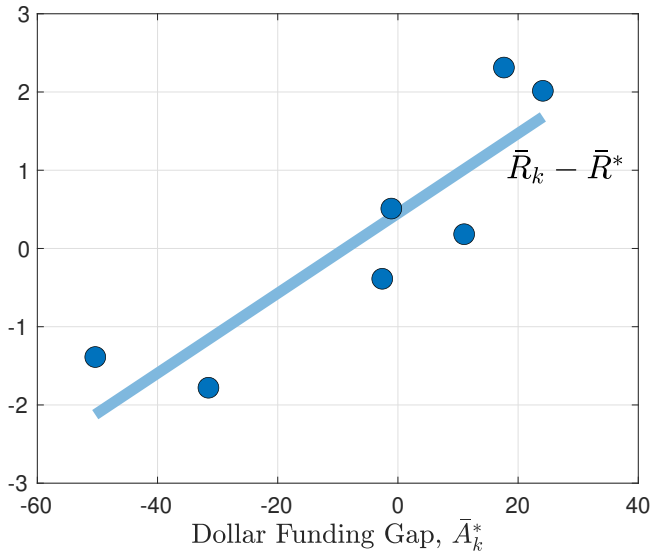



Figure 3: Cross section of average interest rate differentials against the dollar funding gap

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

and external dollar-debt liabilities in percent of domestic GDP of a country.[27] We focus on debt positions as opposed to equity positions as it is the former which require intermediation through currency markets and are subject to currency risk. Column 1 of Table 2 reports the average dollar funding gap $\bar{\mathbb{A}}_k^*$. This gap is positive when local-currency savings are insufficient for local-currency investment needs. In other words, equilibrium in this case features partial dollar borrowing to cover local-currency investment needs. Vice versa, a negative dollar funding gap, $\bar{\mathbb{A}}_k^* < 0$, reflects the excess of local-currency savings over local investment demand, making the associated currency a funding currency for world investment. There is a clear positive correlation between the average dollar funding gap $\bar{\mathbb{A}}_k^*$ and the average interest rate differential $\bar{R}_k - \bar{R}^*$. Currencies with a large dollar funding gap feature high local-currency interest rates, and vice versa. We illustrate this pattern in Figure 3 for G7+ currencies.[28]

Countries with a positive dollar 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 ($\widehat{\overline{UIP}}_k$) 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 OECD currencies and for select EM currencies.[29]

[27] 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.

[28] Note that the measure of the dollar funding gap $\bar{\mathbb{A}}_k^*$ is not quantitatively comparable between OECD and EM currencies, as EM's also cover their local-currency investment needs increasingly through issuance of local-currency debt to foreigners (Du and Schreger, 2022).

[29] 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

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

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

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 as well (see Dao

reported in Table 2.

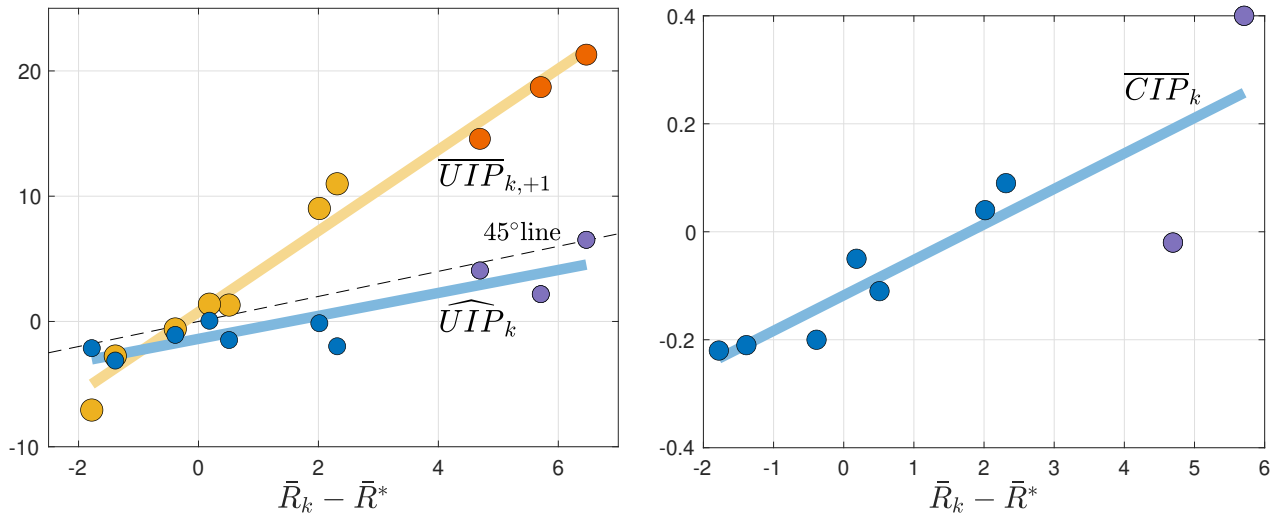



Figure 4: Cross section of the average UIP and CIP deviations against the interest rate differential

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, MXN, ZAR and RUB; the right panel drops RUB due to highly volatile CIP wedge (see Table 2 and Appendix Figure A7).

and Gourinchas, 2024). Nonetheless, there is still a strong positive association between average CIP deviations, average UIP deviations and the average interest rate differential, as illustrated in the right panel of Figure 4.

**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 dollar 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 dollar 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 and, vice versa, investment currencies feature an excess

demand for local-currency investment. This results in the average interest rate differentials which reflect the excess demand for investment over the supply of savings in the local currency. The associated currency risk commands an expected UIP premium which is approximately equal to the interest rate differential. Indeed, in a long-run equilibrium, currencies are not expected to have a trend appreciation or depreciation, hence the unconditional expected UIP premium reflects the local-currency 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. Therefore, it is the local-currency interest rate differential that 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.[30] For funding currencies this means selling dollars forward making it cheap, while for investment currencies this means buying dollars forward making it expensive. Consequently, this commands a positive CIP deviation for investment currencies and a negative CIP deviation for funding currencies, resulting in a positive cross-sectional association between CIP deviations, UIP deviations, and local-currency interest rate differentials. Importantly, recall from e.g. (16) that CIP deviations are defined "in reverse" to UIP and the interest rate differential. Therefore, a positive average CIP deviations for high-interest-rate investment currencies ($\bar{R}_k > R^*$) implies that $\bar{\mathcal{F}}/\bar{\mathcal{E}} > \bar{R}_k/\bar{R}^* > 1$. That is, forward dollars are expensive relative to spot dollars, exceeding the interest rate gap. The opposite is true for low-interest-rate funding currencies with $\bar{\mathcal{F}}/\bar{\mathcal{E}} < \bar{R}_k/\bar{R}^* < 1$ and cheap forward dollars relative to spot dollars. 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.[31]

## 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 the dealer banks. In our dynamic panel of currencies, we estimate the following distributed lag specification for various

[30] 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).

[31] While our results here, as summarized in Figures 3–4, focused mostly on G7+ currencies, Appendix Figures A6–A7 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 (2024).

measures of currency premia $v_{kt}$:

$$\Delta v_{kt} = \alpha_k + \delta_t + \sum_{j=0,1,2} \beta_j \Delta f^*_{k,t-j} + \gamma \Delta w_{kt} + \rho v_{k,t-1} + \varepsilon_{kt}, \tag{23}$$

where $\alpha_k$ and $\delta_t$ are currency and time fixed effects and $w_{kt}$ are currency specific controls. For $v_{kt}$, we adopt the tri-monthly (quarterly) UIP premium $\Delta\widehat{UIP}_{kt}$ 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 premium $CIP_{kt}$, all annualized and expressed in log points (basis points, bps), as defined in (20). In some specifications, we drop time fixed effects $\delta_t$ 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 (23) is the currency specific demand shifter reflected in the position of dealer banks relative to the size of the currency market, $\Delta f^*_{kt}$, defined in (21). 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:

$$\Delta f^*_{kt} = \alpha_k + \delta_t - \underset{[4.50]}{0.130} \cdot f^*_{k,t-1} + \underset{[5.20]}{0.183} \cdot \Delta f^*_{k,t-1} - \underset{[3.83]}{0.119} \cdot \Delta f^*_{k,t-2} + \epsilon_{kt}, \tag{24}$$

with $|t|$-stats reported in brackets, and with the standard deviation of innovation equal to $15.6$.[32] We depict the impulse response of $f^*_{kt}$ to its standardized innovation in the first panel of Figure 8 below, which shows 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 (24), but would otherwise be hard to establish at conventional levels of statistical certainty.

Combining together our statistical model in (23) and (24), we are estimating the responses of currency premia $v_{kt}$ projected on $f^*_{kt}$ innovations. These innovations are not exogenous shocks per se, but rather identify a dynamic event in the time-series, namely the dealer banks expanding or contracting their currency positions. This does not identify the underlying structural reason for this shock — which may be a macroeconomic news or financial shock — but rather estimates the comovement between changes in market currency premia and currency exposure of dealer banks, which are linked by currency supply schedules in Propositions 2. Adding financial conditions variables to the baseline specification as controls for shifts in the supply schedules, leaves $\Delta f^*_{kt}$ to absorb the shifts in currency demand. Our identification argument is laid out in Appendix C.

**Dynamics of UIP and CIP 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.

[32] Some of the variation of $\Delta f^*_{kt}$ is absorbed into time fixed effects, reflecting correlated multi-currency shocks. The time-series process of $\Delta f^*_{kt}$ without absorbing time fixed effects is virtually the same, but with a larger standard deviation of innovation equal to $19.1$.

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 (23) with and without time fixed effects; $|t|$-stats in brackets are computed using Driscol-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.

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 $\Delta f^*_{kt}$. The effect on the UIP premia is both 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.

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.[33] Note that this contrasts with the positive comovement between the two premia apparent in the cross-section of currencies in Table 2

[33]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.

and Figure 4. Recall from the definitions in (4) 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 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. The UIP and CIP premia, as well as interest rates, are tri-monthly and annualized, and we correspondingly adjust the exchange rate changes to be consistent with the decomposition by multiplying them by 4 (recall definitions in (20)). Column (1) and (2) of Table 4 reproduce approximately columns (2) and (6) of Table 3.[34] 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.

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

[34]The slight difference of the specifications is the exclusion of $\Delta CIP_{kt}$ or $\Delta\widehat{UIP}_{kt}$ 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.

Table 4: Decomposition of UIP and CIP premia responses

| Dep. var: | (1) $\Delta\widehat{UIP}_{kt}$ | (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) $\Delta\log(R_{kt}/R^*_t)$ |
|---|---|---|---|---|---|---|
| $\Delta f^*_{kt}$ | $0.171^{***}$ | $0.0000$ | $0.227^{***}$ | $0.225^{***}$ | $0.055^{***}$ | $-0.0005^{**}$ |
| | [15.47] | [0.34] | [23.18] | [22.87] | [7.77] | [2.64] |
| $\Delta f^*_{k,t-1}$ | $-0.052^{***}$ | $0.0003$ | $-0.048^{**}$ | $-0.048^{**}$ | $0.004$ | $-0.0004$ |
| | [5.38] | [1.39] | [3.04] | [3.10] | [0.23] | [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 $\Delta\widehat{UIP}_{kt}$ 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.

