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

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

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

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

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

The time-series patterns of currency premia are more nuanced. *Covered* currency premia change in concert across currencies. Most of this variation is captured by a common component related to global financial market conditions. Funding currencies with a negative funding gap (i.e., excess local-currency savings) see a widening of their negative CIP premia when global financial conditions tighten, while investment (and especially emerging market) 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. Nonetheless, CIP premia are generally stable month-to-month outside periods of global financial and dollar stress, and there is no time-series comovement between CIP and UIP premia for individual currencies after absorbing time fixed effects.

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

We show that currency-specific shocks do not affect the interest rate differential or the forward premium (i.e., the ratio of forward to spot exchange rates), 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. Further, they are associated with long exchange rate half-lives of multiple months and 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, and similar patterns hold for other currencies. These results align closely with the predictions

[1] Futures positions offer an easily measurable and most liquid 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.

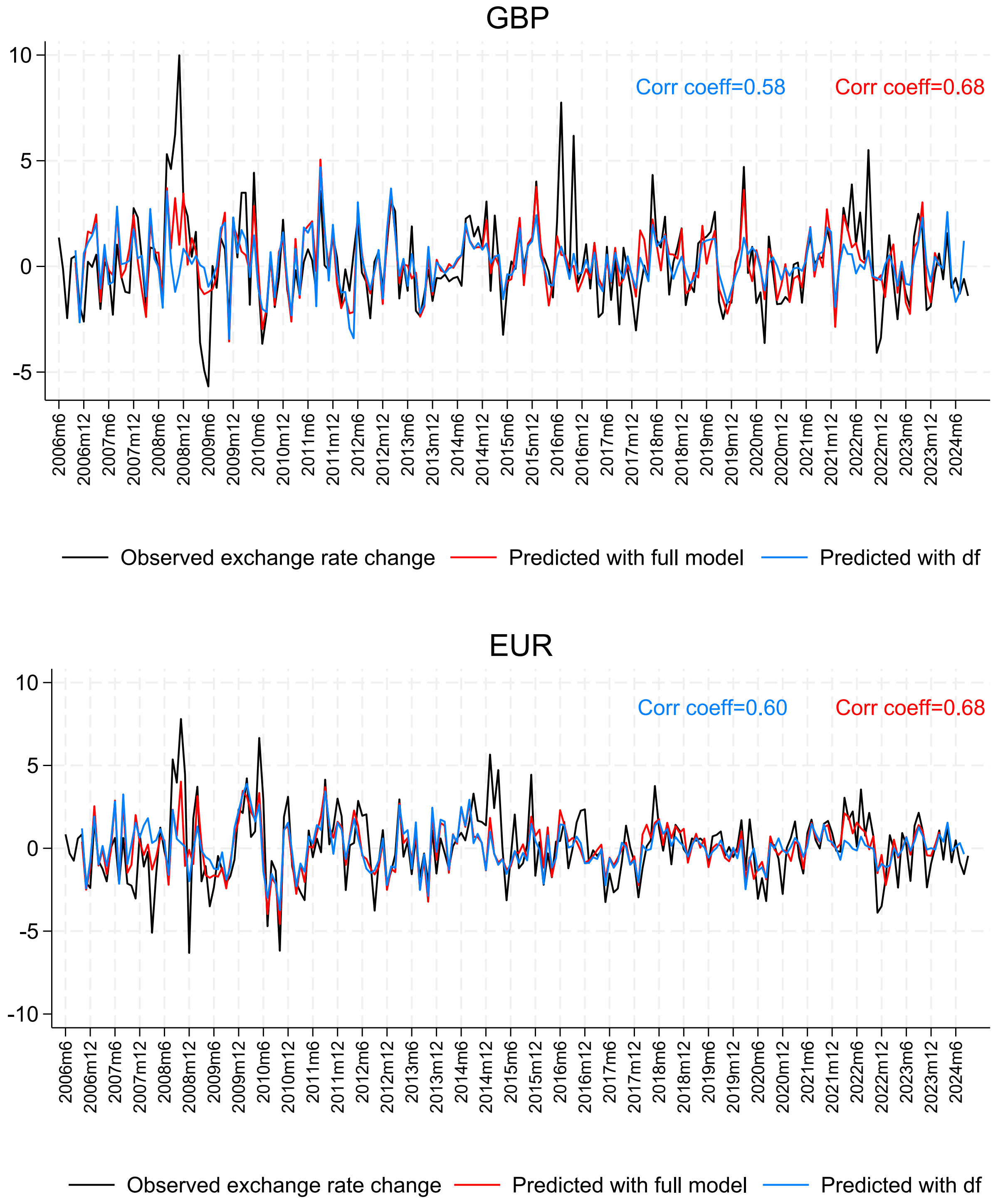

Figure 1: Realized changes in nominal exchange rates and their fitted values

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). Appendix Figure A3 shows the fit for the levels of exchange rates, and Appendix Figures A9–A12 display results for other currencies.

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

This leaves open the question of which shocks are driving the exchange rate. Futures positions of dealer banks may or may not proxy for specific primitive shocks — macroeconomic or financial.[2] They instead identify the resulting variation in net currency demand that must be met by intermediaries at an equilibrium currency premium. Such currency demand can arise from a combination of hedging, speculating or portfolio rebalancing motives among market participants. Spot and forward exchange rates move to ensure the equilibrium premia that allow the currency market to clear. In addition to fundamental volatility, the exchange rate features "excess" volatility due to frictional intermediation. This explains not only the lack of a robust correlation between the exchange rate and fundamentals, but also the large gap in the exchange rate volatility relative to macro variables (Itskhoki and Mukhin, 2021, 2025a).

The main goal of our paper is to document and explain the joint statistical properties of currency premia and exchange rates in a panel of major currencies in both advanced and emerging markets. The novelty of our empirical work is in reconciling the salient patterns of the joint distribution of UIP and CIP deviations and the spot and forward exchange rates, both in the cross-section of currencies and in their time series. In doing so, we impose few theoretical or structural restrictions. Instead, a strength of our approach is to 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.

[2] For instance, we document evidence that both capital inflows into *investment-currency* bonds and dollar asset purchases by *funding-currency* investors correlate with dealer net futures positions and individual exchange rates. However, these macro capital flows lack the robust correlation property that we document is inherent to the net dealer positions.

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. Instead of using order flows to infer the likely shifts in currency demand, we use the actual currency risk positions taken by intermediaries, as suggested by the recent theoretical literature on frictional intermediation (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021, 2025a). We differ from the related literature that focuses on identifying exogenous shifts in currency demand and supply, including Camanho, Hau, and Rey (2022), Beltran and He (2023), Bräuer and Hau (2024), Barbiero, Bräuning, Joaquim, and Stein (2024), in that our goal is not to identify an exogenous currency demand shock or currency supply elasticity, but rather to capture in a reduced form the bulk of the variation in currency premia and exchange rates. We accomplish this by exploiting the remarkable explanatory power of the dealer banks' net FX futures position variable as a proxy for shifts in demand for currency risk.[3] This approach also sets our work apart from the growing literature on estimating structural currency and asset demand following the important work of Koijen and Yogo (2020).[4]

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).[5] A related literature establishing the connection between exchange rates and macro-financial variables includes Lustig, Roussanov, and Verdelhan (2011), Corte, Riddiough, and Sarno (2016), Jiang, Krishnamurthy, and Lustig (2021), Lilley, Maggiori, Neiman, and Schreger (2022).[6] We adopt from this literature the macro-finance variables that have proved to be most correlated with movements in exchange rates, and show how they can be mapped into shifts in intermediated currency supply and demand.

We also build on the growing empirical literature documenting interest rate parity deviations. Deviations from UIP have been extensively studied for decades by the theoretical and empirical literature following Fama (1984) as surveyed in Engel (2014), including Lustig and Verdelhan (2011), Hassan and Mano (2018), Kalemli-Özcan and Varela (2021), and more recently as a transmission

[3]An important advantage of the dealer futures position variable is that it is publicly available for a range of major currencies at high frequency, and, as we show, explains a large amount of variation in exchange rates and currency premia. This differentiates our approach from papers that provide a much more granular look at a particular derivative market, but rely on proprietary or confidential contract-level data (e.g. Hacioğlu-Hoke, Ostry, Rey, Rousset Planat, Stavrakeva, and Tang, 2024).

[4]Our work is also related to the closed-economy literature that estimates slopes of asset demand schedules and includes Koijen and Yogo (2019), Gabaix and Koijen (2021), van der Beck (2022), Haddad, He, Huebner, Kondor, and Loualiche (2025).

[5]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.

[6]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).

mechanism for bond demand shocks across countries in Gourinchas, Ray, and Vayanos (2025). Unlike UIP, the covered interest parity largely held for G10 currencies up until the Global Financial Crisis (GFC). Since then, the deviation from CIP became sizable and persistent across all G10 currencies versus the dollar, as reviewed by Du and Schreger (2022).[7]

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 (2023), 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 deviations. Bacchetta, Benhima, and Berthold (2025) consider the cost of FX interventions in a model of safe-haven countries where both CIP and UIP deviations are present. Consistent with our results, they argue that CIP and UIP deviations can be simultaneously negative for these 'funding' countries (in our notation). Instead of committing to a particular source of shocks or focus on a particular type of currency, our approach offers a framework that characterizes the joint determination of currency premia and exchange rates in a broad panel of currencies, consistent with their observed statistical properties.

2 Model of Currency Intermediation

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

2.1 Global intermediary

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

Balance sheet Table 1 defines the balance sheet variables of the bank and the associated returns. The liability side consists of the net worth W^*_t and external funding D^*_t, which we assume is in dollars. The associated external funding cost on the interbank dollar market is R^*_t. The asset side of the balance sheet consists of dollar reserves $B^*_t \geq 0$ that pay $\underline{R}^*_t$, risky investments $H^*_t \geq 0$ with

[7] The leading explanations for CIP deviations are 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, both in advanced (Ivashina, Scharfstein, and Stein, 2015; Liao and Zhang, 2025) and emerging economies (Dao and Gourinchas, 2025).

Table 1: International Bank: the Balance Sheet

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

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

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

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

We measure the size of the balance sheet with the magnitude of the risky investments H_t^*, leaving out reserves B_t^* and the dollar and LC funding variables A_t^* and D_t^*. Note that A_t^* and D_t^* can take both positive and negative values, with e.g. $A_t^* < 0$ corresponding to a net LC liability.[8]

In addition to the on-balance-sheet operations, Table 1 describes possible off-balance sheet positions. The bank can sell currency forwards and futures. We refer to the combined position F_t^* as just forwards for brevity. When $F_t^* > 0$, the bank sells dollars forward (in exchange for LC) at the forward rate $\mathcal{F}_t$. Conversely, when $F_t^* < 0$, the bank buys dollars and sells LC forward. The payout on a forward position is thus proportional to $(\mathcal{F}_t / \mathcal{E}_{t+1} - 1)$, as $\mathcal{F}_t$ units of LC are exchanged for one dollar. We normalize F_t^* to denote a commitment to buy $R_t \mathcal{E}_t F_t^*$ units of local currency in exchange for $R_t \mathcal{E}_t F_t^* / \mathcal{F}_t$ dollars at $t+1$. This convenient normalization implies that the associated currency-risk exposure equals to F_t^*.[9]

Finally, the bank can also sell dollar swaps, defined as simultaneous spot and forward transactions, with the forward leg at the swap rate $\mathcal{S}_t$. We denote the swap position with S_t^*, which can take positive or negative values. For a unitary positive position, $S_t^* = 1$, the bank exchanges $\mathcal{E}_t$ units of local currency (with a spot value of one dollar) for one dollar at t, and hence forgoes a one-period foreign-currency return $R_t \mathcal{E}_t$ for a dollar return R_t^*. At $t = 1$, the currencies are swapped

[8] Our analysis can be generalized to the case where LC assets and liabilities pay a differential return and the size of the balance sheet is defined as $H_t^* + \max\{A_t^*, 0\} - \min\{D_t^*, 0\}$.

[9] Indeed, one dollar invested in LC pays $R_t \mathcal{E}_t$ LC units at $t+1$ which are then converted back to dollars at the forward rate $\mathcal{F}_t$; thus, $R_t \mathcal{E}_t / \mathcal{F}_t$ characterizes the currency-risk exposure for one dollar committed at t.

back along with a hedge payoff $R_t\mathcal{E}_t/\mathcal{E}_{t+1} - R_t\mathcal{E}_t/\mathcal{S}_t$ in dollars. Putting these flows together yields a dollar return $R_t^* - R_t\mathcal{E}_t/\mathcal{S}_t$ per unit of the swap position S_t^*.[10] Note that swaps result in no additional currency risk exposure since all payoffs are pre-determined in dollars. Appendix Figure A1 illustrates cash flows for all on- and off-balance-sheet currency positions.

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:

$$W_{t+1}^* = \underline{R}_t^* B_t^* + \tilde{R}_{t+1}^* H_t^* + R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} A_t^* - R_t^* D_t^* + R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}\left(\frac{\mathcal{F}_t}{\mathcal{E}_{t+1}} - 1\right) F_t^* + \left(R_t^* - R_t\frac{\mathcal{E}_t}{\mathcal{S}_t}\right) S_t^*. \quad (2)$$

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

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

$$W_{t+1}^* = R_t^*(W_t^* - H_t^* - B_t^*) + \underline{R}_t^* B_t^* + \tilde{R}_{t+1}^* H_t^* + UIP_{t+1} \cdot Z_t^* + CIP_t \cdot X_t^*, \quad (3)$$

where

$$Z_t^* \equiv A_t^* + F_t^* \qquad \text{and} \qquad X_t^* \equiv F_t^* + S_t^* \quad (4)$$

are the currency-risk exposure and the hedged off-balance-sheet exposure of the bank, respectively; the realized UIP and CIP premia are given by:

$$UIP_{t+1} \equiv R_t \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - R_t^* \qquad \text{and} \qquad CIP_t \equiv R_t^* - R_t \frac{\mathcal{E}_t}{\mathcal{F}_t}. \quad (5)$$

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

The currency positions of the bank are summarized in the two exposure variables — the currency-risk exposure Z_t^* and the hedged off-balance-sheet exposure X_t^*. For a given Z_t^*, an increase in X_t^* leads to a larger off-balance sheet position without an increase in currency risk, as the pass-through of exchange rate volatility into net worth volatility is proportional to Z_t^* and does not separately depend on X_t^*, $\frac{\partial(W_{t+1}^*/W_t^*)}{\partial(\mathcal{E}_t/\mathcal{E}_{t+1})} = R_t Z_t^*/W_t^*$.

The compensation for the two exposures are the realized UIP and CIP premia, respectively. Note that they are defined in "reverse" directions in (5): we measure the currency exposure by the risk of

[10] Note that receiving one dollar in exchange for $\mathcal{E}_t$ units of local currency reduces both A_t^* (LC assets) and D_t^* (dollar liabilities) by one period-t dollar without changing the size of the balance sheet, yielding a dollar return $R_t^* - R_t\mathcal{E}_t/\mathcal{E}_{t+1}$. Adding to this the hedge payoff results in $R_t^* - R_t\mathcal{E}_t/\mathcal{S}_t$, i.e., the cash flow on a hedged contract to swap currency returns.

the LC depreciation (an increase in $\mathcal{E}_{t+1}$) and the off-balance-sheet exposure as the cost of foregoing LC return R_t relative to dollar return R_t^*. A forward position F_t^* affects both exposures X_t^* and Z_t^* simultaneously, and hence the payout on forwards collects both UIP and CIP premia. In contrast, swap position S_t^* does not result in exchange rate risk and hence carries only the CIP premium.

Balance sheet constraint The bank maximizes a discounted net worth $\mathbb{E}_t \Theta_{t+1} W_{t+1}^*$ subject to a balance sheet constraint, where Θ_{t+1} a stochastic discount factor such that $\mathbb{E}_t \Theta_{t+1} = 1/R_t^*$. This discount factor may represent risk preferences of the representative household or the owner of the bank. A non-stochastic discount factor, $\Theta_{t+1} \equiv 1/R_t^*$ is admissible, and 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 H_t^*, the currency-risk exposure Z_t^*, and the off-balance-sheet exposure X_t^*. Formally, we write the balance sheet constraint as:

$$B_t^* \geq a_t H_t^* + b_t |Z_t^*| + \delta |X_t^*|, \tag{6}$$

where

$$a_t \equiv \frac{\alpha}{2} \frac{H_t^*}{W_t^*} \qquad \text{and} \qquad b_t \equiv \frac{\gamma \sigma_t}{2} \frac{|Z_t^*|}{W_t^*}. \tag{7}$$

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

The balance sheet constraint (6) reflects the value-at-risk logic: greater exposure results in greater risk, and hence requires additional reserves. Additional risky investment H_t^* and exposure to the currency risk $|Z_t^*|$ require increasingly greater reserves. Indeed, each additional unit of exposure increases the contribution to net worth volatility in proportion to H_t^*/W_t^* and $\sigma_t |Z_t^*|/W_t^*$, respectively, where σ_t is the standard deviation of the carry return (the realized UIP premium). 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 or regulation. Therefore, the associated value at risk increases linearly with exposure $|X_t^*|$ rather than being convex in it, in contrast with $|Z_t^*|$.[11] Due to linearity of the constraint in $|X_t^*|$, we additionally assume that $|X_t^*| \leq \bar{X}^*$ for some $\bar{X}^*$.

Optimal portfolio The bank solves the following portfolio problem:

$$\max_{B_t^* \geq 0, H_t^* \geq 0, X_t^*, Z_t^*} \mathbb{E}_t \Theta_{t+1} W_{t+1}^* \quad \text{subject to (2), (6)–(7) and } |X_t^*| \leq \bar{X}^*. \tag{8}$$

[11] Intuitively, a leveraged risky position comes not only at the risk of losing its value, but also with the price risk of the underlying asset. The risk of X_t^* is a drift linked to counterparty default for forwards (and reflected in trading margin requirements for futures), while the risk of Z_t^* is a diffusion linked to the value of the underlying asset price. More generally, we could consider a class of reserve-requirement functions $\frac{1}{1+\epsilon}\big(|\cdot|/W_t^*\big)^{\epsilon}$ 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.

We denote with μ_t/R_t^* the Lagrange multiplier on the balance sheet constraint (6). We assume the bank takes returns $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$ and exchange rates $\{\mathcal{E}_t, \mathcal{F}_t\}$ as given, and make the following assumption which ensures that $H_t^* > 0$ and the balance sheet constraint is binding irrespective of the conditions in the currency market:

Assumption 1 *Reserves are costly, $\underline{R}_t^* < R_t^*$, and risky investment are profitable, $\mathbb{E}_t[\Theta_{t+1}\tilde{R}_{t+1}] > 1$.*

Furthermore, we denote the expected UIP premium as:

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

where $\widehat{\mathcal{E}}_t \equiv 1/\mathbb{E}_t\big[\frac{\Theta_{t+1}/\mathcal{E}_{t+1}}{\mathbb{E}_t\Theta_{t+1}}\big]$ is the risk-neutral expectation of the future spot exchange rate. With this, we prove in Appendix B the following characterization of the optimal portfolio positions of the bank:

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 must equal the forward exchange rate in equilibrium, $\mathcal{S}_t = \mathcal{F}_t$; and (b) the optimal portfolio choice of the bank satisfies:*

$$\frac{Z_t^*}{W_t^*} = \frac{1}{\gamma\mu_t\sigma_t}\overline{UIP}_t \qquad \textit{and} \qquad |X_t^*| = \begin{cases} 0, & \textit{if } |CIP_t| < \delta\mu_t, \\ \in [0, \bar{X}^*], & \textit{if } |CIP_t| = \delta\mu_t, \\ \bar{X}^*, & \textit{if } |CIP_t| > \delta\mu_t, \end{cases} \tag{10}$$

and X_t^* has the same sign as CIP_t.

When the balance sheet constraint is binding, the opportunity cost of expanding an exposure which requires one extra dollar of reserves is equal to $\mu_t = R_t^* - \underline{R}_t^*$, and hence the bank will only take such exposure if it is sufficiently compensated. Additional off-balance-sheet exposure X_t^* requires a proportional increase in B_t^*, and the bank is willing to take it if $|CIP_t| \geq \delta\mu_t$, but not otherwise. Furthermore, X_t^* has the same sign as CIP_t since the associated revenue of the bank $CIP_t \cdot X_t^*$ must be positive to cover the opportunity cost of reserves. For example, for a constant $CIP_t = \delta\mu_t$, the bank is willing to take any position $X_t^* \in [0, \bar{X}^*]$. Required reserves are convex in risky exposures H_t^* and Z_t^*. As a result, the bank is willing to expand its currency exposure only if it obtains a larger UIP premium, and hence Z_t^*/W_t^* is increasing in $\overline{UIP}_t$ and decreasing in the associated balance-sheet cost $\gamma\mu_t\sigma_t$.

Lastly, note that the currency-risk exposure Z_t^* is associated with both local currency investment A_t^* and forward positions F_t^*. Both must carry an expected UIP premium for the bank to take them on the margin. 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 with the CIP premium. Thus, a forward position of the bank carries both currency premia, $\overline{UIP}_t + CIP_t = R_t\mathcal{E}_t\big(\frac{1}{\widehat{\mathcal{E}}_t} - \frac{1}{\mathcal{F}_t}\big)$.

2.2 Currency market equilibrium

Taking as given the path of interest rates and asset returns, $\{\underline{R}_t^*, R_t^*, R_t, \tilde{R}_{t+1}^*\}$, we now focus on the partial equilibrium in the currency market and solve for the two exchange rates: the spot exchange rate $\mathcal{E}_t$ and the forward exchange rate $\mathcal{F}_t$. The two exchange rates correspond to the two equilibrium premia reflected in the expected UIP deviation and the CIP deviation.[12] We focus on a given currency k market and hence still suppress the currency index.

