Uncovered Interest Parity in High Frequency

Ingomar Krohn* Philippe Mueller† Paul Whelan‡

March 20, 2025

Abstract

We examine violations of uncovered interest parity (UIP) at daily and intraday levels, accounting for discrete interest payments in foreign exchange markets. Using regression- and portfolio-based methods, we reject the expectations hypothesis during the intraday period, but not overnight, and trading strategies exploiting UIP violations appreciate almost exclusively during the intraday period. The strategies exhibit distinctly different returns on FOMC and macro announcement days. However, while returns behave similarly intraday vs. overnight, they disagree on announcement vs. non-announcement days. The cross-sectional carry portfolio mostly appreciates on announcement days, while the dollar carry strategy that exploits time-series variation in average interest rate differentials generates positive returns on non-announcement days. An adjusted dollar carry strategy, always long foreign currencies on announcement days, yields over 11% annually.

JEL classification: D9, E3, E4, G12, G13, G14

Keywords: foreign exchange, uncovered interest parity, carry trade, high-frequency returns, macro announcements.

First Version: June 2024.

This Version: March 2025.

The views expressed in this paper are solely those of the authors and do not necessarily reflect the position of the Bank of Canada. We gratefully acknowledge financial support from INQUIRE Europe.

*Bank of Canada, 234 Wellington St. W, Ottawa, ON K1A 0G9, Canada, Email: IKrohn@bank-banque-canada.ca

†Warwick Business School, Coventry, CV4 7AL, UK, Email: Philippe.Mueller@wbs.ac.uk

‡The Chinese University of Hong Kong, New Territories, Hong Kong, Email: paulwhelan@cuhk.edu.hk

The forward premium puzzle and the failure of uncovered interest parity (UIP) have held centre stage in international finance for decades. Violations of UIP are often traced back to the empirical observation that high interest rate currencies tend to appreciate rather than depreciate as dictated by UIP. This has inspired a plethora of research on time variation of currency risk premia, predominantly focusing on tests at monthly or lower frequencies. A key takeaway from this literature is the identification of numerous profitable trading strategies, commonly known as "carry trades," which reflect various violations of UIP.[1] However, the extant literature has failed to pin down where UIP violations originate.

In this paper, we investigate the origins of UIP violations by examining currency returns over (very) short horizons. Through high-frequency regression and portfolio-based tests, we uncover three novel findings: (*i*) once interest rate payments are accounted for, currency risk premia are close to zero overnight; thus, UIP violations can almost exclusively be attributed to return patterns observed during U.S. intraday hours; (*ii*) trading strategies associated with UIP violations exhibit distinctly different return patterns on announcement days versus all other days. Abstracting from interest rate payments, the carry portfolio appreciates on announcement days and depreciates on non-announcement days. In contrast, returns to the dollar carry portfolio are positive on non-announcement days and negative on announcement days; (*iii*) quantifying the origins of UIP violations on announcement days, we find that 47% of carry returns are earned on macro announcement days (i.e., GDP, CPI, and non-farm payroll announcements), which constitute 13% of the days in our sample, and 16% of carry returns are earned on FOMC days, which account for only 3% of the days in our sample. Taken together, almost two thirds of total excess returns are earned on one sixth of the days in our sample.

We establish our empirical findings by constructing a dataset consisting of high-frequency spot and forward rates that allows us to carefully account for settlement conventions in the FX market. Indeed, the high-frequency nature of our empirical framework does not follow from a straightforward application of traditional lower frequency tests. Daily and intraday analyses require taking into account that interest on currency positions is paid at 17:00 Eastern Time (ET) as a lump sum covering the whole 24-hour period, which we use as the cutoff time to mark the end of the day. That is, the total interest is paid every day at the beginning of the overnight period, whereas no interest is charged on positions that are opened and closed within the day.

[1] The traditional carry trade for example exploits cross-sectional violations of UIP by sorting currencies based on interest rate differentials. The dollar carry trade, on the other hand, exploits a cross-time violation of UIP by trading the U.S. dollar against a basket of foreign currencies depending on time series variation in average interest rate differentials.

Moreover, FX spot transactions are not settled immediately, but generally with a two-day lag. This means that the FX spot data used in the existing literature is not suitable to study the relationship between interest rates (or forward premiums) and exchange rate changes at higher frequencies. In order to correctly calculate daily excess currency returns, we work with data on overnight, tomorrow-next and spot-next forwards that are not commonly used in the academic literature. In doing so, we are able to construct daily and intraday FX excess returns for a cross section of the G9 currencies over the period from January 1999 to December 2023. Contrary to the existing literature, this then allows us to study, for example, Fama (1984) regressions or the Hassan and Mano (2018) decomposition in high frequency.

First, we study high frequency Fama (1984) regressions and show that UIP deviations, viewed from the perspective of a U.S. investor, are driven by intraday spot dynamics. The slope coefficient of conventional UIP regressions estimated at a daily frequency switches from a positive value of 1.31 (not statistically different from the UIP prediction of unity) during the overnight hours, to -1.28 during the intraday period for the panel of G9 currencies vis-à vis the U.S. dollar.[2] This pattern is a robust feature of the data, with our sample spanning over 25 years of high-frequency data and currencies that collectively represent more than 75% of the daily average trading volume. We find the switch in the coefficient estimate for all currencies in the sample individually, as well as estimating panel regressions with currency and/or time fixed effects. Moreover, the main result holds for different subsample periods and is also obtained when using differences in short-term deposit rates to calculate interest differentials instead of currency forwards.