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 in the broad dollar index as the 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 positions $\Delta f^*_{kt}$ 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 a stark contrast, the variation in the dealers' futures positions, $\Delta f^*_{kt}$, is robustly irrelevant for the variation in CIP premia, with rather precisely estimated coefficients of zero for every currency.[35] However, VIX and, especially, the broad dollar co-move significantly with CIP premia for most currencies with many $t$-stats above 2. These variables, together with the lagged level of the

[35] At higher frequency, using weekly data, we find some 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] |
| $\Delta \log \overline{\mathcal{E}^{USD}_t}$ | $1.506^{***}$ [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] |
| $\Delta \log \text{VIX}_t$ | $-0.103^{***}$ [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] |
| 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] |
| $\Delta \log \overline{\mathcal{E}^{USD}_t}$ | $-0.0228^{**}$ [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] |
| $\Delta \log \text{VIX}_t$ | $-0.0015^{***}$ [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] |
| 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.

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. Namely, typical month-to-month shifts in currency demand are translated into corresponding changes in UIP premia required for intermediation by currency dealers. However, there is no such effect on CIP premia, which remain stable despite movements in UIP.

Our second observation from Table 5 is that the co-movement of the broad dollar and UIP premia are remarkably similar across currencies — with the broad dollar appreciation associated with increasing UIP premia (i.e., more positive or less negative) for every currency with $t$-stats around 4. In contrast, the co-movement with VIX is clearly differentiated 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. In particular, we find that the VIX impact on UIP premium varies monotonically from negative to positive as we go from the currency with the largest negative local-currency funding gap (JPY) to the largest positive funding gap (MXN), with highly significant estimates in each case but EUR where the effect happens to be close to a precise zero.

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 the funding currencies and more positive for commodity and EM currencies, however, with the statistical association that is rather weak in the latter group. In contrast, in response to the appreciation of the broad dollar, CIP premia tend to move in the opposite direction relative to UIP premia. The broad dollar tends to comove strongly and negatively with CIP premia for most G7+ currencies, with the exception of NZD (and it comoves positively with CIP for 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.[36]

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 spreading out of both UIP and CIP premia across currencies in response to the tightening of the general financial conditions, as proxied by VIX, is consistent with the theoretical prediction summarized in (18). 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 local-currency funding gap $\bar{\mathbb{A}}_k^*$, recall (19). Signs and magnitudes of the long-run currency premia are shaped by $\bar{\mathbb{A}}_k^*$ (Table 2), and they expand proportionally when financial conditions tighten. We further confirm this prediction in Appendix Tables A6 and A7 where we interact $\bar{\mathbb{A}}_k^*$ 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 this interaction terms has an important predictive effect for the response of both currency premia in a G7+ panel.[37]

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 lower-frequency movements associated with the global financial (and dollar) cycle. Figure 5 provides an effective summary of much of the 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

[36]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.

[37]While the broad dollar index correlates strongly with both UIP and CIP premia, driving their negative comovement, the interpretation is more complex. Broad dollar appreciations likely capture both shifts in demand in the currency market towards the dollar and away from each currency (like the common component of all $\Delta f_{kt}^*$), as well as the general tightening of financial conditions (like an increase in VIX). Additionally, movements in the broad dollar are associated with shifts in the dollar swap market reflecting the increased demand to buy dollar assets, which plausibly dominates the effect on CIP (see empirical evidence in Avdjiev, Du, Koch, and Shin, 2019; De Leo, Keller, and Zou, 2024).

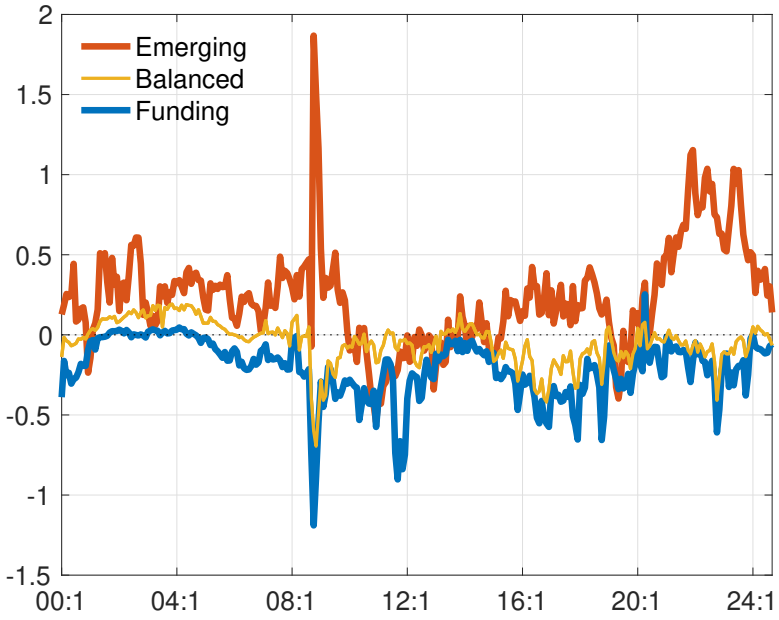



Figure 5: CIP premia by currency bins

Note: 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.

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. 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 specification for individual currencies $k$:

$$\Delta \log \mathcal{E}_{kt} = \alpha_k + \sum_{j=0,1,2,3} \Delta f^*_{k,t-j} + \gamma_k \Delta w_{kt} + \rho_k \log \mathcal{E}_{k,t-1} + \epsilon_{kt}, \tag{25}$$

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. We use the Treasury basis instead of the Broad Dollar in the exchange rate regression to capture shocks to dollar asset demand as before but avoid mechanical correlation due to major currencies' weights in the Broad dollar. We also report the results in the panel of G7+ currencies with and without time fixed effects.

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) | G7+ Panel (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta f^*_{kt}$ | $0.071^{***}$ | $0.061^{***}$ | $0.103^{***}$ | $0.060^{***}$ | $0.050^{***}$ | $0.062^{***}$ | $0.069^{***}$ | $0.045^{***}$ | $0.068^{***}$ | $0.056^{***}$ |
| | [9.04] | [12.65] | [9.71] | [7.63] | [11.63] | [11.79] | [15.87] | [4.00] | [26.81] | [26.48] |
| $\Delta f^*_{k,t-1}$ | 0.006 | $-0.005$ | 0.007 | $-0.005$ | $-0.003$ | 0.004 | $-0.002$ | 0.006 | $-0.002$ | $-0.006$ |
| | [0.97] | [1.17] | [0.98] | [1.16] | [0.54] | [0.55] | [0.46] | [0.86] | [0.50] | [1.54] |
| $\Delta f^*_{k,t-2}$ | $0.015^{**}$ | $0.018^{***}$ | $0.027^{***}$ | 0.004 | 0.003 | 0.008 | $0.015^{***}$ | 0.010 | $0.013^{***}$ | $0.010^{***}$ |
| | [2.21] | [5.11] | [4.35] | [0.90] | [0.73] | [1.04] | [2.71] | [1.65] | [4.61] | [3.94] |
| $\Delta(i_{kt} - i^*_t)$ | $-1.739^{**}$ | $-0.004$ | $-2.906^{***}$ | $-2.875^{***}$ | $-2.942^{***}$ | $-3.793^{***}$ | $-2.908^{***}$ | $-1.362$ | $-2.563^{***}$ | $-2.887^{**}$ |
| | [2.31] | [0.00] | [3.14] | [3.95] | [3.72] | [3.60] | [4.46] | [1.59] | [4.40] | [2.09] |
| $\Delta$T-basis$_t$ | 0.851 | $-1.802^{*}$ | $-1.533$ | $-1.052$ | $-2.591^{***}$ | $-3.104^{***}$ | $-2.089^{**}$ | $-3.336^{**}$ | $-1.608^{***}$ | |
| | [1.00] | [1.90] | [1.55] | [1.31] | [2.78] | [3.24] | [2.03] | [2.43] | [2.91] | |
| $\Delta \log \text{VIX}_t$ | $-0.014^{*}$ | $-0.004$ | $-0.006$ | 0.001 | $0.010^{*}$ | $0.034^{***}$ | $0.019^{**}$ | $0.034^{**}$ | 0.005 | |
| | [1.68] | [0.44] | [0.72] | [0.18] | [1.86] | [4.07] | [2.17] | [2.40] | [0.97] | |
| $\Delta \log \mathbb{W}^*_t$ | 0.011 | $-0.030$ | $-0.074^{***}$ | $-0.098^{***}$ | $-0.086^{***}$ | $-0.084^{***}$ | $-0.104^{***}$ | $-0.115^{***}$ | $-0.067^{***}$ | |
| | [0.44] | [1.64] | [5.31] | [3.26] | [4.17] | [3.16] | [2.82] | [2.81] | [3.79] | |
| $\log \mathcal{E}_{k,t-1}$ | 0.007 | $-0.017$ | 0.017 | $-0.002$ | $-0.002$ | 0.004 | $-0.004$ | $-0.005$ | $-0.001$ | $-0.009$ |
| | [0.84] | [1.58] | [1.50] | [0.17] | [0.18] | [0.39] | [0.36] | [0.66] | [0.09] | [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 | 0.594 |
| std of innovation (%) | 1.32 | 1.30 | 1.16 | 1.09 | 0.93 | 1.19 | 1.61 | 0.90 | 1.29 | 0.87 |
| half-life (months) | 8 | 7 | $\infty$ | 8 | 8 | 12 | 6 | 6 | 9 | 9 |

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. T-basis$_t$ stands for the 12-month Treasury basis computed as the difference in the 12-month Treasury yield in each currency relative to the Dollar Treasury yield, both swapped into Dollar uwing the 12-month forward rate.

We report the results in Table 6. There is a strong contemporaneous response of the spot exchange rate to the dealer positions shocks 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 dealer currency $k$ positions, representing a shift in the market demand towards dollar and away from currency $k$, is associated with an 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 1.2%, 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. Although the FX futures market is more shallow and data on dealer futures positions not widely available for emerging market currencies (apart from MXN), we obtain consistent results for their exchange rates using data for the panel for four EM currencies with much sparser futures data in Appendix Table A5. As in our baseline sample, shifts in dealer futures positions strongly move EM currency exchange rates to accommodate the changes in the correspondiong UIP premia in Appendix Table A4.

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.

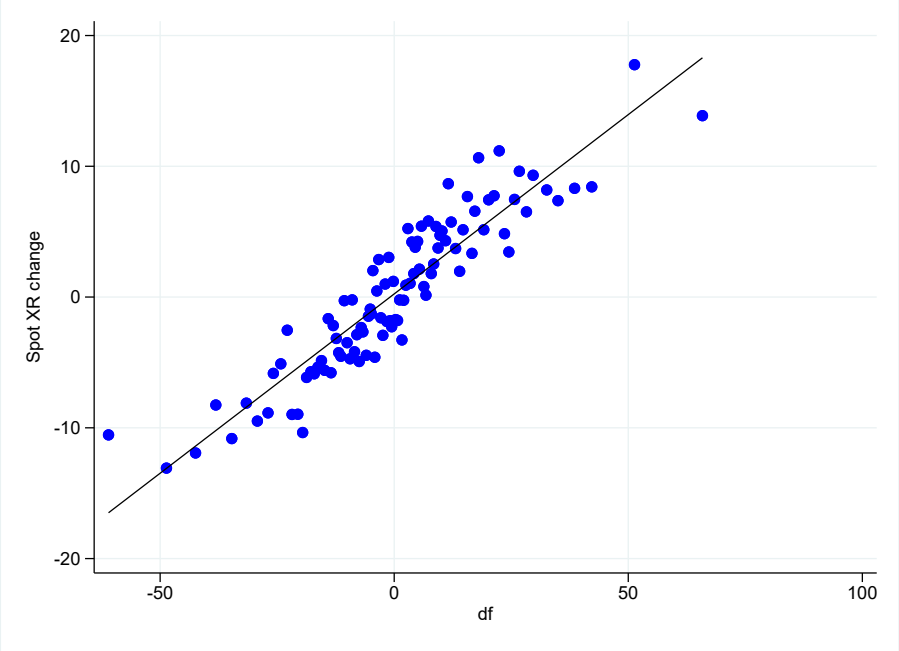



Figure 6: Dealer positions and exchange rate changes: scatter plot of $\Delta \log \mathcal{E}_{kt}$ against $\Delta f^*_{kt}$

Note: Left panel is a raw scatter plot of exchange rate changes $\Delta \log \mathcal{E}_{kt}$ on changes in dealer positions $\Delta f^*_{kt}$ with all currencies pooled together and all observations binned into 100 bins based on realizations of $\Delta f^*_{kt}$.