The two premia equilibrate supply and demand in the currency market. We first consider a special case with exogenous demand to borrow in LC $\mathbf{A}_t^*$, to sell LC forward $\mathbf{F}_t^*$, and to swap dollars for LC $\mathbf{S}_t^*$, all of which may take positive or negative values. We later relax the assumption of exogenous demand and consider a general case that we take to the data. We further refer to $\mathbf{X}_t^* \equiv \mathbf{F}_t^* + \mathbf{S}_t^*$ and $\mathbf{Z}_t^* \equiv \mathbf{A}_t^* + \mathbf{F}_t^*$ as, respectively, *hedged* and *unhedged* currency demand. Intuitively, we can view $\mathbf{Z}_t^*$ as demand to sell LC risk, while $\mathbf{X}_t^*$ as demand to hold LC assets without the associated currency risk (when $\mathbf{Z}_t^*$ is held constant).

In equilibrium, currency demand must be met by respective currency supply by a collection of intermediaries $i \in \mathcal{I}_t$. Proposition 1 characterizes currency supply schedules of an individual intermediary bank i: Z_{it}^* and X_{it}^* given by (10). Recall that conditional on Z_{it}^* and X_{it}^*, the intermediary bank is indifferent between various combinations of $(A_{it}^*, F_{it}^*, S_{it}^*)$ as it views them as perfect substitutes. Market clearing requires:

$$\sum\nolimits_{i\in\mathcal{I}_t} Z_{it}^* = \mathbf{Z}_t^* \qquad \text{and} \qquad \sum\nolimits_{i\in\mathcal{I}_t} X_{it}^* = \mathbf{X}_t^*, \tag{11}$$

Assuming that all banks face the same UIP and CIP deviations allows for aggregation of positions under equilibrium prices. In particular, individual banks may differ in their net worth W_{it}^* and balance-sheet constraint parameters γ_{it} and δ_{it}, but face the same market prices and hence $\mu_t = R_t^* - \underline{R}_t^*$ and $\sigma_t^2 = R_t^2 \text{var}_t\big(\mathcal{E}_t/\mathcal{E}_{t+1}\big)$ are common across banks.

Combining market clearing equation (11) with the optimal supply schedules of the intermediary banks (10) results in the following equilibrium characterization (see Appendix B):

Proposition 2 *The expected UIP and CIP premia that equilibrate the currency market equal:*

$$\overline{UIP}_t = \bar{\gamma}_t \mu_t \sigma_t \cdot \frac{\mathbf{Z}_t^*}{\mathbf{W}_t^*} \qquad \textit{and} \qquad CIP_t = \begin{cases} \bar{\delta}_t \mu_t, & \textit{if } \mathbf{X}_t^* > 0, \\ -\bar{\delta}_t \mu_t, & \textit{if } \mathbf{X}_t^* < 0, \end{cases} \tag{12}$$

where $\mathbf{W}_t^* \equiv \sum_{i\in\mathcal{I}_t} W_{it}^*$ is the aggregate net worth of intermediary banks, $\bar{\gamma}_t \equiv \big(\frac{1}{\mathbf{W}_t^*}\sum_{i\in\mathcal{I}_t} W_{it}^*/\gamma_{it}\big)^{-1}$ is the hyperbolic weighted average of γ_{it} across banks, and $\bar{\delta}_t = \delta_{it}$ is the tightness of the balance sheet constraint of the marginal intermediary bank i supplying forwards and swaps.[13]

[12] Note that $\overline{UIP}_t$ depends on both the current spot exchange rate $\mathcal{E}_t$ and the expectation of the future exchange rate $\mathcal{E}_{t+1}$, or more precisely $\widehat{\mathcal{E}}_t$ defined in equation (9), while CIP_t depends on the forward premium $\mathcal{F}_t/\mathcal{E}_t$.

[13] Formally, $\bar{\delta}_t$ is such that all banks $i \in \mathcal{I}_t$ 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.

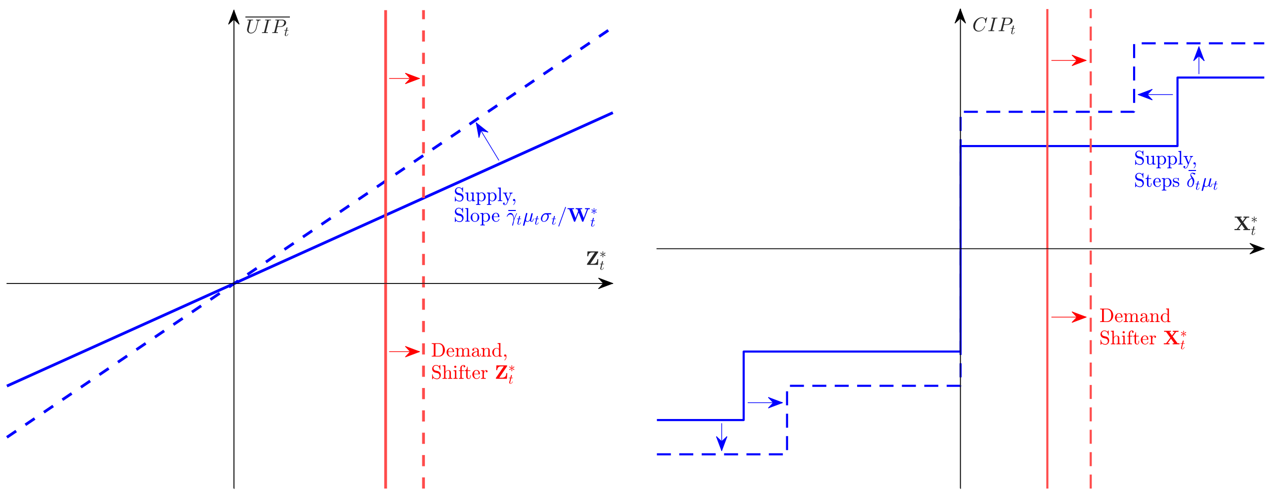

Figure 2: Currency market equilibrium

Note: The figure illustrates currency market equilibrium described in Proposition 2: changes in $\bar{\gamma}_t\mu_t\sigma_t/\mathbf{W}_t^*$ rotate (change the elasticity) of the unhedged currency supply schedule in the left panel, while changes in $\bar{\delta}_t\mu_t$ change the step function of the hedged currency supply in the right panel; shifts in $\mathbf{Z}_t^* = \mathbf{A}_t^* + \mathbf{F}_t^*$ and $\mathbf{X}_t^* = \mathbf{F}_t^* + \mathbf{S}_t^*$ translate into movements along the respective currency supply schedules in response to shifts in currency demand.

Proposition 2 emphasizes both the key similarities and the key differences between the equilibrium UIP and CIP premia. Both UIP and CIP premia expand in periods of large financial spreads as captured by $\mu_t = R_t^* - \underline{R}_t^*$ due to the overall tightened funding constraints. CIP and expected UIP premia have the sign of hedged and unhedged currency demand, $\mathbf{X}_t^*$ and $\mathbf{Z}_t^*$, respectively. 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 in these distributions (first order stochastic dominance) increasing the equilibrium premia.

The main difference between UIP and CIP premia is that the UIP premium increases monotonically in the unhedged currency demand $\mathbf{Z}_t^*$ with a slope $\bar{\gamma}_t\mu_t\sigma_t/\mathbf{W}_t^*$, while the size of the CIP deviation depends only on the aggregate financial conditions $\bar{\delta}_t\mu_t$ and the *direction* of the hedged currency demand, i.e., the sign of $\mathbf{X}_t^*$. We illustrate this stark testable implication in Figure 2.[14] Conditions (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. In particular, we expect the UIP premium to respond continuously to currency demand shocks, while the CIP premium to shift only with aggregate market conditions captured by $\bar{\delta}_t\mu_t$ without responding to local currency demand shocks. Conditions (12) also characterize the response of the spot and forward exchange rates $\mathcal{E}_t$ and $\mathcal{F}_t$ to currency demand shocks.[15]

[14]This difference is likely less pronounced in levels, as $\bar{\delta}_t$ may be increasing in $\mathbf{X}_t^*/\mathbf{W}_t^*$ in equilibrium, which requires more banks to become active, increasing δ_{it} of the marginal bank. Nonetheless, for local changes, we assume and later verify in the data that $\bar{\delta}_t$ does not change with month-to-month variation in currency demand, absent major shocks.

[15]Note that the level of the exchange rate is determined by other equilibrium forces left outside our partial equilibrium model, i.e., the equilibrium in the goods market and the country's budget constraint (see Itskhoki and Mukhin, 2021).

Endogenous shifts in currency demand The description above was simplified in that it assumed exogenous shifts in currency demand that are accommodated by a group of intermediaries that move along their currency supply schedules. We now discuss how the characterization in Proposition 2 generalizes to the case where shifts in currency demand are further microfounded. For brevity, we focus here on the market for unhedged currency risk, and a similar characterization applies in the hedged currency market.

Without loss of generality, we can partition all agents participating in the currency market into two subsets, $\mathcal{I}$ and $\mathcal{I}^N$, and we label them as intermediaries and non-intermediaries. Any agent $i \in \mathcal{I} \cup \mathcal{I}^N$ takes a currency exposure Z_{it}^*. Equilibrium in a zero-net-supply currency risk market requires $\sum_{i\in\mathcal{I}} Z_{it}^* + \sum_{i\in\mathcal{I}^N} Z_{it}^* = 0$. Therefore, the market clearing condition (11) is generalized to feature an endogenous shifter $\mathbf{Z}_t^* \equiv -\sum_{i\in\mathcal{I}^N} Z_{it}^*$ such that in equilibrium we still have $\sum_{i\in\mathcal{I}} Z_{it}^* = \mathbf{Z}_t^*$.

Finally, we assume that the currency position of any agent i satisfies:

$$\frac{Z_{it}^*}{W_{it}^*} = \rho_{it} \cdot \overline{UIP}_t - \lambda_{it}. \tag{13}$$

Greater expected currency premium compels agents to take larger currency positions with individual *slope* parameters $\rho_{it} \geq 0$ and subject to a demand *shifter* λ_{it} which reflects binding portfolio constraints and/or subjective expectations.[16] In general, every agent has a shifter and a slope in their portfolio choice, which are more suitable terms than "demand" and "supply" in a zero-net-supply currency market. For example, an intermediary's portfolio choice rule characterized in Proposition 1 satisfies (13) as a special case with $\lambda_{it} = 0$ and $\rho_{it} = 1/(\gamma_{it}\mu_t\sigma_t)$.

We focus on variation around a long-run equilibrium in which agents $i \in \mathcal{I} \cup \mathcal{I}^N$ have a currency-demand shifter $\bar{\lambda}_i$ and a slope $\bar{\rho}_i$, as well as net worth $\bar{W}_i^*$, and we define their cross-sectional averages as $\Lambda \equiv \sum_i \bar{W}_i^* \bar{\lambda}_i$ and $\varrho \equiv \sum_i \bar{W}_i^* \bar{\rho}_i$. By market clearing, the long-run UIP premium is given by $\overline{UIP} = \varrho^{-1}\Lambda$, and it is generally different from zero as long as currency demand shifters do not average out and $\Lambda \neq 0$. This is the currency fixed effect. The remaining characterization is in deviations from this long-run equilibrium (see Appendix B).

In particular, the currency position (13) of agent i can be approximated as follows:

$$\frac{\tilde{Z}_{it}^*}{\bar{W}_i^*} = \bar{\rho}_i \cdot \widetilde{UIP}_t - \xi_{it}, \qquad \text{where} \qquad \xi_{it} \equiv \tilde{\lambda}_{it} + \overline{UIP} \cdot \tilde{\rho}_{it} + \frac{\bar{Z}_i^*}{\bar{W}_i^*}\frac{\tilde{W}_{it}^*}{\bar{W}_i^*}. \tag{14}$$

and tildes denote variation around the long-run values, e.g., $\tilde{Z}_{it}^* \equiv Z_{it}^* - \bar{Z}_i^*$ and $\widetilde{UIP}_t \equiv \overline{UIP}_t - \overline{UIP}$. The representation in (14) features a constant agent-specific slope $\bar{\rho}_i$ and a demand shifter ξ_{it} that depends on three terms, namely, the variations in the primitive demand shifter $\tilde{\lambda}_{it}$, in the slope $\tilde{\rho}_{it}$, and in the agent's net worth $\tilde{W}_{it}^*$. The variation in the slope of currency supply for a subset of agents (or their net worth) becomes a currency demand shock for the market, as we show next.

[16] Note that (13) can be viewed as an OLS projection for a general portfolio choice rule; in this case, λ_{it} is a residual uncorrelated with $\overline{UIP}_t$.

Lemma 2 (a) *The equilibrium variation in the UIP premium is given by:*[17]

$$\widetilde{UIP}_t = \varrho^{-1} \cdot \Xi_t, \qquad \text{where} \qquad \Xi_t \equiv \sum\nolimits_{i\in\mathcal{I}\cup\mathcal{I}^N} \bar{W}_i^* \xi_{it}$$

is the aggregate shift in currency demand and $\varrho \equiv \sum_{i\in\mathcal{I}\cup\mathcal{I}^N} \bar{W}_i^* \bar{\rho}_i$ *is the aggregate slope of currency supply.* (b) *The equilibrium variation in the combined currency position of the intermediary sector is:*

$$\tilde{\mathbf{Z}}_t^* = \varrho_I \cdot \widetilde{UIP}_t - \sum\nolimits_{i\in\mathcal{I}} \bar{W}_i^* \xi_{it},$$

where $\varrho_I \equiv \sum_{i\in\mathcal{I}} \bar{W}_i^* \bar{\rho}_i$ *is the long-run slope of currency supply by the intermediary sector and* $\sum_{i\in\mathcal{I}} \bar{W}_i^* \xi_{it}$ *is the combined shifter in the intermediaries' currency positions.*

This lemma generalizes the result of Proposition 2 to the case with endogenous shifts in currency demand. In particular, a component of the aggregate shift in currency demand arises from the intermediary sector: $\Xi_t = \sum_{i\in\mathcal{I}} \bar{W}_i^* \xi_{it} + \sum_{i\in\mathcal{I}^N} \bar{W}_i^* \xi_{it}$. Even under the conditions of Proposition 1, where $\lambda_{it} = 0$ for all intermediaries $i \in \mathcal{I}$, variation in their net worth W_{it}^* and slopes $\rho_{it} = 1/(\gamma_{it}\mu_t\sigma_t)$ translates into effective demand shifts. However, if this variation is small relative to aggregate shifts in currency demand, then the combined currency position of the intermediary sector $\mathbf{Z}_t^*$ tracks closely the variation in the UIP premium. In the limiting case when this variation is absent, we again recover the result of Proposition 2 that $\overline{UIP}_t = \varrho_I^{-1} \cdot \mathbf{Z}_t^*$ where $\varrho_I^{-1} = \bar{\gamma}\mu\sigma/\mathbf{W}^*$. In other words, when the intermediary sector features stable currency supply and few shocks to currency demand, the net currency position of intermediaries tracks closely the UIP premium. We formalize this claim in Appendix B.

The expressions in Proposition 2 and Lemma 2 are equilibrium relationships resulting in a correlation between the combined currency position of intermediaries and the UIP premium. As Figure 2 illustrates, given a stable supply schedule of intermediaries (as formalized in Lemma 2), variation in their aggregate positions are in a one-to-one relationship with the equilibrium UIP premium. Shifts in intermediaries supply schedules, if not controlled for, reduce the size of this correlation. In any case, this is an equilibrium comovement and not a causal relationship.[18] The predictions of the theory — in particular, in Propositions 1 and 2 — is that intermediaries take currency positions in response to shifts in aggregate currency demand and make predictable currency returns in the form of UIP (and CIP) premia.

[17] Note that the overall UIP premium is given then by $\overline{UIP}_t = \overline{UIP} + \widetilde{UIP}_t = \varrho^{-1} \cdot (\Lambda + \Xi_t)$.

[18] Note that intermediary sector may or may not be essential in the equilibrium UIP determination. For example, when a subset of intermediaries are small relative to the overall currency market in terms of their net worth, their currency positions respond to the UIP premium, but do not affect its equilibrium value: in terms of Lemma 2, these intermediaries are too small to affect either ϱ or Ξ_t. We show in the data, however, that the net position of the intermediary sector is large relative to the overall market.

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 (12) as:

$$\overline{UIP}_{kt} \equiv R_{kt}\frac{\mathcal{E}_{kt}}{\widehat{\mathcal{E}}_{kt}} - R_t^* = \bar{\gamma}_{kt}\mu_t\sigma_{kt}\cdot\frac{\mathbf{Z}_{kt}^*}{\mathbf{W}_{kt}^*}, \tag{15}$$

$$CIP_{kt} \equiv R_t^* - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} = \begin{cases} \bar{\delta}_{kt}\mu_t, & \text{if } \mathbf{X}_{kt}^* > 0, \\ -\bar{\delta}_{kt}\mu_t, & \text{if } \mathbf{X}_{kt}^* < 0, \end{cases} \tag{16}$$

where the tightness of the balance-sheet constraint $\mu_t = R_t^* - \underline{R}_t^*$ is common across currencies, while all other variables, in general, vary in the cross section of currencies. Note that $\mathcal{E}_{kt}$ and $\mathcal{F}_{kt}$ are the spot and forward exchange rates of currency k for one dollar, $\hat{\mathcal{E}}_{kt}$ is the (risk-neutral) expectation of the future currency k spot exchange rate defined in (9), R_{kt} is the currency k interest rate, and R_t^* is the dollar interest rate. Finally, $\mathbf{X}_{kt}^*$ and $\mathbf{Z}_{kt}^*$ are hedged and unhedged demand for currency k that in equilibrium are accommodated by the intermediary sector.

Cross section of currencies A fundamental difference between countries is the supply of local-currency savings relative to the demand for local-currency investment. This mismatch needs to be intermediated. In the notation of our model, the aggregate *local-currency funding gap* corresponds to $\mathbf{A}_{kt}^*$ which measures the extent of local-currency investment that needs to be covered with foreign-currency funding. Thus, $\mathbf{A}_{kt}^* > 0$ corresponds to countries with excess demand for local-currency funding or insufficient supply of local-currency savings. Conversely, $\mathbf{A}_{kt}^* < 0$ corresponds to countries with excess supply of local-currency savings, and hence a need to convert them into foreign-currency (dollar) investments. Empirically, $\mathbf{A}_{kt}^*$ is a persistent slow-moving variable.

Instead of specifying a complete general equilibrium model, we make the following two empirically-motivated assumptions that allow us to link currency returns to the local-currency funding gap:

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

This is a martingale assumption on the nominal exchange rate. It can be readily generalized to an environment with drift due to systematic inflation differentials, which are effectively absent in our sample of developed countries between 2000 and 2020.[19]

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

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

Countries with a local-currency funding gap, $\mathbf{A}^*_{kt} > 0$, have insufficient local funds to satisfy local-currency investment. This pushes up the local-currency interest rate and attracts foreign capital. Conversely, countries with excess supply of local-currency funding, $\mathbf{A}^*_{kt} < 0$, feature low local-currency interest rates and capital outflows. Thus, R_{kt} correlates positively with $\mathbf{A}^*_{kt}$. Investors follow the interest rate differentials and generate demand for swaps as they seek higher return investments without exposure to the currency risk, and hence $\mathbf{S}^*_{kt}$ has the same sign as $\mathbf{A}^*_{kt}$. Similarly, investing in the high-interest-rate currency creates hedging demand to sell this currency forward, and hence $\mathbf{F}^*_{kt}$ has the same sign as $\mathbf{A}^*_{kt}$.[20] Assumption 3 is the summary of these relationships which are in line with the patterns in the data. In particular, the relationship between $\mathbf{A}^*_{kt}$ and $R_{kt} - R^*_t$ is verified in Section 3.2, while the correlation between $\mathbf{A}^*_{kt}$ and $\mathbf{S}^*_{kt}$ and between $\mathbf{A}^*_{kt}$ and $\mathbf{F}^*_{kt}$ are documented, e.g., by Moskowitz, Ross, Ross, and Vasudevan (2024) and Hacioğlu-Hoke, Ostry, Rey, Rousset Planat, Stavrakeva, and Tang (2024), respectively.

Proposition 3 *Under Assumption 2 and 3, currencies with a local-currency funding gap, $\mathbf{A}^*_{kt} > 0$, feature positive UIP and CIP premia, and expensive forward dollars, $\mathcal{F}_{kt} > \mathcal{E}_{kt}$; and vice versa.*

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

$$\mathbb{E}\big\{\overline{UIP}_{kt}\big\} = \mathbb{E}\{R_{kt} - R^*_t\}. \tag{17}$$

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. Then, by Proposition 2, this interest rate differential must equal the compensation collected by the intermediary banks for their persistent currency-risk exposure reflected in $\mathbf{Z}^*_{kt} = \mathbf{A}^*_{kt} + \mathbf{F}^*_{kt}$, which by Assumption 3 is positive for countries with scarce local-currency funding ($\mathbf{A}^*_{kt} > 0$) and high interest rates, and vice versa.

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

$$CIP_{kt} = R^*_t - R_{kt}\frac{\mathcal{E}_{kt}}{\mathcal{F}_{kt}} > 0 \qquad \Rightarrow \qquad \frac{\mathcal{F}_{kt}}{\mathcal{E}_{kt}} > \frac{R_{kt}}{R^*_t} > 1, \tag{18}$$

that is, a local-currency forward premium beyond an already positive interest rate differential. In words, forward dollars are expensive in countries with a local-currency funding gap $\mathbf{A}^*_{kt} > 0$ and high interest rates, a cross-sectional version of the forward premium puzzle. Similarly, CIP

[20] Intuitively, the interest rate differentials are a source of demand for high-interest-rate currency swaps and to sell this currency forward. That is, $R_{kt} > R^*_t$ results in demand to buy local-currency swaps $\mathbf{S}^*_{kt} > 0$ and sell local currency forward $\mathbf{F}^*_{kt} > 0$, while $R_{kt} < R^*_t$ results in demand for dollar swaps $\mathbf{S}^*_{kt} < 0$ and to sell dollar forwards $\mathbf{F}^*_{kt} < 0$. High interest rate is generally reflective of other high-return local investment opportunities which may be the ultimate goal of currency swaps and the reason for hedging needs. 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, $\mathbf{F}^*_{kt} > 0$.

premium is negative and forward dollars are cheap, $\mathcal{F}_{kt}/\mathcal{E}_{kt} < R_{kt}/R_t^* < 1$, for currencies with $\mathbf{A}_{kt}^* < 0$ and $\mathbf{X}_{kt}^* < 0$. The equilibrium forward rate compensates the intermediary banks with an appropriate CIP premium for their swap and forward positions over and above the interest rate gap between the two currencies.

