Breaking Parity:
Equilibrium exchange rates and currency premia*

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Abstract

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

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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 (Meese and Rogoff, 1983). From a micro perspective, exchange rates are prices that equilibrate demand and supply in currency markets (Evans and Lyons, 2002). In contrast to the weak link with aggregate macro variables, exchange rates correlate strongly with deviations from covered and uncovered interest parity (CIP and UIP) conditions, suggesting that these wedges play an important role in intermediating currency demand and supply. One should therefore be able to trace movements in 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 of the spot and forward exchange rates.

To guide our analysis, we set up a partial equilibrium model of the currency market. At the center of the model are global intermediary banks (with their affiliated broker-dealer branches) that step in to clear the currency market when there remains net demand for currency at equilibrium prices. The banks are subject to a value-at-risk-type balance-sheet constraint 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 hedged currency returns is compensated with CIP deviations. Given interest rate differentials, spot and forward exchange rates adjust to ensure the equilibrium currency premia for the banks to clear the currency market. We show that the data aligns closely with the predictions of our 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 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 the 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 forward dollars.

[1] Persistent excess supply of local-currency savings drives down the equilibrium 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: forward dollars are cheap relative to spot to compensate the suppliers of swaps and forwards for foregoing high foreign-currency interest rates. 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 expensive (relative to spot).

This is characteristic of investment, commodity and emerging market currencies (e.g., Australian and New Zealand dollars, Mexican peso, and to a lesser extent Canadian dollar).

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

In contrast, uncovered currency premia move strongly in response to currency-specific demand shocks which have no discernable effect on the CIP deviations. We capture these shocks with the change in net currency futures positions of dealer banks, reflecting the need to clear excess demand in a specific currency market.[2] This currency-specific variable explains a large portion of variation in both expected and realized UIP premia in the panel of currencies. Expected UIP premia are two orders of magnitude more variable than the corresponding CIP premia. Like CIP premia, UIP premia also respond to aggregate shocks in the broader financial markets, but these global forces only account for a small portion of the larger overall variation in UIP deviations, which are currency-specific.

We further show that currency-specific shocks do not affect the interest rate differential or the forward premium, but instead result in large and persistent swings in both spot and forward exchange rates. Changes in the currency futures positions of dealer banks account for the bulk of variation in spot exchange rates for all currencies with available data and result in long half-lives of many months, and hence predictable currency returns. Figure 1 showcases the tight relationship between realized changes in the spot pound and euro exchange rates (vis-à-vis the US dollar) and changes in the respective futures positions of dealer banks.[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 to compensate the bank-holding company. While the local-currency interest rate differential and the forward premium equilibrate the currency market in the cross-section, it is the volatile and persistent fluctuations in the spot and forward exchange rates that allow for the adjustment of currency premia necessary to equilibrate the currency market in response to shocks.

We find robustly predictable currency returns in the time series conditional on the changes in dealer positions. Specifically, investors with open currency positions before the shock experience

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

[3]Same patterns hold for other currencies, as we show in Appendix Figures A9–A10, while Appendix Figures A3 and A11–A12 show the fit for the levels of exchange rates.

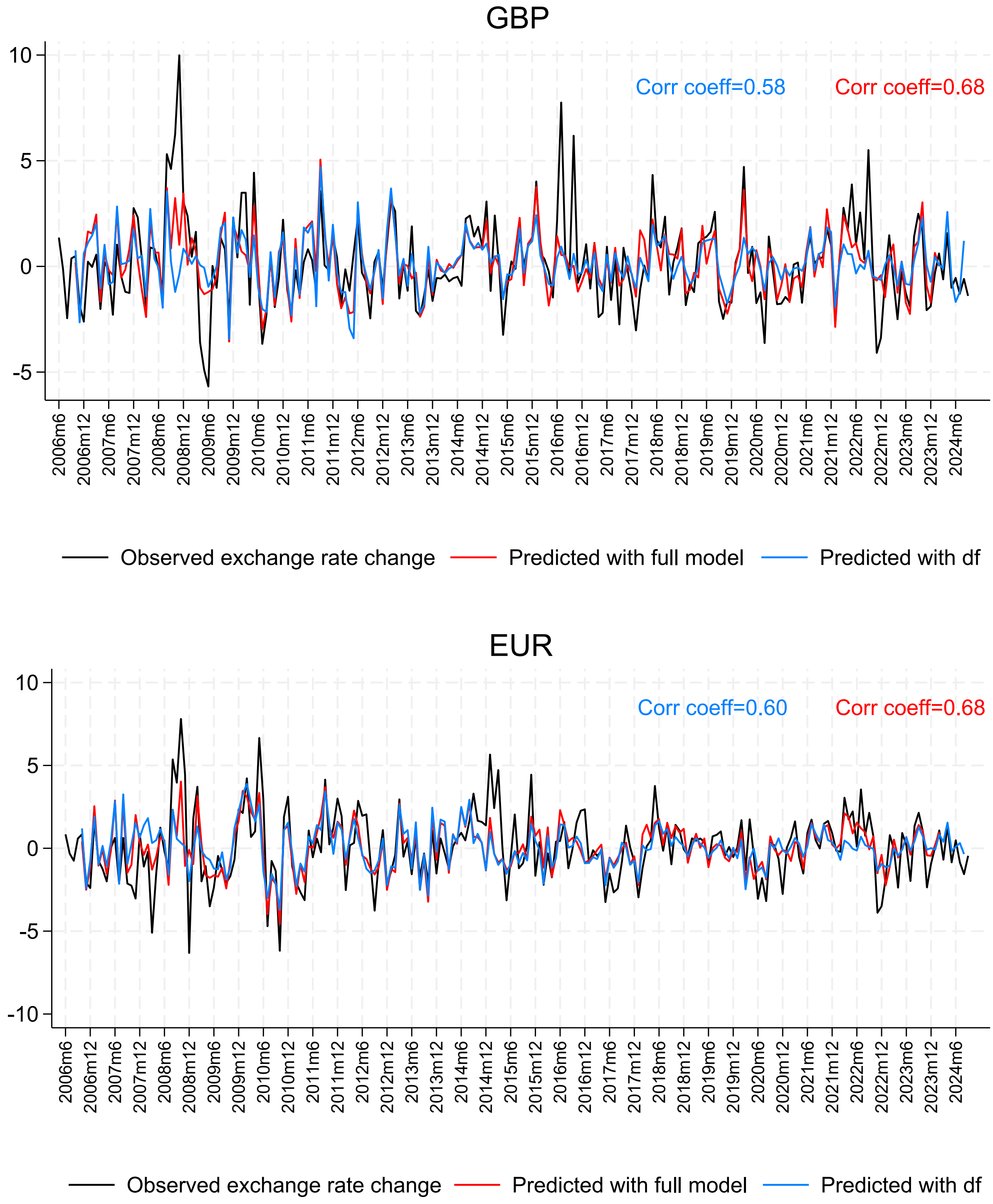

Figure 1: Realized changes in nominal exchange rates and their fitted values

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

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

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 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, 2025a).

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

Related literature Our paper follows the tradition of the pioneering study by Evans and Lyons (2002), who first established a strong connection between currency trading and exchange rates. However, instead of using order flows to infer the likely shifts in currency demand, we use the actual currency positions taken by intermediaries, as suggested by recent theoretical literature on frictional intermediation (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021, 2025a). We differ from the related literature that focuses on identifying exogenous shifts in demand for (and supply of) currencies, including Camanho, Hau, and Rey (2022), Beltran and He (2023), Barbiero, Bräuning, Joaquim, and Stein (2024), in that our goal is not to identify an exogenous currency demand shock, but rather to capture in a reduced-form way the bulk of the variation in currency premia and exchange rates, which we accomplish by exploiting the remarkable explanatory power of dealer banks' net FX futures position data. This approach also sets our work apart from the growing literature on estimating structural currency and asset demand following Koijen and Yogo (2020).

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

We also build on the growing empirical literature documenting interest rate parity deviations. Deviations from UIP have been extensively studied for decades by the theoretical and empirical literature following Fama (1984), including Lustig and Verdelhan (2011), Hassan and Mano (2018), Kalemli-Özcan and Varela (2021), and surveyed in Engel (2014). Unlike UIP, the covered interest parity largely held for G10 currencies up until the Global Financial Crisis (GFC). Since then, the deviation from CIP became sizable and persistent across all G10 currencies versus the dollar, as review by Du and Schreger (2022a). The leading explanation for CIP deviations centers around the post-GFC tightening of bank regulation which constrains the expansion of intermediaries' balance sheets (Du, Tepper, and Verdelhan, 2018) and divergent dollar funding costs of international banks (Rime, Schrimpf, and Syrstad, 2022). More generally, factors driving demand for dollar funding and hedging interact with these supply-side intermediation frictions in determining the CIP premium (Ivashina, Scharfstein, and Stein, 2015; Liao and Zhang, 2025).

The vast majority of the literature has studied either the deviation from UIP or CIP in isolation, while our conceptual framework offers an understanding of their joint determination and the resulting implications for exchange rate dynamics. A paper which also studies both wedges is Greenwood, Hanson, Stein, and Sunderam (2020), who highlight shocks to currency-specific long-term bond supply as a source for correlated UIP and CIP deviations. De Leo, Keller, and Zou (2024) show how carry trade inflows into emerging markets subject to capital controls can also cause a co-movement between UIP and CIP deviation. There is growing evidence that determinants of these wedges correlate with the exchange rate, while the underlying shocks may differ from preferences for asset convenience to any shock that shifts currency demand requiring frictional intermediation. The shared testable implication of many such theories is that variables affecting intermediaries' balance sheet should, in turn, affect equilibrium parity wedges and hence the exchange rate. Therefore, instead of committing to a particular source of shocks to these parity wedges, we offer a general framework

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

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

that describes their joint determination under a general type of shock, and one that is consistent with statistical properties of these wedges across a broad set of currencies.

2 Model of Currency Intermediation

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

2.1 Global 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 given 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 assume 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 combines together reserves and risky assets, leaving 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, with e.g. $A^*_t < 0$ corresponding to a net LC liability.[6]

[6] 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 $Y^*_t := B^*_t + H^*_t + \big[A^*_t\big]^+ + \big[-D^*_t\big]^+$ with $\big[x\big]^+ \equiv \max\{x, 0\} > 0$.

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 \$	$D_t^* \,:\, R_t^*$
$A_t^* \quad : R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}$	€ investment (\$ value)		
Off balance sheet (zero-wealth positions)			
$F_t^* \;:\; \frac{R_t\mathcal{E}_t}{\mathcal{F}_t}\big(\frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1\big)$	currency forward		
$S_t^* \;:\; R_t^* - R_t\frac{\mathcal{E}_t}{\mathcal{S}_t}$	currency swap		

In addition to the on-balance-sheet operations, the bank sells currency forwards and futures F_t^*, and we refer to the combined position as just forwards for brevity. 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 dollars forwards, i.e. sells LC forwards. 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, given by $\Big(\frac{R_t\mathcal{E}_t}{\mathcal{E}_{t+1}} - \frac{R_t\mathcal{E}_t}{\mathcal{F}_t}\Big) F_t^* = \Big(\frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1\Big)\frac{R_t\mathcal{E}_t}{\mathcal{F}_t}F_t^*$. 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^*.[7]

Finally, the bank also sells dollar swaps. Per unit of a swap position S_t^*, the financial payout at $t+1$ is R_t^* dollars in exchange for $R_t\mathcal{E}_t$ units of local currency converted to dollars at the swap exchange rate $\mathcal{S}_t$. That is, the total payout on the off-balance sheet swap position S_t^* is $\big(R_t^* - R_t\frac{\mathcal{E}_t}{\mathcal{S}_t}\big)S_t^*$. 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.[8] 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 result in no additional currency risk exposure since all payoffs are pre-determined in dollars.[9] Appendix Figure A1 illustrates cash

[7]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.

[8]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.

[9]Given our definition of the size of the balance sheet Y_t in (2), swaps do not affect it either. More generally, with the definition of Y_t in footnote 6, swaps change simultaneously both assets and liabilities, A_t^* and D_t^*.

flows for both on-balance-sheet and off-balance-sheet asset holdings.

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

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

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. 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.[10]

[10]Conventional wisdom suggests that banks do not carry signficant exposure to foreign exchange risk, due to prudential regulation and internal risk management, though actual data on this has been scant. Research using newly available supervisory data has started to provide visibility into the opaque off-balance-sheet derivative exposure, showing that combining all spot and derivative positions at the bank-holding level, large entities in the US and Europe still have substantial unhedged FX positions Z^*_t (see Moskowitz, Ross, Ross, and Vasudevan, 2024; Abbassi and Bräuning, 2021).

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 Θ_{t+1} has the property that $\mathbb{E}_t\Theta_{t+1} = 1/R^*_t$, and it may arise from the discount factor of the representative household or the owner of the bank. Note that a non-stochastic discount factor, $\Theta_{t+1} \equiv 1/R^*_t$ is admissible, and it corresponds to a risk-neutral bank.

The balance sheet constraint, in turn, requires the bank to set aside dollar reserves B^*_t that generally earn a lower return $\underline{R}^*_t < R^*_t$, and increasingly more reserves with various exposures of the bank — namely, the size of its balance sheet 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 $\sigma^2_t \equiv R^2_t \cdot \text{var}_t\big(\mathcal{E}_t/\mathcal{E}_{t+1}\big)$ 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 to H^*_t/W^*_t and $\sigma_t|Z^*_t|/W^*_t$, respectively, where σ_t is the standard deviation of the carry return (realized UIP premium). Correspondingly, α and γ reflect the risk weights of the bank's positions.

The reserve requirement associated with the non-stochastic off-balance-sheet exposure X^*_t is different. The risk associated with such position is not in the volatility of returns, but in the counterparty risk, and thus does not scale up with the size of the position (assuming 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.[11] 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 μ_t/R^*_t the Lagrange multi-

[11] 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.

plier 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):

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:*

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

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

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

In contrast, risky exposures 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 σ_t^2 is associated with an effect 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 $(Z_t^*)^2$.[12]

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

[12] A similar argument applies 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.

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 creates an off-balance-sheet exposure similar to that of a swap position S_t^*, and both must be compensated on the margin by the CIP premium CIP_t. Thus, an F_t^* position of the bank is compensated in expectation with both premia:

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

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, $\mathcal{S}_t = \mathcal{F}_t$, 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.[13]

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 δ_{it} for the marginal bank supplying forwards and swaps.[14] 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

[13]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).