All mean reversion in the exchange rate response comes from mean reversion in the dealer positions. Recall that our estimated specification (24) implies a half-life of 6 months for a shock to $f^*_{kt}$, and a corresponding half-life of 9 months for the exchange rate in the panel of G7+ currencies (see half-lives for individual currencies in Table 6).[38] Figure 8 plots the impulse response for a typical exchange rate in a panel of G7+ currencies to a one standard deviation increase in the dealer currency position using the panel specification with time fixed effects.

The statistical model (25) accounts for 45–60% of the variation in spot exchange rates changes. The combined explained variation is due to the dealer positions as well as the more conventional variables that are used to correlate the exchange rate with. From Table 6, we see that changes in the interest rate differential have a strong association with exchange rate appreciations for all currencies but CHF and MXN.[39] The Treasury basis has the expected negative effect on exchange rates which increases in magnitude and significance as we move from funding toward investment currencies (that is from left to right in Table 6). This is consitent with results in the literature (see Lustig and Krishnamurthy) and imply a global demand shift to Dollar which 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 and our model, which predicts a differential

[38]Note that specification (24) imposes stationarity. An alternative specification in changes implies no mean reversion in $f^*_{kt}$ and, therefore, no mean reversion in the exchange rate.

[39]For MXN, as is the case for other EM currencies, a higher local interest rate is often associated with higher domestic risks, leading to a depreciation instead of appreciation as in AE's (see e.g. Kalemli-Ozcan and Varela, 2025).

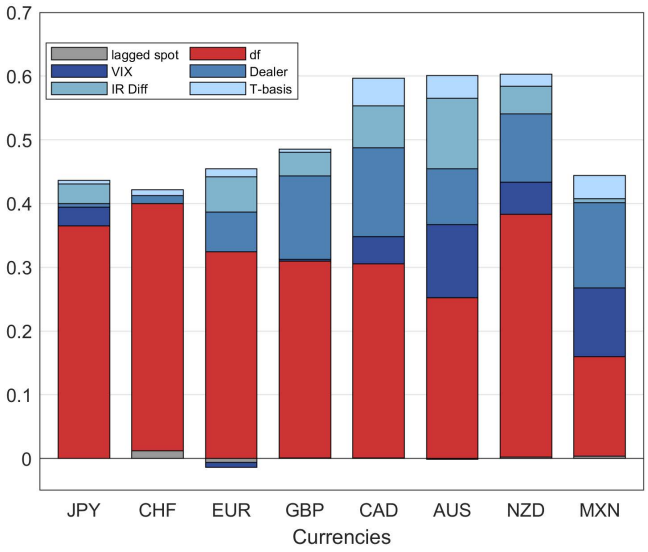



Figure 7: Contributions to $R^2$ by regressor

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

impact of financial conditions on currency supply across currencies with different underlying Dollar gaps. The spot exchange rate is therefore the main margin of adjustment for the UIP premium in the time series. Controlling for changes in log dealer wealth, another proxy for intermediation capacity of the financial market, also has strong association with exchange rates of investment currencies as predicted by the model: a decrease in dealer wealth is associated with depreciation of all currencies except for CHF and JPY with $t$-stats of 3 or more.

Despite these statistical associations with conventional macro-finance variables, the dealer positions have a large and independent contributions 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 CHE. 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.[40] 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 of Figure 6.

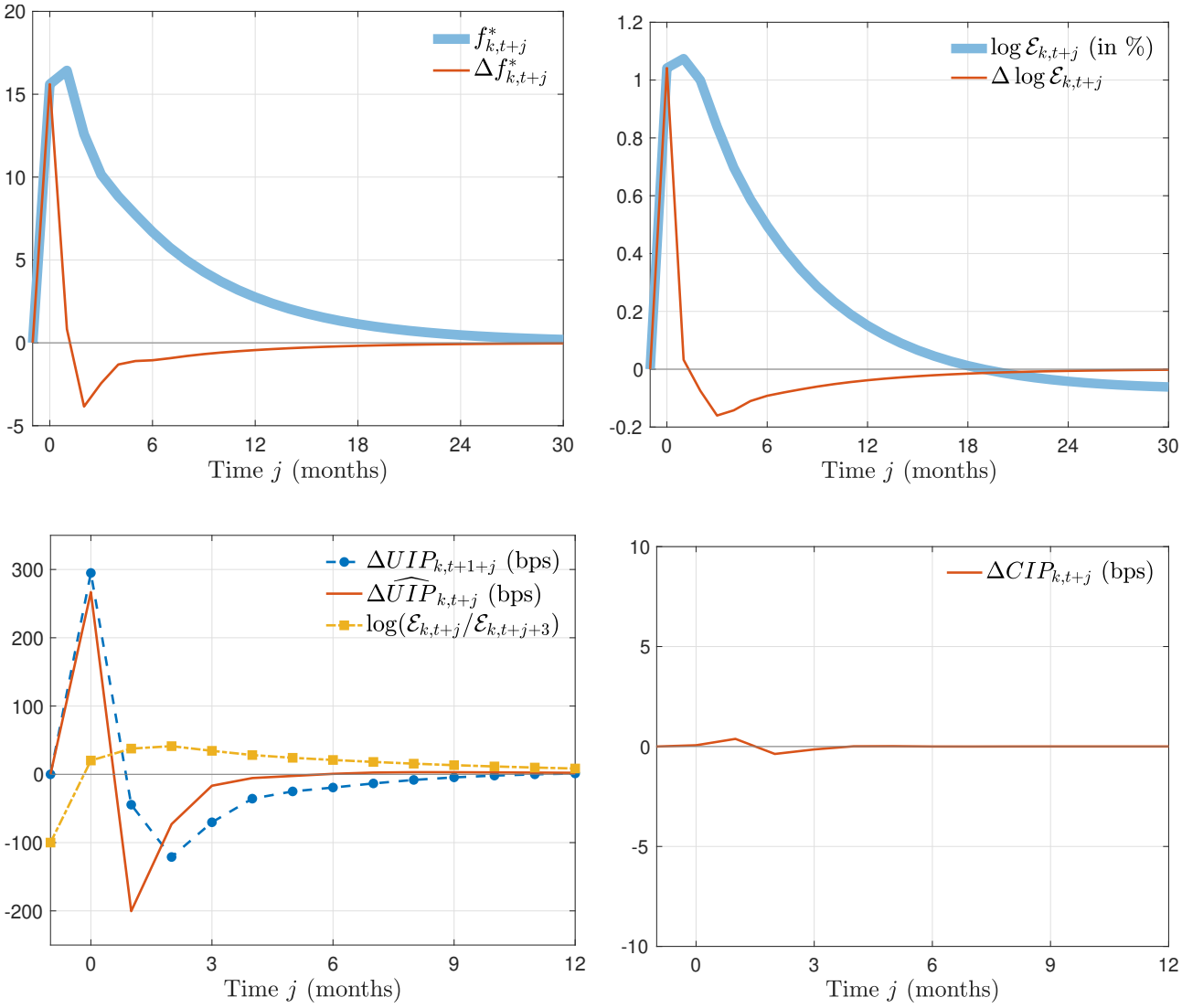
To further illustrate the fit of our statistical model (25), we plot the predicted components of the

[40]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 $R^2$.

Figure 8: Impulse responses to an idiosyncratic $\Delta f^*_{kt}$ shock in a panel of G7 currencies (with time fixed effects)




changes and cumulated levels for each exchange rates. The results for EUR and GBP are reported in Figures 1 and A2 in the introduction, while results for all other currencies are reported in Appendix Figures A8–A11. 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 (in changes and in levels, respectively) with their predicted components. 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 on the fit in changes.

**IRFs and Currency carry returns** We conclude our empirics discussion by looking at the realized currency returns projected on the dealer position shocks. A one standard deviation innovation to $\Delta f^*_{kt}$ is associated with virtually no change in the covered interest rate premium and a minimal change in the interest rates of the order of 1-2 basis points (see impulse responses in the Appendix).

The bulk of the currency returns are driven by the dynamics of the nominal exchange rates which are summarized with an impulse response in Figure 8.[41] We calculate the implied shock to currency (carry) returns for positions taken at $t+j$ — before the shock ($j < 0$) and in response to the shock ($j \geq 0$) — and report it in the same figure. For a one standard deviation positive innovation in $f^*_{kt}$ at $t$, there is a negative currency $k$ return for those with an open position before $t$ of the order of magnitude of 500 basis points (on a 3-month carry position, annualized). Those who open the carry position at $t+j$ for $j \geq 0$ collect an expected positive carry return of about 100 basis points (again, on a 3-month carry position, annualized) over the following year, gradually converging towards zero. The return reaches its peak at 176 basis points three months after the shock.

# 4 Interpretation

TO BE COMPLETED

Three big points:

1. CIP and UIP are very different beasts, and FX dynamics is largely about UIP
2. Frictional nature of UIP deviations which requires premia for intermediation: profits and losses in the financial sector.
3. Frictional nature of FX variation — even if underlying shocks are fundamental, they are frictionally intermediated resulting in extra FX volatility. The model with the same fundamental shocks without frictional intermediation (UIP holding) will result in much less equilibrium exchange rate volatility. Disconnect is not just about correlations but also about the gap in vol for FX relative to macro.

[41] Note that the impulse response of the UIP premia cannot be readily interpreted as the expected returns, as we estimate our specifications in changes. Therefore, we cumulated the estimated impulse responses for changes in the exchanger rate and the interest rate differential into levels, and calculated the implied path of returns using the formula for the carry trade return, $R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{E}_{k,t+3}} - R^*_t$.

# References


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.

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.

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.

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.

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.

Dao, M. C., and P.-O. Gourinchas (2024): "CIP Deviations in Emerging Markets: Drivers and Policies," working paper.

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): "Sovereign Risk, Currency Risk, and Corporate Balance Sheets," *The Review of Financial Studies*, 35(10), 4587–629.

Du, W., A. Tepper, and A. Verdelhan (2018): "Deviations from Covered Interest Rate Parity," *The Journal of Finance*, 73(3), 915–957.

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 K. D. West (2005): "Exchange Rates and Fundamentals," *Journal of Political Economy*, 113(3), 485–517.

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., 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.

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.

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.

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, 2183–2232.

——— (2023): "Optimal Exchange Rate Policy," NBER Working Paper No. 31933.

——— (2024): "What Drives the Exchange Rate?," *IMF Economic Review*, forthcoming.

——— (2025): "Mussa Puzzle Redux," *Econometrica*, forthcoming.

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.

Jeanne, O., and A. K. Rose (2002): "Noise Trading and Exchange Rate Regimes," *The Quarterly Journal of Economics*, 117(2), 537–569.

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.