The long-run equilibrium outcomes summarized in (17) and (18) emphasize the difference from the frictionless benchmark in which covered and uncovered parities hold and the interest rate differential R_{kt}/R_t^* equals both the forward premium $\mathcal{F}_{kt}/\mathcal{E}_{kt}$ and the expected (risk-neutral) currency depreciation $\widehat{\mathcal{E}}_{kt}/\mathcal{E}_{kt}$. Under frictional intermediation, currency premia persist in equilibrium to accommodate hedged and unhedged currency demand that result from the country's funding gap.

Currency premia dynamics The predictions of our model, as summarized in currency supply schedules (15)–(16), have further implications for currency premia and exchange rate dynamics. First, consider a small local-currency demand shock $\mathrm{d}f_{kt}^*$ such that $\mathrm{d}f_{kt}^* > 0$ corresponds to a forward sale of local currency for dollars with $\mathrm{d}\mathbf{Z}_{kt}^*/\mathrm{d}f_{kt}^* > 0$ and $\mathrm{d}\mathbf{X}_{kt}^*/\mathrm{d}f_{kt}^* > 0$. These result in shifts along currency supply schedules, as in Figure 2, such that:

$$\mathrm{d}\,\overline{UIP}_{kt}/\mathrm{d}f_{kt}^* > 0 \qquad \text{and} \qquad \mathrm{d}\,CIP_{kt}/\mathrm{d}f_{kt}^* = 0, \tag{19}$$

The CIP remains unchanged provided the change in $\mathrm{d}f_{kt}^*$ is small enough not to affect the identity of the marginal bank and leaving $\bar{\delta}_{kt}$ unchanged in (16).

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

$$\mathrm{d}\left|\overline{UIP}_{kt}\right|/\mathrm{d}\mu_t > 0 \qquad \text{and} \qquad \mathrm{d}\left|CIP_{kt}\right|/\mathrm{d}\mu_t > 0, \tag{20}$$

and we furthermore have that the impact of financial shocks on the UIP premium is increasing in the funding gap, $\mathrm{d}\overline{UIP}_{kt}/\mathrm{d}\mu_t \propto \mathbf{A}_{kt}^*$. That is, both UIP and CIP premia span out becoming more positive for investment currencies with $\mathbf{A}_{kt}^* > 0$ and more negative for funding currencies with $\mathbf{A}_{kt}^* < 0$, as by Assumption 3 the funding gap $\mathbf{A}_{kt}^*$ determines the long-run levels of currency demand $\mathbf{Z}_{kt}^*$ and $\mathbf{X}_{kt}^*$. Finally, the same comparative dynamics as in (20) applies for shocks to $\bar{\gamma}_{kt}/\mathbf{W}_{kt}^*$ and to $\bar{\delta}_{kt}$ for UIP and CIP premia, respectively, capturing shocks to supply of currency intermediation. In practice, we expect these shocks to be highly correlated with the global financial and dollar cycles.

3 Empirical Results

We now turn to data to test the key empirical predictions resulting from Section 2. We first describe the data used to test these predictions, including the construction of UIP and CIP deviations, the data on intermediary currency positions, 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 and futures position. These are the G7+ advanced economies and 4 emerging market currencies.[21] 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.

Following the definitions of UIP and CIP premia in (5) 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:

$$\begin{aligned} CIP_{kt} &= -(r_{kt} - r_t^{US}) + 4 \cdot \log(\mathcal{F}_{kt}/\mathcal{E}_{kt}), \\ UIP_{k,t+3} &= \quad (r_{kt} - r_t^{US}) - 4 \cdot \log(\mathcal{E}_{k,t+3}/\mathcal{E}_{kt}), \\ \widehat{UIP}_{kt} &= \quad (r_{kt} - r_t^{US}) - 4 \cdot \log\big(\widehat{\mathcal{E}}_{kt}/\mathcal{E}_{kt}\big), \end{aligned} \tag{21}$$

where r_{kt} is the net 3-month money market or deposit interest rate for currency k, r_t^{US} is the corresponding US dollar interest rate, both annualized; $\mathcal{E}_{kt}$ is the spot exchange rate in month t (in units of local currency k per US dollar), $\mathcal{F}_{kt}$ is the 3-month outright forward exchange rate quoted in t, and $\widehat{\mathcal{E}}_{kt}$ is the 3-month ahead consensus survey exchange rate forecast at t.[22] Thus, the final term in each equation in (21) measures an annualized depreciation rate — forward, realized, and forecasted, respectively. Note that, as in the theory, the direction of the CIP premium is measured "in reverse" to conform with the conventional basis definition.

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

[21] We adopt the currency market terminology for G7+ currencies that include 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 in our sample are Mexican Peso (MXN), Brazilian Real (BRL), South African Rand (ZAR) and Russian Ruble (RUB).

[22] 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.

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.

Local-currency funding gap Proposition 3 suggests that the local-currency funding gap $\mathbf{A}^*_{kt}$ is the key determinant of currency premia in the cross-section. Recall that this variables measures the gap between local-currency investment needs and supply of savings. That is, a country with a positive average gap $\bar{\mathbf{A}}^*_k \equiv \mathbb{E}A^*_{kt} > 0$ needs foreign-currency funding to cover local-currency investment. Assuming foreign-currency funding is mostly in US dollar, we proxy for $\mathbf{A}^*_{kt}$ with the negative of the *external dollar asset gap* defined as the difference between external dollar-debt assets and dollar-debt liabilities in percent of domestic GDP, and refer to it simply as the *funding gap*.[23]

Intermediary banks FX positions Our theory emphasizes changes in net futures and forward positions $\mathbf{F}^*_{kt}$ of the intermediary sector as a proxy for shifts in the currency demand. While forwards are traded in OTC markets, are much less liquid and hard to observe, futures are exchange-traded standardized contracts and can therefore capture fast-moving market conditions. We use net futures positions of FX intermediaries in various currencies vis-à-vis the US dollar from the publicly-available CFTC's *Traders in Financial Futures* (TFF) weekly report. The TFF report provides a weekly snapshot (as of each Tuesday) of the aggregate net long/short futures positions of every major currency traded on the Chicago Mercantile Exchange (CME), broken down into the underlying positions of four institutional categories of large traders: "Dealer/Intermediary", "Asset Manager", "Leveraged Funds" and "Other" (e.g., corporate treasurers, smaller banks). The first category is conventionally called the "sell side", while the other categories represent the "buy side". Such *sell-side* entities on FX futures markets are primarily represented by broker-dealer arms of a handful of major global banks such as Goldman Sachs, JP Morgan and Deutsche Bank.[24]

We scale the monthly dealer net futures position by the size of the market measured by the total amount of open interest on the CME for a given currency:[25]

$$f^*_{kt} = 100 \cdot \frac{\text{Dealer Net Position}_{kt}}{\frac{1}{m}\sum_{j=0}^{m-1}\text{Open Interest}_{k,t-j}}, \tag{22}$$

[23] These data, constructed by Benetrix, Gautam, Juvenal, and Schmitz (2019) and updated by Allen and Juvenal (2025), are part of a comprehensive decomposition of external balance sheets across countries by major currencies, done at the annual frequency and available from 1990 to 2020. We focus on debt positions (as opposed to equity) as these require intermediation through currency markets and are more likely to be hedged than equity.

[24] See the full list at 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. A number of studies have used the non-commercial futures position in the COT report as a measure of speculative FX exposure (see e.g. Klitgaard and Weir, 2004; Brunnermeier, Nagel, and Pedersen, 2009; Tornell and Yuan, 2012; Hong and Yogo, 2012; Stavrakeva and Tang, 2020). Instead, we use the TFF breakdown of positions by trader type, irrespective of their trading motive, as it is more fitting with our theory and, as it turns out, also with the data.

[25] The underlying TFF data is weekly with futures positions recorded on Tuesday of each week. To smooth out the noise in any particular Tuesday, we take the average of the weekly positions over the month to obtain our monthly data.

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). As our baseline, we take the 12-month moving average of monthly open interest contracts in the denominator (i.e., $m = 12$) to capture the slow-moving trend growth in the market size. All empirical results are robust when we use a different horizon m for the moving average or just the month-specific open interest, $m = 1$, as in all cases the bulk of the variation in Δf^*_{kt} comes from the variation in the net position in the numerator.

Both dealer net position and open interest in (22) are measured in number of standardized contracts (in fixed currency k units, such as 125K euros), and the scaling makes our measure *unitless*. More precisely, we express the dealer net position as % of the size of the market, irrespective of the currency or standardized units in which the size of the market is evaluated.[26] This eliminates from our measure a potential source of mechanical correlation with the exchange rate: specifically, it requires an active change in the positions of some participants, rather than a pure valuation effect, for f^*_{kt} to change.

A positive value for f^*_{kt} means that dealer banks are long in the FX currency future and short the US dollar, and hence accommodate the opposite position of the market composed, in turn, primarily of asset managers/institutional investors and leveraged/hedge funds (see Appendix Table A2).[27] Appendix Table A3 reports summary statistics for monthly changes in dealer net futures positions, Δf^*_{kt}, by currency.[28] These changes are large as dealer banks are the key market makers, with one standard deviation change in their net positions amounting to nearly 20 percent of the total futures market size for each currency. Furthermore, dealer banks change positions in both directions over time, from being short to long in any given currency against the dollar. Appendix Figure A5 plots dealer net futures positions by currency: while they do co-move in tandem to some extent, likely driven by shifts in broad dollar demand and other global factors, there is a substantial currency-specific variation.

Although CME is the largest FX futures market worldwide, the futures market itself makes up a smaller share of the total FX derivative trade, and a larger volume of FX trade occurs in forwards and swaps.[29] In recent years, however, trading volumes in CME-listed FX futures have grown signif-

[26] This is precise when $m = 1$ in (22) and holds as an accurate approximation for $m > 1$, including when $m = 12$. We confirm this by re-evaluating the positions in the definition of f^*_{kt} in US dollars and verify that the resulting Δf^*_{kt} are nearly perfectly correlated with our baseline measure.

[27] This negative correlation in positions raises the question of who collects and who pays the currency premium. We show below that dealer/intermediary positions are associated with positive expected currency returns, albeit with modest Sharpe ratios. It is natural that asset managers pay the currency hedging premium, while leveraged funds are likely engaged in more complex asset-market strategies with higher Sharpe ratios for which the currency leg is only a small component of the returns.

[28] For G7+ currencies, TFF reports go back to June 2006 providing us with 218 monthly observations per currency. The Mexican Peso (MXN) is the only emerging market currency for which we have comparable coverage. TFF also reports positions 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.

[29] The 2022 BIS Triennual Survey reports that the average daily trading volume was \$0.3 trillion for the exchange-traded FX futures and options, \$1.2 trillion in outright forwards, \$3.8 trillion in FX swaps, and compared to \$2 trillion in spot trading volume. The US dollar was on one side of around 90 percent of all FX trades. See BIS (2025).

icantly, especially for G7 currencies, becoming a major venue for FX price discovery (Levich, 2012; Hong and Yogo, 2012; BIS, 2024). To the extent price discovery happens in the futures market, shifts in positions in this market should be indicative of broader shifts in currency demand, a feature we exploit and validate in our empirical exercise below.

Slope of the currency supply Besides shifts in dealer banks' currency positions proxied by (22), 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 $\mathbf{W}_t^*$, or the balance-sheet constraint parameters $\bar{\gamma}_{kt}$ and $\bar{\delta}_{kt}$. In practice, empirical measures of these slope variables tend to be correlated. Higher dollar funding costs are often associated with more global risk aversion, larger implied volatility, lower bank net worth, and lower associated intermediation capacity (see e.g. Miranda-Agrippino and Rey, 2022; Avdjiev, Du, Koch, and Shin, 2019). The sample correlation matrix in Appendix Table A4 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.[30] The Japanese yen and Swiss franc, as well as the Euro, feature lower average interest rates relative to the dollar, while other currencies have a higher average interest rate, especially commodity currencies — Australian and New Zealand dollars — and emerging market currencies, the latter countries reflecting in part both inflation and default risks in addition to currency risk.

Column 1 of Table 2 reports the average funding gap $\bar{\mathbf{A}}_k^*$ which is our proxy for the gap between local-currency investment needs and supply of savings. There is a clear positive correlation between the average funding gap $\bar{\mathbf{A}}_k^*$ and the average interest rate differential $\bar{R}_k - \bar{R}^*$. Currencies with a large funding gap feature high local-currency interest rates, and vice versa. We illustrate this pattern in Figure 3 for G7+ currencies and in Appendix Figure A7 for a broader set of currencies.

Countries with a positive funding gap and positive interest rate differentials feature positive

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

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

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

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

average currency returns (average realized UIP deviations, $\overline{UIP}_{k,+1}$), positive average expected survey-based UIP deviations ($\widehat{UIP}_k$) and positive average CIP deviations ($\overline{CIP}_k$), and vice versa, as we report in columns 3–5 of Table 2. The larger the average interest rate differential, $\bar{R}_k - \bar{R}^*$, the larger the UIP and CIP deviations. We illustrate these patterns in the two panels of Figure 4, both for G7+ currencies and for select EM currencies.[31]

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

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

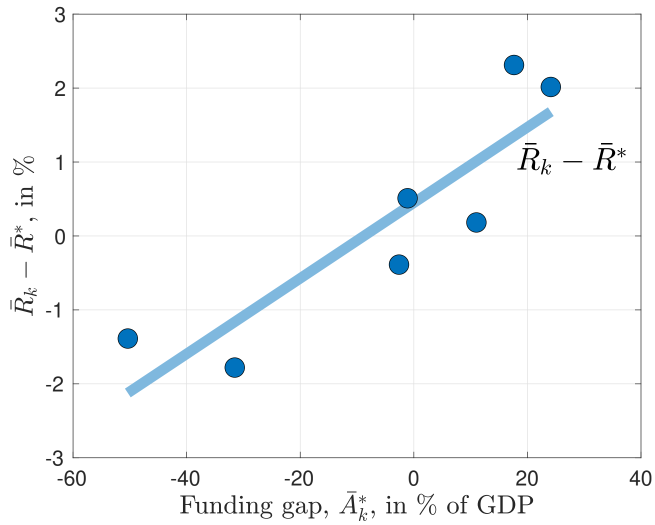

Figure 3: Cross section of average interest rate differentials against the funding gap

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

realized currency returns (UIP deviations) $\overline{UIP}_{k,+1}$ are considerably larger — about five-fold — yet still exhibit a strong positive association with both expected UIP deviations and the average interest rate differential.

In contrast, CIP deviations on average are an order of magnitude smaller (20 basis points, or 0.2%, annualized, or less) and have a standard deviation over time of about the same magnitude (20 basis points). Note that the standard deviation can be considerably larger for EM currencies, and the conventional CIP deviations are measured less reliably for these currencies since they incorporate local currency credit risk (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 and in Appendix Figure A8.

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

The other two groups contain Canadian, Australian and New Zealand dollars (CAD, AUD, NZD) as *investment/commodity* currencies featuring 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 curren-

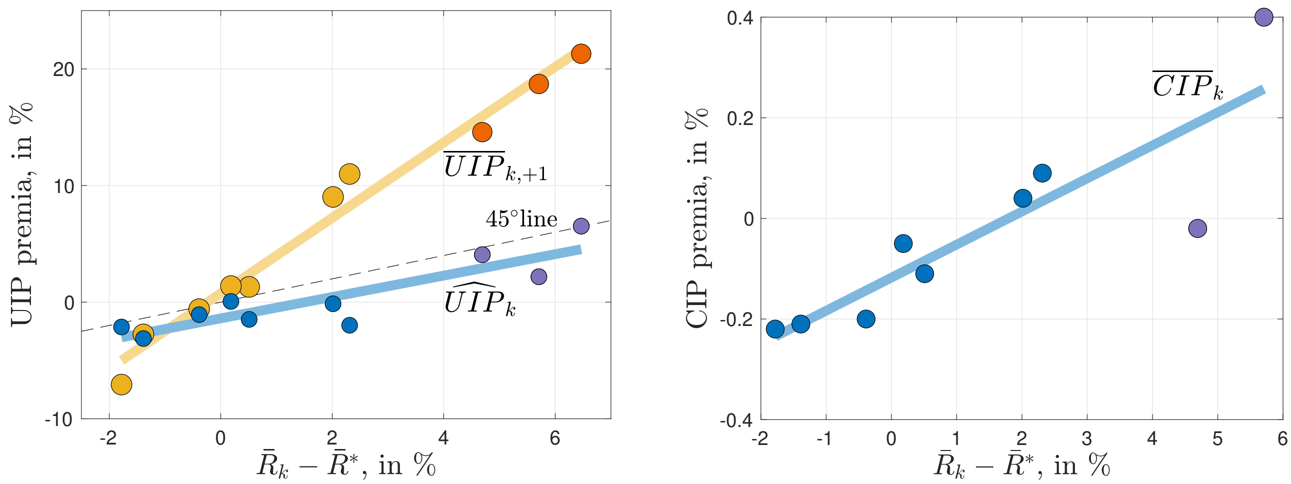

Figure 4: Cross section of the average UIP and CIP deviations against the interest rate differential

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

cies, 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 ($\mathbf{A}_k^* < 0$) and, vice versa, investment currencies feature an excess demand for local-currency investment ($\mathbf{A}_k^* > 0$). This results in negative average interest rate differentials in the former and positive average interest rate differential in the latter. The associated currency risk commands an expected UIP premium which is approximately equal to the interest rate differential. This prediction holds well in our sample for the expected survey-based UIP deviation that lines up closely with the average interest rate differential. In the long run, the local-currency interest rate differential compensates for the currency-risk exposure arising from the currency's average funding gap, acting as a limit on interest rate equalization across countries.

Investment in high-interest-rate currencies also creates demand to (partially) sell these currencies forward and swap the return differential.[32] For funding currencies, this means selling dollars forward. For intermediaries to buy these forward dollars, they must be sufficiently cheap, i.e., the CIP premium must be negative: the forward premium must be smaller than the interest rate differential. Conversely, for investment currencies this means buying dollars forward. For intermediaries to supply these forward dollars, they must be sufficiently expensive, i.e., the CIP premium must be positive: the forward premium must exceed the interest rate differential. This results in a positive

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

cross-sectional association between CIP deviations (a compensation for return swap), UIP deviations (a compensation for currency risk), and local-currency interest rate differentials (reflecting the funding gap). As discussed in the theory Section 2.3, this is the manifestation of the *forward premium puzzle*: 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.[33]

3.3 Dynamics of currency premia

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

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

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

where θ_k and θ_t are currency and time fixed effects and w_{kt} are currency specific controls. For v_{kt}, we adopt the 3-months ahead UIP premium $\widehat{UIP}_{kt}$ using survey expectations of the future exchange rate, the ex-post realized tri-monthly UIP deviation $UIP_{kt,t+3}$, and the 3-months CIP premium CIP_{kt}, all annualized and expressed in log points, as defined in (21). In some specifications, we drop time fixed effects θ_t and include aggregate time-series controls such as VIX and other variables that proxy for the overall financial conditions. The time frequency is monthly and all variables are measured as monthly averages of daily or weekly values.

The key right-hand-side variable in our projection (23) is the currency-specific demand shifter as captured by the net futures position of dealer banks relative to the size of the currency market, Δf^*_{kt}, defined in equation (22). An increase in f^*_{kt} implies that the dealer banks absorb currency k futures and sell dollars forward, and hence the rest of the currency k market demands dollars forward. This variable exhibits very persistent dynamics in the panel of currencies which we capture with the following estimated time-series process:

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

with $|t|$-stats reported in brackets, and with the standard deviation of innovation equal to 15.6.[34]

[33] 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).

[34] 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.

We depict the impulse response of f^*_{kt} to its standardized innovation in the left panel of Figure 8 below, which shows a considerable amount of persistence with eventual mean reversion and a half life of 6 months.

Combining together our statistical model in (23) and (24), we are estimating the responses of currency premia v_{kt} projected on f^*_{kt} innovations, capturing shifts in currency demand, and controlling for shifters of currency supply w_{kt}. This specification emerges as the empirical *reduced-form* counterpart of the equilibrium UIP and CIP conditions (15) and (16). Appendix C provides a detailed exposition of our identification argument which we summarize here. The underlying assumption is that Δf^*_{kt} is an effective proxy for changes in the overall forward positions $\Delta \mathbf{F}^*_{kt}$ of the intermediary sector, and hence in its hedged and unhedged currency exposure, $\Delta \mathbf{X}^*_{kt}$ and $\Delta \mathbf{Z}^*_{kt}$. We can write an unobservable first-stage projection for $\Delta \mathbf{Z}^*_{kt}$ as:

$$\Delta \mathbf{Z}^*_{kt} = \alpha_k + \alpha_t + \eta_k \Delta f^*_{kt} + u_{kt}, \tag{25}$$

and similarly for $\Delta \mathbf{X}^*_{kt}$. This first stage must feature $\eta_k > 0$ and a significant R^2 for the implementable reduced-form specification (23) to have explanatory power, which we show is strongly the case in the data.

Our underlying assumption is that changes in the "Dealer/Intermediary" net position in a currency's futures, Δf^*_{kt}, contain an important signal for the overall demand shift for that currency in the wider FX derivative and spot markets, which is ultimately accommodated by a consolidated global intermediary sector. In other words, the levels of f^*_{kt} can be systematically different from the levels of $\mathbf{Z}^*_{kt}$ and $\mathbf{X}^*_{kt}$, but all we require is that Δf^*_{kt} correlates with $\Delta \mathbf{F}^*_{kt}$, and hence with $\Delta \mathbf{Z}^*_{kt}$ and $\Delta \mathbf{X}^*_{kt}$.[35] An increase in f^*_{kt} reflects a demand shock from the rest of the market to buy dollars and sell currency k forward, i.e., an increase in $\mathbf{F}^*_{kt}$ that forms parts of both unhedged and hedged currency demand shifters, $\mathbf{Z}^*_{kt}$ and $\mathbf{X}^*_{kt}$ in (15) and (16). To accommodate the increase in $\mathbf{Z}^*_{kt}$ and $\mathbf{X}^*_{kt}$, intermediaries require higher uncovered and covered currency premia respectively, according to Proposition 2.