[14]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. See Appendix B.

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. 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 banks (8) results in the following equilibrium characterization (see Appendix B):

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 γ_{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 spot and forward exposure $\mathbb{Z}^*_t = \mathbb{A}^*_t + \mathbb{F}^*_t$ 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.[15] Finally, the UIP and CIP depend on the distribution of the banks' balance sheet constraint parameters $\{\gamma_{it}, \delta_{it}\}$ summarized by $(\bar{\gamma}_t, \bar{\delta}_t)$, with a shift upward (first order stochastic dominance) in these distributions increasing the equilibrium premia.

The main difference between UIP and CIP premia is that the UIP premium increases monotonically in the size of the aggregate demand for currency spot and forwad exposure relative to the aggregate net worth of the dealer banks, $\mathbb{Z}^*_t/\mathbb{W}^*_t$, while the size of the CIP deviation depends only on the aggregate financial conditions $\bar{\delta}_t \mu_t$ and the *direction* of the forward and swap demand $\mathbb{X}^*_t$. This is a stark testable implication, illustrated in Figure 2, that we bring to the data.[16] 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

[15]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.

[16]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 δ_{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.

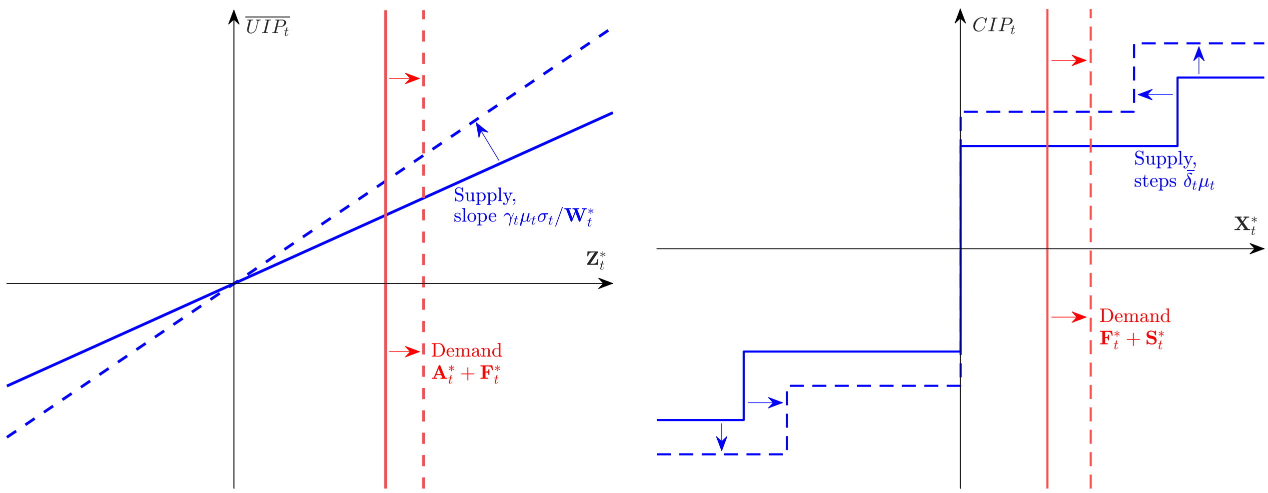

Figure 2: Currency market equilibrium: currency risk and currency swaps

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.

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.[17]

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 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 banks that move along their supply curves (8). Note that the role of intermediaries can be played by any agent in the economy to the extent their currency positions respond to UIP and CIP premia.[18] 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.

[17] 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).

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

2.3 Testable implications

We now make use of Proposition 2 to summarize the empirical implications of our theory for the long run and the short run — that is, for the cross section of currency premia and for the dynamic response of currency premia and exchange rates to shocks. We bring back the currency index k and rewrite the currency supply schedules in (11) and (12) as:

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

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

where the tightness of the balance-sheet constraint μ_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 ("risky" and "hedged") exposure to currency k that are intermediated by 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.[19]

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

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

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 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 with these swap positions. Similarly, investing in the high interest rate currency creates demand to sell dollars forward ($\mathbb{F}^*_{kt} < 0$) 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. Recent papers that analyze comprehensive supervisory data for FX derivatives holdings by global banks largely validate these assumptions.[20]

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

The local-currency funding gap similarly determines the off-balance sheet exposure $\mathbb{X}^*_{kt} = \mathbb{F}^*_{kt} + \mathbb{S}^*_{kt}$, which by Assumption 3 is also positive for countries with scarce local-currency funding ($\mathbb{A}^*_{kt} >$

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

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 intermediary banks with an appropriate CIP premium for their swap positions to give up the high local-currency rate of return.[21]

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:[22]

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

   provided that the change in $\mathrm{d}f_{kt}^*$ is small enough not 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 intermediary banks with tighter constraints.

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

[21] 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.

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

μ_t on the UIP premium is increasing in $\mathbb{A}^*_{kt}$, offering another testable implication which we write as follows:

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

The same comparative dynamics as in (18) applies to shocks to $\bar{\gamma}_{kt}/\mathbb{W}^*_{kt}$ for UIP premia and to shocks to $\bar{\delta}_{kt}$ for CIP premia, both proxying for shocks to supply of currency intermediation.[23]

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 Δf^*_{kt}, as well as on proxies for changes in μ_t and $(\bar{\gamma}_t, \bar{\delta}_t, \mathbb{W}^*_t)$ interacted with the currency k slow-moving local-currency funding gap $\mathbb{A}^*_{kt}$. 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.

3 Empirical Results

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

3.1 Data

UIP and CIP premia Our sample consists of currencies for which we have empirical proxies for changes in intermediaries' net forward position. These are the G7+ advanced economies and 4 emerging market currencies.[24] To construct UIP and CIP premia with respect to the US dollar at monthly frequency for our sample currencies, we choose the horizon to be 3 months, which is the maturity with the most liquid forward markets and over which professional survey exchange rate forecasts are readily available. We follow the literature (Kalemli-Özcan and Varela, 2021) and use the monthly 3-month ahead exchange rate forecasts from Consensus Forecast surveys (Consensus Economics). For the interest rate component of the parities we also follow the literature and use 3-month money market interest rates or interbank deposit rates, depending on availability. Spot and forward exchange rates are taken as monthly averages of daily values. Further details on underlying data series and their descriptions are reported in Appendix Table A1.

[23] 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.

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

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

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

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.[25] Thus, the final term in each equation in (20) measures a depreciation rate — forward, realized, and forecasted, respectively — 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.[26]

Appendix Figures A4 plots the UIP and CIP premia for G7+ currencies and MXN (as a typical EM for which we have the best data). Several stylized facts stand out: the UIP premium is 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 A6 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. Such *sell-side* entities on FX futures markets are primarily represented by broker-dealer arms of major global banks such as Goldman Sachs, JP Morgan, Deutche Bank, etc.[27]

[25] 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.

[26] 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).

[27] See full list here: https://www.cmegroup.com/markets/fx/fx-futures-and-options-block-and-efrp-providers.html.

The TFF complements and disaggregates the more well-known *Commitment of Traders Report* (COT) from the CFTC, which splits reportable futures positions instead according to two main trading motives: commercial (hedging) and non-commercial (speculative) traders. This breakdown is inherently uncertain, as a given trader can take position in the futures market for either hedging, speculating or market making on different occasions and across different organizational units within a firm. Instead, the TFF data that we use only relies on the position breakdown by trader type, irrespective of their trading motive.[28]

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.[29]

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 Δf^*_{kt} comes from the net position in the numerator.

A positive value for f^*_{kt} means that dealer banks are long in the FX currency future and short the US dollar future, accommodating the opposite position of the market (composed, in turn, primarily of asset managers/institutional investors and hedge funds). Appendix Figure A5 plots the dealer net futures position by 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 substantial currency-specific variation in net futures positions.

[28] 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; Stavrakeva and Tang, 2020). To the best of our knowledge, we are the first ones to use the TFF data split.

[29] 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).

Appendix Table A2 reports some summary statistics for the monthly change in dealer's net futures position, Δf^*_{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.[30] 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 show that under reasonable assumptions, the change in the "Dealer/Intermediary" net position in a currency's futures, Δf^*_{kt}, contains an important signal for the overall demand shift for that currency in the wider FX derivative and spot markets, which is ultimately intermediated by consolidated global banks. This is because the affiliated dealer banks pass on their excess net exposure to their parent banks to maintain a hedged balance sheet as required by regulation (see Appendix Figure A2). In other words, even though the aggregate currency exposure of intermediaries, $\mathbb{Z}^*_{kt}$ and $\mathbb{F}^*_{kt}$, may both 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.[31] Under these assumptions, the resulting unobserved "first-stage" regression:

$$\Delta \mathbb{Z}^*_{kt} = \alpha_k + \eta_k \Delta f^*_{kt} + u_{kt}, \tag{22}$$

must feature $\eta_k > 0$ and a large R^2, which is a necessary condition for a significant explanatory power in the implementable "reduced-form" specifications that regress changes in currency premia on Δf^*_{kt}. The same applies for the off-balance sheet exposure $\Delta \mathbb{X}^*_{kt}$, as we detail in Appendix C.

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 μ_t, the net worth of dealer banks $\mathbb{W}^*_t$, the expected exchange rate volatility σ^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,

[30]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).

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

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 μ_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.[32] The Japanese yen and Swiss franc, as well as the Euro, feature lower average interest rates relative to the dollar, while other currencies have a higher average interest rate. 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.

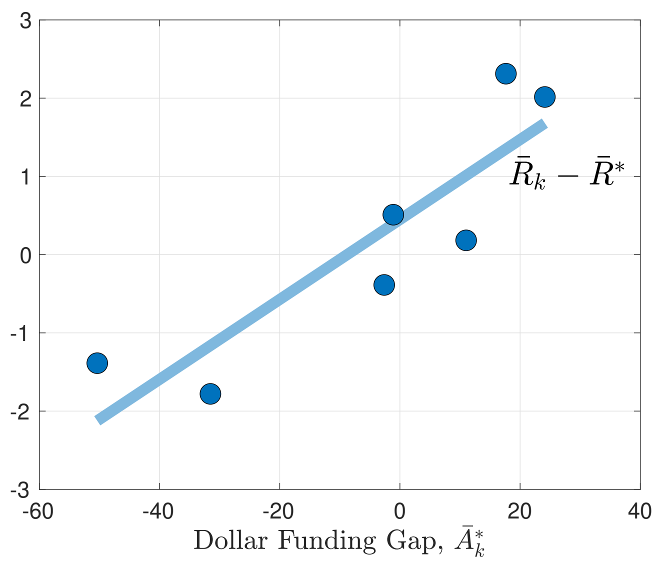

Figure 3: Cross section of average interest rate differentials against the dollar funding gap

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.

Recall from Section 2.3 the average 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

[32] 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.

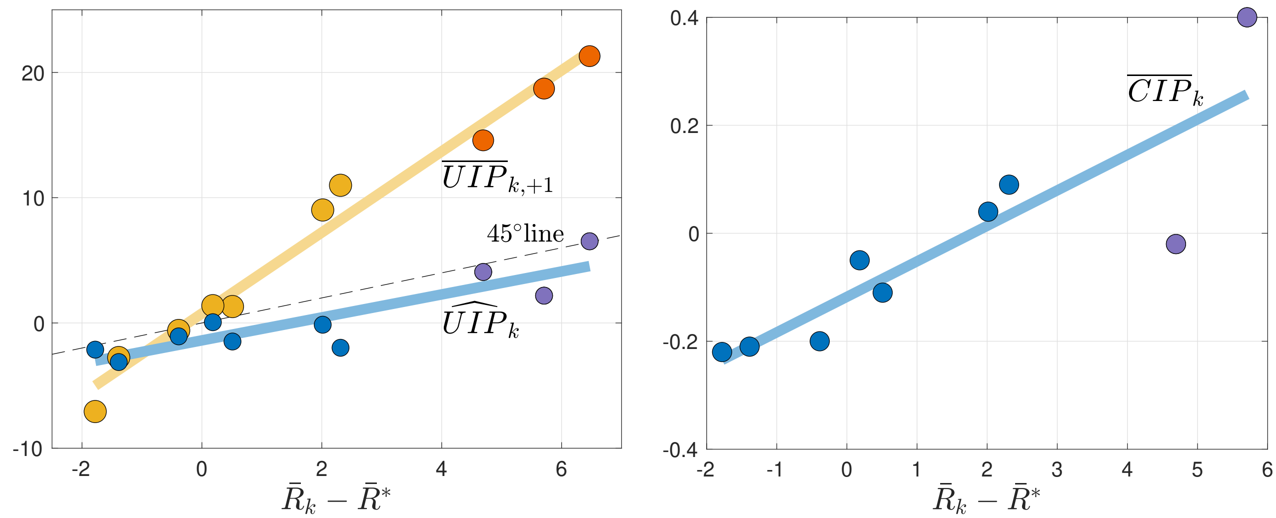

Figure 4: Cross section of the average UIP and CIP deviations against the interest rate differential

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 A8).

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 and external dollar-debt liabilities in percent of domestic GDP of a country.[33] 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 local-currency funding gap $\bar{\mathbb{A}}_k^*$ and the average interest rate differential $\bar{R}_k - \bar{R}^*$. Currencies with a large funding gap feature high local-currency interest rates, and vice versa. We illustrate this pattern in Figure 3 for G7+ currencies.[34]

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

[33]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.

[34]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, 2022b).

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 for local-currency interest rates and exchange rate surveys).

Figure 4, both for OECD currencies and for select EM currencies.[35]

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

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

0.2%, annualized, or less) and have a standard deviation over time of about the same magnitude (20 basis points). Note that the standard deviation can be considerably larger for EM currencies, and the conventional CIP deviations are measured less reliably for these currencies (see Dao and Gourinchas, 2025). Nonetheless, there is still a strong positive association between average CIP 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.[36] For funding currencies this means selling

[36]Hedging of FX risk is in many instances required by regulation or internal risk management, especially for banks

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. 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.[37]

3.3 Dynamics of currency premia

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

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

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

where α_k and δ_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, as defined in (20). In some specifications, we drop time fixed effects δ_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.

Specification (23) emerges as the empirical reduced-form counterpart to the equilibrium UIP and CIP conditions (13) and (14). The underlying assumption is that Δf^*_{kt} is an effective proxy for changes in the overall unhedged and hedged currency exposure, $\Delta\mathbb{Z}^*_{kt}$ and $\Delta\mathbb{X}^*_{kt}$, of the intermediary banks, as described above in equation (22). We detail the identification strategy behind the estimating equation (23) in Appendix C.

and institutional investors (see Du and Huber, 2024).