Liao, G., and T. Zhang (2020): "The Hedging Channel of Exchange Rate Determination," *International Finance Discussion Papers*, 1283.

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.

Obstfeld, M., and K. S. Rogoff (2001): "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?," in *NBER Macroeconomics Annual 2000*, vol. 15, pp. 339–390.

Rey, H. (2013): "Dilemma not trilemma: the global financial cycle and monetary policy independence," *Jackson Hole Symposium Proceedings*.

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

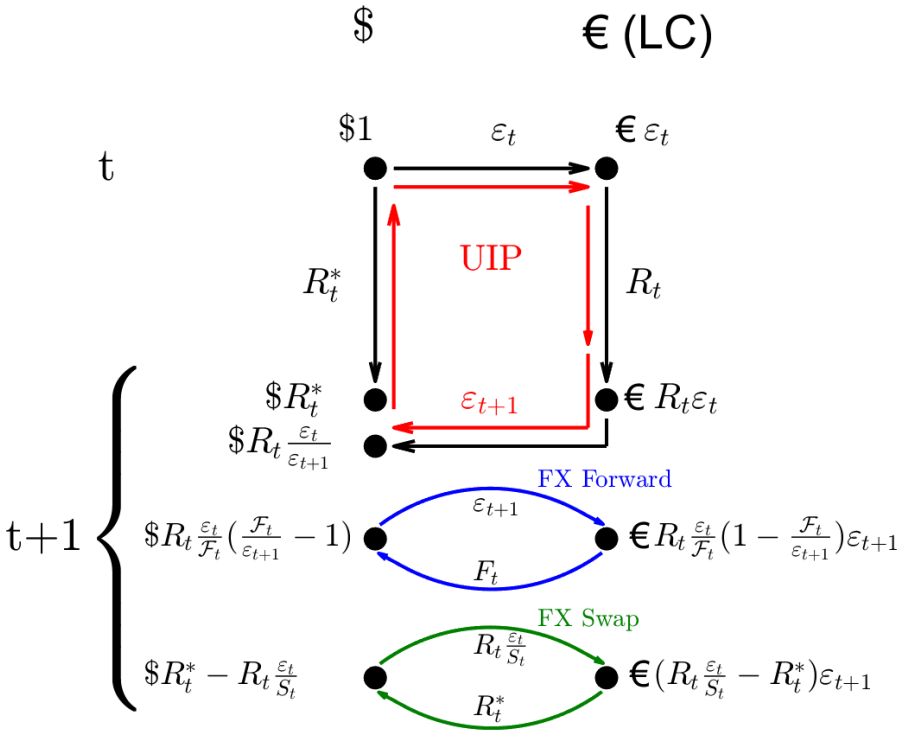



Figure A1: Illustration for balance sheet in Table 1: possible currency trades

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

| Currency | Ticker (3M) | Description (3M) |
|---|---|---|
| | | **Interest Rates** |
| 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 | MXTIIE3M=RR | Mexican Peso 3 Month TIIE Interbank Rate |
| BRL | BRRED90D=CBBR | BRL 90D Discount Rate |
| ZAR | JIBAR3M= | South African Rand 3 Month JIBAR |
| RUB | RUB3MD= | Russian Rubel 3 Month deposit |
| | | **Forward Rates/Premia** |
| 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 statsitics 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* | |
| $\Delta(EFFR_t - IORB_t)$ | 0.0057 | -0.1121* | 0.0662* | 0.1507* | 0.3506* |

Note: Entries show monthly pairwise correlation coefficients. * indicate statistical signifcance 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-Aggreppino and Rey (2022). $EFFR - IORB$ 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) |
|---|---|---|---|---|---|---|---|
| | EM panel | | | | | | |
| $\Delta\widehat{UIP}_{kt}$ | Baseline | Time FE | USD & VIX | MXN | ZAR | RUB | BRL |
| $\Delta f^*_{kt}$ | $0.139^{***}$ | $0.096^{***}$ | $0.075^{***}$ | $0.075^{***}$ | $0.029$ | $0.140^{**}$ | $0.035^{**}$ |
| | [5.91] | [2.93] | [3.88] | [3.55] | [0.56] | [2.26] | [2.14] |
| $\Delta f^*_{k,t-1}$ | $-0.064^{**}$ | $-0.042$ | $-0.053^{**}$ | $-0.052^{**}$ | $0.011$ | $-0.041$ | $-0.008$ |
| | [2.37] | [1.06] | [2.26] | [2.32] | [0.25] | [0.34] | [0.22] |
| $\Delta CIP_{kt}$ | $0.463$ | $-1.251^{**}$ | $-0.341$ | $-2.558^{***}$ | $0.155$ | $-1.858^{***}$ | $-3.639^{*}$ |
| | [0.33] | [2.08] | [0.36] | [3.79] | [0.04] | [4.62] | [1.67] |
| $\Delta \log \overline{\mathcal{E}_t^{USD}}$ | | | $2.477^{***}$ | $1.917^{***}$ | $6.414^{***}$ | $1.999^{**}$ | $2.491^{***}$ |
| | | | [5.46] | [4.02] | [7.14] | [2.07] | [3.35] |
| $\Delta \log \text{VIX}_t$ | | | $0.075^{***}$ | $0.089^{***}$ | $0.052$ | $0.114^{**}$ | $0.078$ |
| | | | [2.76] | [2.77] | [0.95] | [2.56] | [1.62] |
| $\widehat{UIP}_{k,t-1}$ | $-0.366^{***}$ | $-0.431^{***}$ | $-0.379^{***}$ | $-0.351^{***}$ | $-0.569^{***}$ | $-0.456^{***}$ | $-0.477^{***}$ |
| | [6.40] | [5.12] | [5.77] | [4.54] | [9.00] | [5.74] | [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 Marlet 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: $\Delta \log \mathcal{E}_{kt}$ | (1) MXN | (2) RUB | (3) BRL | (4) ZAR | (5) EM Panel | (6) EM Panel |
|---|---|---|---|---|---|---|
| $\Delta f^*_{kt}$ | $0.045^{***}$ | $0.056^{**}$ | $0.026^{***}$ | $0.049^{***}$ | $0.044^{***}$ | $0.032^{***}$ |
| | [4.00] | [2.19] | [2.86] | [2.90] | [4.55] | [3.74] |
| $\Delta f^*_{k,t-1}$ | 0.006 | 0.022 | 0.003 | $-0.007$ | 0.003 | $-0.004$ |
| | [0.86] | [0.72] | [0.28] | [0.37] | [0.47] | [0.45] |
| $\Delta f^*_{k,t-2}$ | 0.010 | 0.005 | $0.019^{*}$ | 0.001 | 0.007 | 0.008 |
| | [1.65] | [0.28] | [1.86] | [0.050] | [1.59] | [1.46] |
| $\Delta(i_{kt} - i^*_t)$ | $-1.362$ | $1.974^{***}$ | $1.990^{**}$ | $-3.445$ | $1.863^{***}$ | $1.970^{***}$ |
| | [1.59] | [21.08] | [2.45] | [1.28] | [7.49] | [12.85] |
| $\Delta$T-basis$_t$ | $-3.336^{**}$ | $-2.053$ | 1.573 | $-4.891^{**}$ | $-2.481$ | |
| | [2.43] | [0.63] | [0.38] | [2.02] | [1.16] | |
| $\Delta \log \text{VIX}_t$ | $0.034^{**}$ | $0.049^{**}$ | 0.042 | $-0.003$ | $0.038^{**}$ | |
| | [2.40] | [2.12] | [1.29] | [0.08] | [2.15] | |
| $\Delta \log \mathbb{W}^*_t$ | $-0.115^{***}$ | $-0.105^{***}$ | $-0.061$ | $-0.216^{**}$ | $-0.084^{**}$ | |
| | [2.81] | [3.54] | [0.74] | [2.49] | [2.38] | |
| $\Delta \log \mathcal{E}_{k,t-1}$ | $-0.005$ | $-0.001$ | $-0.016^{**}$ | $-0.030$ | $-0.006$ | $-0.013$ |
| | [0.66] | [0.17] | [2.32] | [0.98] | [0.99] | [1.13] |
| Observations | 209 | 149 | 134 | 78 | 570 | 588 |
| Within $R^2$ | 0.444 | 0.598 | 0.209 | 0.328 | 0.374 | 0.798 |
| # Currency FE | | | | | 4 | 4 |
| Time FE | | | | | | ✓ |

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 heteroskedacticity 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) | (3) $\mu = -DealerW$ | (4) | (5) $\mu = -GFCy$ | (6) | (7) $\mu = EFFR - IORB$ |
|---|---|---|---|---|---|---|---|
| $\Delta f^*_{kt}$ | $0.163^{***}$ | $0.169^{***}$ | $0.165^{***}$ | $0.175^{***}$ | $0.172^{***}$ | $0.161^{***}$ | $0.155^{***}$ |
| | [11.88] | [13.14] | [12.49] | [13.10] | [12.65] | [12.52] | [11.68] |
| $\Delta f^*_{k,t-1}$ | $-0.044^{***}$ | $-0.044^{***}$ | $-0.043^{***}$ | $-0.041^{***}$ | $-0.040^{***}$ | $-0.045^{***}$ | $-0.042^{***}$ |
| | [3.76] | [3.68] | [3.51] | [3.12] | [2.91] | [3.31] | [2.99] |
| $\Delta f^*_{k,t-2}$ | $0.011$ | $0.013$ | $0.012$ | $0.022^{**}$ | $0.020^{*}$ | $0.017$ | $0.016^{*}$ |
| | [1.03] | [1.17] | [1.17] | [2.02] | [1.94] | [1.38] | [1.69] |
| $\Delta \log \overline{\mathcal{E}_t^{USD}}$ | $1.468^{***}$ | $1.413^{***}$ | $1.363^{***}$ | $1.258^{***}$ | $1.256^{***}$ | $1.818^{***}$ | $1.586^{***}$ |
| | [9.63] | [9.13] | [9.13] | [6.67] | [6.39] | [8.95] | [7.15] |
| $\Delta \log \text{VIX}_t$ | $0.050^{***}$ | | $0.035^{**}$ | | $0.007$ | | $0.057^{***}$ |
| | [3.28] | | [2.21] | | [0.36] | | [3.59] |
| $\Delta \log \text{VIX}_t \times \bar{\mathbb{A}}^*_{kt}$ | $0.002^{***}$ | | $0.002^{***}$ | | $0.001^{*}$ | | $0.002^{***}$ |
| | [5.08] | | [3.56] | | [1.76] | | [5.10] |
| $\Delta \mu_t$ | | $0.134^{***}$ | $0.084^{*}$ | $3.651^{**}$ | $3.394^{*}$ | $4.532$ | $3.856$ |
| | | [2.75] | [1.89] | [2.44] | [1.73] | [1.04] | [1.19] |
| $\Delta \mu_t \times \bar{\mathbb{A}}^*_{kt}$ | | $0.006^{***}$ | $0.002^{*}$ | $0.205^{***}$ | $0.135^{***}$ | $0.372$ | $0.315^{**}$ |
| | | [6.42] | [1.76] | [5.57] | [3.32] | [1.45] | [2.02] |
| $\bar{\mathbb{A}}^*_{kt}$ | $0.022$ | $0.023$ | $0.022$ | $0.036$ | $0.037$ | $0.009$ | $0.010$ |
| | [1.00] | [1.02] | [0.98] | [1.53] | [1.55] | [0.39] | [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 $\bar{\mathbb{A}}^*_{kt}$, 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 heteroskedacticity 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) | (4) $\mu = -GFCy$ | (5) | (6) $\mu = EFFR - IORB$ | (7) |
|---|---|---|---|---|---|---|---|
| $\Delta f^*_{kt}$ | 0.0003 | 0.0004 | 0.0003 | 0.0005 | 0.0005 | −0.0000 | −0.0001 |
| | [0.79] | [1.00] | [0.88] | [1.57] | [1.53] | [0.17] | [-0.36] |
| $\Delta f^*_{k,t-1}$ | −0.0002 | −0.0002 | −0.0001 | −0.0002 | −0.0002 | −0.0001 | −0.0001 |
| | [0.74] | [0.80] | [0.73] | [0.73] | [0.72] | [0.32] | [0.40] |
| $\Delta \log \overline{\mathcal{E}^{USD}_t}$ | −0.0189** | −0.0233** | −0.0217** | −0.0189*** | −0.0192*** | −0.0096* | −0.0082 |
| | [2.37] | [2.30] | [2.36] | [3.31] | [3.33] | [1.78] | [1.62] |
| $\Delta \log \text{VIX}_t$ | −0.0002 | | −0.0005 | | −0.0002 | | −0.0000 |
| | [0.44] | | [1.29] | | [0.59] | | [0.05] |
| $\Delta \log \text{VIX}_t \times \bar{\mathbb{A}}^*_{kt}$ | 0.00002*** | | 0.0000 | | 0.0001 | | 0.00002** |
| | [2.67] | | [1.55] | | [0.47] | | [2.55] |
| $\Delta \mu_t$ | | 0.0013 | 0.0019* | −0.0398 | −0.0305 | 0.164*** | 0.168*** |
| | | [1.33] | [1.69] | [1.20] | [1.12] | [2.97] | [3.05] |
| $\Delta \mu_t \times \bar{\mathbb{A}}^*_{kt}$ | | 0.0001** | 0.0000 | 0.0017* | 0.0015 | 0.0095** | 0.0092*** |
| | | [2.52] | [0.91] | [1.85] | [1.59] | [2.33] | [2.77] |
| $\bar{\mathbb{A}}^*_{kt}$ | −0.0001 | −0.0001 | −0.0001 | −0.0001 | −0.0000 | −0.0002 | −0.0002 |
| | [0.22] | [0.22] | [0.24] | [0.11] | [0.097] | [0.37] | [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 $\bar{\mathbb{A}}^*_{kt}$, 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 heteroskedacticity robust standard errors shown in brackets.