Given the unobserved first stage (25), our specification (23) projects currency premia (returns) on a proxy for innovations in the currency exposure of global intermediaries (portfolio positions). This is, of course, not a causal relationship. However, as we show in Lemma 2 and Appendix C, when regression (23) features a high R^2, our proxy for intermediary sector currency exposure $\mathbf{Z}^*_{kt}$ must be capturing well the overall shifts in currency k demand that shape equilibrium currency premia. These innovations are not proxies for structural shocks such as macroeconomic news or financial shocks, but instead capture the resulting shifts in currency demand and the associated changes in currency premia, which in turn are linked by currency supply schedules in Propositions 2.

[35] Similar arguments and evidence for the futures market's role in price discovery and as proxy for currency demand in the broader FX market is given by e.g. Hong and Yogo (2012), Tornell and Yuan (2012), Levich (2012). Most recently, using proprietary contract-level data from the London FX derivatives market, Hacioğlu-Hoke, Ostry, Rey, Rousset Planat, Stavrakeva, and Tang (2024) document correlation patterns between spot exchange rates and net forward positions that are consistent with our results that rely on publicly available futures data from CME.

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.

Dynamics of currency premia We start with the pooled sample of G7+ currencies and report the results in Table 3 for survey-expected UIP premium, realized UIP premium, and CIP premium. We find a strong contemporaneous response and ensuing mean reversion for both survey-expected and realized UIP premia, and no response of the CIP premium to the shock to dealer positions in the futures market Δf^*_{kt}. These results are consistent with Proposition 2. The effect on the UIP premium is large and statistically significant (with t-stats of 12 or more). A one standard deviation innovation in 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 $\bar{\delta}_{kt}\mu_t$. 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.[36] 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 (5) 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, and the two correlate positively in the cross section.

In the time-series, in contrast, the periods of high currency k UIP premia are also periods of high hedged return on currency k, and vice versa, translating into a negative comovement detected in Table 3. 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 specifications in Table 3. With time fixed effects, there is no longer any significant covariation between currency-specific CIP and UIP premia. In other words, the time-series comovement between UIP and CIP is not currency specific, but instead is driven by broad financial and currency market conditions.

Decomposition of currency premia Table 4 provides the decomposition of the UIP and CIP premia responses into their individual components: spot and forward exchange rates, survey exchange rate expectations (3-month ahead), and tri-monthly interest rate differentials. Column (1) and (2) of Table 4 reproduce approximately columns (2) and (6) of Table 3.[37] 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 can now 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 the spot exchange rate is stronger than the response of the UIP premium (by 270 basis points) as the survey expected exchange rate 3 months ahead also depreciates but by a considerably smaller amount.

To summarize, much of the movement in UIP premium comes from the on-impact change in the spot exchange rate, and not from the interest rate. This is in contrast with the cross-sectional

[36] 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.

[37] 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.

pattern documented in Table 2 and Figure 4) where the survey UIP premium reflects the interest rate differential nearly one-to-one. 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 a proxy for the global financial cycle (overall financial market conditions) and log changes in the broad dollar index as a proxy for the global dollar cycle. We focus on the G7+ currencies (from our panel specification) plus MXN, and report results for other EM currencies with sparser data in Appendix Table A5.

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 changes in the broad dollar index and VIX. Dealer positions together with the broad dollar and the VIX explain between 53% and 67% of the variation in currency-specific UIP premia. This is quite a remarkable fit given the large amount of seemingly idiosyncratic variations in UIP deviations.

In stark contrast, the variation in the dealers' futures positions, Δf_{kt}^*, is robustly irrelevant for the variation in CIP premia, with rather precisely estimated coefficients of zero for every currency.[38]

[38] 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; see Appendix Table A9.

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.

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 for 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 across currencies — with funding currencies (JPY, CHF and to a lesser extent EUR) experiencing a reduction in UIP which become more negative, while all other currencies (investment and EMs, and to a lesser extent GBP) see an increase in their positive UIP premia with higher VIX. To be more precise, we find that the estimated impact of VIX on UIP premium varies continuously from negative to positive as we go from the largest negative funding gaps (JPY and CHF) to the largest positive funding gaps (AUD and NZD, as well as MXN), with highly significant estimates in each case but the EUR, where the effect happens to be close to a precise zero (as expected for a currency with *balanced* local-currency funding). For CIP premia, the pattern of comovement with the VIX is similar to that of UIP premia: increases in VIX tend to make CIP premia more negative for funding currencies and more positive for investment, commodity and EM currencies.[39]

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 (20). Furthermore, theory predicts that this differential impact of the global financial cycle on currency premia stems from the countries' local-currency savings-investment imbalance as captured by the funding gap $\bar{\mathbf{A}}_k^*$. Signs and magnitudes of the long-run currency premia are shaped by $\bar{\mathbf{A}}_k^*$ (Table 2), and they expand proportionally when financial conditions tighten. We further confirm this prediction in Appendix Tables A7 and A8 where we interact $\bar{\mathbf{A}}_k^*$ 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: the broad dollar appreciation is associated with increasing UIP premia for every currency (i.e., UIP premia becoming more positive or less negative). 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). Broad dollar appreciations likely capture both general shifts in demand towards the dollar (i.e., the common component of all Δf_{kt}^*), but additionally via shifts in demand for dollar swaps (see Ivashina, Scharfstein, and Stein, 2015) and a correlated broad tightening of financial conditions, which complicates the interpretation of the response to this shock. 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.

To conclude, unlike UIP, CIP premia do not feature significant month-to-month variation idiosyncratic to shifting demand for individual currencies. Instead, CIP premia feature pronounced and persistent lower-frequency movements associated with the global financial and dollar cycles. 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

[39] 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 forward premia in Section 3.2).

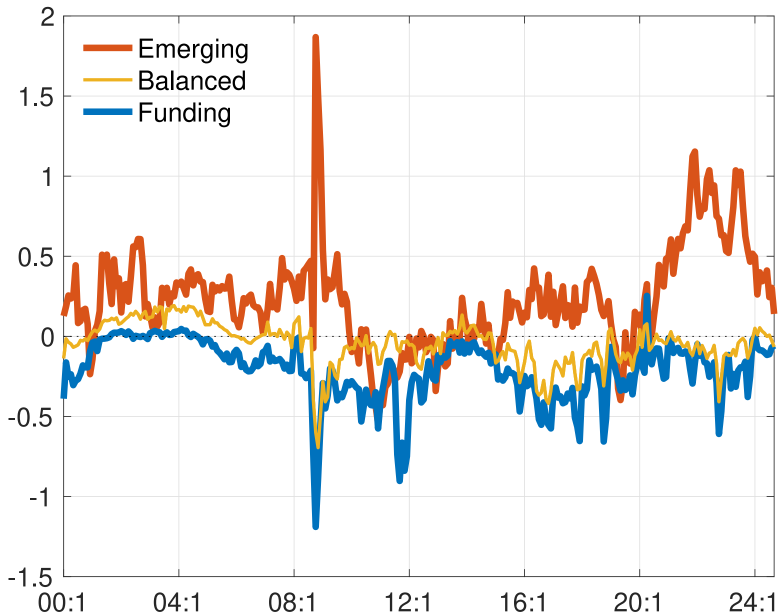

Figure 5: CIP premia by currency bins

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

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 G7+ currencies and highly statistically significant.

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

$$\Delta \log \mathcal{E}_{kt} = \theta_k + \sum_{j=0,1,2,3} \beta_{kj} \Delta f^*_{k,t-j} + \gamma_k \Delta w_{kt} + \rho_k \log \mathcal{E}_{k,t-1} + \epsilon^e_{kt}, \quad (26)$$

where w_{kt} include conventional variables used in exchange rate regressions including the interest

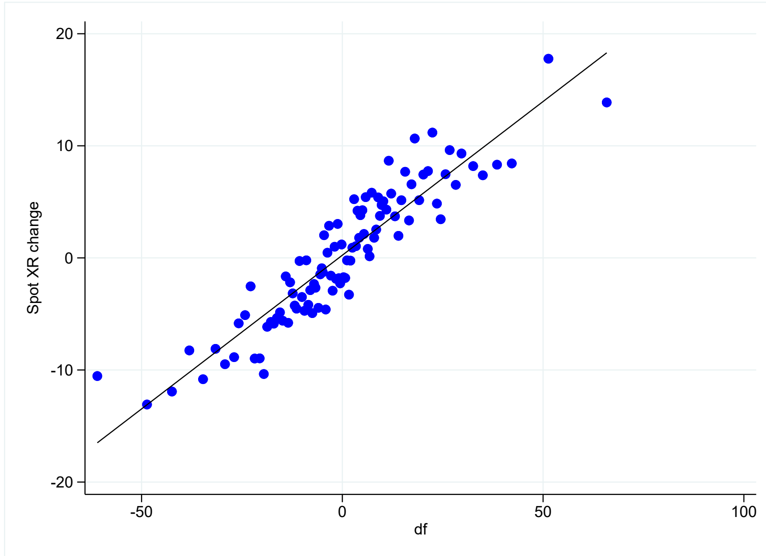

Figure 6: Dealer positions and exchange rate changes: scatter plot of $\Delta \log \mathcal{E}_{kt}$ against Δf^*_{kt}

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.

rate differential $i_{kt} - i^*_t$, the Treasury basis, and the VIX. The Treasury basis is computed as the difference between the 12-month US Treasury yield and the average of 12-month Treasury yields in G10 currencies swapped into dollar using the corresponding 12-month forward exchange rate. We use this variable in the exchange rate regressions instead of the broad dollar to capture shocks to dollar safe asset demand but avoid the mechanical correlation due to major currencies' weights in the broad dollar index. We also report the results in the panel of G7+ currencies with and without time fixed effects.[40]

We report the results in Table 6. There is a strong contemporaneous response of the spot exchange rate to the dealer position shock for every currency, with t-stats around 10 and ranging from 4.0 for MXN and 7.6 for GBP at the lower end to 12.6 for CHF and 15.9 for NZD at the higher end. An increase in dealers' currency k position, representing a shift in the market demand away from currency k towards the dollar, is associated with a quantitatively strong contemporaneous depreciation of currency k. The magnitudes of the coefficients are remarkably consistent across currencies. For a one standard deviation innovation in individual 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 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.

[40] We obtain consistent results for emerging market currencies, reported in Appendix Table A6, even though their FX futures markets are shallower and data on dealer futures positions sparser.

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.

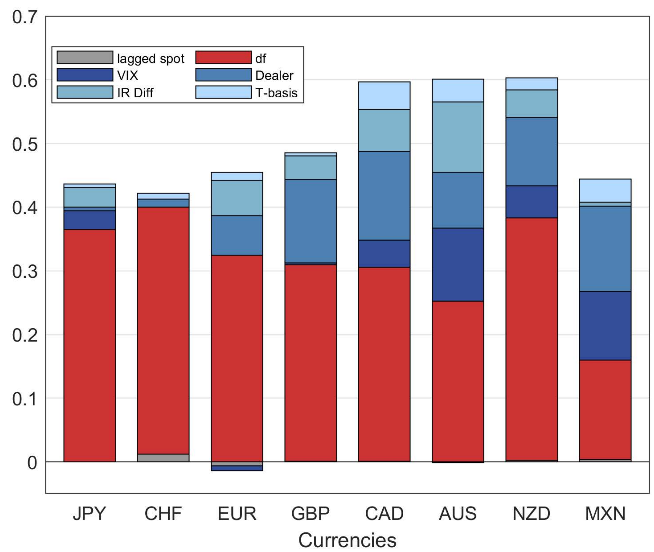

Figure 7: Exchange rate regressions (26): contributions to R^2 by regressor

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 41).

Recall that our estimated specification (24) implies half lives of 5 and 6 months for a shock to f^*_{kt}, and a corresponding half lives of 6 and 8 months for the exchange rate in the panel of G7+ currencies, for the specification with and without time fixed effects, respectively. For individual currencies, the half lives vary from 6 to 13 months across currencies, and it is ∞ for GBP (see the last line in Table 6).

The statistical model (26), 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 safe assets and associated depreciation of other currencies — which increases in magnitude and significance as we move from funding toward investment currencies (from left to right in Table 6). This is consistent with the results in the literature (see Jiang, Krishnamurthy, and Lustig, 2021) and implies that a global shift in demand towards dollar safe assets depreciates investment currencies more than funding currencies. 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, wich also showed a differential impact of financial conditions on currency premia in proportion with their funding status. Controlling for changes in log dealer wealth, another proxy for intermediation capacity, also has strong association with exchange rates: a decrease in dealer wealth is associated with depreciation of all currencies except for the funding currencies CHF and JPY.

Despite these statistical associations with conventional macro-finance variables, the dealer position maintains a large and independent contribution to the fit of the statistical model, explaining the majority of variation in the exchange rate. Table 6 reports the share of total R^2 due to this variable alone, which ranges from 35% and 42% for MXN and AUD, to 64% and 69% for GBP and EUR, to 81% and 89% for JPY and CHE. For all currencies but MXN and AUD, changes in dealer positions account for the majority of explained variation even when taking into account the possible correlation between right-hand side variables. We show the full variance decomposition of the model R^2 in Figure 7.[41] 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 (26), we plot the predicted components of the changes and cumulated levels for each exchange rate. 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 components based on the dealer positions alone are around 0.6 for most currency (with the exception of MXN for which it is 0.5). These correlations for the full model are around 0.7. The fit in levels is equally strong, but it can be misleading for a model with near-non-stationary variables, and this is why one should focus only on the fit in changes.

Impulse responses 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 endogenous dealer position f^*_{kt} at time t according to the estimated statistical model (24) and (26). Figure 8 plots the estimated impulse responses, for the levels and changes of $f^*_{k,t+j}$ in the left panel and of $\log \mathcal{E}_{k,t+j}$ in the right panel, using point estimates from the panel specification for G7+ currencies with time fixed effects.

We find a persistent impulse response conditional on an innovation in the dealer net futures position. The dealer net futures position itself mean reverts with a half life of 5 months, while the exchange rate mean reverts somewhat slower with a longer half live of 6 months. On impact of a

[41] 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.

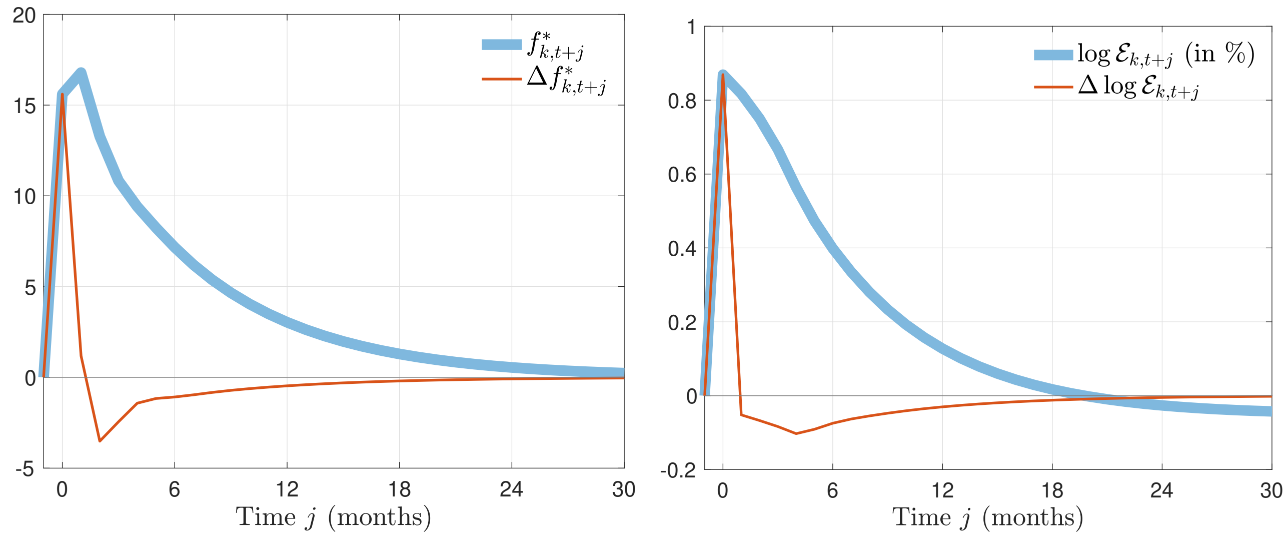

Figure 8: Impulse response to an innovation to Δf^*_{kt}

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. Table 7 provides alternative estimated using predictive local projections. See Appendix Figure A13 for specification without time fixed effects and Appendix Figure A14 for individual currencies.

one standard innovation to f^*_{kt}, a typical exchange rate depreciates by 0.87% (87 log points) and then gradually appreciates over the following 18 months, by an average of 6 log points monthly over the first 12 months. Appendix Figure A13 plots alternative impulse responses for the specification without time fixed effects, in which case the exchange rate responds by 1.29% on impact and then mean reverts with a longer half life of 8 months, and Appendix Figure A14 shows impulse responses for individual currencies.

The distinctive feature of this impulse response is that a large unexpected depreciation on impact is followed by a sequence of small predictable appreciations thereafter. This shape of the impulse response is a characteristic feature of frictional intermediation models of the exchange rate that reproduce its excess volatility via an overshooting mechanism (see Itskhoki and Mukhin, 2021). The exchange rate must depreciate sufficiently on impact so that intermediaries can step in to accommodate the shift in the currency demand and expect to make positive currency returns from the predictable appreciation.

Predictable currency returns Lastly, 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 Δ of currency premia defined in (21) does not correspond to the future expected currency return since it features the past exchange rate. 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

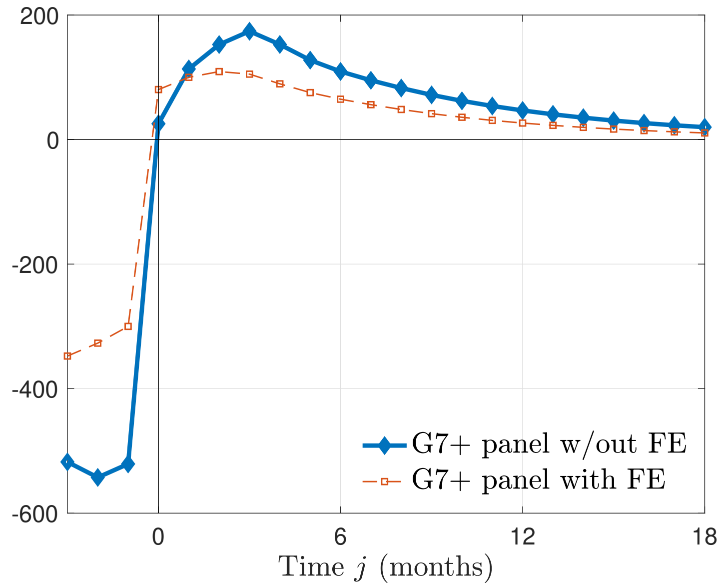

Figure 9: Currency returns (basis points) around the innovation to f^*_{kt}

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. Table 7 provides alternative estimated using predictive local projections.

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 we show in Appendix Figure A15.

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 depreciation 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.[42]

This situation describes an equilibrium exchange rate response that supports positive expected currency returns for intermediary banks subject to a "no-good-deal" bound on the carry trade Sharpe ratio (see Chernov, Haddad, and Itskhoki, 2024). Less surprise volatility in the exchange rate would make the currency trade sufficiently appealing for broader groups of investors, while less predictable mean reversion in the exchange rate would make it insufficiently attractive for intermediaries to absorb the currency risk. Thus, our proxy for currency demand shocks, Δf^*_{kt}, rationalizes both the surprise variation in the exchange rate and the intertemporal profile of predictable currency returns following the shock which together support equilibrium dynamics with frictional intermediation.

The impulse response constructed in Figure 9 uses the statistical model in (24) and (26). The estimates of projection (26), reported in Table 6, show that the bulk of the association between the exchange and dealer net futures positions is contemporaneous, and the predictability is largely driven by mean reversion in Δf^*_{kt} estimated in (24). This raises the question of predictability of exchange rates relying only on past observed dealer positions, unconditional of its future path.

Panel A of Table 7 reports the estimates of the following predictability regression for horizons $h = 1, .., 6$ and $h = 12$ months ahead:

$$\log \mathcal{E}_{k,t+h} - \log \mathcal{E}_{kt} = \theta_{kh} + \beta_h \Delta f^*_{kt} + \gamma_h \Delta \log \mathcal{E}_{kt} + \rho_h \log \mathcal{E}_{kt} + \epsilon^e_{kth}, \tag{27}$$

and the first column of the table reports the contemporaneous specification for comparison. The local projection (27) relaxes the assumptions in the statistical model (24) and (26) and evaluates the predictive power of Δf^*_{kt} directly. The estimates imply that a standard deviation increase in $\Delta f^*_{kt} = \mathrm{std}(\Delta f^*_{kt}) = 20$ (in percent of open positions) is associated with a 1.38% depreciation on impact and a predictable appreciation of 0.52% during the next four months. These local projections further allows us to construct two alternative impulse responses of the exchange rate for a given shock to $\Delta \log \mathcal{E}_{kt}$, namely, with and without a contemporaneous change in Δf^*_{kt}. When the exchange rate changes without a contemporaneous change in dealer net positions, its dynamics feature both short-run momentum and medium-run mean reversion captured by the terms $\gamma_h > 0$ and $\rho_h < 0$. In contrast, when an exchange rate change occurs alongside the change in Δf^*_{kt}, its impulse response is captured by estimated $\beta_h < 0$ terms which predict partial mean reversion from $h = 1$ onwards.

[42] 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).