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

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, Δf^*_{kt}, defined in equation (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:

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

with $|t|$-stats reported in brackets, and with the standard deviation of innovation equal to 15.6.[38] We depict the impulse response of f^*_{kt} to its standardized innovation in the first panel of Figure 8 below, which shows a considerable amount of persistence with eventual mean reversion and a half-life of 6 months. The stationarity of f^*_{kt} is implied by the times-series process in (24), but would otherwise be hard to establish at conventional levels of statistical confidence, as we further discuss below.

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 when dealer banks expand or contract 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 Δf^*_{kt} to absorb the shifts in currency demand. As we show in Appendix C, the R^2 in specification (23) is the right metric to assess how closely we approximate aggregate currency demand shocks with the shifts in the dealer banks' net futures positions.

As discussed above, we interpret the variation in f^*_{kt} as capturing shifts in currency demand k, with an increase in f^*_{kt} reflecting a demand to buy dollars and sell currency k forward, i.e. an increase in $\mathbb{F}^*_{kt}$ that forms part of both unhedged and hedged currency demand, $\mathbb{Z}^*_{kt}$ and $\mathbb{X}^*_{kt}$ in (13)–(14). This requires a greater supply of currency by intermediary banks that charge the respective currency premia, according to Proposition 2. The aggregate component of Δf^*_{kt} common across many currencies may proxy for a general shift in the financial market, and therefore we control for broad financial market conditions to isolate the variation in Δf^*_{kt} that is specific to demand shifts for currency k.

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.

[38] Some of the variation in Δf^*_{kt} is absorbed into time fixed effects, reflecting correlated multi-currency shocks. The time-series process for Δf^*_{kt} without absorbing time fixed effects is virtually the same, but with a larger standard deviation of innovation equal to 19.1. We check that additional lags in (24) are insignificant.

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

Dep. var Δv_{kt} :	$\Delta\widehat{UIP}_{kt}$		$\Delta UIP_{kt,t+3}$		ΔCIP_{kt}	
	(1)	(2)	(3)	(4)	(5)	(6)
Δf^*_{kt}	0.203^{***}	0.171^{***}	0.226^{***}	0.189^{***}	-0.0000	-0.0000
	[16.61]	[15.35]	[12.15]	[11.83]	[0.01]	[0.06]
$\Delta f^*_{k,t-1}$	-0.059^{***}	-0.053^{***}	0.000	-0.002	-0.0004	0.0002
	[5.03]	[5.31]	[0.02]	[0.13]	[1.57]	[1.07]
ΔCIP_{kt}	-6.753^{***}	0.491	-11.660^{***}	-2.432		
	[3.33]	[0.15]	[3.19]	[0.95]		
$\Delta\widehat{UIP}_{kt}$					-0.0018^{**}	0.0002
					[2.82]	[0.19]
$v_{k,t-1}$	-0.462^{***}	-0.499^{***}	-0.144^{***}	-0.193^{***}	-0.264^{***}	-0.272^{***}
	[10.57]	[9.26]	[5.48]	[7.11]	[8.01]	[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 Δf^*_{kt}. These results are consistent with Proposition 2. 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 Δf^*_{kt} (equal to 15.6) is associated with a nearly 300 basis point increase in both UIP premia (or 400 basis points if time fixed effects are not absorbed). Interestingly, the expected survey UIP provides a very accurate prediction for the realized UIP deviation in projection on the dealer positions shock, and for this reason in what follows we focus on the survey-based measure of the UIP premium.

The explained variation of survey UIP premium is $R^2 = 0.466$ before including time fixed effects and increases to $R^2 = 0.705$ after including time fixed effects. In contrast, most variation in CIP premia in the panel of currencies is absorbed by time fixed effects. While UIP premia are two orders of magnitude more volatile (recall standard deviations in Table 2), the CIP premia exhibit more persistence and are driven by aggregate (rather than currency-specific) shocks. This is again in line with Proposition 2, which suggests that changes in CIP should come not from idiosyncratic currency flows, but from broader financial conditions captured by $(\bar{\gamma}_k\mu_t, \bar{\delta}_k\mu_t)$. Indeed, most of the CIP_{kt} variation in the panel is captured by common shocks across all currencies.

Table 3 also reveals that, despite the lack of CIP response to dealer positions, there is a negative comovement between UIP and CIP premia at monthly frequency.[39] Note that this contrasts with the positive comovement between the two premia apparent in the cross-section of currencies in Table 2 and Figure 4. Recall from the definitions in (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.[40] 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 Δf^*_{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 Δf^*_{kt} (or, more precisely, declines by less than 1 basis point in response to a one standard deviation increase in Δf^*_{kt}). In contrast, both spot and forward exchange rates depreciate very strongly with an increase in Δf^*_{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.

[39]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.

[40]The slight difference of the specifications is the exclusion of ΔCIP_{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) ΔCIP_{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) $\Delta\log(R_{kt}/R^*_t)$
Δf^*_{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 ΔCIP_{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 summarize, much of the movement in UIP premium comes from the on-impact change in the spot exchange rate, and not from the interest rate. This is in contrast with the cross-sectional pattern documented in Table 2 and Figure 4) where the survey UIP premium reflects the interest rate differential nearly one-to-one (*cf.* Hassan and Mano, 2018). Furthermore, the absence of the dynamic response of the CIP premium is not due to a lack of the exchange rate adjustment, but instead due to synchronized spot and forward depreciations that fully offset each other keeping CIP premium stable (and generally non-zero, as described in Table 2).

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

We make the following observations about the response of UIP and CIP premia in panels A and B of Table 5, respectively. First, the effects of dealers' position Δf^*_{kt} on expected UIP premia are remarkably consistent across currencies, including EM currencies. The t-stats on Δf^*_{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.

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 $\Delta\widehat{UIP}_{kt}$								
Δf^*_{kt}	0.191***	0.113***	0.252***	0.153***	0.107***	0.162***	0.166***	0.075***
	[8.07]	[5.05]	[5.33]	[6.49]	[6.71]	[5.46]	[8.19]	[3.55]
$\Delta \log \text{VIX}_t$	−0.103***	−0.068**	−0.017	0.048**	0.079***	0.154***	0.117***	0.089***
	[3.21]	[2.06]	[1.19]	[2.17]	[6.41]	[5.32]	[6.19]	[2.77]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	1.506***	1.827***	2.119***	1.446**	1.804***	1.410**	1.687***	1.917***
	[4.04]	[4.84]	[9.71]	[3.99]	[5.84]	[3.51]	[3.74]	[4.02]
Panel B: Dependent variable ΔCIP_{kt}								
Δf^*_{kt}	−0.0004	0.0004	−0.0006	0.0003	0.0008	0.0000	0.0001	−0.0011
	[0.93]	[0.86]	[0.67]	[0.74]	[1.59]	[0.14]	[0.25]	[0.59]
$\Delta \log \text{VIX}_t$	−0.0015***	−0.0014*	−0.0012**	−0.0004	0.0001	0.0006	0.0009*	0.0005
	[2.79]	[1.95]	[2.23]	[1.00]	[0.32]	[0.81]	[1.86]	[0.27]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	−0.0228**	−0.0158	−0.0250**	−0.0192**	−0.0199***	−0.0240***	0.0002	0.0735*
	[2.16]	[1.31]	[2.26]	[2.00]	[3.71]	[4.02]	[0.02]	[1.82]
Observations	216	216	216	216	216	216	216	216
R^2 for $\Delta\widehat{UIP}_{kt}$	0.560	0.539	0.623	0.570	0.671	0.629	0.568	0.529
R^2 for ΔCIP_{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 Δf^*_{kt} and the lagged level of the dependent variable, as well as controls for either ΔCIP_{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.

In stark contrast, the variation in the dealers' futures positions, Δf^*_{kt}, is robustly irrelevant for the variation of CIP premia, with rather precisely estimated coefficients of zero for every currency.[41] However, VIX and, especially, the broad dollar co-move significantly with CIP premia for most currencies. Still, these variables, together with the lagged level of the CIP premium, explain only about 20% of the variation in currency-specific CIP premia (contrast with the high R^2 in Table 3 in the panel with time fixed).

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

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

[41] At higher frequency, using weekly data, we find some statistically significant association between dealers' positions Δf^*_{kt} and ΔCIP_{kt}, but these effects are small both quantitatively and statistically (in terms of R^2); see Appendix Table A8.

across currencies — with funding currencies (JPY, CHF and to a lesser extent EUR) experiencing a reduction in UIP and become more negative, while all other currencies (investment and EMs, and to a lesser extent GBP) see an increase in their positive UIP premia with higher VIX. To be more precise, we find that the estimated impact of VIX on UIP premium varies continuously from negative to positive as we go from the largest negative local-currency funding gaps (JPY and CHF) to the largest positive funding gaps (AUD and NZD, as well as MXN), with highly significant estimates in each case but the EUR, where the effect happens to be close to a precise zero (as expected for a currency with *balanced* local-currency funding). For CIP premia, the pattern of comovement with the VIX is similar to that of UIP premia: increases in VIX tend to make CIP premia more negative for funding currencies and more positive for investment, commodity and EM currencies.[42]

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 μ_t in Proposition 2). The widening of both UIP and CIP premia across currencies in response to the tightening of general financial conditions, as proxied by VIX, 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 these interaction terms have an important predictive effect for the response of both currency premia in a G7+ panel.

Finally, unlike with VIX, the co-movement of UIP premia with the broad dollar are remarkably similar across currencies — with the broad dollar appreciation associated with increasing UIP premia (i.e., UIP premia becoming more positive or less negative) for every currency. Similarly, the broad dollar tends to comove strongly and negatively with CIP premia for most G7+ currencies, with the exception of NZD (as well as MXN). Interestingly, the negative comovement between UIP and CIP premia for individual currencies, which we observed in Table 3, effectively disappears once we control for the broad dollar and the VIX.[43] Broad dollar appreciations likely capture both general shifts in demand towards the dollar (like the common component of all Δf^*_{kt}, but additionally via shifts in demand for dollar swaps, see Ivashina, Scharfstein, and Stein, 2015), as well as the general tightening of financial conditions (like an increase in VIX).

To conclude, unlike UIP, CIP premia do not feature significant month-to-month variation id-

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

[43] 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.

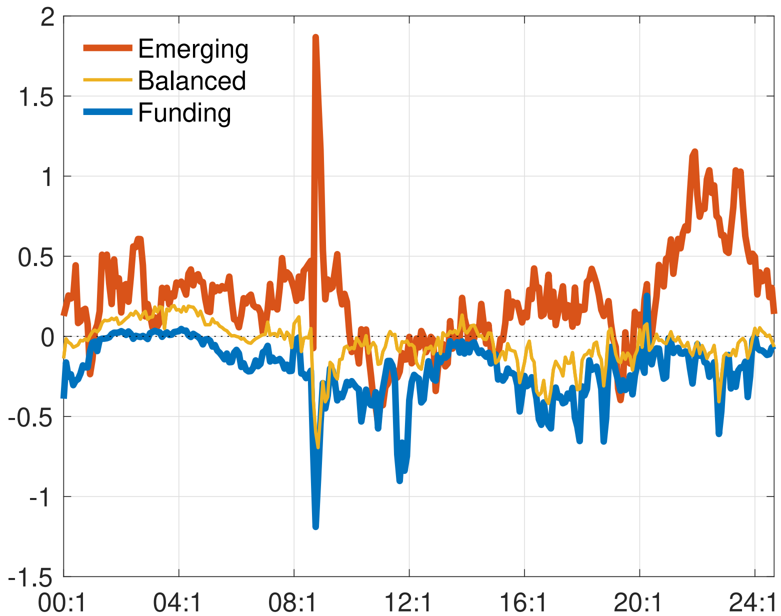

Figure 5: CIP premia by currency bins

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

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

3.4 Exchange rate dynamics

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

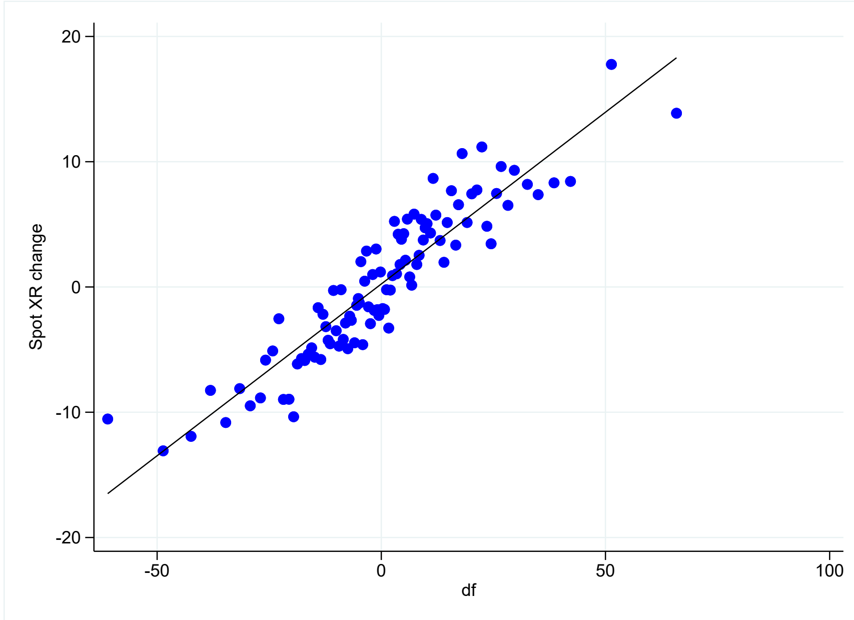

Figure 6: Dealer positions and exchange rate changes: scatter plot of $\Delta \log \mathcal{E}_{kt}$ against Δf^*_{kt}

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

G7+ currencies and highly statistically significant.

We unpack this correlation further by estimating the following dynamic projection for individual currencies k (all G7+ currencies and MXN):

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

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. The Treasury basis is computed as the difference between the 12-month US Treasury yield and corresponding Treasury yields in each currency swapped into dollar using the 12-month forward exchange rate. We use this variable in the exchange rate regressions instead of the broad dollar to capture shocks to dollar asset demand but avoid the 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.[44]

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 dealers' currency k positions, representing a shift in the market demand away from currency k towards the dollar, is associated with a quantitatively strong contemporaneous

[44]We obtain consistent results for emerging market currencies, reported in Appendix Table A5, even though their FX futures markets are shallower and data on dealer futures positions sparser.

depreciation of currency k. The magnitudes of the coefficients are remarkably consistent across currencies. For a one standard deviation innovation in individual Δf^*_{kt}, currency k depreciates by around 1.3%, ranging from 0.9% for MXN and CAD to 1.3% for JPY and CHF and 1.6% for NZD. After absorbing time fixed effects in a panel of G7+ currencies, a one standard deviation innovation to dealer currency positions is associated with a 0.9% depreciation of the currency against the dollar.