Table A8: Weekly CIP panel

| | G7+ panel | | EM panel | |
|---|---|---|---|---|
| Dep. var: $\Delta CIP_{k,t}$ | (1) | (2) | (3) | (4) |
| $CIP_{k,t-1}$ | $-0.090^{***}$ | $-0.061^{***}$ | $-0.085^{***}$ | $-0.134^{**}$ |
| | [6.27] | [5.31] | [2.93] | [2.14] |
| $\Delta f^*_{kt}$ | $0.0002^{**}$ | $0.0003^{**}$ | $0.001^{**}$ | $-0.001$ |
| | [2.56] | [2.50] | [1.99] | [0.38] |
| $\Delta f^*_{k,t-1}$ | $0.000$ | $-0.000$ | $-0.001$ | $-0.000$ |
| | [0.47] | [0.26] | [1.31] | [0.22] |
| $\Delta \log \overline{\mathcal{E}_t^{USD}}$ | $-0.012^{**}$ | | $0.052^{***}$ | |
| | [3.12] | | [3.67] | |
| $\Delta \log \text{VIX}_t$ | $-0.0004^{***}$ | | $0.001$ | |
| | [3.99] | | [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|-statsitics computed using Driscoll-Kraay autocorrelation and heteroskedacticity robust standard errors shown in brackets. $^{***}$,$^{**}$ ,$^{*}$ denote statistical significance at the 1, 5 and 10 percent level respectively.

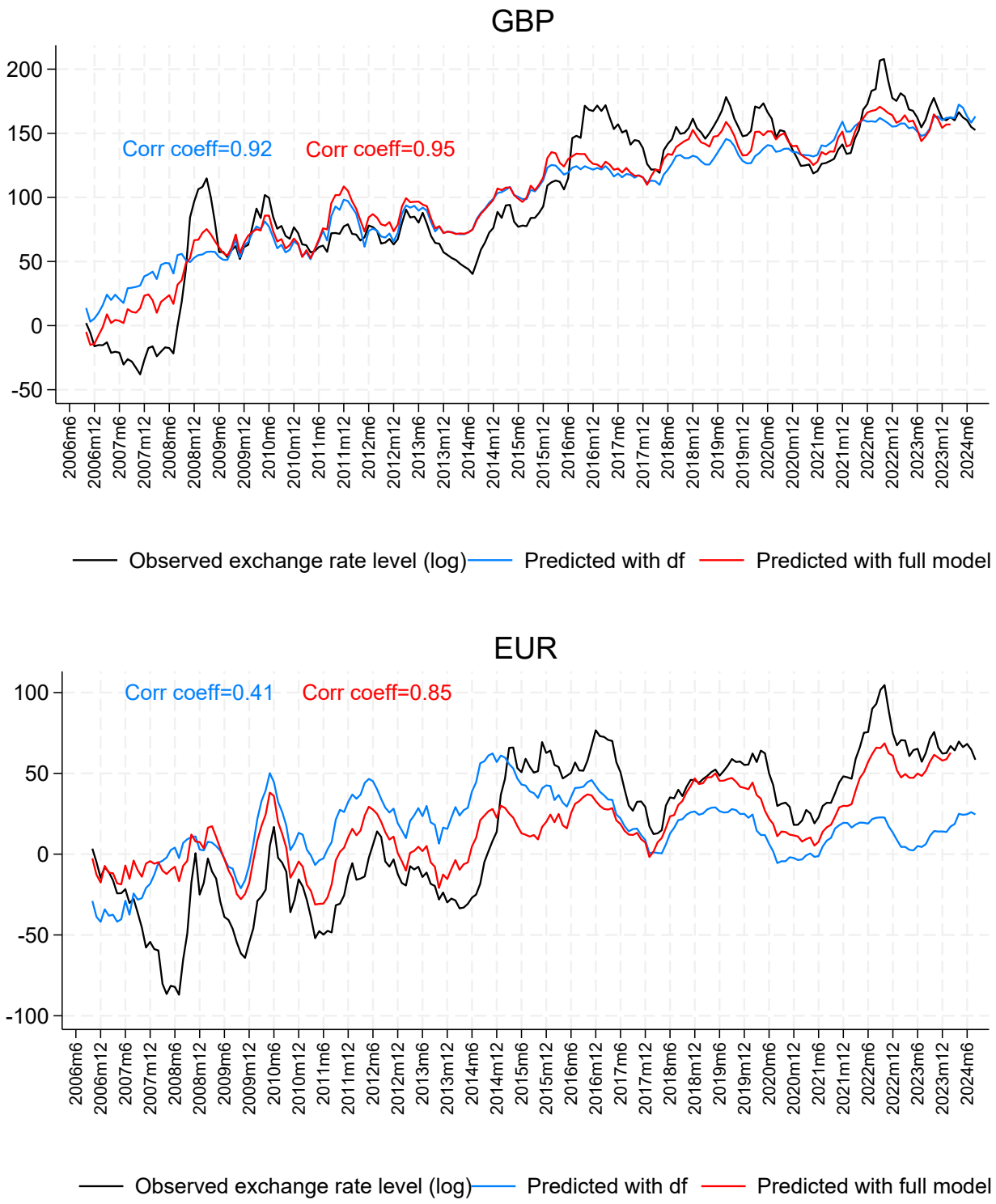



Figure A2: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values

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 A3: Time series of survey UIP and CIP premia: G7 and MXN