Table 7: Exchange rate and excess return predictability

Panel A	$\Delta \log \mathcal{E}_{kt}$	$\log \mathcal{E}_{k,t+h} - \log \mathcal{E}_{kt}$						
		$h = 1$	$h = 2$	$h = 3$	$h = 4$	$h = 5$	$h = 6$	$h = 12$
Δf^*_{kt}	0.069***	−0.014***	−0.016***	−0.022**	−0.026**	−0.018*	−0.010	0.023
	[22.14]	[3.55]	[2.92]	[2.51]	[2.57]	[1.93]	[0.95]	[0.88]
$\Delta \log \mathcal{E}_{kt}$		0.374***	0.458***	0.505***	0.529***	0.500***	0.462***	−0.015
		[6.79]	[4.54]	[3.72]	[3.08]	[2.74]	[2.99]	[0.05]
$\log \mathcal{E}_{kt}$		−0.021***	−0.046***	−0.072**	−0.098**	−0.121**	−0.143**	−0.257***
		[2.95]	[2.74]	[2.62]	[2.52]	[2.44]	[2.43]	[3.04]
$\log \mathcal{E}_{k,t-1}$	0.001							
	[0.15]							
Observations	1,596	1,589	1,582	1,575	1,568	1,561	1,554	1,512
# of currencies	7	7	7	7	7	7	7	7
Within R^2	0.359	0.105	0.075	0.069	0.071	0.075	0.079	0.121
Panel B	$rx_{k,t-3,t}$	$rx_{k,t,t+h}$						
$\Delta f^*_{kt}/\text{std}(\Delta f^*_{kt})$	−5.382***	3.416***	2.025***	1.866**	1.605***	0.889**	0.422	−0.223
	[6.99]	[3.60]	[2.97]	[2.59]	[2.61]	[1.97]	[0.98]	[0.44]

Notes: Panel A reports coefficient estimates for the local projection (27) for $h = 1, .., 6$ and $h = 12$. Column 1 repeats the baseline exchange rate regression from Table 6 without lags of Δf^*_{kt} or other controls. Sample includes G7+ currencies with currency fixed effects. $|t$-stats$|$ using Driskoll-Kraay panel heteroskedasticity and autocorrelation robust standard errors in brackets. Panel B reports the estimates from a corresponding specification which replaces the dependent variable with excess returns $rx_{k,t,t+h}$ (in % annualized) on a carry trade that borrows in dollar and invests in currency k for h months (see footnote 43). A standard deviation of Δf^*_{kt} is $\text{std}(\Delta f^*_{kt}) = 20$, and panel B reports the standardized responses. First column reports the result for $rx_{k,t-h,t}$, i.e., returns on a 3-month carry taken at $h = -3$ before the shock. Appendix Figure A16 plots the associated impulse responses.

The exchange rate impulse responses for the two cases — namely, with and without a change in Δf^*_{kt} — are plotted in Appendix Figure A16a, and they are markedly different. Without a change in Δf^*_t, a contemporaneous depreciation shock (normalized to be 1 percent) persists several months into the future. When the same size of a depreciation shock is accompanied by a corresponding increase in Δf^*_t instead, the same depreciation on impact is followed by a series of predictable subsequent appreciations, similar to the result from the more structural model in Figure 8. However, unlike the estimates in Figure 8, the impulse response in Table 7 and Appendix Figure A16a does not rely on mean reversion in f^*_{kt}.

These predictable currency movements give rise to significant expected excess returns. Panel B of Table 7 reports the predictability results for the annualized excess returns $rx_{k,t,t+h}$ from borrowing in dollar and investing in currency k for h months starting at t conditional on a standard shock to Δf^*_{kt}.[43] These carry returns, in response to a standardized increase in dealers' net futures position,

[43] Formally, we re-estimate the same local projection as (27) replacing the dependent variable with the ex-post annualized carry return $rx_{k,t,t+h} \equiv (12/h)\left[(r_{k,t,t+h} - r^{US}_{t,t+h}) - (\log \mathcal{E}_{k,t+h} - \log \mathcal{E}_{kt})\right]$, where $r_{k,t,t+h} - r^{US}_{t,t+h}$ is the currency k money-market interest rate differential vis-à-vis the US for h month borrowing. The R^2 in return predictability regressions are nearly the same as in the exchange rate regressions in Panel A. The predictability results are robust to inclusion of time fixed-effects, additional lags of variables, different measures of dollar and foreign interest rates, and are estimated to be significantly larger during sub-periods with tighter financial conditions.

are estimated to be 3.42% annualized for the first month, becoming smaller with each additional month, but still remaining significantly positive at 1.87% percent (187 bps) annualized after three months. As before, this return predictability is entirely driven by the predictable mean reversion in the exchange rate documented above. The first column additionally reports that the return is -5.38% annualized on a three-month carry open at $h = -3$ conditional on a future standardized change in Δf^*_{kt}. These magnitudes are remarkably consistent, albeit decaying faster for $h > 4$, with the excess returns estimated in Figure 9 which relied on a different statistical model. This is because the implied dynamics for the exchange rate are similar across the two specifications in the short-run: both implying a cumulative appreciation that reverses around 40 percent of the impact depreciation after four months. We plot the estimated impulse response for excess returns in Appendix Figure A16b.

3.5 What do dealer FX positions capture?

We next address the question of what the dealer futures position ultimately measures. Dealer banks usually maintain a hedged balance sheet as required by regulation. Therefore, any change in net demand for currency risk that dealer banks accommodate (proxied with Δf^*_{kt}) may ultimately not be held on dealer banks' balance sheets, but passed on to other (non-dealer) intermediary in the system through so-called internalization (see Moore, Schrimpf, and Sushko, 2016). We illustrate such a position passthrough between a dealer bank subsidiary and its non-dealer parent bank in Appendix Figure A2. Recent research using supervisory data shows that combining all spot and derivative positions at the bank-holding level, large entities in the US and Europe indeed hold substantial unhedged currency exposure (see Abbassi and Bräuning, 2021; Barbiero, Bräuning, Joaquim, and Stein, 2024). Large international banks thus form an important intermediary sector and changes in futures positions of their affiliated dealer banks are informative of the shifts in the broad currency exposure of these intermediaries.[44]

We have documented that the change in dealers' net futures position Δf^*_{kt} has remarkable explanatory power for exchange rates and uncovered currency premia, consistently so across currencies and time. We have remained agnostic about the source of variation in currency demand that is ultimately accommodated by intermediaries. However, it is interesting to explore whether these monthly changes in currency demand are related to aggregate measures of capital flows. This would offer external validation for Δf^*_{kt} as a proxy for underlying shifts in currency demand.

Fundamentally, demand for FX forwards and futures reflects demand to buy or sell currency risk (vis-à-vis the dollar) aggregated across various market participants. This can be demand to buy/sell FX risk by dollar-funded investors or dollar risk by foreign-currency-funded investors. As such, we expect the former source for dollar risk demand to be most relevant for investors in dollar assets that are funded by currencies with persistently lower interest rates than the dollar, which are typically

[44] An alternative interpretation is that dealer bank positions proxy for shifts in currency demand that are ultimately absorbed by other players in the intermediary sector.

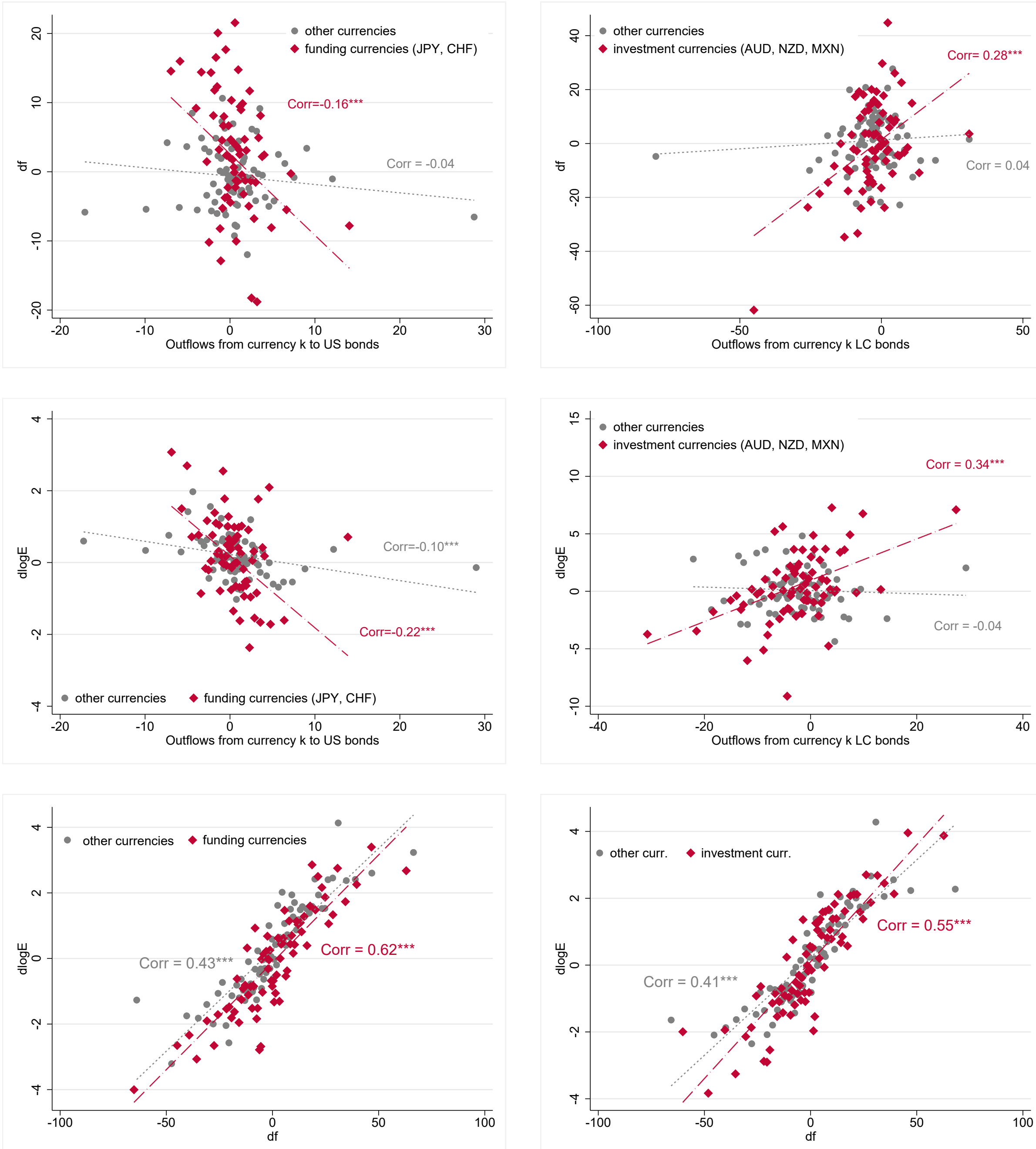

Figure 10: Capital (out)flows, changes in dealer FX positions Δf^*_{kt}, and exchange rate depreciations $\Delta \log \mathcal{E}_{kt}$, for currencies by funding (left) and investment status (right)

Note: The figures display bin scatter plots for (1) Δf^*_{kt} against aggregate measures of capital flows in the top row; (2) $\Delta \log \mathcal{E}_{kt}$ against the same measures of capital flows in the middle row; and (3) $\Delta \log \mathcal{E}_{kt}$ against Δf^*_{kt} in the bottom row. Figures in the left columns separate funding currencies (JPY, CHF) from other G7+ currencies and MXN; figures in the right column separate investment currencies (AUD, NZD, MXN) from other G7 currencies. The measure of capital outflows from country k is, in the left column, the monthly percent change in the foreign holdings of US bonds by country k; and, in the right column, the negative of the quarterly percent change in foreign holdings of local-currency k bonds (see text for details). Currency-month observations are collapsed into 75 bins in each figure. Each figure reports corresponding correlations for monthly changes across all observations.

funding currencies. Fluctuations in demand to buy/sell FX risk, on the other hand, should primarily emanate from dollar-funded investors in currencies that have persistently higher interest rates than the dollar, which are the typical carry-trade destination currencies (i.e., investment currencies).

These are exactly the pattern we document in Figure 10. The three panels on the left separate the two persistent *funding currencies*, JPY and CHF, from the other G7+ currencies and MXN. Using Treasury International Capital (TIC) database, we show (with red diamonds) that when investors from Japan and Switzerland buy more US bonds (Treasuries, Agency, and Corporate) — that is, a capital outflow from these countries and towards the US — we observe a decrease in dealer futures positions f^*_{kt} for these currencies (with a significant negative correlation of 0.16 in monthly changes) as well as an appreciation of these currencies (with a significant correlation 0.22 in monthly changes).[45] The fact that capital outflows are associated with an exchange rate appreciation for these currencies may appear surprising at first glance. However, this simply reflects the logic of the hedging mechanism: as funding-currencies investors acquire more dollar assets, they sell the dollar forward to dampen their exposure. This reduces f^*_{kt} implying that dealers must absorb more of the dollar risk which requires a depreciation of the dollar (see Liao and Zhang, 2025; Du and Huber, 2024). There is no comparable co-movement between this measure of capital flows and dealer positions or the exchange rates for other currencies (grey circles in the plots). In contrast, the association between changes in dealer futures positions and the exchange rates holds across both subsets of currencies, as shown in the lower-left panel of the figure and is also consistent with Figure 6.

The three right panels of Figure 10 separate out, in turn, the three *investment currencies* in our panel, namely, AUD, NZD and MXN. For these plots, we use the IMF quarterly data on foreign holdings of local-currency bonds (from Arslanalp and Tsuda, 2012, 2014, updated through 2024Q4), corresponding to international capital flows in and out of these countries.[46] We observe a strong association between these capital flows and dealer futures positions and exchange rate movements for the three investment currencies, but not for other G7+ currencies. Specifically, for investment currencies, capital outflows from local-currency bonds are associated with a depreciation and an increase in f^*_{kt}, i.e., an increase in the amount of local-currency risk to be absorbed by the intermediaries. This is the opposite pattern from the one observed for outflows from funding currencies. A possible interpretation is that FX derivatives are used to speculate or amplify exposure to investment currencies instead of hedging (see Sialm and Zhu, 2024; De Leo, Keller, and Zou, 2024; Chen and Zhou, 2025). Inflows into investment currencies come with increased demand to buy local currency

[45] We proxy for flows in and out of US bonds with the change in stocks of foreign holdings, which are in principle also affected by valuation effects. By limiting to long-term bond positions and leaving out equity holdings, we are able to leave out the largest swings in valuation effects (see FEDS Note 2024). Moreover, our results are robust to adjustments for valuation effects using variation in US Treasury yields at various maturities.

[46] This dataset offers an internationally comparable measure of foreign (bank and non-bank) investor holdings of domestic local-currency (and separately foreign currency in the case of EMs) sovereign debt, consistently defined as gross debt (mainly bonds and loans) of the general government at consolidated basis. The holdings are recorded at face value, or otherwise adjusted for valuation effects, allowing us to interpret changes in holdings as measuring transaction flows (debt sales/purchases or redemption/roll-off by foreign investors). See Arslanalp and Tsuda (2012) for details.

forward, and hence with an associated currency appreciation.[47]

The striking fact is that, while the sign of the correlation between capital flows and the exchange rate is currency-specific and depends on the balance between hedging and speculation motives, the association between dealer FX positions and the exchange rate holds in all subsamples, as we show in the two lower panels of Figure 10. In other words, we find that the two different measures of capital flows correlate with the exchange rate *if and only if* they correlate with our proxy for shifts in currency risk demand, namely, the dealer net FX futures positions f^*_{kt}. Even more surprising is that the sign of the correlation between capital flows and the exchange rate depends on whether the capital flow increases or decreases the demand for currency risk, as captured by Δf^*_{kt}, rather than on the direction of the capital flow.

This leads us to three observations. First, the robust correlation between dealer FX positions and the exchange rate corroborates the role of Δf^*_{kt} as the proximate measure of shifts in currency demand or, more precisely, demand for currency risk exposure. Second, dealer net positions and shifts in currency demand do not simply map into primitive macroeconomic or financial shocks that result in broad international capital flows. Third, put together, these observations help make sense of the exchange rate disconnect, namely, the absence of robust correlation between the exchange rate and various macroeconomic variables and, in particular, aggregate capital flows. Shifts in currency demand and the resulting movements in the exchange rate depend on the details of currency risk allocation across participants in financial markets rather than on (net) international asset positions across countries.

4 Discussion and conclusion

In this paper, we provide a description of joint statistical properties 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 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

[47] This time-series correlation operates in reverse from the pattern we observed in levels in the cross section, where demand for capital from abroad is associated with FX hedging demand and positive UIP premia on average. However, in the times series, periods of additional capital inflows into investment currencies are associated with greater risk appetite and lower FX hedging demand, resulting in temporarily lower UIP premium and local currency appreciation.

Japan and Switzerland, feature: (i) low local-currency interest rates, (ii) negative UIP premia that reflect the interest rate differential, and (iii) negative CIP premia which reflect cheap forward (relative to spot) dollars. The opposite is true for investment, commodity and emerging-market currencies of countries with insufficient local-currency savings which require international (dollar) funding to finance domestic investment.

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.[48] 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 (i.e., "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 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 limit 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.[49] Hence, a model with the same set of fundamental shocks but frictionless intermediation with uncovered parity holding would result in very different equilibrium exchange rate dynamics. Finally, our framework offers a real-time way (at a weekly or monthly frequency) to measure expected UIP deviations

[48] 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.

[49] 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.

which emerge in concert with the shifts in currency futures positions of dealer banks. Alternative measures of the frictional UIP premium are notoriously difficult given the unobservable exchange rate expectations involved in the construction of this variable at high frequency.

A number of open questions, both positive and normative, remain for future work. For example, what is the allocation of currency risk exposure among the various participants of the financial markets and the nature of shifts in their currency demand? Although we model a typical intermediary as a global bank with an affiliated dealer branch, our framework extends to intermediation by any agent with a stable currency supply schedule. Similarly, our framework does not rely on a distinction between hedgers and speculators as often assumed in the literature, since each agent can act on either motive and the equilibrium UIP is the result of the interaction between shifts in currency demand and supply. Another avenue to explore further 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, as illustrated by the case for 'basis control' in Gourinchas (2022). Of course, conducting such optimal policy analysis requires a fully-specified general equilibrium model.[50] 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.

[50] 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

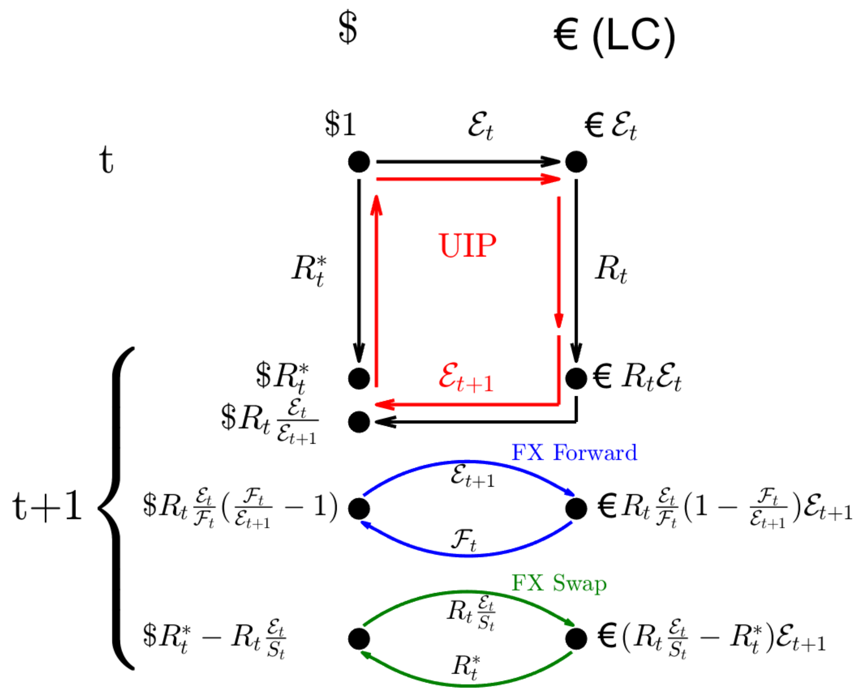


Figure A1: Illustration for balance sheet in Table 1: possible currency trades

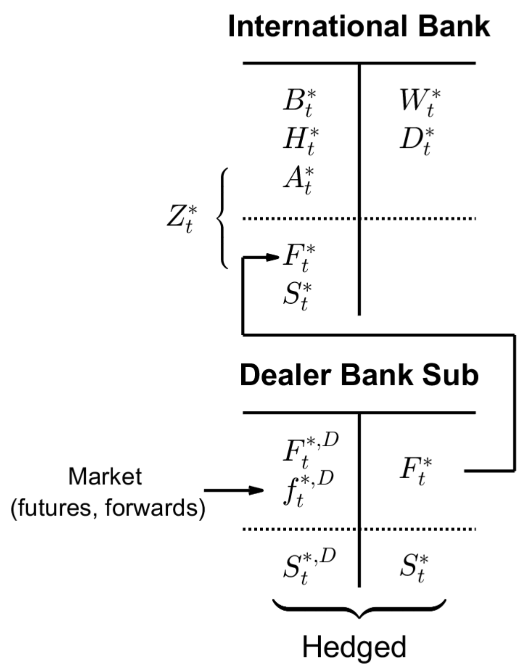


Figure A2: Illustration of international intermediary bank and its dealer subsidiary: FX exposure passthrough

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: Correlation of changes in net futures positions with Dealer/Intermediary Δf^*_{kt}

	JPY	CHF	EUR	GBP	CAD	AUD	NZD
Asset manager	-0.702	-0.702	-0.767	-0.596	-0.525	-0.699	-0.632
Leveraged funds	-0.834	-0.793	-0.697	-0.906	-0.865	-0.934	-0.896
Other	0.158	0.049	0.023	-0.004	0.055	-0.216	-0.051

Table A3: 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 A4: 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 A5: 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 A6: 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 A7: 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 A8: CIP panel regressions with dollar gap interaction and alternative measures of μ

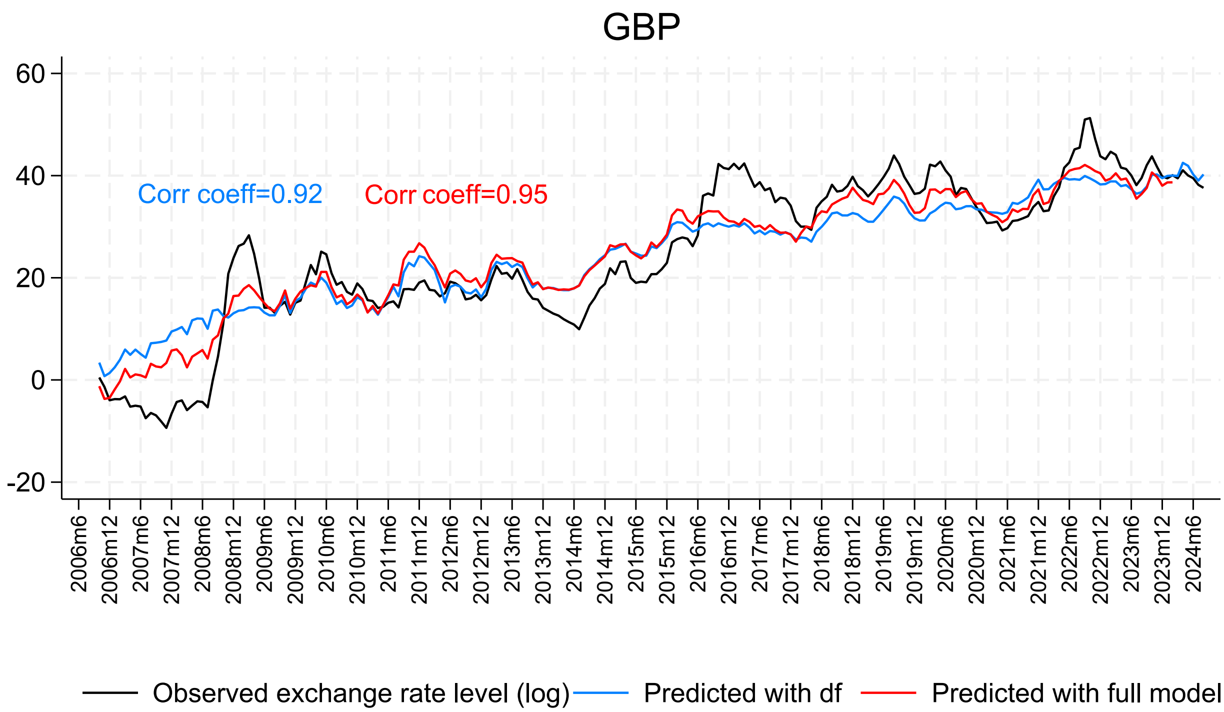
Dep. var: ΔCIP_{kt}	(1) $\mu = VIX$	(2) $\mu = -DealerW$	(3)	(4) $\mu = -GFCy$	(5)	(6) $\mu = EFFR - IORB$	(7)
Δf^*_{kt}	0.0003	0.0004	0.0003	0.0005	0.0005	−0.0000	−0.0001
	[0.79]	[1.00]	[0.88]	[1.57]	[1.53]	[0.17]	[-0.36]
$\Delta f^*_{k,t-1}$	−0.0002	−0.0002	−0.0001	−0.0002	−0.0002	−0.0001	−0.0001
	[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 A9: 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 A6. 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.