Furthermore, these exchange rate movements are very persistent, exhibiting virtually no exogenous mean reversion as reflected in $\hat{\rho}_k \approx 0$ estimates on the lagged exchange rate for all k in Table 6. All mean reversion in the exchange rate response comes from mean reversion in the dealer positions. Recall that our estimated specification (24) implies a half-life of 5 or 6 months for a shock to f^*_{kt}, and a corresponding half-life of 6 or 8 months for the exchange rate in the panel of G7+ currencies, for the specification with or without time fixed effects, respectively. For individual currencies, the half-lives vary from 6 to 13 across currencies, and it is ∞ for GBP (see the last line in Table 6).[45]

The statistical model (25), as estimated in Table 6, accounts for 45 to 60% of the variation in spot exchange rate changes for individual currencies, as well as in the pooled panel (and 70% with time fixed). The combined explained variation is due to the dealer positions as well as the more conventional variables that correlate with the exchange rate. Changes in the interest rate differential have a strong association with exchange rate appreciations for all currencies but CHF and MXN.

The Treasury basis has a negative effect on exchange rates — a reduction in the basis captures increased demand for dollar assets and associated depreciation of other currencies — which increases in magnitude and significance as we move from funding toward investment currencies (from left to right in Table 6). This is consistent with the results in the literature (see Jiang, Krishnamurthy, and Lustig, 2021) and implies that a global shift in demand towards dollar safe assets depreciates investment currencies more than funding ones. The VIX, in turn, has a weakly appreciating impact on funding currencies, while the impact turns to a depreciating one for commodity and investment currencies. This is consistent with the corresponding results for the UIP discussed above with a differential impact of financial conditions on currency premia in proportion with their local-currency funding gap. Controlling for changes in log dealer wealth, another proxy for intermediation capacity, also has strong association with exchange rates: a decrease in dealer wealth is associated with depreciation of all currencies except for CHF and JPY with t-stats of 3 or more.

Despite these statistical associations with conventional macro-finance variables, the dealer position maintains 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

[45] 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.

Table 6: Spot Exchange Rates

	JPY	CHF	EUR	GBP	CAD	AUD	NZD	MXN	G7+ Panel	
Dep.var: $\Delta \log \mathcal{E}_{kt}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δf^*_{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]
ΔT-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 Δf^*_{kt}:										
share of R^2	0.812	0.890	0.686	0.636	0.515	0.416	0.628	0.352	0.776	0.602
std of innovation (%)	1.32	1.30	1.16	1.09	0.93	1.23	1.61	0.91	1.29	0.87
half-life (months)	8	6	∞	6	6	13	6	7	8	6

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

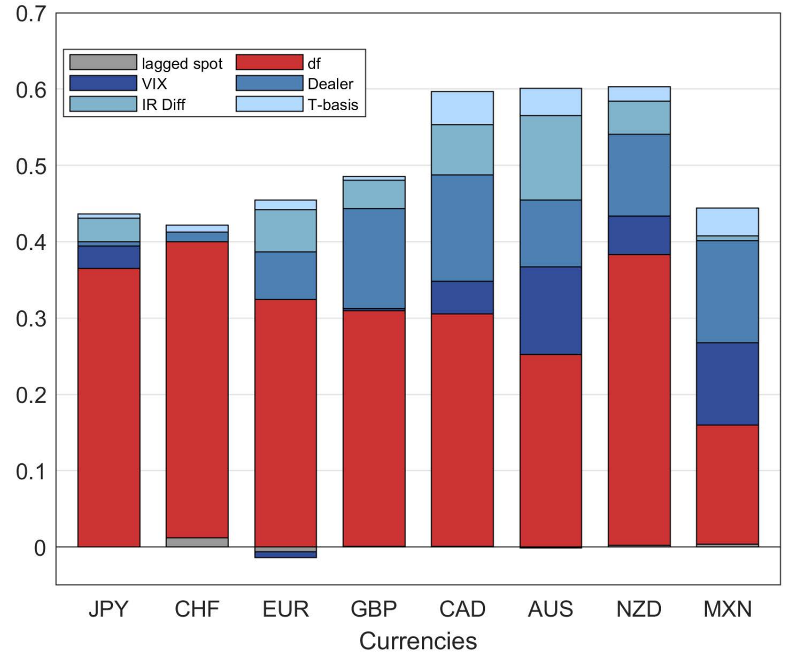

Figure 7: Exchange rate regressions (25): contributions to R^2 by regressor

Note: Bars show the decomposition of R^2 of regressions in Table 6 into the respective contributions of individual regressors by currency (see text and footnote 46).

R^2 in Figure 7.[46] The robust relationship between dealer positions and exchange rate movements across currencies and the large share of the explained variance together account for the tight fit in the scatter plot in Figure 6 above.

To further illustrate the fit of our statistical model (25), we plot the predicted components of the changes and cumulated levels for each exchange rates. The results for EUR and GBP are reported in Figures 1 in the introduction (and in Appendix Figure A3 in levels), while results for all other currencies are reported in Appendix Figures A9–A12. The figures plot the fit of the full model and the partial fit due to dealer positions only. The figures also report the resulting correlations between exchange rates with their predicted components (in changes and in levels, respectively). The high quality of the fit is apparent from observing the plots and confirmed in high correlation coefficients. In particular, the correlation in changes between exchange rates and their predicted component based on the dealer positions alone are around 0.6 for most currency (with the exception of MXN for which it is 0.5). These correlations for the full model are around 0.7. The fit in levels is equally strong, but it can be misleading for a model with near-non-stationary variables, and this is why one should focus only on the fit in changes.

[46]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.

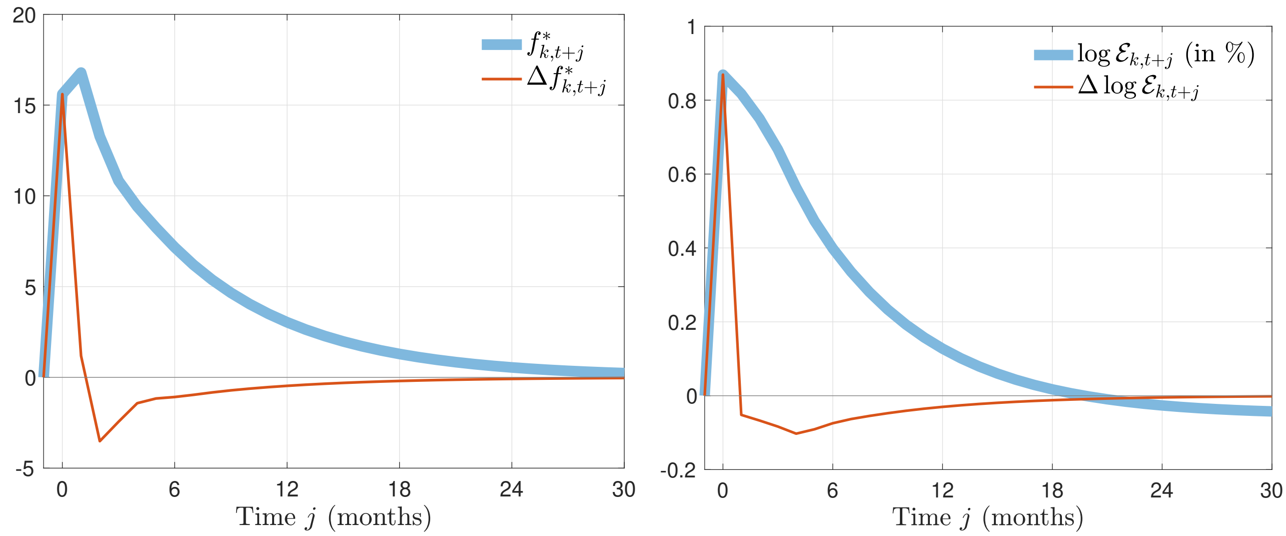

Figure 8: Impulse response to an innovation to Δf^*_{kt}

Note: Impulse responses are constructed for a one standard-deviation innovation to f^*_{kt} using point estimates from the pooled panel specification with time fixed effects for G7+ currencies, as reported in (24) and in column 10 of Table 6.

Impulse responses and currency returns We focused so far on the contemporaneous comovement between the dealers' futures positions, currency premia and exchange rate changes. To complete our description of the dynamics of currency premia and exchange rates, we now turn to describing the estimated impulse responses conditional on a shock to the dealers' futures position. As before, this does not assume that changes in the dealers' positions are exogenous; instead we interpret our results as describing the dynamic statistical properties of currency premia and exchange rates conditional on a standardized shock to the evolution of endogenous dealer positions, that is, $\mathbb{E}_t\{\Delta \log \mathcal{E}_{k,t+j} | \Delta f^*_{kt}\}$ according to the estimated statistical model (24)–(25).[47]

Figure 8 plots the estimated impulse response to a one standard deviation innovation in the dealers' futures position f^*_{kt} at t for the dealers' position evolution itself (in levels and in changes, $f^*_{k,t+j}$ and $\Delta f^*_{k,t+j}$) in the left panel and for the corresponding log exchange rate against the dollar (also in levels and in changes, $\log \mathcal{E}_{k,t+j}$ and $\Delta \log \mathcal{E}_{k,t+j}$) in the right panel. We use the point estimates from the panel specification for G7+ currencies with time fixed effects, as reported in (24) and in column 10 of Table 6.

We find a persistent impulse response to the dealers' position innovation, with half lives of 5 months and 6 months respectively for the dealers' position and the exchange rate, respectively. On impact of a one standard innovation to f^*_{kt}, a typical exchange rate depreciates by 0.87% (87 log basis points) and then gradually appreciates over the following two years, by an average of 6 log basis points monthly over the first 12 months. The distinctive feature of this impulse response is that the large unexpected devaluation on impact is followed by a sequence of predictable small appreciations (compare with the theoretical impulse response in Itskhoki and Mukhin, 2021). Appendix Figure A13

[47]Formally, we trace out the predicted dynamic paths of $f^*_{k,t+j}$, $\log \mathcal{E}_{k,t+j}$ and other variables for $j \geq 0$ when the innovation to f^*_{kt} is equal to its one standard deviation, i.e., $\epsilon^f_{kt} = \sigma_{fk} = \text{std}(\epsilon^f_{kt})$ in (24).

plots alternative impulse responses for the specification without time fixed effects, in which case the exchange rate responds by 1.29% on impact and then mean reverts with a longer half life of 8 months.[48]

Finally, we turn to the impulse responses for currency premia and interest rates, and evaluate the predictable path of currency returns conditional on an innovation to dealers' position f^*_{kt}. Note that this cannot be done directly using currency premia regressions in Tables 3-5 as the time change to currency premia defined in (20) does not correspond to the impulse response of currency returns. Instead, we need to decompose currency premia into their individual components, construct their respective projections on the innovation to f^*_{kt}, and then assemble it back into an impulse response for currency returns. For example, for realized currency returns, $UIP_{kt,t+3} = (r_{kt} - r^{US}_t) - 4 \cdot \log(\mathcal{E}_{k,t+3}/\mathcal{E}_{kt})$, we use local projections for $\Delta(r_{kt} - r^{US}_t)$ and $\Delta \log \mathcal{E}_{kt}$ to construct the path of $\partial UIP_{k,t+j,t+3+j}/\partial f^*_{kt}$ for $j \geq -3$. Similarly, we construct the predicted path of CIP returns.

We find that a one standard deviation innovation to Δf^*_{kt} is associated with virtually no change in the covered interest rate premium $CIP_{k,t+j}$ and no change in the interest rates differential $r_{k,t+j} - r^{US}_{t+j}$, at any horizon $j \geq 0$. The estimated effects are of the order of magnitude of one tenth of a basis point for both variables in a panel of G7+ currencies, with or without time fixed effects, as shown in Appendix Figure A16.

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

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

[48] Appendix Figure A14 shows impulse responses for individual currencies. Appendix Figure A15 plots impulse responses for the specification which does *not* force mean reversion in specification (24) by omitting the lagged level control $f^*_{k,t-1}$, in which case f^*_{kt} has an impulse response close to a random walk and the exchange rate mean reverts very slowly with virtually an infinite half live (despite the continued inclusion of lagged $\log \mathcal{E}_{k,t-1}$ into (25)).

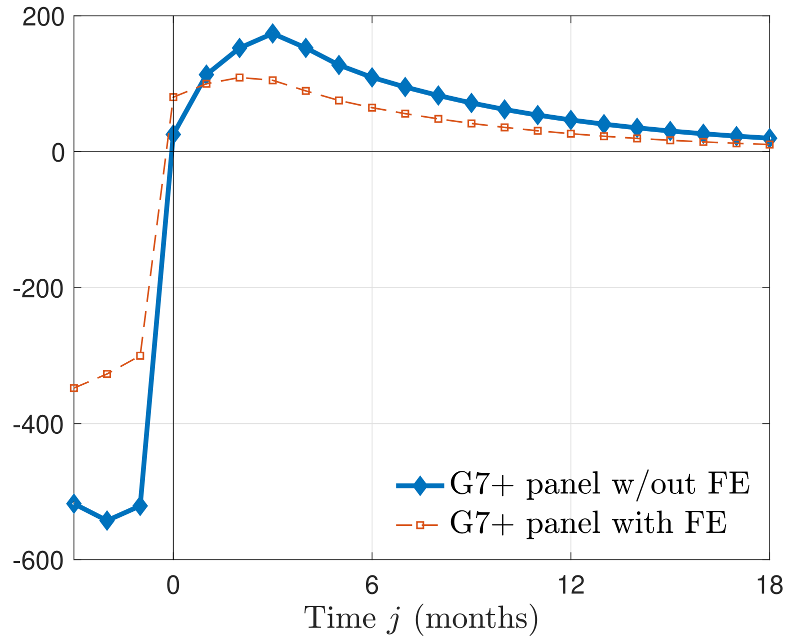

Figure 9: Currency returns (basis points) around the innovation to f^*_{kt}

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

Essentially the entire currency return described above is driven by the predictable movement in the spot exchange rate, as follows from the impulse responses of the interest rate (effectively zero) and the exchange rate described above. An essential feature of the exchange rate impulse response is the predictable gradual appreciation of currency k over the following year following a sharp depreciation on impact. Indeed, the sharp depreciation is what creates both the value loss on impact of the shock (the "steamroller") and the generally high underlying volatility for currency trading, as this depreciation is unanticipated. The gradual predictable appreciation is what gives the intermediary bank the expected return, but with a modest Sharpe ratio given the risk (the "pennies" that they collect in front of a steamroller).[49] Indeed, this situation describes an equilibrium exchange rate response that supports positive expected currency returns for dealer banks subject to a "no-good-deal" bound on the carry trade Sharpe ratio (see Chernov, Haddad, and Itskhoki, 2024). Less surprise volatility in the exchange rate would make the currency trade too appealing for broader groups of investors, while less predictable mean reversion in the exchange rate would make it not sufficiently attractive to dealer banks. Our proxy for currency demand shocks, Δf^*_{kt}, allows to rationalize both the surprise variation in the exchange rate on impact of the shock and the intertemporal profile of predictable currency returns following the shock.