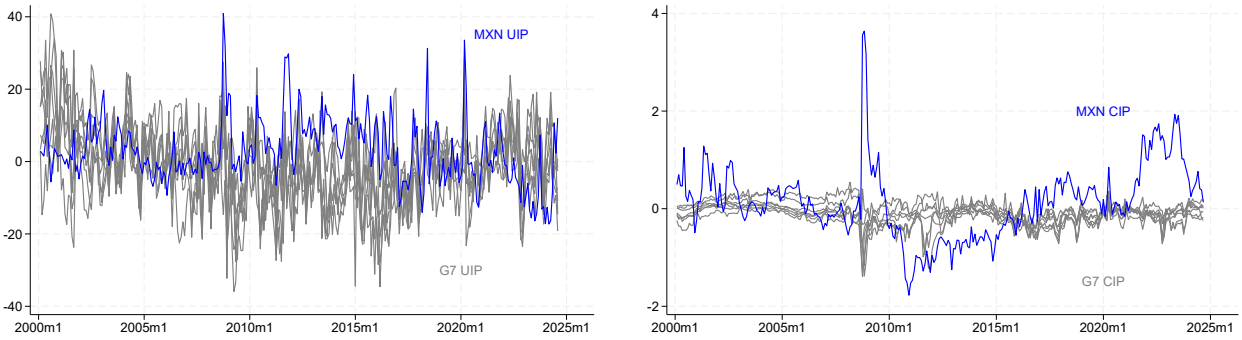



Figure A4: Dealers net futures position by G7 currency

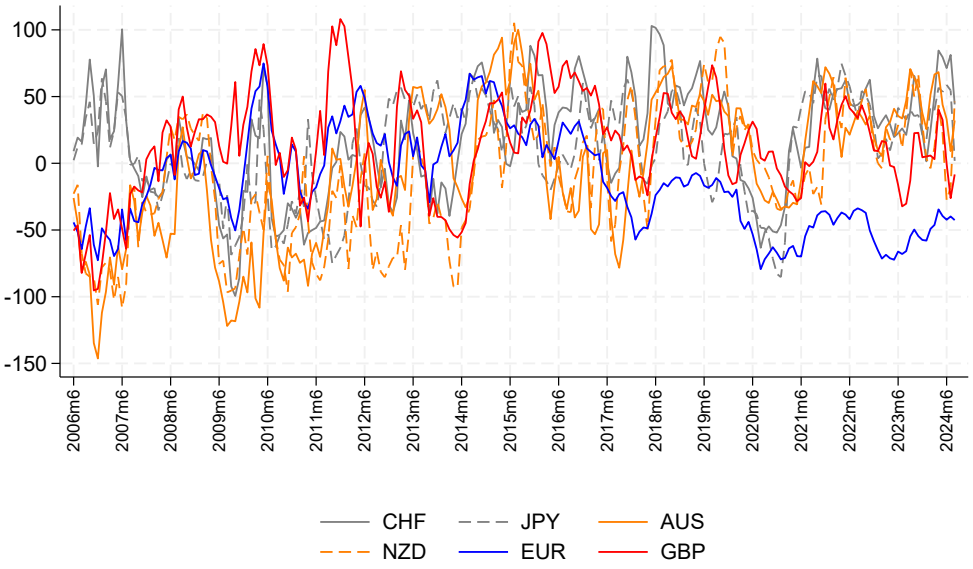
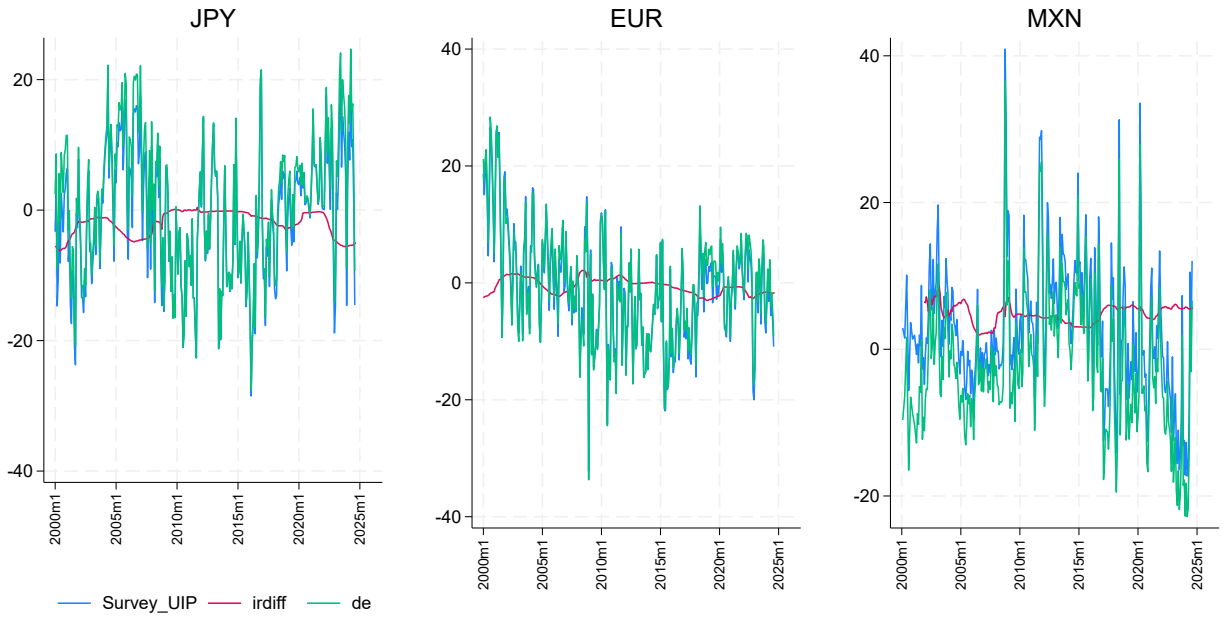
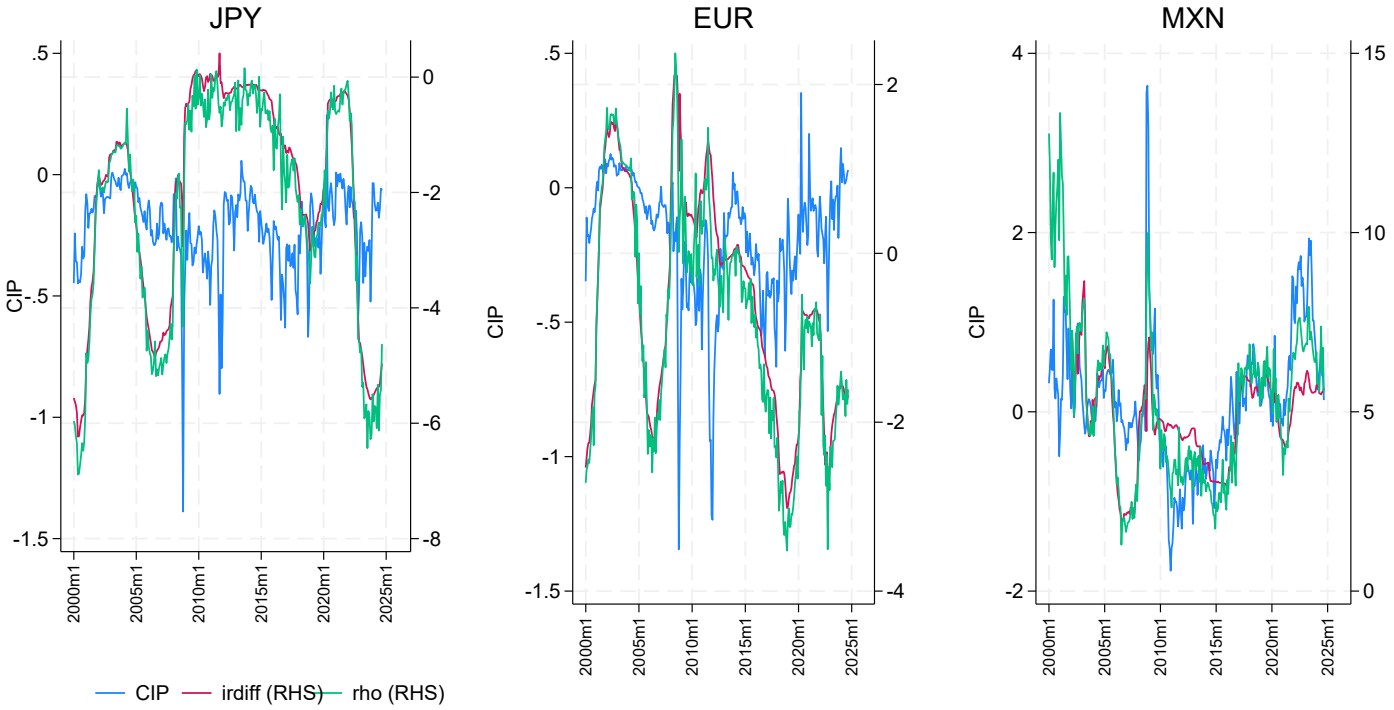


Figure A5: UIP and CIP decomposition

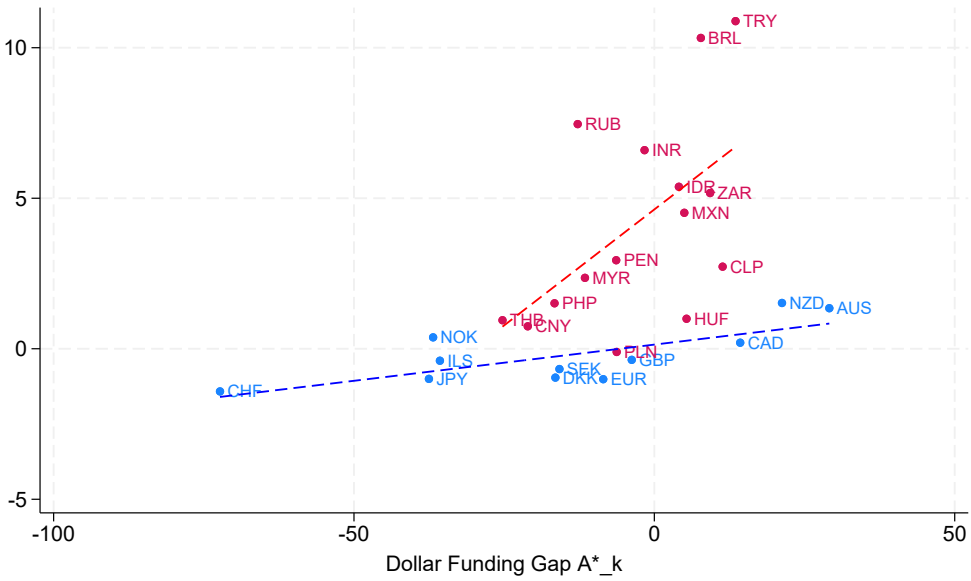



(a) UIP decomposition for JPY, EUR, MXN.



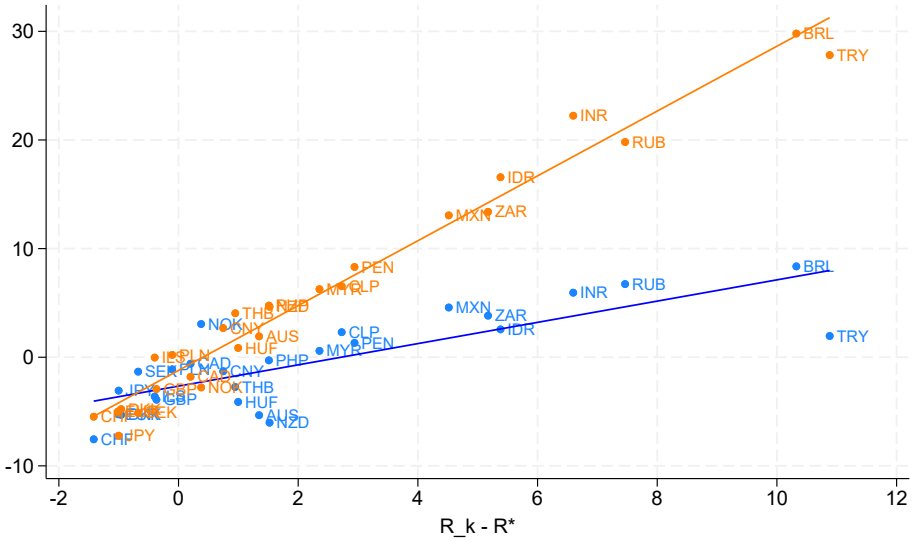

(b) CIP decomposition for JPY, EUR, MXN.

Figure A6: Cross section of average interest rate differentials (in %) against the average dollar funding gap (advanced economies and emerging markets currencies)

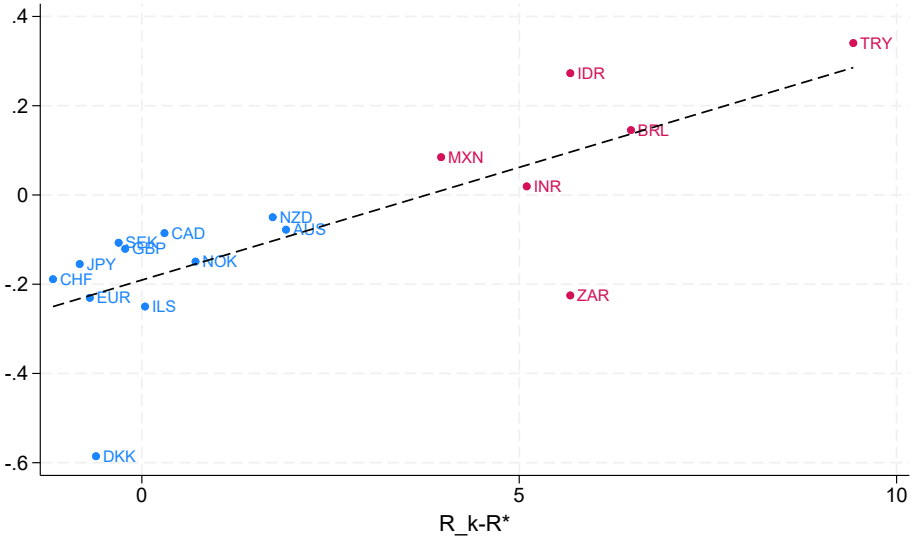



Notes: This figure generalizes Figure 3 in the main text to a broader set of advanced economies and emerging market currencies, illustrating group-specific slopes for the scatter plot of the average dollar funding gap and interest rate differential vis-à-vis the dollar (red for EM, blue for AE currencies).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

Figure A7: Cross section of the average UIP and CIP deviations (in %) against the average interest rate differential