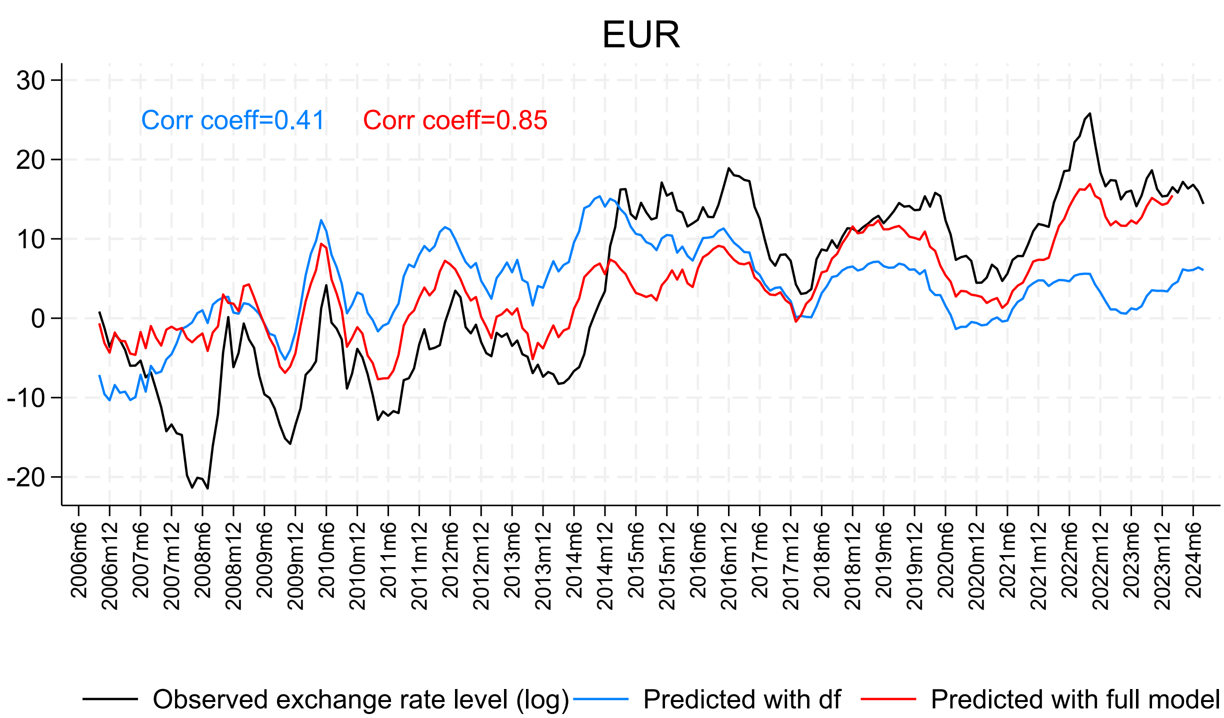
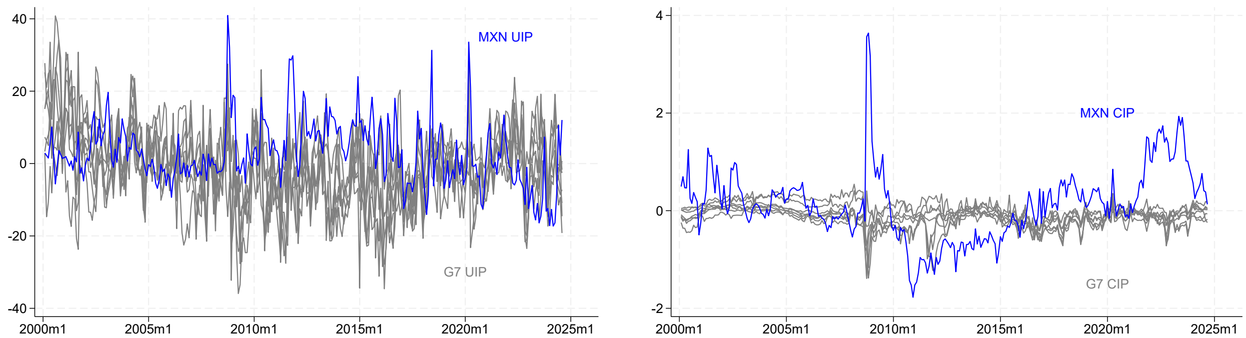


Figure A3: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values

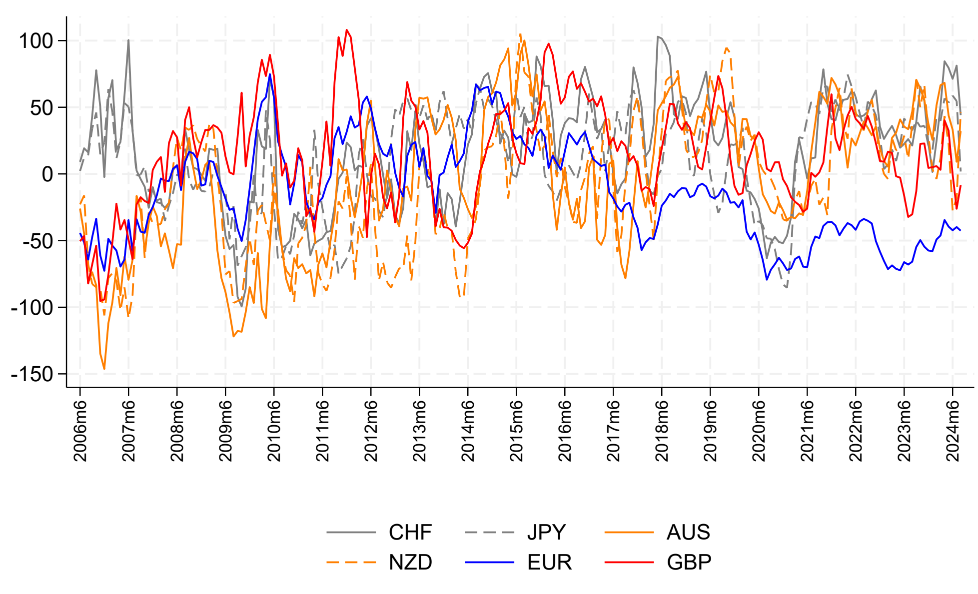
Note: The figures plot the realization of the log of the spot exchange rates $\log \mathcal{E}_{kt}$ for the euro and the British pound along with the cumulated fitted values from an empirical model of $\Delta \log \mathcal{E}_{kt}$ using only the currency futures positions of dealer banks Δf^{*}_{kt}, 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



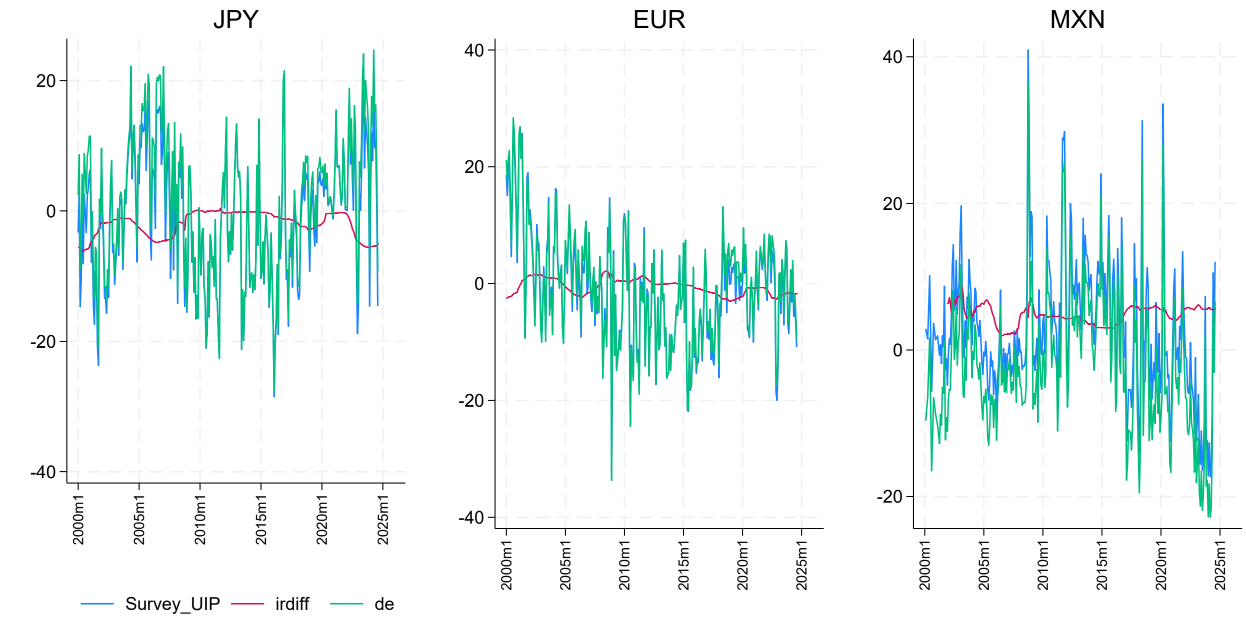
Notes: Left figure plots the 3-month survey UIP premium for G7 currencies (gray) and Mexican Peso (blue), in percent annualized. Right figure plots the 3-month CIP premium for G7 currencies (gray) and Mexican peso (blue), in percent annualized. Source: Bloomberg, Refinitiv, IMF IFS, Consensus Economics.

Figure A5: Dealers net futures position by G7 currency

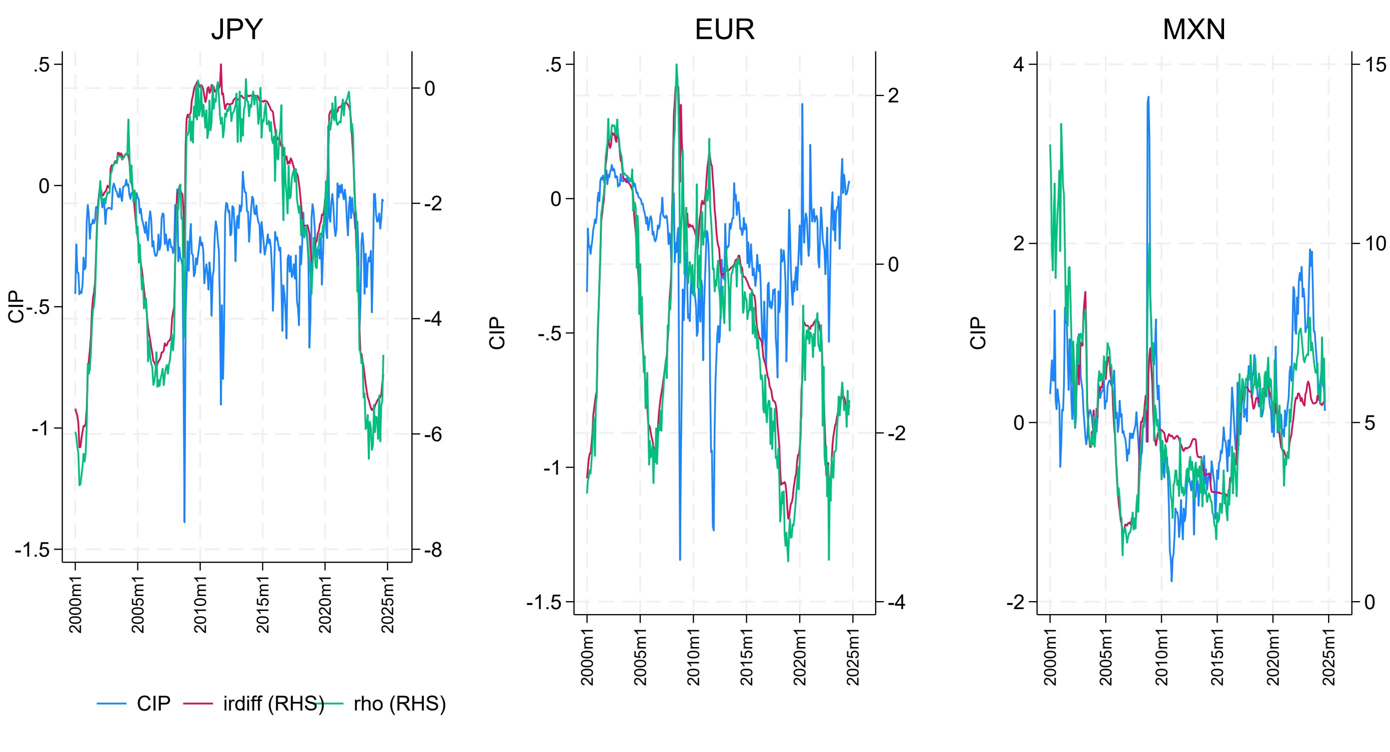


Notes: The figure plots the time series for net futures positions of dealer banks on the Chicago Mercantile Exchange by currency, in percent of 12-month moving average total open positions in each currency. Data are monthly averages of weekly numbers. Source: CFTC Traders in Financial Futures (TFF) Weekly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

Figure A6: UIP and CIP decomposition



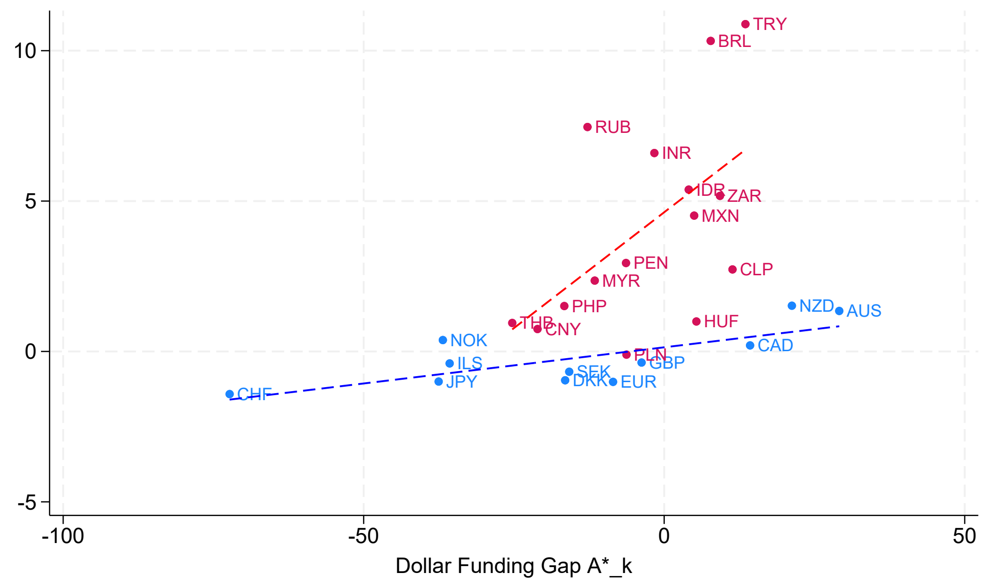
(a) UIP decomposition for JPY, EUR, MXN.



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

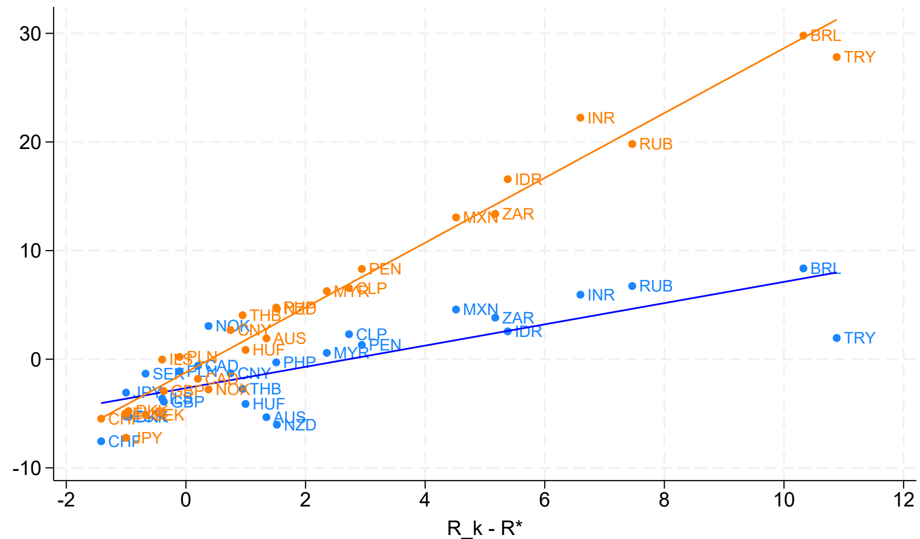
Notes: Panel (a) shows the decomposition of the survey UIP premium into the local currency vs. dollar interest rate differential (irdiff) and expected appreciation (de). Panel (b) decomposes the CIP premium into the interest differential (irdiff) and forward premium (rho).