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

4 Discussion and conclusion

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

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

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

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

Unlike for CIP premia, time fixed effects and aggregate financial conditions explain only a small portion of variation in UIP premia, which respond most strongly to shifts in currency-specific demand as proxied by dealer banks' futures positions. We show that it is the dynamics of the spot exchange rate that ensures the response of both expected UIP premium and the ex post currency returns, while the interest rate differential does not respond to shifts in currency demand.[50] An increase in dealer banks' futures position in currency k is strongly correlated with a contemporaneous depreciation of currency k against the dollar, driving a significant financial loss for those exposed to this currency before the shock. In contrast, intermediaries that take currency k position in response to the shock obtain predictable positive expected returns, albeit with a modest Sharpe ratio due to the high volatility of the exchange rate (that is, "collecting pennies in front of a steamroller").

These dynamics of currency returns are ensured by a times-series process for exchange rates that features persistent innovations and long half-lives, yet with a small predictable mean reversion over a period of multiple quarters. This emphasizes the frictional nature of exchange rate fluctuations that ensure both predictable returns (UIP deviations) and large unpredictable innovations that tightly bound the Sharpe ratio of currency carry trades. Lower predictable returns would be inconsistent with frictional intermediation of the currency risk which requires an equilibrium premium, while lower volatility would violate a "no-good-deal" bound for currency trading. Even if underlying shocks are fundamental macroeconomic shocks, capital flows and changing currency positions associated with these shocks require intermediation in the currency market, which in turn leads to a volatile near-random-walk process for the exchange rate, consistent with exchange rate disconnect.[51] Hence, a model with the same set of fundamental shocks but frictionless intermediation with uncovered parity holding must result in very different equilibrium exchange rate dynamics.

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

A number of open questions, both positive and normative, remain for future work. For example,

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

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

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

Turning to policy, a question of keen interest concerns the rationale and relevant target for official FX interventions and other exchange rate policy tools. The frictional intermediation that we emphasize suggests a rationale for policy interventions that lean against currency demand shocks by (partially or fully) eliminating currency premia and stabilizing the exchange rate. Stabilizing the UIP premium amounts to accommodating or dampening currency-specific demand shocks, and as a result largely stabilizing the spot exchange rate. In contrast, stabilizing the CIP premium means leaning against the global financial and dollar cycles in the currency market, and by doing so, stabilizing the forward premium without eliminating fluctuations in the spot exchange rate. A combination of these wedges can therefore serve as operational targets for the policy maker depending on which type of shock needs to be managed. Of course, conducting such optimal policy analysis requires a fully-specified general equilibrium model.[52] 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.

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

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A Additional Tables and Figures

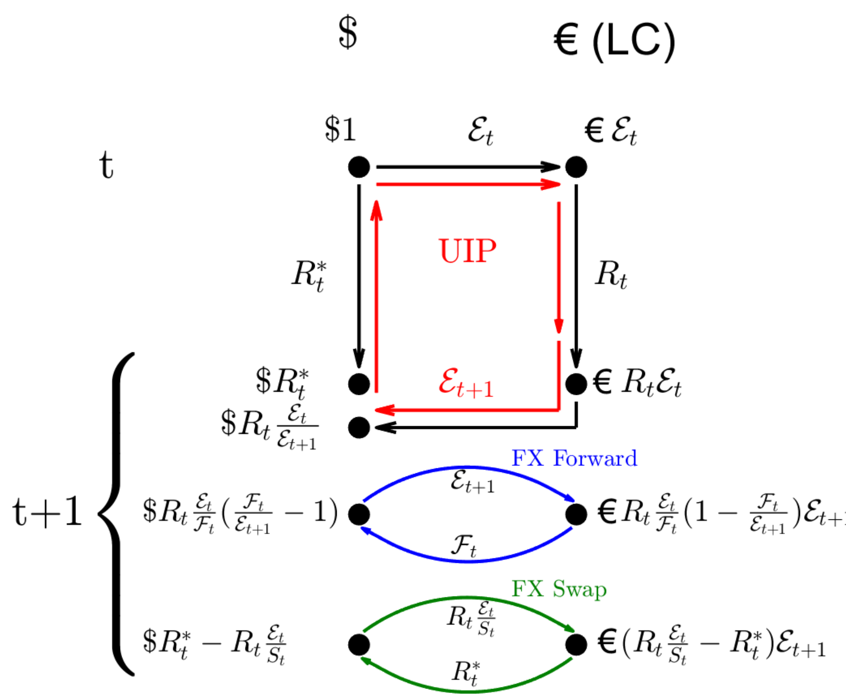


Figure A1: Illustration for balance sheet in Table 1: possible currency trades

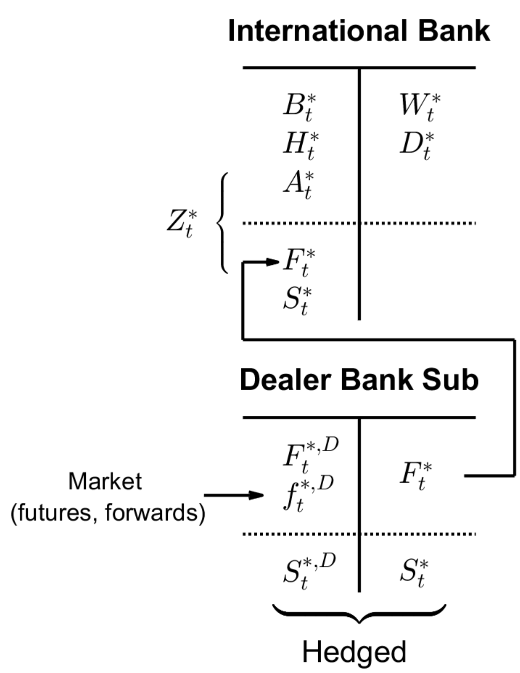


Figure A2: Illustration of international intermediary bank and its dealer subsidiary: FX exposure passthrough

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

Currency	Ticker (3M)	Description (3M)
		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 Δf^*_{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). 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: $\Delta\widehat{UIP}_{kt}$	(1) EM panel Baseline	(2) EM panel Time FE	(3) EM panel USD & VIX	(4) MXN	(5) ZAR	(6) RUB	(7) BRL
Δf^*_{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]
ΔCIP_{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

	MXN	RUB	BRL	ZAR	EM Panel	
Dep. Var: $\Delta \log \mathcal{E}_{kt}$	(1)	(2)	(3)	(4)	(5)	(6)
Δf^*_{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]
ΔT-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
# Currency FE					4	4
Time FE						✓
Within R^2	0.444	0.598	0.209	0.328	0.374	0.798

Notes: Regression specification and variable definitions follow Table 6, applied to monthly spot exchange rate changes of EM currencies with available data on dealer futures positions from the CFTC's TFF database. |t|-stats computed using Newey West standard errors in columns 1-4 and Driscoll-Kraay autocorrelation and 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 μ

Dep. var: $\widehat{UIP}_{k,t}$	(1) $\mu = VIX$	(2) $\mu = -DealerW$	(3)	(4) $\mu = -GFCy$	(5)	(6) $\mu = EFFR - IORB$	(7)
Δf^*_{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 μ_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 μ 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 μ

Dep. var: ΔCIP_{kt}	(1) $\mu = VIX$	(2) $\mu = -DealerW$	(3)	(4) $\mu = -GFCy$	(5)	(6) $\mu = EFFR - IORB$	(7)
Δf^*_{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]
$\Delta \log \overline{\mathcal{E}_t^{USD}}$	−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 μ_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 μ 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]
Δf^*_{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 Δf^*_{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.

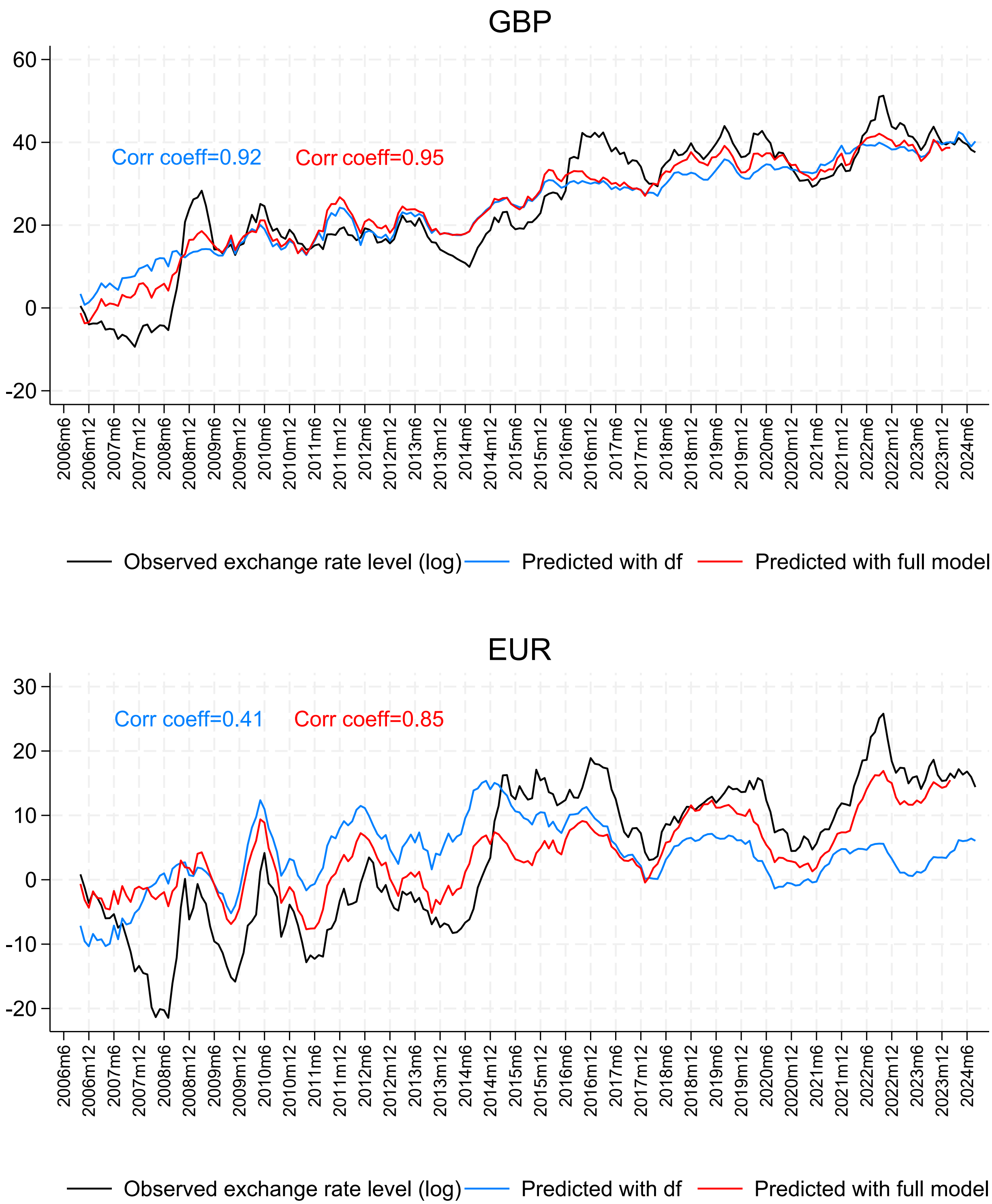
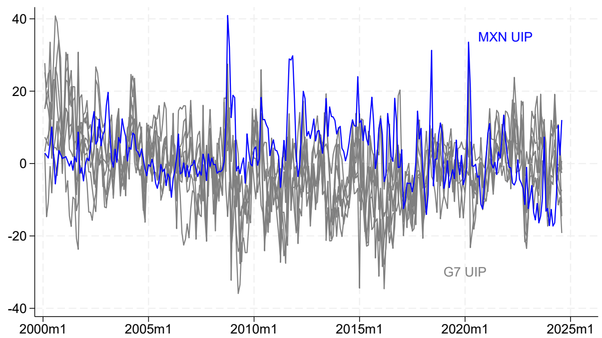