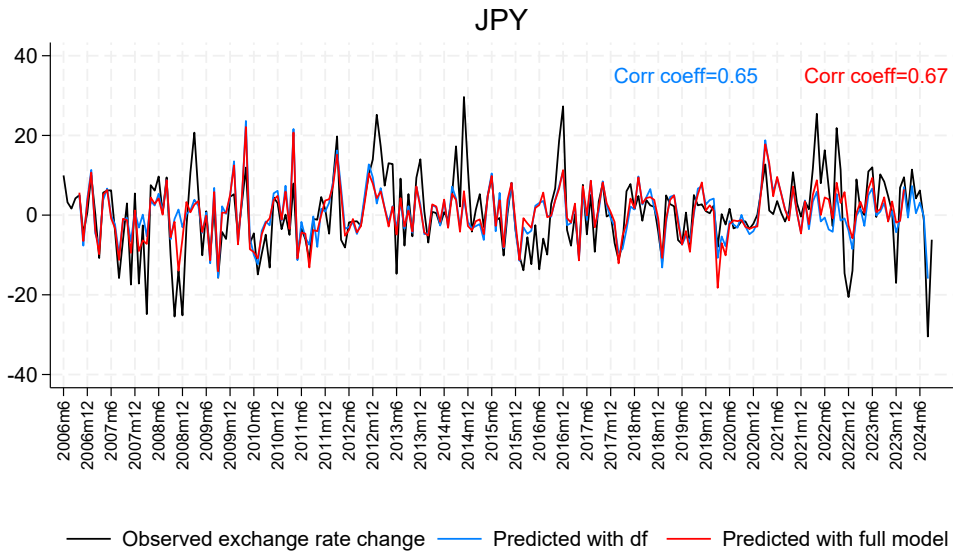

(a) Survey (blue) and realized (orange) 3-month UIP deviations against 3-month IR differential

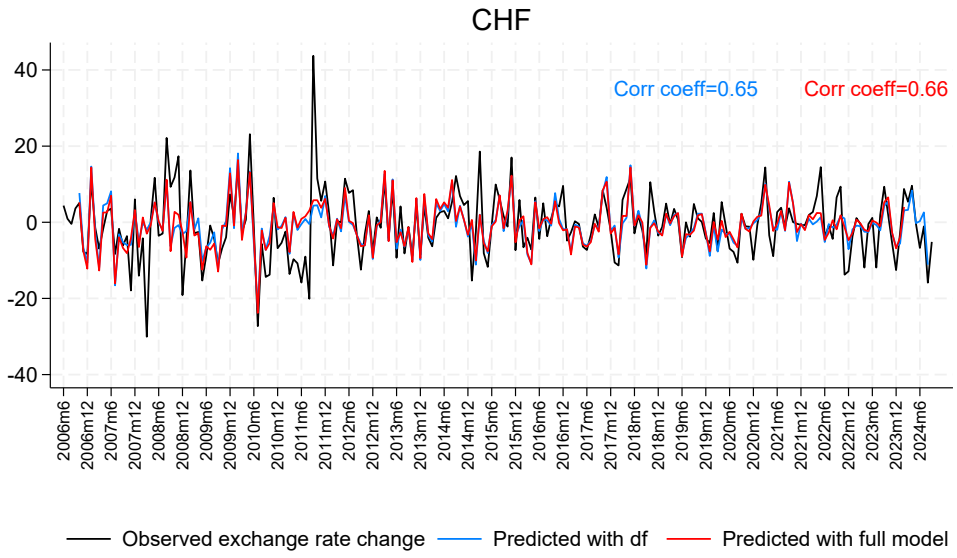



(b) 12-month CIP deviation and IR differential, purified CIP for EM currencies (red).

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 (2024). 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 A8: Realizations of $\Delta \log \mathcal{E}_{kt}$ and its fitted values for individual currencies



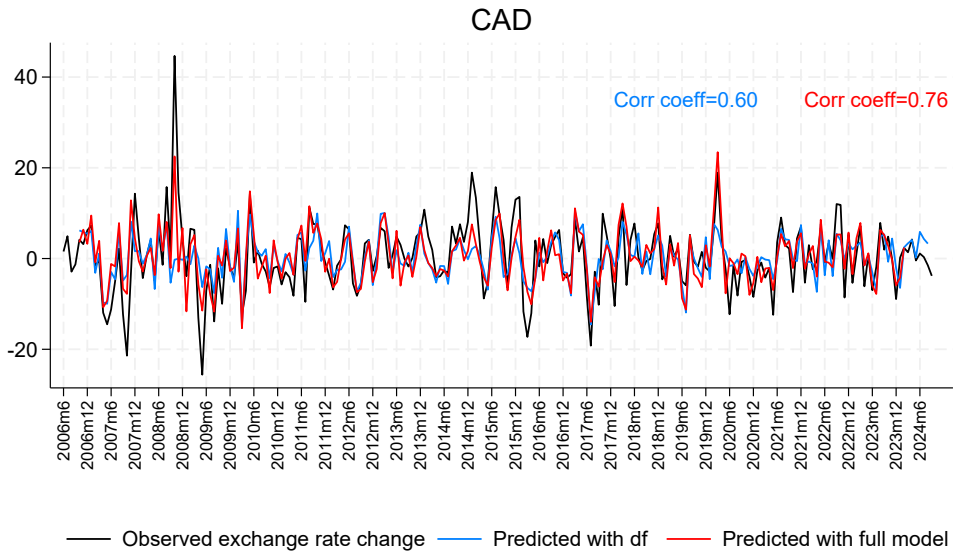
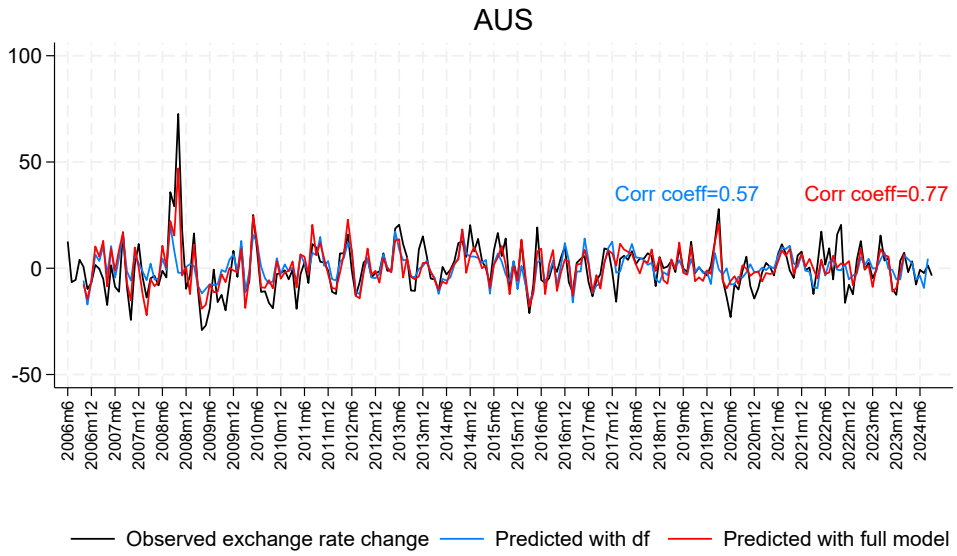
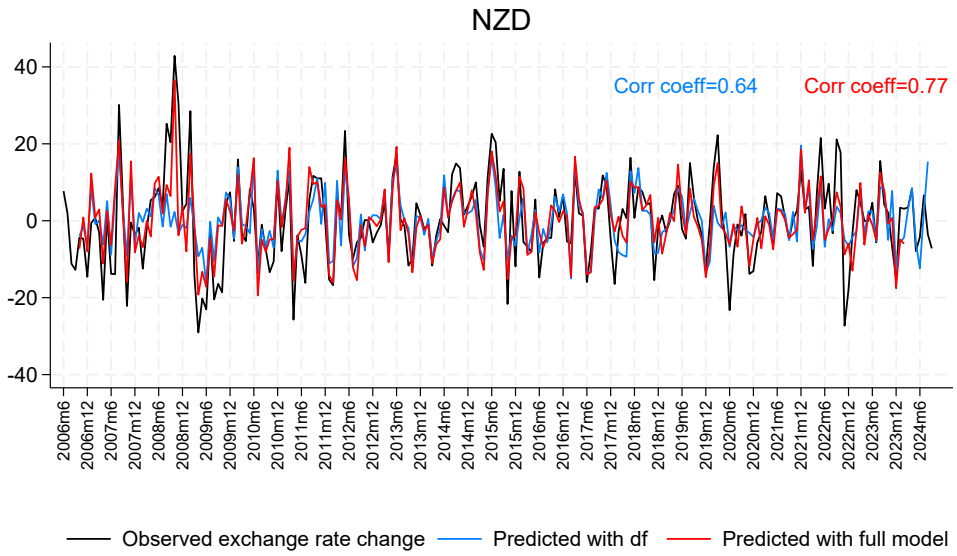



Figure A9: Realizations of $\Delta \log \mathcal{E}_{kt}$ and its fitted values for individual currencies(continued)