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

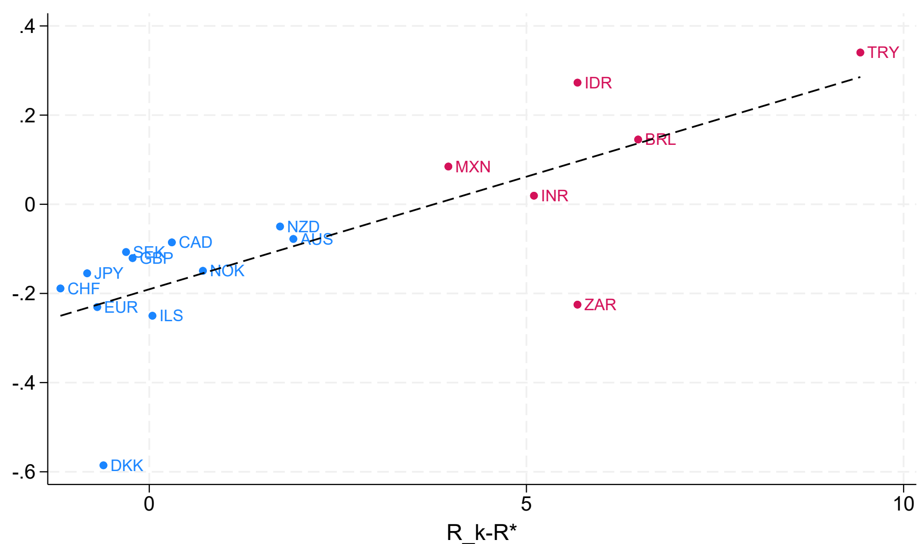


Notes: This figure generalizes Figure 3 in the main text to a broader set of advanced economies and emerging market currencies, illustrating group-specific slopes for the scatter plot of the average local-currency funding gap and interest rate differential vis-à-vis the dollar (red for EM, blue for AE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

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



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



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

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

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

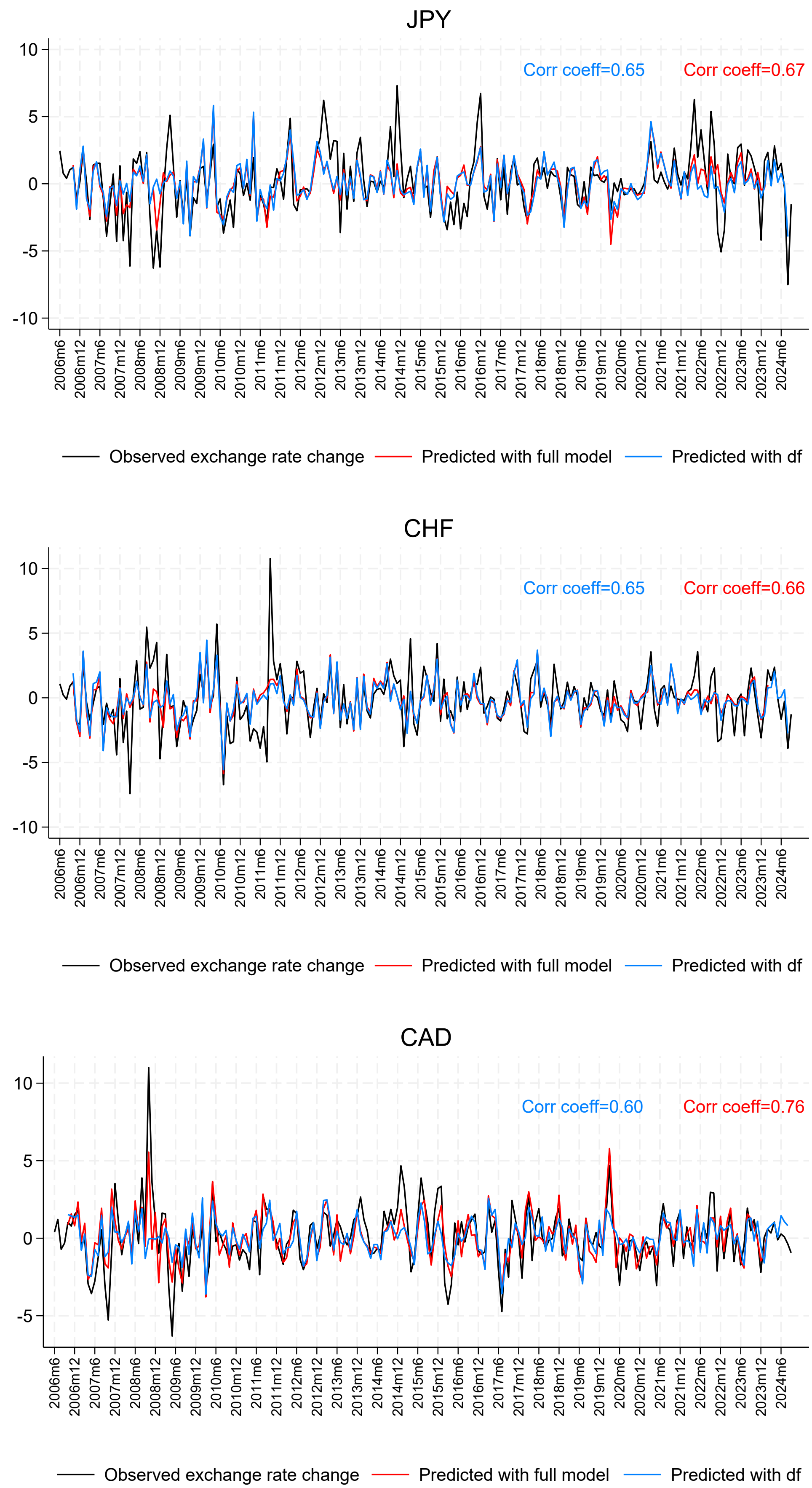
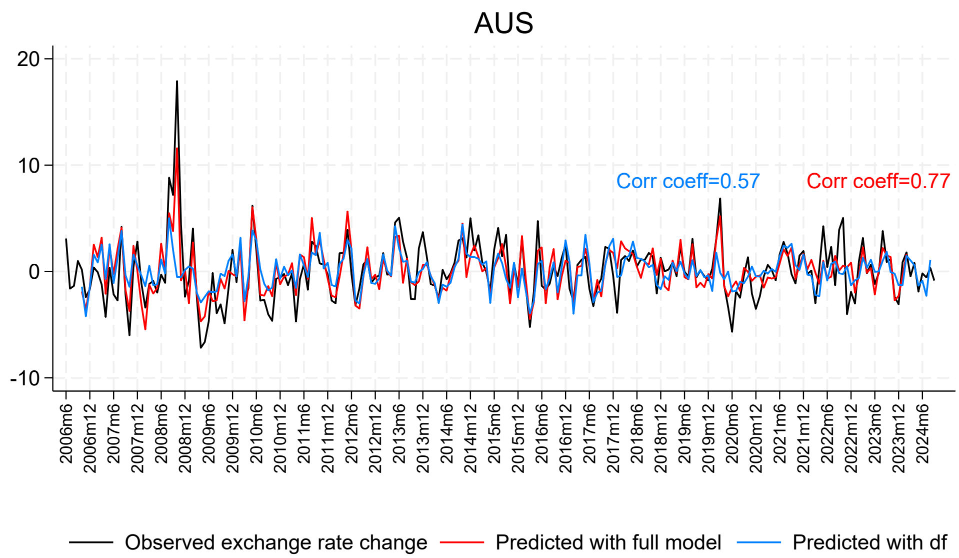
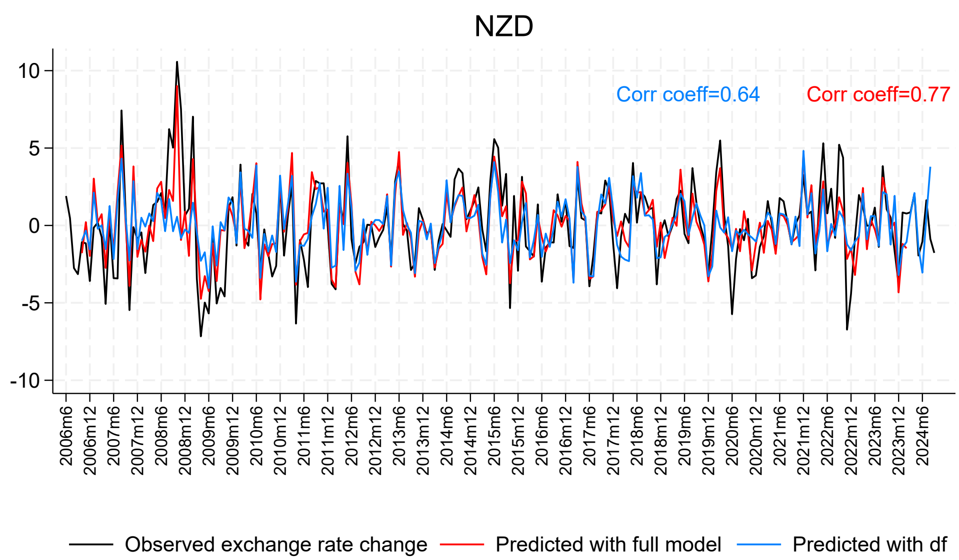


Figure A10: Realizations of $\Delta \log \mathcal{E}_{kt}$ and its fitted values for individual currencies(continued)





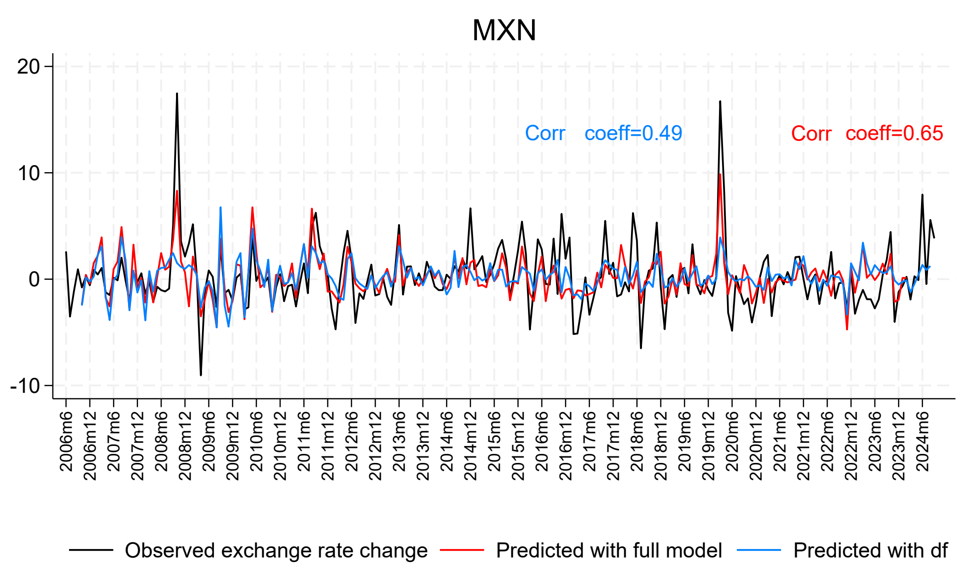


Figure A11: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies

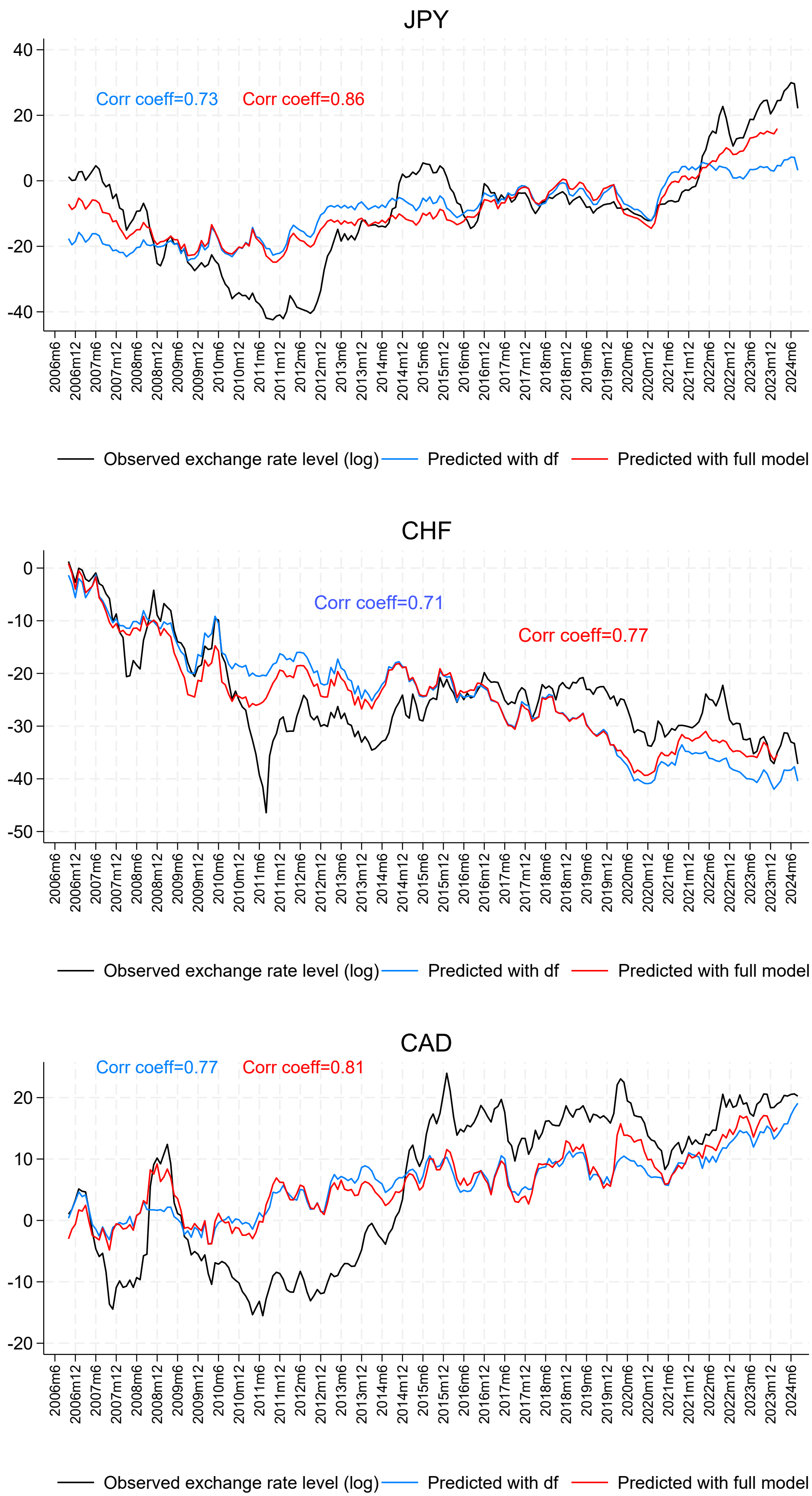
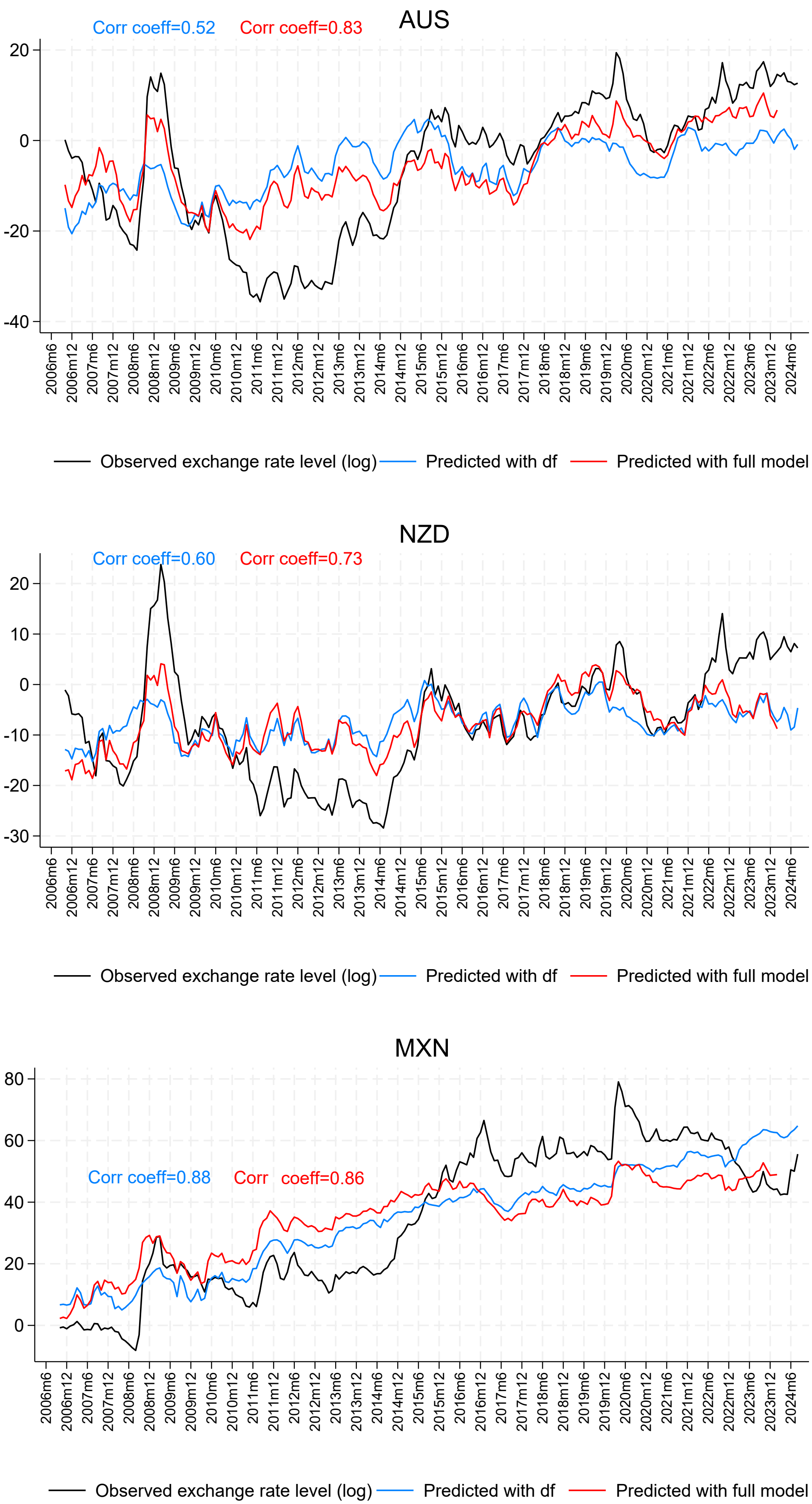


Figure A12: Realizations of $\log \mathcal{E}_{kt}$ and its fitted values for individual currencies (continued)



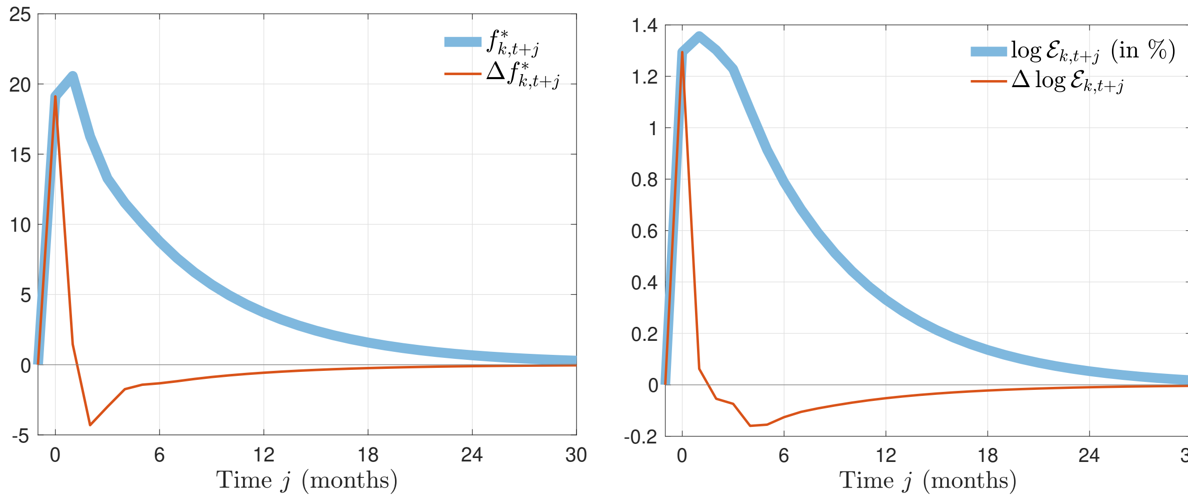


Figure A13: Impulse response to an innovation to Δf^*_{kt}: no time fixed effect

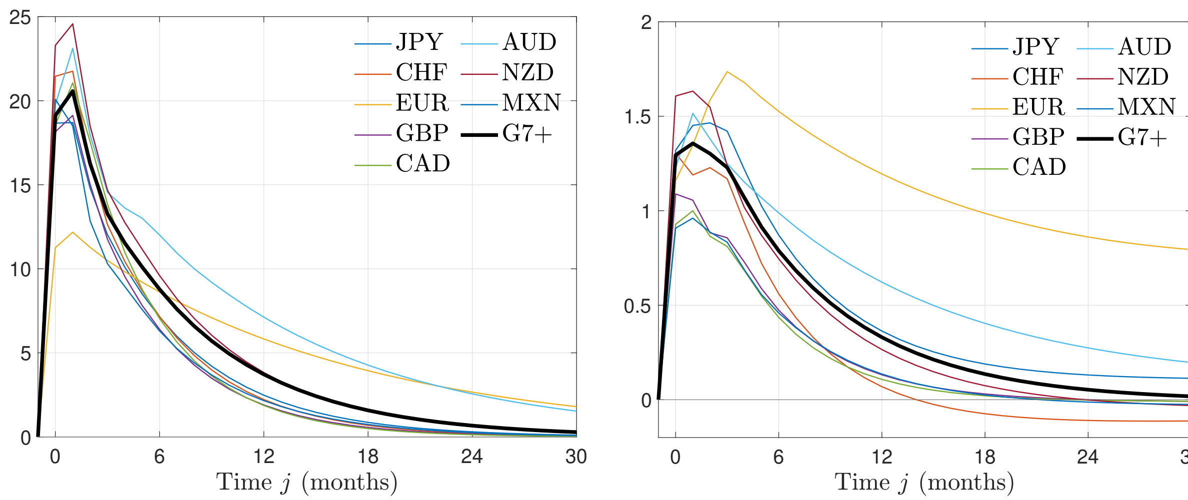


Figure A14: Impulse response to an innovation to Δf^*_{kt}: individual currencies

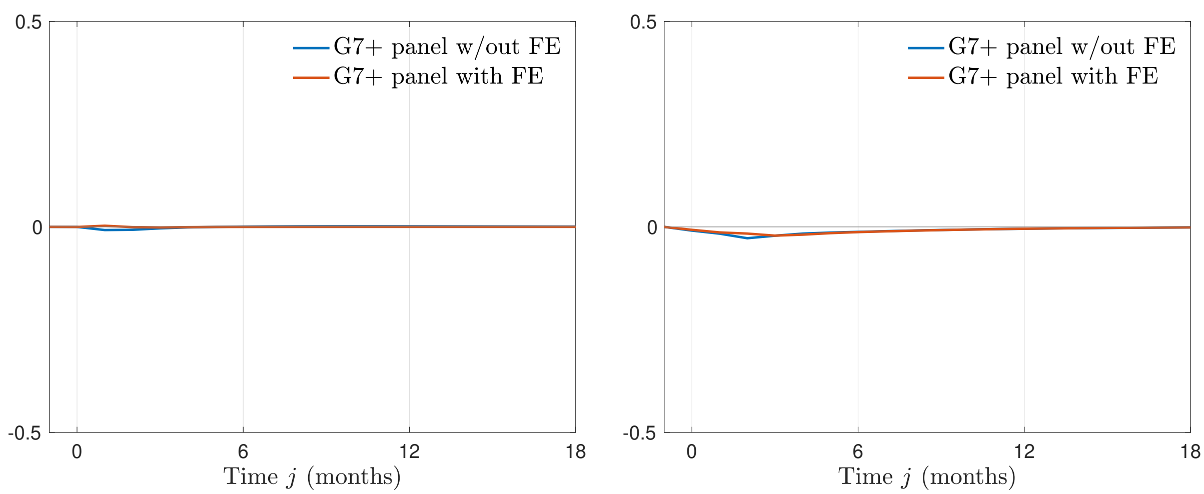


Figure A15: Impulse responses of $CIP_{k,t+j}$ (left) and $r_{k,t+j} - r^{US}_{t+j}$ (right) to a Δf^*_{kt} innovation

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). See Figure 8 for comparison with the baseline panel specification with time fixed effects. Bottom row plots impulse responses for CIP premia and interest rate differentials in a G7+ panel. Unlike upper panels (which are in % changes), bottom row reports results in annualized basis points, like returns in Figure 9 (that is, 0.5 on the y-axis is half a basis points, or 0.005%).