Figure A3: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values

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

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



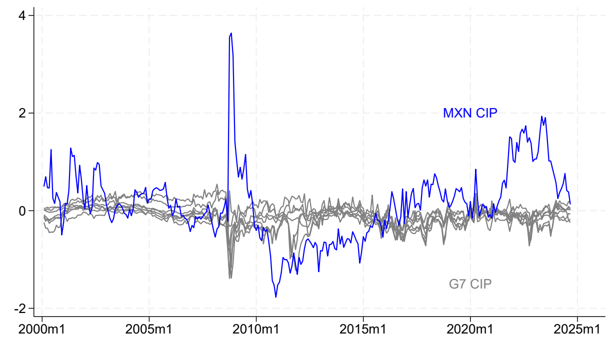


Figure A5: Dealers net futures position by G7 currency

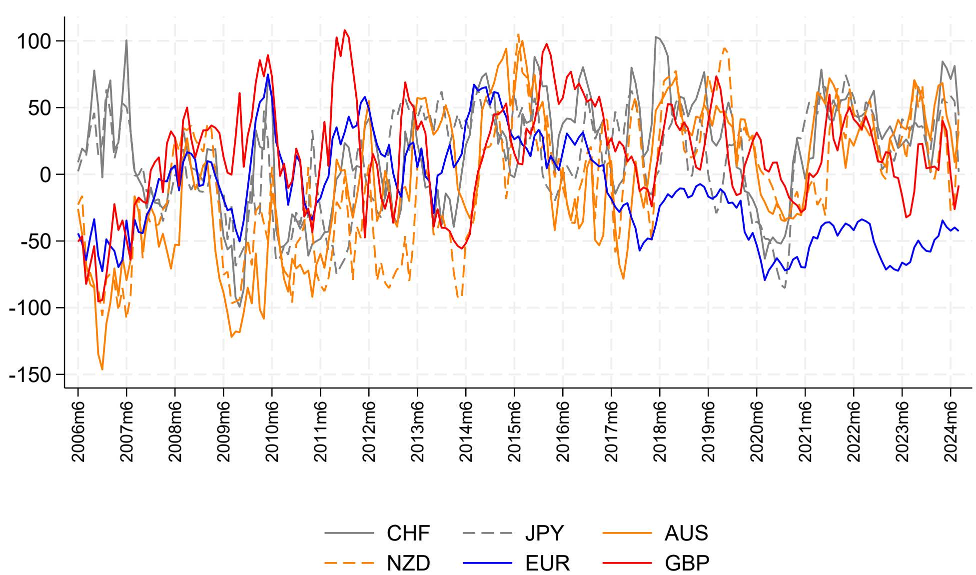
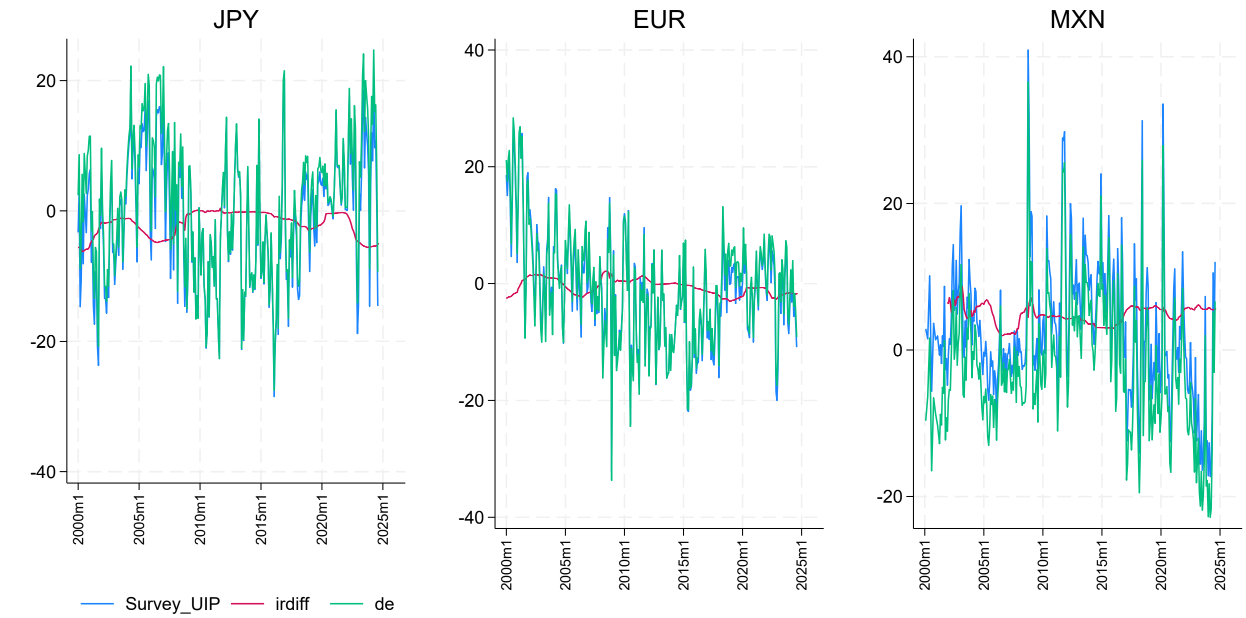
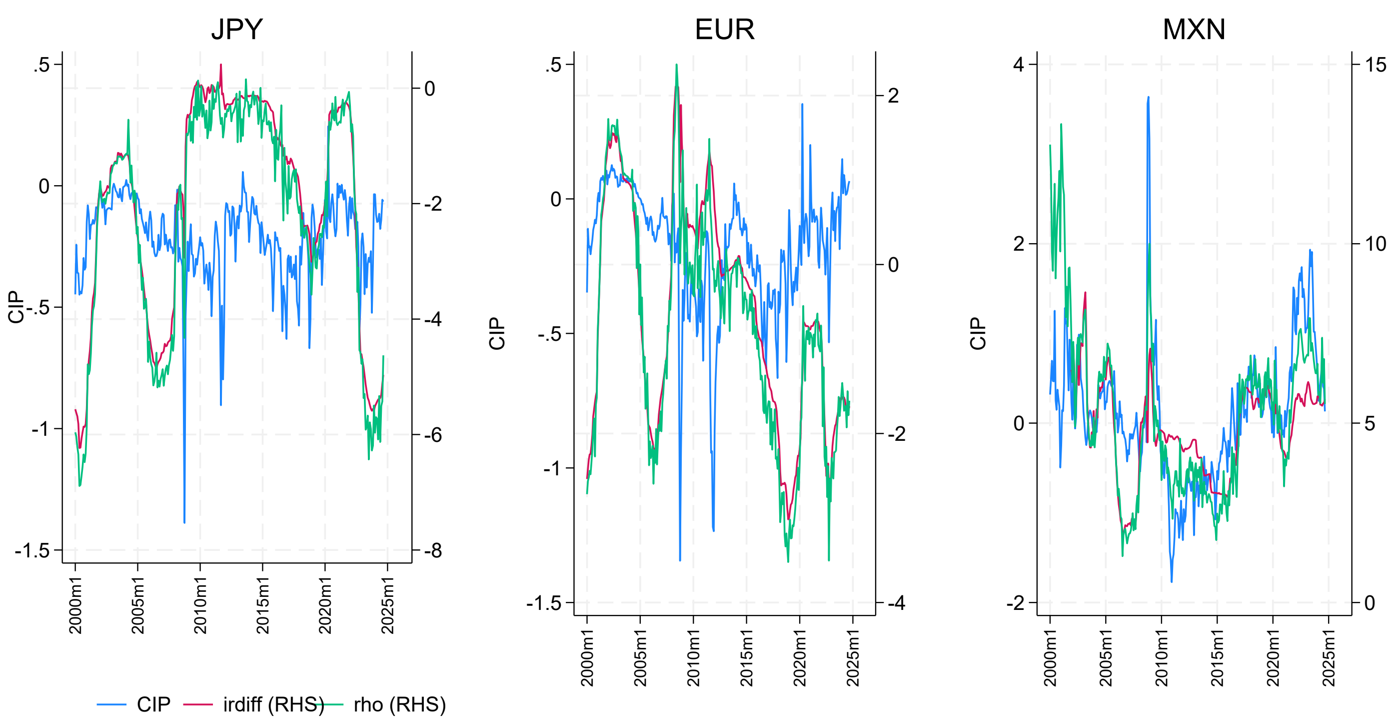


Figure A6: UIP and CIP decomposition

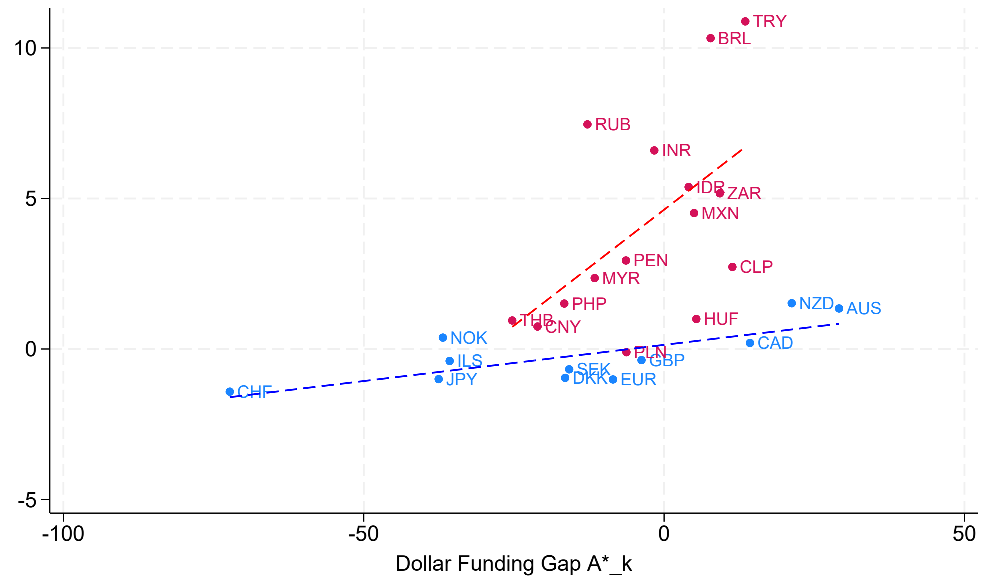


(a) UIP decomposition for JPY, EUR, MXN.



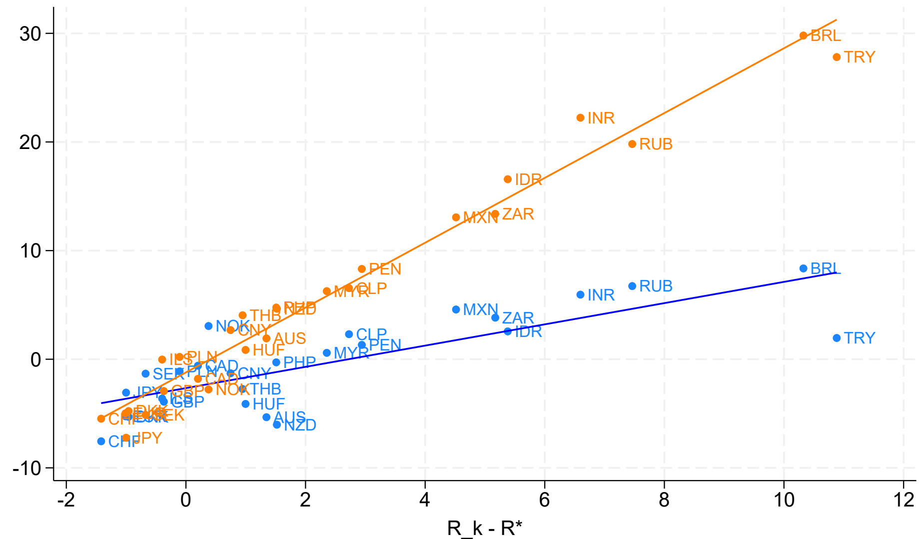
(b) CIP decomposition for JPY, EUR, MXN.

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

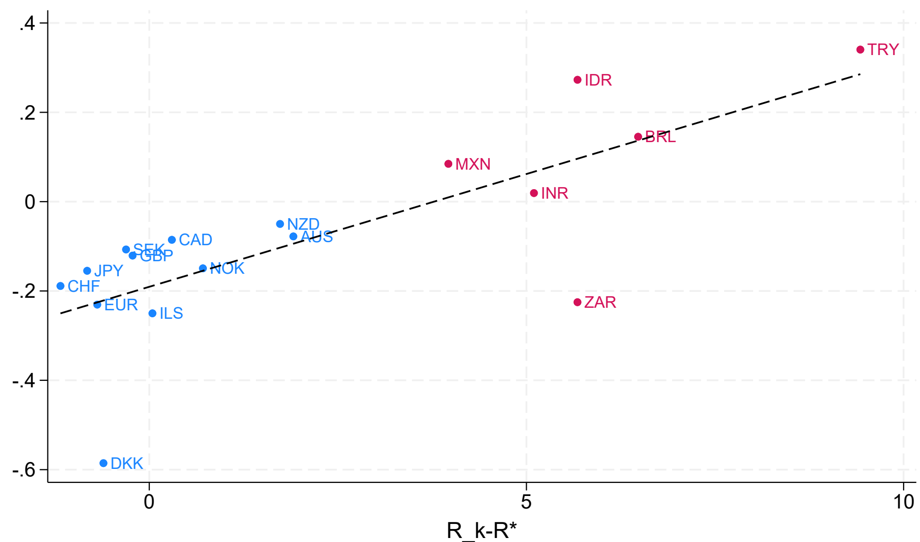


Notes: This figure generalizes Figure 3 in the main text to a broader set of advanced economies and emerging market currencies, illustrating group-specific slopes for the scatter plot of the average dollar funding gap and interest rate differential vis-à-vis the dollar (red for EM, blue for AE currencies). 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 A8: Cross section of the average UIP and CIP deviations (in %) against the average interest rate differential