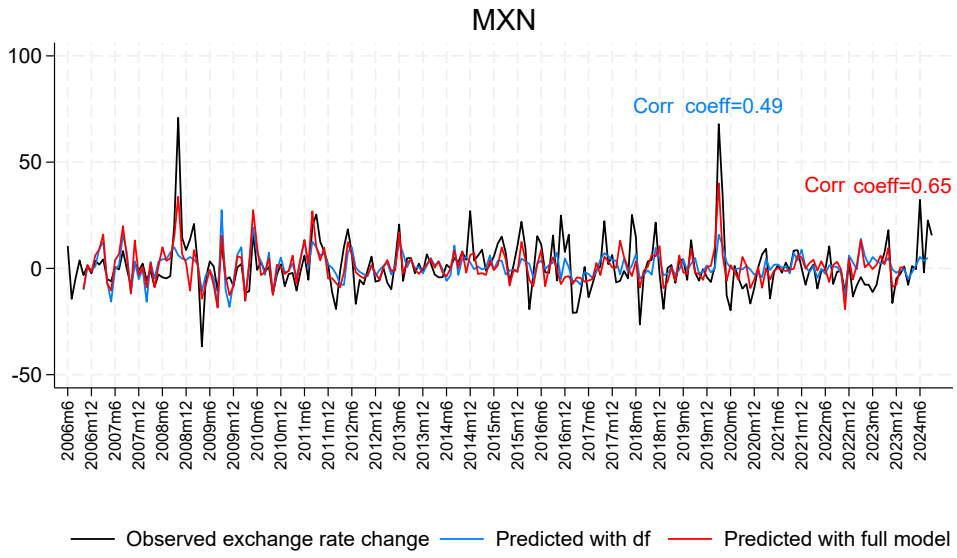



Figure A10: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies

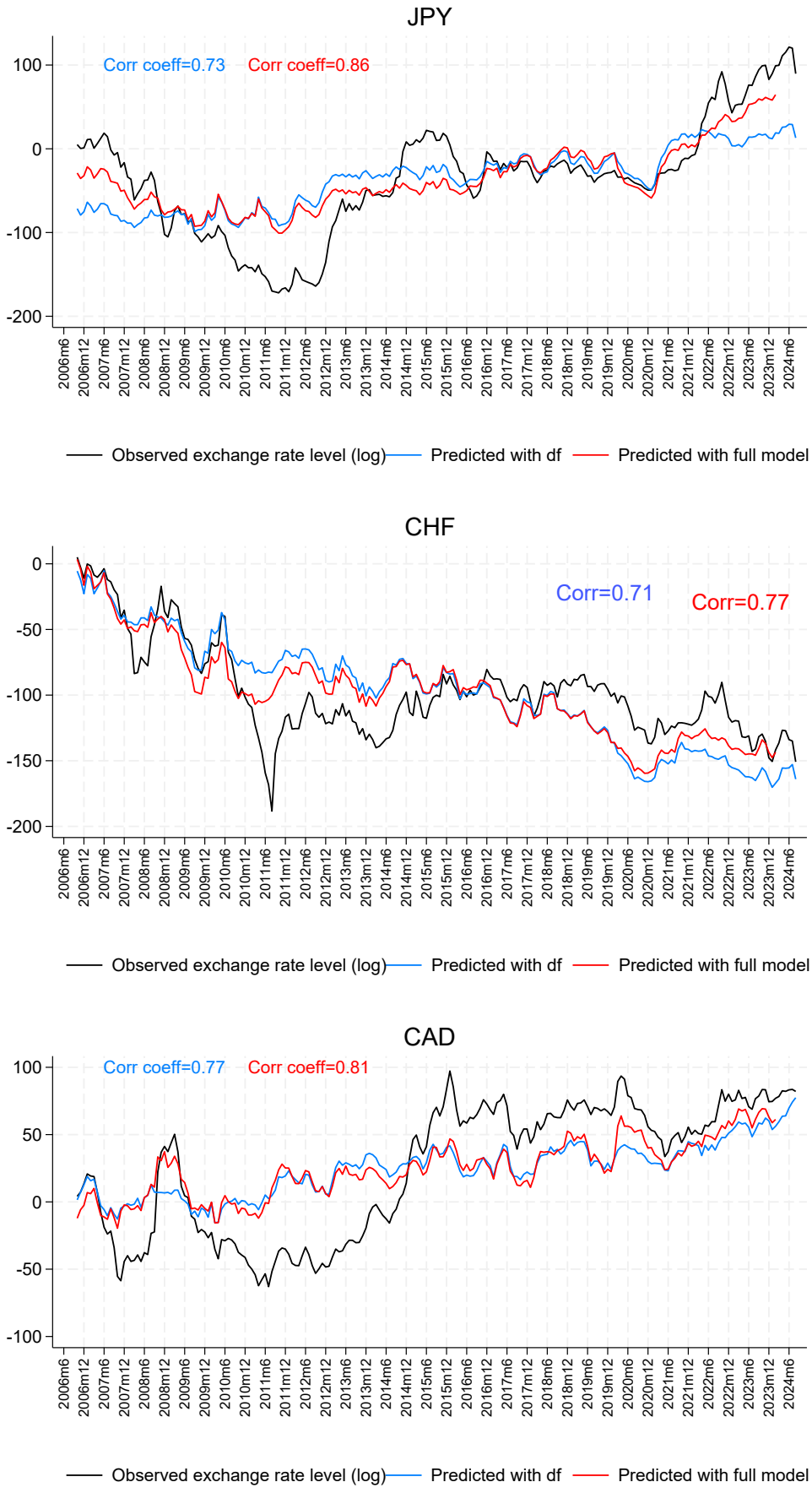
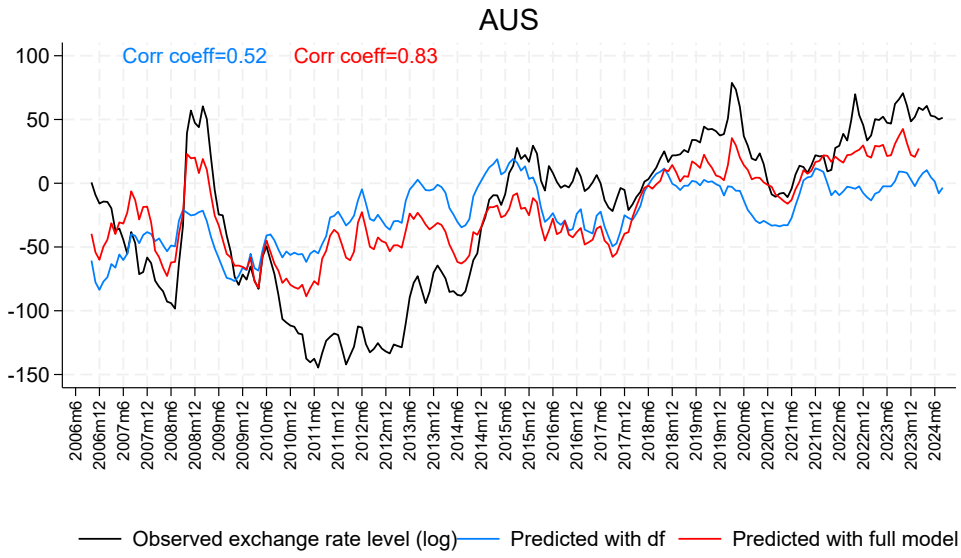
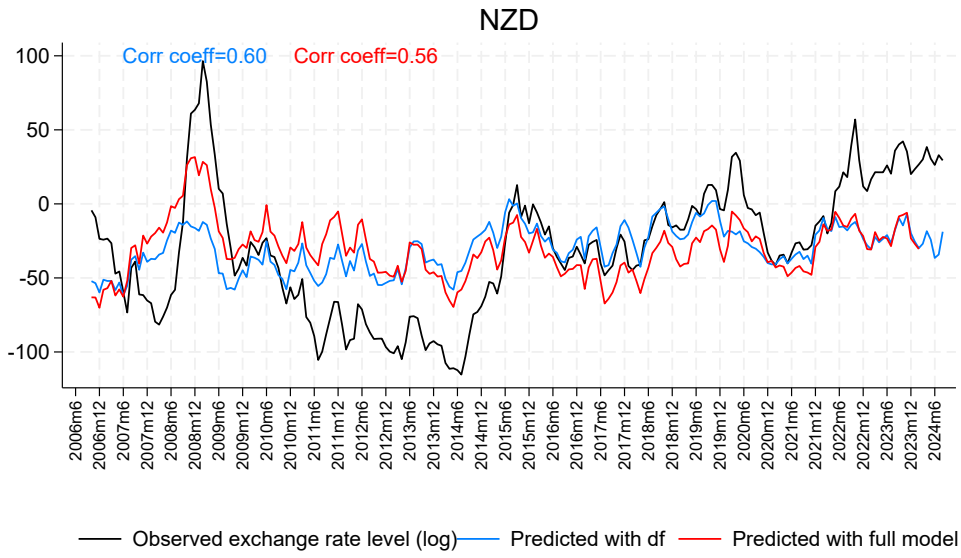
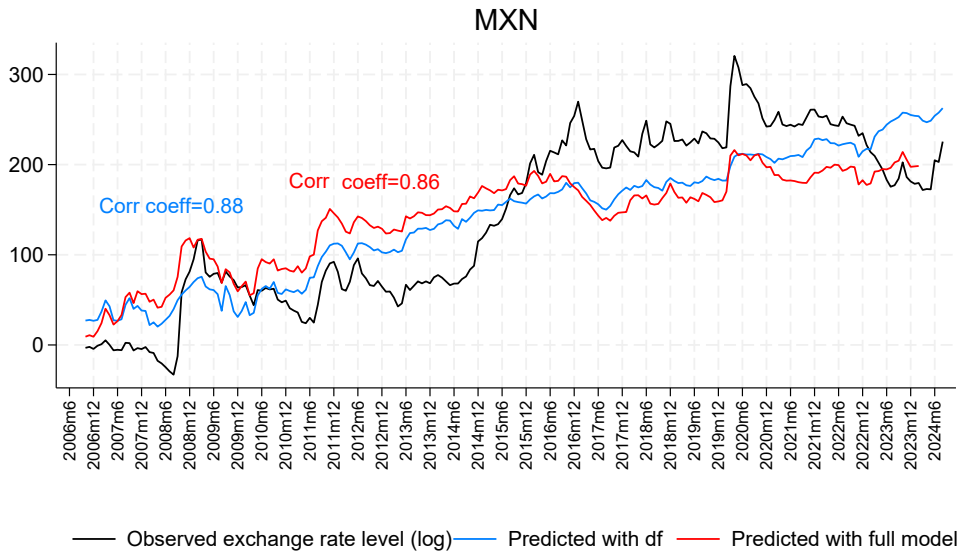


Figure A11: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies (continued)



# B Proofs

**Proof of Proposition 1** Substitute the expression for net worth evolution (3) and simplify using $\mathbb{E}_t\Theta_{t+1} = 1/R_t^*$:

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

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:

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

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 $\overline{UIP}_t = R_t^*\mathbb{E}_t\big[\Theta_{t+1}UIP_{t+1}\big]$, and result in the expressions in the proposition, given that $R_t^* = 1/\mathbb{E}_t\Theta_{t+1}$. ■

**Proof of Proposition 2** Condition (11) is the direct result of aggregation of individual bank positions $Z_{it}^* = A_{it}^* + F_{it}^*$ in the optimality condition (8) after rearranging it as $\overline{UIP}_t \cdot \frac{W_{it}^*}{\gamma_{it}} = \mu_t\sigma_t \cdot Z_{it}^*$ and imposing market clearing $\sum_i Z_{it}^* = \mathbb{Z}_t^*$ from (10). Bringing the resulting term $\sum_i W_{it}^*/\gamma_{it}$ to the right-hand side yields (11), with $\overline{UIP}_t$ defined in (9).

Condition (12) follows a similar logic with the difference that the optimality condition (8) 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 (8) 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) $\bar{\delta}_t = \min\{\delta_{it} : X^*_{it} \text{ is unconstraint}\}$. 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 constrainted 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 (12) 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 (23) and (24) in Section 3.3 and (25) in Section 3.4.

Consider first 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 dynamics projections and contemporaneous correlations are sufficient. We then estimate the following specification:

$$\Delta v_{kt} = \alpha_k + \delta_t + \beta \Delta f^*_{kt} + \gamma w_{kt} + \varepsilon_{kt}.$$

What does this regression identify? We show below that this is a reduced-form where the meaningful statistic is the $R^2$ and its decomposition into contributions from specific variables, while the value of the estimated coefficients do not have a structural meaning beyond their signs.

For concreteness, we focus on the case of the equilibrium expected UIP premium, $\overline{UIP}_{kt}$, characterized in Proposition 2 such that:

$$\overline{UIP}_{kt} = \mu_t \sigma_{kt} \Big( \sum\nolimits_{i \in \mathcal{I}^D_{kt}} W^*_{it}/\gamma_{it} \Big)^{-1} \cdot \mathbb{Z}^*_{kt},$$

where $\mathbb{Z}^*_{kt} = \sum_{i \in \mathcal{I}^D_{kt}} Z^*_{kit}$ is the aggregate currency $k$ exposure of dealer banks, $i \in \mathcal{I}^D_{kt}$, such that $\overline{UIP}_k t = \mu_t \sigma_{kt} \gamma_{it}/W^*_{it} \cdot Z^*_{kit}$ for each such bank. The goal is to estimate the following specification:

$$\Delta \overline{UIP}_{kt} = \alpha_k + \beta_k \Delta \log \mathbb{Z}^*_{kt} + \gamma_k \Delta w_{kt} + \varepsilon_{kt},$$

where $\Delta w_{kt}$ are proxies for the $\Delta \log(\mu_t \sigma_{kt}) - \Delta \log \Big( \sum_{i \in \mathcal{I}^D_{kt}} W^*_{it}/\gamma_{it} \Big)$ term.

The challenge is that the combined currency exposure of dealer banks, $\mathbb{Z}^*_{kt}$, who price the currency risk is unobservable. We, therefore, conjecture that our measure of the net futures positions of Dealers/Intermediaries, $\Delta f^*_{kt}$ defined in (21), can act as an effective proxy. We conjecture the following relationship:

$$\Delta \log \mathbb{Z}^*_{kt} = \phi_k + \eta_k \Delta f^*_{kt} + u_{kt},$$

and discuss below how it can be validated using the available data.