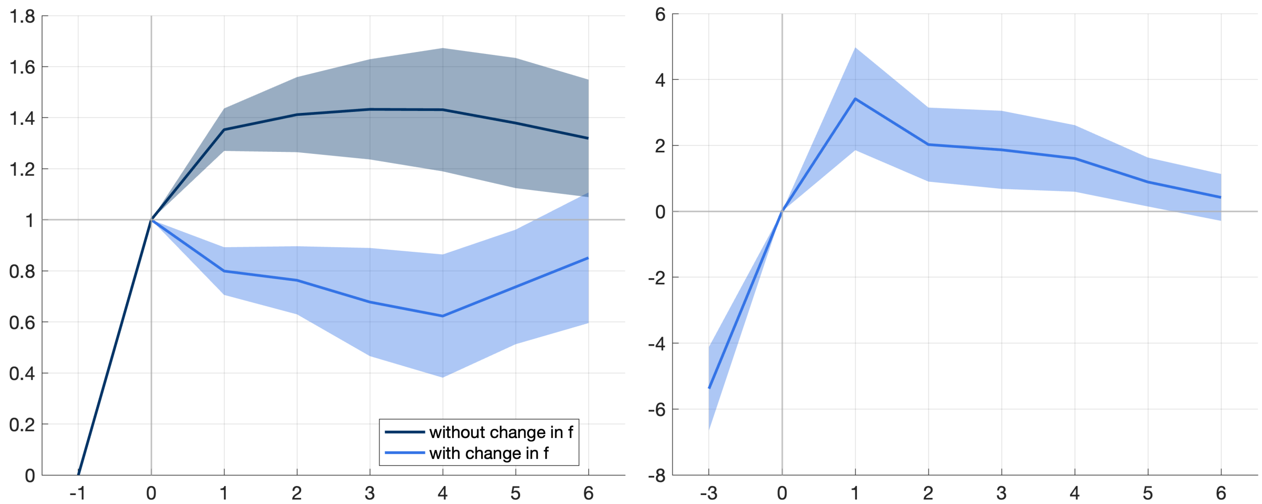


Figure A16: Impulse Response of log spot exchange rate $\log \mathcal{E}_{k,t+h}$ (left) and excess returns $rx_{k,t,t+h}$ (right)

Note: The figures plot estimates from the predictive local projections in Panels A and B of Table 7, respectively. Left panel normalizes the exchange rate impulse at $t = 0$ to 1% and plots the predicted future movements in the exchange for $h = 1, .., 6$ months with $\Delta f^*_{tk} = 0$ (in black) and with $\Delta f^*_{kt} = 14.45$ (in blue), i.e., the change in Δf^*_{kt} corresponding to a 1% depreciation on impact. Right panel plots the impulse response of currency excess returns $rx_{k,t,t+h}$ for horizons $h = 1, .., 6$ months (in annualized %) to a one standardized shock $\Delta f^*_{kt} = 20$, as well as $rx_{k,t-3,t}$ at $h = -3$ month. Both panels report 90 percent confidence intervals for point estimates.

B Proofs

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

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

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 in excess of reserves H_t^* is determined from the second optimality conditions which also 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 The UIP condition in (12) is the direct result of aggregation of individual bank positions $Z_{it}^* = A_{it}^* + F_{it}^*$ in the optimality condition (10) after rearranging it as $\overline{UIP}_t \cdot \frac{W_{it}^*}{\gamma_{it}} = \mu_t\sigma_t \cdot Z_{it}^*$ and imposing market clearing $\sum_i Z_{it}^* = \mathbf{Z}_t^*$ from (11). Bringing the resulting term $\sum_i W_{it}^*/\gamma_{it}$ to the right-hand side yields (12), with $\overline{UIP}_t$ defined in (9).

The CIP condition in (12) follows a similar logic with the difference that the optimality condition (10) 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:

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

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 $\mathbf{X}_t^* = \mathbf{F}_t^* + \mathbf{S}_t^*$, which is the reason for the second equality above. We generalize the optimality condition (10) 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 $\mathbf{X}_t^* = \sum_i X_{it}^*$ with individual positions X_{it}^* indeterminant as banks are indifferent who supplies forwards and swaps. Alternatively, if banks are heterogenous with a distribution $\{\delta_{it}\}$, then only the most unconstrained banks supply swaps such that: (2) either $\bar{\delta}_t = \min_i \delta_{it}$ or (3) $\bar{\delta}_t = \min\{\delta_{it} : X_{it}^* \text{ is unconstrained}\}$. In the former case, only the most efficient banks (with lowest δ_{it}) serve the market. In the latter case, the most efficient banks are constrained and the marginal (indifferent) bank supplying swaps has $\delta_{it} > \min_i \delta_{it}$; all banks with lower 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 $\text{sign}(CIP_t) = \text{sign}(\mathbf{X}_t^*)$. ■

Derivations and proof of Lemma 2 We start with the currency positions (13) for agents $i \in \mathcal{I} \cup \mathcal{I}^N$ and the associated market clearing in $\sum_{i \in \mathcal{I} \cup \mathcal{I}^N} Z_{it}^* = 0$. We denote with $\bar{\rho}_i = \mathbb{E}\rho_{it}$, $\bar{\lambda}_i = \mathbb{E}\lambda_{it}$ and $\bar{W}_i^* = \mathbb{E}W_{it}^*$ the agent-specific averages over time (or in the point of approximation, i.e., the long-run equilibrium). Having $\bar{\lambda}_i$ not equal to zero at least for some agents is essential for this approximation.[1] Taking the first-order Taylor expansion of (13) around $(\bar{\rho}_i, \bar{\lambda}_i \bar{W}_i^*)$ results in (14) where at the point of approximation $\bar{Z}_i^* = \bar{\rho}_i \cdot \overline{UIP} - \bar{\lambda}_i$. By market clearing for $\{\bar{Z}_i^*\}$, we have $\overline{UIP} = \varrho^{-1}\Lambda$ with $\varrho \equiv \sum_i \bar{W}_i^* \bar{\rho}_i$ and $\Lambda \equiv \sum_i \bar{W}_i^* \bar{\lambda}_i$, as defined in the text. Note that deviations from the point of approximation are denoted with tildes, that is, $\tilde{W}_{it}^* \equiv \mathrm{d}W_{it}^* = W_{it}^* - \bar{W}_i^*$, and similarly for other variables.

Since market clearing holds in every equilibrium, it must hold both for the point of approximation $\{\bar{Z}_i^*\}$ and for any equilibrium $\{Z_{it}^*\}$, and therefore we also have $\sum_{i \in \mathcal{I} \cup \mathcal{I}^N} \tilde{Z}_{it}^* = 0$. Combining this with (14) allows us to solve for $\widetilde{UIP}_t = \varrho^{-1} \cdot \Xi_t$, where $\Xi_t \equiv \sum_{i \in \mathcal{I} \cup \mathcal{I}^N} \bar{W}_i^* \xi_{it}$ with $\xi_{it} = \tilde{\lambda}_{it} + \overline{UIP} \cdot \tilde{\rho}_{it} + \frac{\bar{Z}_i^*}{\bar{W}_i^*} \frac{\tilde{W}_{it}^*}{\bar{W}_i^*}$, as stated in the lemma. Furthermore, from (14), we have:

$$\frac{\tilde{Z}_{it}^*}{\bar{W}_i^*} = \frac{\bar{\rho}_i}{\varrho} \cdot \Xi_t - \xi_{it}.$$

Combining this with $\frac{\bar{Z}_i^*}{\bar{W}_i^*} = \frac{\bar{\rho}_i}{\varrho} \cdot \Lambda - \bar{\lambda}_i$, we have $\frac{Z_{it}^*}{\bar{W}_i^*} = \bar{\rho}_i \cdot \overline{UIP}_t - (\bar{\lambda}_i + \xi_{it})$, where we used that the overall UIP premium is given then by $\overline{UIP}_t = \overline{UIP} + \widetilde{UIP}_t = \varrho^{-1} \cdot (\Lambda + \Xi_t)$. For intermediary banks $i \in \mathcal{I}$, if $\lambda_{it} = \bar{\lambda}_i = 0$, we have:

$$\forall i \in \mathcal{I} \qquad \frac{Z_{it}^*}{\bar{W}_i^*} = \bar{\rho}_i \cdot \overline{UIP}_t - \underbrace{\left(\overline{UIP} \cdot \tilde{\rho}_{it} + \frac{\bar{Z}_i^*}{\bar{W}_i^*} \frac{\tilde{W}_{it}^*}{\bar{W}_i^*}\right)}_{\text{(supply) shifter}}.$$

Next we rewrite the market clearing as follows:

$$\sum\nolimits_{i \in \mathcal{I}} Z_{it}^* = -\sum\nolimits_{i \in \mathcal{I}^N} Z_{it}^* = \mathbf{Z}_t^*$$

Aggregating the positions of intermediary banks above, we have:

$$\mathbf{Z}_t^* = \sum\nolimits_{i \in \mathcal{I}} Z_{it}^* = \overline{UIP}_t \cdot \underbrace{\sum\nolimits_{i \in \mathcal{I}} \bar{W}_i^* \bar{\rho}_i}_{\equiv \varrho_I} - \sum\nolimits_{i \in \mathcal{I}} \bar{W}_i^* \left(\overline{UIP} \cdot \tilde{\rho}_{it} + \frac{\bar{Z}_i^*}{\bar{W}_i^*} \frac{\tilde{W}_{it}^*}{\bar{W}_i^*}\right).$$

Or written in deviations, $\tilde{\mathbf{Z}}_t^* = \varrho_I \cdot \widetilde{UIP}_t - \sum_{i \in \mathcal{I}} \bar{W}_i^* \xi_{it}$, as stated in the lemma. Furthermore, if $\sum_{i \in \mathcal{I}} \bar{W}_i^* (\bar{\lambda}_i + \xi_{it}) = 0$, then $\mathbf{Z}_t^* = \varrho_I \cdot \overline{UIP}_t$, analogous to Proposition 2. Lastly, the time-series correlation between $\overline{UIP}_t$ and $\mathbf{Z}_t^*$ is shaped by the relative volatility of $\varrho_I \Xi_t$ and $\varrho \sum_{i \in \mathcal{I}} \bar{W}_i^* \xi_{it}$, as we prove in Appendix C. ■

[1] The exact solution for the UIP premium is $\overline{UIP}_t = \left(\sum_{i \in \mathcal{I} \cup \mathcal{I}^N} W_{it}^* \rho_{it}\right)^{-1} \left(\sum_{i \in \mathcal{I} \cup \mathcal{I}^N} W_{it}^* \lambda_{it}\right)$, and hence $\overline{UIP}_t = 0$ when $\sum_{i \in \mathcal{I} \cup \mathcal{I}^N} W_{it}^* \lambda_{it} = 0$, or when $\rho_{it} \to \infty$ for some agents.

C Time-series Identification

This appendix lays out the identification argument behind the local projection regressions (23) and (24) in Section 3.3 and (26) in Section 3.4.

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

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

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

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

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). We define the net exposure of all intermediaries as:

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

which by market clearing implies that $\sum_{i \in \mathcal{I}^N_k} Z^*_{it} = -\mathbf{Z}^*_{kt}$.

Next we follow the decomposition in the Proof of Lemma 2 in Appendix B and express the position of any agent i in currency k as:

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

where $\overline{UIP}_{kt}$ is the expected payout per unit of currency exposure, and we impose orthogonality as a matter of OLS decomposition rather than economic structure.

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:*

$$\overline{UIP}_{kt} = \frac{1}{\varrho^I_k + \varrho^N_k} \cdot \Xi_{kt}, \qquad \textit{where} \qquad \Xi_{kt} \equiv \xi^I_{kt} + \xi^N_{kt} = \sum\nolimits_{i \in \mathcal{I}_k} \bar{W}^*_i \xi_{it} + \sum\nolimits_{i \in \mathcal{I}^N_k} \bar{W}^*_i \xi_{it}$$

is the currency k demand shock, $\varrho^I_k \equiv \sum_{i \in \mathcal{I}_k} \bar{W}^*_i \rho_i$ and $\varrho^N_k \equiv \sum_{i \in \mathcal{I}^N_k} \bar{W}^*_i \rho_i$. The equilibrium net position of all intermediaries combined is given by:

$$\mathbf{Z}^*_{kt} = -\xi^I_{kt} + \varrho^I_k \cdot \overline{UIP}_{kt} = -\xi^I_{kt} + \frac{\varrho^I_k}{\varrho^I_k + \varrho^N_k} \Xi_{kt} = \frac{1}{\varrho^I_k + \varrho^N_k} (\varrho^I_k \xi^N_{kt} - \varrho^N_k \xi^I_{kt}).$$

Proof: Substitute (A4) into (A2) and aggregate using the definitions of ξ^J_{kt} and ϱ^J_k for $J \in \{I, N\}$. Substitute the resulting expressions into (A3) to obtain the characterization of $\mathbf{Z}^*_{kt}$. ■

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, $\varrho^I_k + \varrho^N_k$.

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 intermediaries, for currency k:

$$\overline{UIP}_{kt} = \alpha + \beta \mathbf{Z}^*_{kt} + \epsilon_{kt}. \tag{A5}$$

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

Corollary A1 *The coefficient β and R^2 in the regression (A5) are equal to:*

$$\beta = \frac{1}{\varrho^I_k} \cdot \frac{\text{cov}(\xi^N_{kt} + \xi^I_{kt}, \xi^N_{kt} - \varrho^N_k/\varrho^I_k \cdot \xi^I_{kt})}{\text{var}(\xi^N_{kt} - \varrho^N_k/\varrho^I_k \cdot \xi^I_{kt})} \qquad \textit{and} \qquad R^2 = \frac{\text{cov}(\xi^N_{kt} + \xi^I_{kt}, \xi^N_{kt} - \varrho^N_k/\varrho^I_k \cdot \xi^I_{kt})^2}{\text{var}(\xi^N_{kt} + \xi^I_{kt})\text{var}(\xi^N_{kt} - \varrho^N_k/\varrho^I_k \cdot \xi^I_{kt})}.$$

When $\text{var}(\xi^I_{kt})/\text{var}(\xi^N_{kt}) \to 0$, *we have* $\beta \to 1/\varrho^I_k$ *and* $R^2 \to 1$, *provided* $\rho^I_k > 0$.

Proof: This is a corollary of characterization in Proposition A1 after using the fact that $\beta = \frac{\text{cov}(\overline{UIP}_{kt}, \mathbf{Z}^*_{kt})}{\text{var}(\mathbf{Z}^*_{kt})}$ and $R^2 = \frac{\text{cov}(\overline{UIP}_{kt}, \mathbf{Z}^*_{kt})^2}{\text{var}(\overline{UIP}_{kt})\text{var}(\mathbf{Z}^*_{kt})}$ as the square of the correlation coefficient. Substitution of the expressions for $\overline{UIP}_{kt}$ and $\mathbf{Z}^*_{kt}$ from Proposition A1 and simple algebraical manipulations yield the result. Notice that as $\text{var}(\xi^I_{kt})/\text{var}(\xi^N_{kt}) \to 0$ we must also have $\text{cov}(\xi^N_{kt}, \xi^I_{kt})/\text{var}(\xi^N_{kt}) = \text{corr}(\xi^N_{kt}, \xi^I_{kt}) \cdot \big(\text{var}(\xi^I_{kt})/\text{var}(\xi^N_{kt})\big) \to 0$, which yields the characterization of β and R^2 in the limit. ■

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

$$\text{cov}(\xi^N_{kt} + \xi^I_{kt}, \xi^N_{kt} - \varrho^N_k/\varrho^I_k \cdot \xi^I_{kt}) > 0 \quad \Leftrightarrow \quad \varrho^I_k \text{var}(\xi^N_{kt}) + (\varrho^I_k - \varrho^N_k)\text{cov}(\xi^N_{kt}, \xi^I_{kt}) > \varrho^{\cdot}_k \text{cov}(\xi^I_{kt}).$$

Therefore, large ρ^I_k/ρ^N_k and large $\text{var}(\xi^N_{kt})/\text{var}(\xi^I_{kt})$ ensure this is the case. Note that this means that, for intermediaries, 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-intermediaries. In the limit of, $\text{var}(\xi^N_{kt})/\text{var}(\xi^I_{kt}) \to 0$, the intermediaries net positions become a perfect instrument for the demand shock in the currency market. Intuitively, this is the situation when the intermediaries mostly move along their currency supply with almost *no* shifts in this schedule due to ξ^I_{kt}, in relative terms to the size of ξ^N_{kt}, and hence their net position $\mathbf{Z}^*_{kt}$ becomes a perfect instrument for the currency demand shock Ξ_{kt}. This is reflected in the full $R^2 = 1$. Note that the estimated coefficient in this case recovers the elasticity $1/\varrho^I_k$, but not the aggregate elasticity of the currency market, $1/(\varrho^I_k + \varrho^N_k)$, which is relevant in shaping the equilibrium UIP premium in Proposition A1.

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

As a final example, consider the case where $\varrho^N_k = 0$, that is, when the net position of all non-intermediaries exhibits only demand shifts but no net currency supply, resulting in $\mathbf{Z}^*_{kt} = \xi^N_{kt}$. Note that the full currency demand shock is still given by $\Xi_{kt} = \xi^N_{kt} + \xi^I_{kt}$. Therefore, we have:

$$\beta = \frac{1}{\varrho^I_k} \cdot \left[1 + \text{corr}(\xi^I_{kt}, \xi^N_{kt}) \left(\frac{\text{var}(\xi^I_{kt})}{\text{var}(\xi^N_{kt})}\right)^2\right] \qquad \text{and} \qquad R^2 = 1 - \big[1 - \text{corr}(\xi^I_{kt}, \xi^N_{kt})\big]^2 \cdot \frac{\text{var}(\xi^I_{kt})}{\text{var}(\xi^N_{kt} + \xi^I_{kt})}.$$

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

More generally, R^2 is the measure of the proximity of $\mathbf{Z}^*_{kt}$ and Ξ_{kt}, that is, how close the net intermediaries' position approximates the aggregate demand shock in the currency k market, irrespectively of the bias of the estimated coefficient β.

Regression with controls Consider now an alternative specification to (A5) which controls for ξ^I_{kt} (in line with the expansion of ξ_{it} for intermediaries in Lemma 2). This corresponds to the controls for $\bar{\gamma}_{kt}\mu_t$ and $\mathbf{W}^*_{kt}$ that we include in our empirical specifications. We then have:

$$\overline{UIP}_{kt} = \alpha + \beta \mathbf{Z}^*_{kt} + \gamma \xi^I_{kt} + \epsilon_{kt}, \tag{A6}$$

where in practice the specification is again estimated in changes over time. The estimate β in this case is equivalent to the pairwise regression coefficient in the projection of the residualized $\overline{UIP}_{kt}$ on the residualized $\mathbb{Z}^*_{kt}$ after eliminating the variation associated with ξ^I_{kt}. We can use Proposition A1 and its corollary to show that this case corresponds to the situation with $\mathrm{var}(\xi^I_{kt})/\mathrm{var}(\xi^N_{kt}) = 0$ in the pairwise specification, and hence $\beta = 1/\varrho^I_k$ and $R^2 = 1$.

Empirical proxies In the data, we cannot perfectly observe either $\overline{UIP}_{kt}$ or $\mathbf{Z}^*_{kt}$. 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, $\mathbf{Z}^*_{kt}$, is unobservable. We construct a proxy for $\mathbf{Z}^*_{kt}$ for the intermediary bank sector from the futures market positions f^*_{kt} of the affiliated dealer-bank arms of large international banks.[2] 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 $\Delta\mathbf{Z}^*_{kt}$ taken on by the intermediary bank sector that prices the currency risk. Formally, this corresponds to the unobservable "first-stage":

$$\Delta\mathbf{Z}^*_{kt} = \alpha_k + \eta_k \Delta f^*_{kt} + u_{kt}, \tag{A7}$$

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, $\mathbf{Z}^*_{kt} = \mathbf{A}^*_{kt} + \mathbf{F}^*_{kt}$, 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 $\Delta\mathbf{F}^*_{kt}$. Finally, we assume that the net spot currency position $\mathbf{A}^*_{kt}$ 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 $\Delta\mathbf{Z}^*_{kt}$, while the currency fixed effect α_k in (A7) absorbs the slower-moving currency-specific trends in the savings gap.[3]

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 $\mathbf{Z}^*_{kt} = \mathbf{A}^*_{kt} + \mathbf{F}^*_{kt}$, the relevant variable for CIP premium is $\mathbf{X}^*_{kt} = \mathbf{S}^*_{kt} + \mathbf{F}^*_{kt}$, where $\mathbf{S}^*_{kt}$ are the net swap positions of intermediary banks. Our empirical variable Δf^*_{kt} is the most direct proxy for $\Delta\mathbf{F}^*_{kt}$, and we find it to be a strong predictor of the UIP premium for every currency. Therefore, the absence of any correlation between

[2] 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).

[3] The identification strategy in equation (A7) remains valid even if Δf^*_{kt} and $\Delta\mathbf{A}^*_{kt}$ are not correlated, as long as movements in $\Delta\mathbf{A}^*_{kt}$ do not fully offset movements in $\Delta\mathbf{F}^*_{kt}$ when projected on Δf^*_{kt}.

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 $\Delta\mathbf{X}^*_{kt}$ is zero in the unobservable "second stage" specification (parallel to (A6)). The virtually implausible alternative is that the correlation between Δf^*_{kt} and $\Delta\mathbf{X}^*_{kt}$ happens to be close to zero for every currency. This requires that the movement in swap positions $\Delta\mathbf{S}^*_{kt}$ nearly perfectly offset the movements in forward positions $\Delta\mathbf{F}^*_{kt}$, keeping $\Delta\mathbf{X}^*_{kt} \approx 0$, a knife-edge situation even for a single currency, let alone for every currency in the panel.[4] Therefore, we conclude that $\beta^{CIP}_k = 0$ in (A1) for every k is the consequence of locally elastic supply of hedged dollars, $\varrho^I_k \to \infty$ 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 (21), 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.

[4] 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.