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



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

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

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

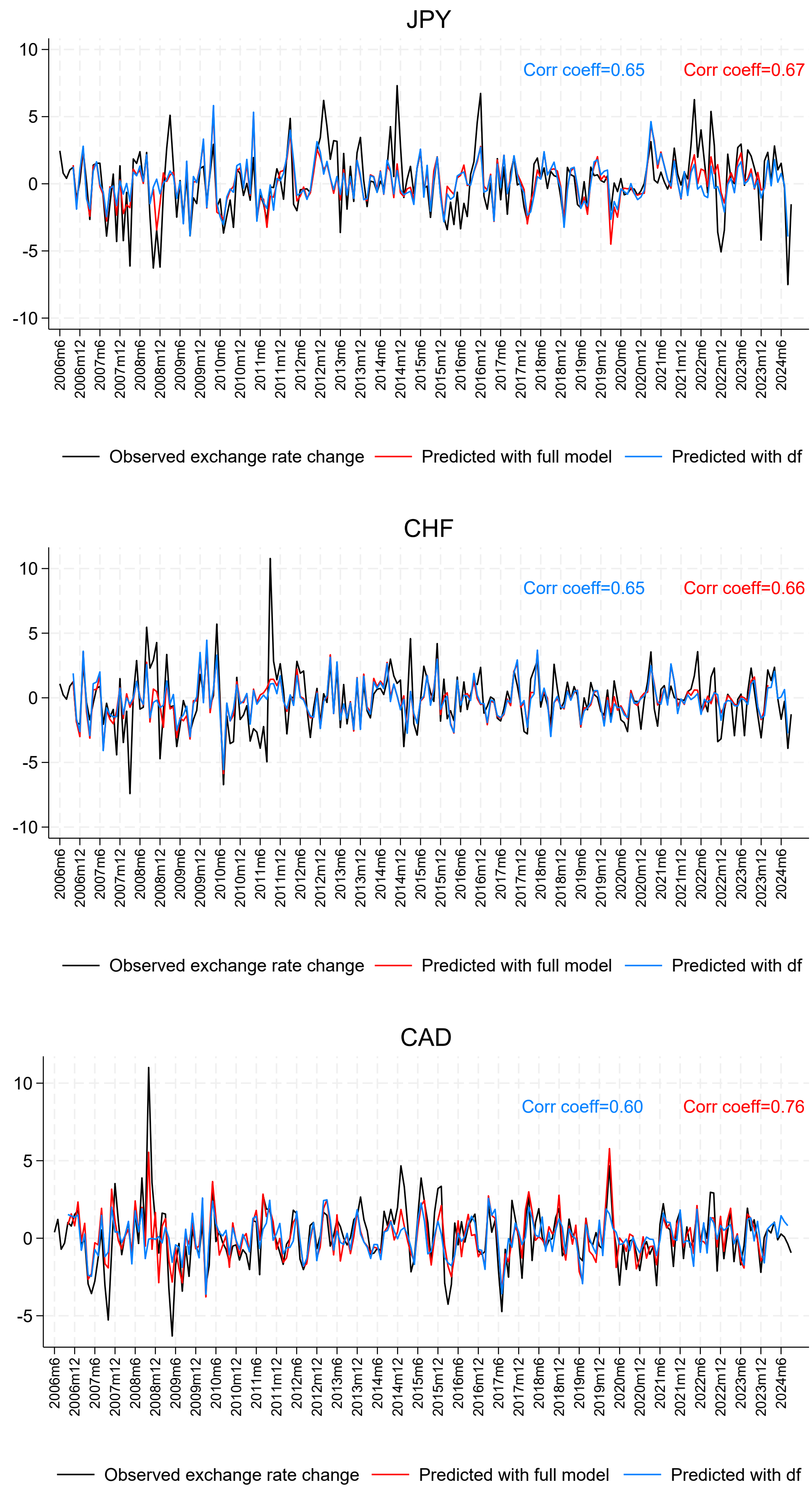
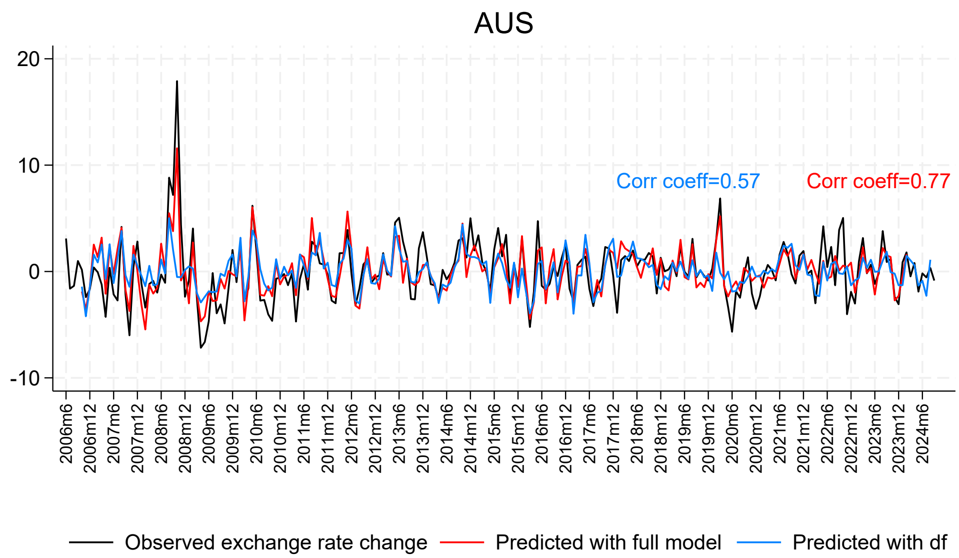
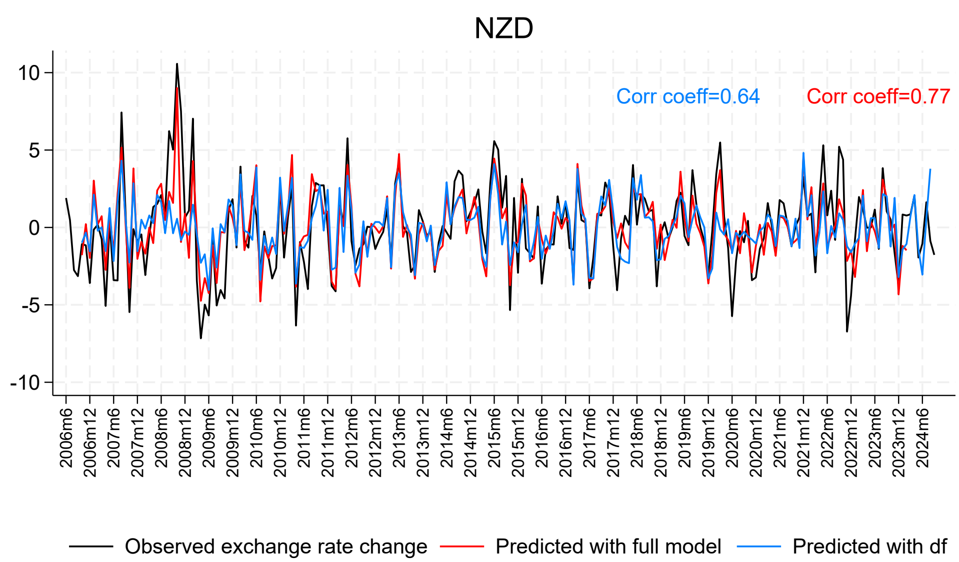


Figure A10: Realizations of $\Delta \log \mathcal{E}_{kt}$ and its fitted values for individual currencies(continued)





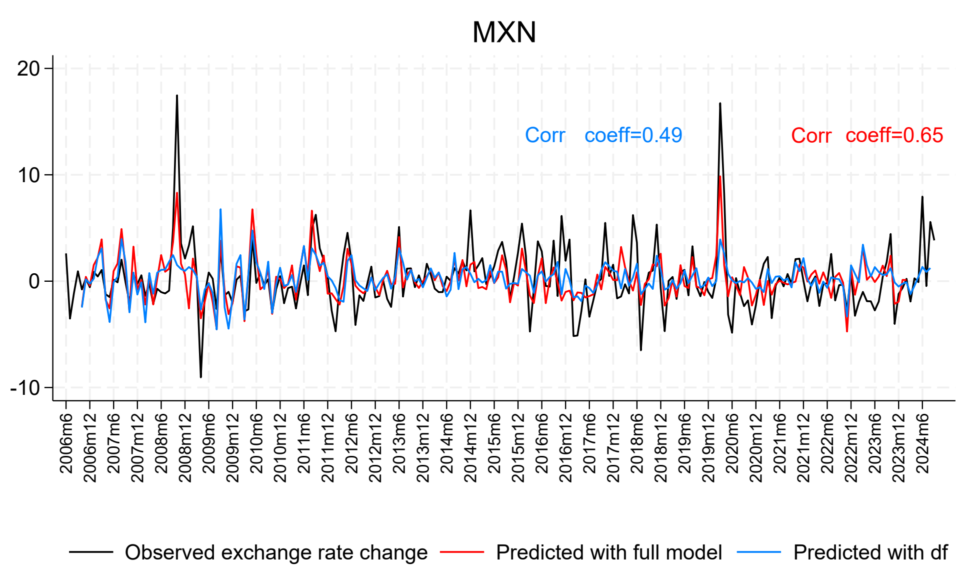


Figure A11: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies

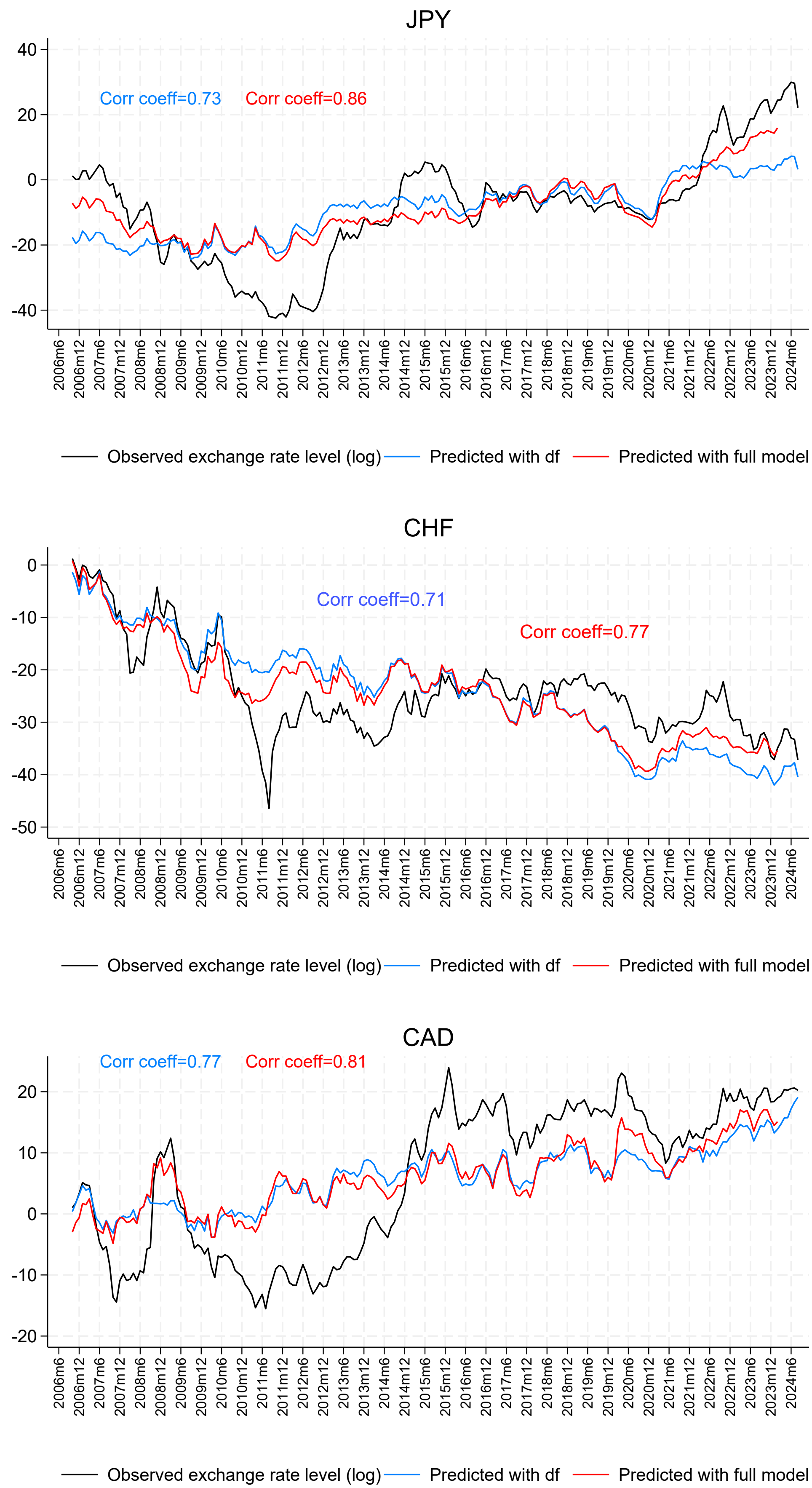
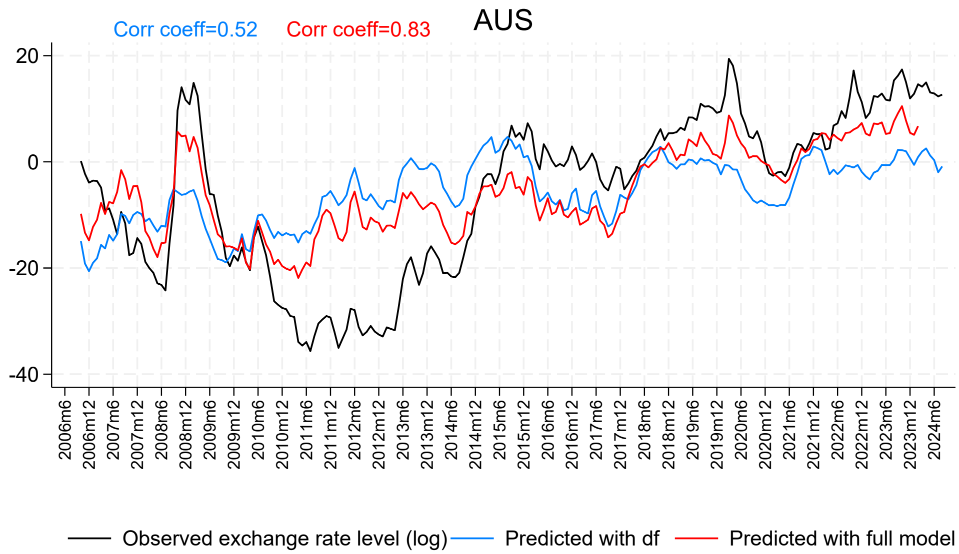
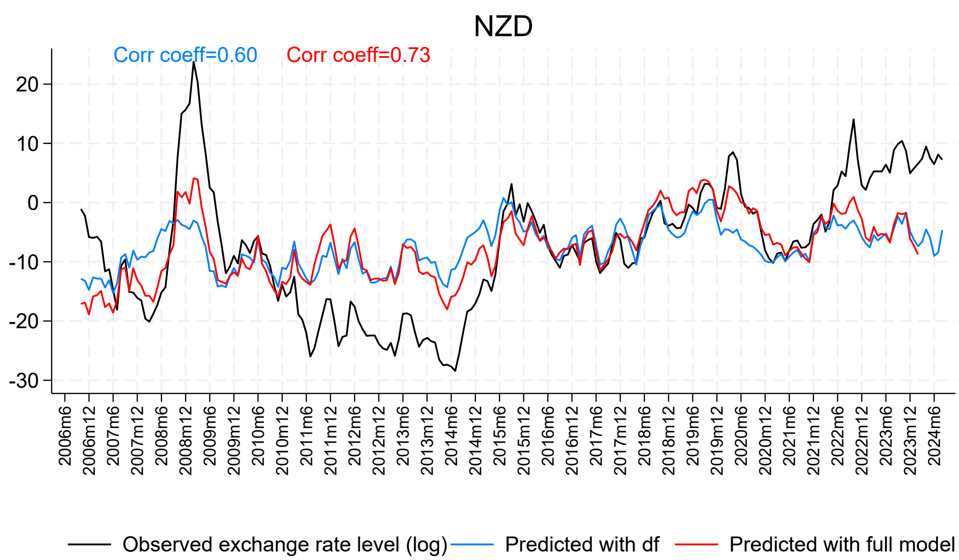
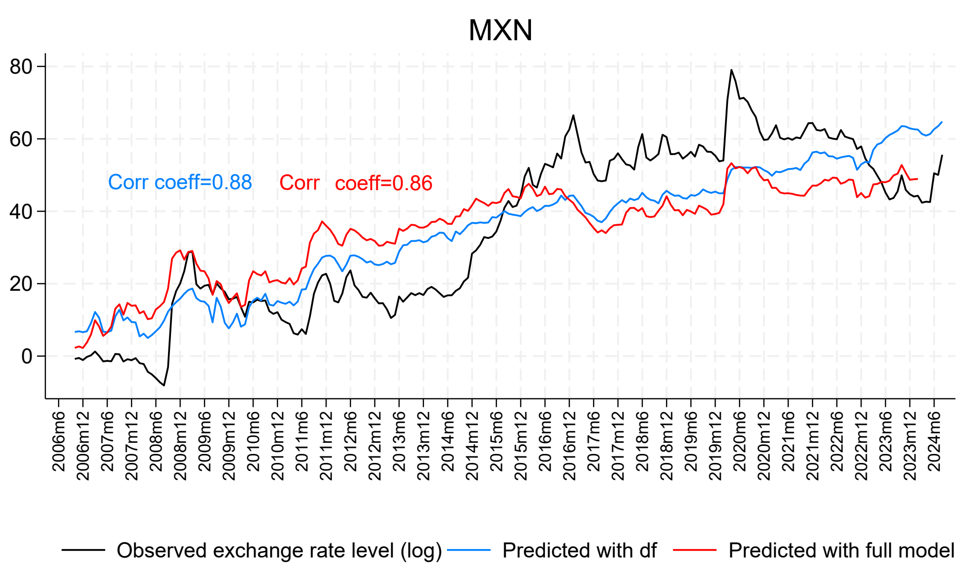


Figure A12: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies (continued)







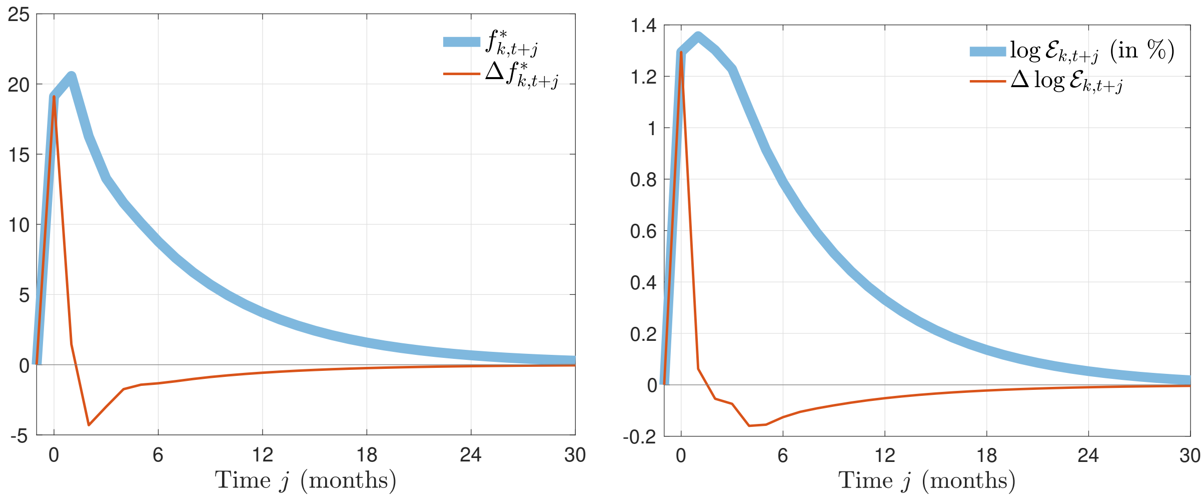


Figure A13: Impulse response to an innovation to Δf^*_{kt}: no time fixed effect

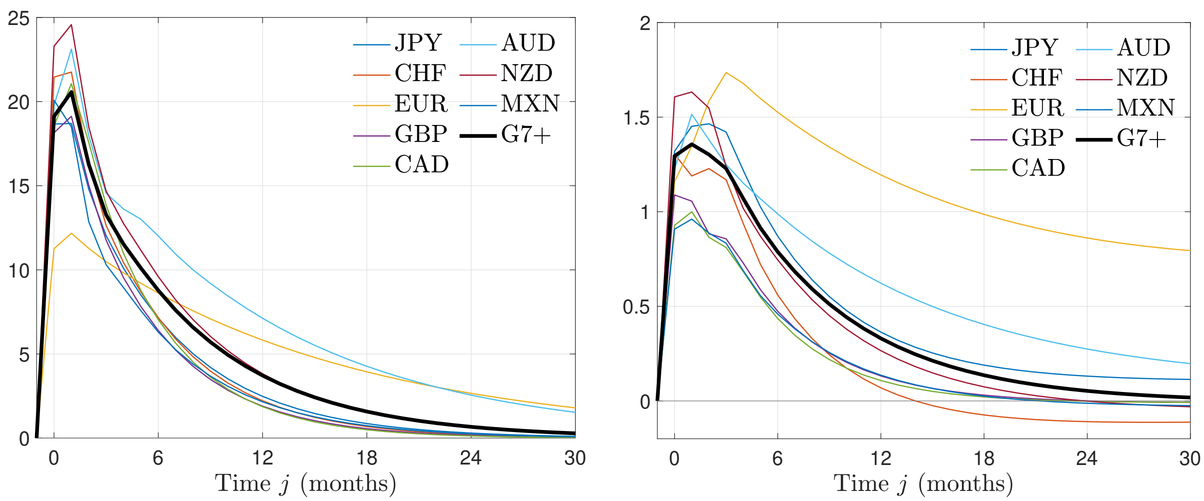


Figure A14: Impulse response to an innovation to Δf^*_{kt}: individual currencies

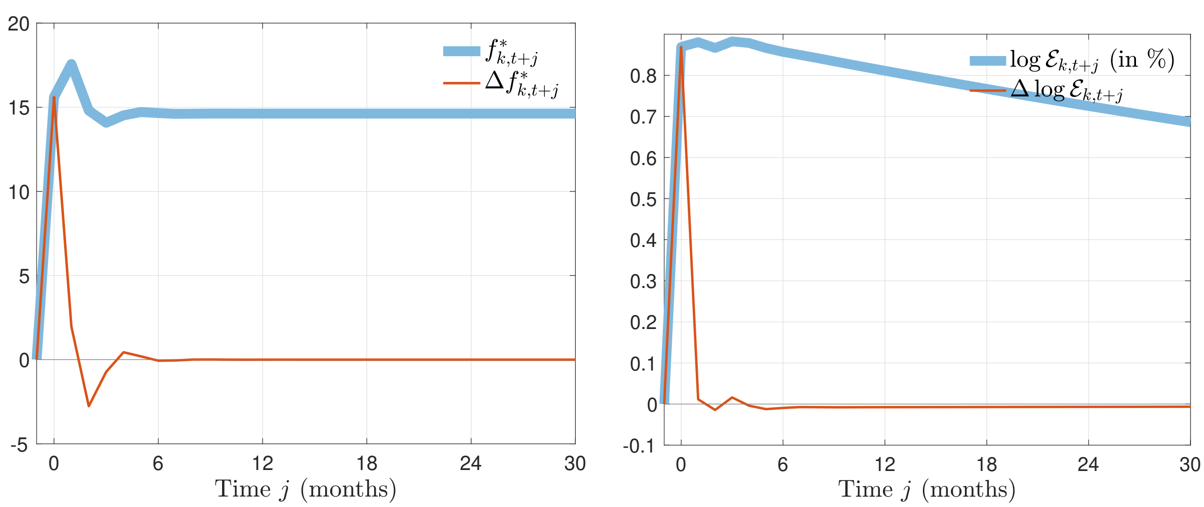


Figure A15: Impulse response to an innovation to Δf^*_{kt}: no mean reversion in (24)

Note: Top row plots impulse responses for the pooled G7+ panel specification *without* time fixed effects. Middle row plots impulse responses for individual currencies (black lines are for the G7+ panels without time fixed effects, as in the top row). Bottom row plots impulse responses for the G7+ panel with time fixed effects, but without lagged level $f^*_{k,t-1}$ in specification (24) for Δf^*_{kt}. See Figure 8 for comparison with the baseline panel specification with time fixed effects.

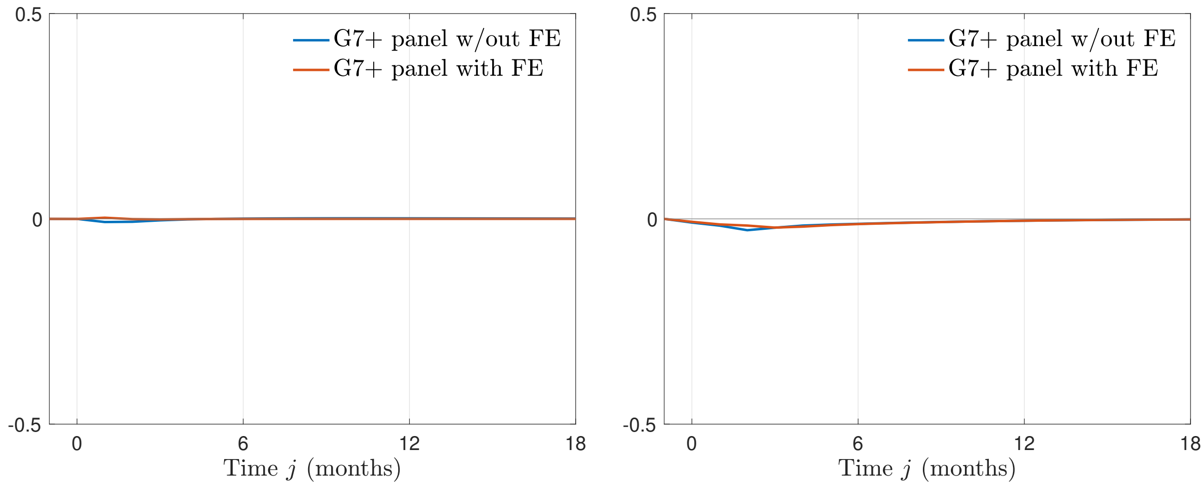


Figure A16: Impulse responses of $CIP_{k,t+j}$ (left) and $r_{k,t+j} - r^{US}_{t+j}$ (right) to a Δf^*_{kt} innovation

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

B Proofs

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

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

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:

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

where $\mathrm{sign}(X_t^*) = \frac{\partial|X_t^*|}{\partial X_t^*}$ 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:

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

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 δ_{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 δ_{it} are active in this market as well, and all banks with a higher δ_{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.

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

$$\Delta v_{kt} = \alpha_k + \delta_t + \beta \Delta f^*_{kt} + \gamma w_{kt} + \varepsilon_{kt}. \tag{A1}$$

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

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

$$\sum\nolimits_{i \in \mathcal{I}_k} Z^*_{it} = 0 \tag{A2}$$

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

$$\mathbb{Z}^D_{kt} \equiv \sum\nolimits_{i \in \mathcal{I}^D_k} Z^*_{it}, \tag{A3}$$

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

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

$$Z^*_{it} = -\xi_{it} + \rho_i \cdot \overline{UIP}_{kt}, \qquad \xi_{it} \perp \overline{UIP}_{kt}, \tag{A4}$$

where $\overline{UIP}_{kt}$ is the expected payout per unit of currency exposure (as in (3) in Lemma 1). Assumption (A4) states that the exposure of any agents can be decomposed into the position taken for the purposes of collecting the (expected) currency return and the residual shifter ξ_{it} that by construction is orthogonal to the expected currency return. More precisely, equation (A4) holds without loss of generality as a decomposition of the currency exposure into its projection component onto the expected premium and the projection residual. Note that it is useful to think of the projection component in (A4) as the currency supply portion of the position and the orthogonal shifter as the currency demand portion, with each agent's position containing both elements of currency supply (in response to the currency premium) and currency demand (orthogonal to the currency premium).

While we expect (A4) to hold for every agent in the market as a reduced-form representation of their position, for dealer banks' with positions characterized by Proposition 1, decomposition (A4) also has a structural interpretation. Rewrite optimality condition in (8) as $Z_{it} = \rho_{it} \cdot \overline{UIP}_{kt}$ for any $i \in \mathcal{I}_k^D$ and where $\rho_{it} \equiv W_{it}^* / [\gamma_{it} \mu_t \sigma_{kt}]$. Then we can take a Taylor expansion around the unconditional mean of the position, $\bar{Z}_i = \bar{\rho}_i \cdot \mathbb{E}\overline{UIP}_{kt}$, as:

$$\mathrm{d}Z_{it} = -\xi_{it} + \bar{\rho}_i \cdot \mathrm{d}\overline{UIP}_{kt}, \qquad \text{where} \qquad \xi_{it} \equiv \frac{\bar{Z}_i}{\bar{\rho}_i} \cdot \mathrm{d}\rho_{it} = \bar{Z}_i \cdot \mathrm{d}\log \rho_{it}. \tag{A5}$$

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

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

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

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

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

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

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

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

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

$$\overline{UIP}_{kt} = \alpha_D + \beta_D \mathbb{Z}_{kt}^D + \epsilon_{kt}^D. \tag{A6}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\Delta\mathbb{Z}^D_{kt} = \alpha_k + \eta_k \Delta f^*_{kt} + u^D_{kt}, \tag{A8}$$

which must have $\eta_k > 0$ and a sufficiently high R^2 for our implemented "reduced-form" specification that regresses ΔUIP_{kt} on Δf^*_{kt} to have explanatory power.

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

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

Decomposition of currency premia dynamics Given the empirical definitions of currency premia in (20), we can decompose their estimated impulse responses from specifications in (A1) (and their generalizations (23) that permit for more dynamics) into the impulse response of individual components — the interest rate differential, the forward premium, the current and future (expected) spot exchange rate. The case of interest rates and forward premia is straightforward, as these variables only feature objects known at t. The decomposition of the currency premia requires additional care since the realized carry trade return features both the current and future exchange rate. Therefore, we construct the individual impulse response for the exchange rate, and then aggregate it into the currency premium component-by-component.

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

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

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