Second, we study high-frequency intraday UIP deviations using a portfolio approach. Hassan and Mano (2018) propose a decomposition that maps UIP violations to a set of trading strategies that can be adapted to our high-frequency empirical setting. We follow their approach and decompose the unconditional covariance of expected currency returns (or "risk premia") with forward premia into a cross-currency, a between-time-and-currency, and a cross-time component. This allows us to construct high-frequency return series for the carry trade (traditional and static), the dollar carry trade and the forward premium trade that generate average annualised excess returns equal to 3.63%, 5.34%, 4.54% and 2.83%, respectively.[3] With the exception of the static carry strategy, 95% to 186% of the total excess returns are earned during the intraday period.

[2]For a smaller and shorter sample, Chaboud and Wright (2005) find support for UIP over very short windows of data that span the time of the discrete interest payment.

[3]Unlike the traditional carry portfolio, the static carry portfolio is never re-balanced and is based on long-term (or expected) interest rate differentials in the cross-section. The forward premium trade exploits deviations from currency specific interest rate differentials in the time series.

Take the traditional carry strategy, for example, that invests in high interest currencies while shorting low interest rate currencies. According to UIP, the interest rate differential that is earned should be offset by depreciation of the carry trade portfolio. Over our sample period, the return contribution from the interest rate differential is exactly 3.63%, i.e., the total excess return earned on the strategy. The reason for the positive excess return is that the exchange rate changes in the portfolio leave the value unchanged instead of resulting in a loss to offset the "carry." Further decomposing the close-to-close returns, we find that the total annualised overnight change in the price of the carry portfolio is −3.45%, almost fully offsetting the interest that is paid at the beginning of the overnight period, and resulting in roughly zero excess return overnight. During the day, however, the carry portfolio exhibits a reversal and appreciates by 3.44% annualised as high interest rate currencies tend to appreciate while low interest rate currencies tend to depreciate.[4]

Third, we study the link between UIP violations and news. To this end, we split our sample into announcement and non-announcement days, and we show that both FOMC announcement days as well as scheduled major U.S. macroeconomic releases are fundamental sources of time-varying currency risk premia. Although these days account for one sixth of our sample, around two thirds of total currency excess returns for the traditional as well as the static carry strategy are earned on these days. In fact, focusing only on the appreciation and depreciation of the carry portfolios (i.e., ignoring the interest rate differential), we find that both portfolios on average depreciate on non-announcements days while they strongly appreciate on FOMC and macro announcement days. The dollar carry and forward premium portfolios, on the other hand, exhibit very different patterns. Their overall positive excess returns are exclusively earned on non-announcement days. Both exhibit significantly negative average excess returns on announcement days that become even more negative if the positive contribution from the interest rate differential is removed.

Fourth, combining the high-frequency results for strategies based on UIP violations together with the fact that the dollar portfolio (i.e., an unsigned version of the dollar carry portfolio) earns significant positive returns on FOMC and macro announcement days, we can propose an "adjusted" dollar carry strategy. The adjustment is very simple, straightforward and implementable in real-time. Consider first the simple dollar carry strategy that goes long or short the dollar portfolio depending on the average interest rate differential and combine this with a long position in the dollar portfolio on all announcement days (regardless of the interest rate differential). This

[4]This empirical result is in line with the findings in Lyons and Rose (1995) who show that currencies that are potentially exposed do devaluation risk intraday should appreciate systematically. However, they focus on a entirely different time period and currencies within the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) that was designed to stabilize currency movements within the European Union before the introduction of the euro.

simple strategy combines the high returns of the dollar portfolio on announcement days with the high returns of the dollar carry strategy on non-announcement days. Abstracting from transaction costs, the strategy is highly statistically significant and generates annual returns of around 11% over our sample period spanning 24 years.

What broader insights can be drawn from these findings? International asset pricing models can generally be classified into two categories: (*i*) reduced-form (statistical) models and (*ii*) structural (equilibrium) models. For theorists working within the first category, an important takeaway is that the world is far from normally distributed, and that "jumps" or special days play a critical role in explaining currency dynamics. Notably, similar models already exist in the fixed income and options literature, offering a useful starting point for further exploration (see, e.g., Piazzesi (2005), Dubinsky and Johannes (2006), and Kim and Wright (2014)). For theorists adopting a general equilibrium perspective, an analogous observation holds: a small fraction of days accounts for a disproportionately large fraction of compensation for bearing currency risk. Further evidence supporting this observation comes from our high-frequency decompositions, which demonstrate that the majority of cross-sectional violations of UIP occur during pre-announcement windows. This finding aligns with models in which investors exhibit a preference for the early resolution of uncertainty as in, for example, Ai and Bansal (2018).

In summary, our findings provide novel evidence on the drivers of currency risk premia. While Fama (1984) suggests that UIP deviations are consistent with perfect risk-sharing and a time-varying risk premium, alternative explanations have also been proposed, such as deviations from full-information rational expectations (see, e.g., Froot and Ramadorai (2005) and Stavrakeva and Tang (2024)), or imperfect risk-sharing, market segmentation, and the role of financial intermediation (see, e.g., Gabaix and Maggiori (2015) and Chernov, Haddad, and Itskhoki (2024)). We interpret our findings as evidence that UIP deviations primarily reflect compensation for risk, to which investors are exposed predominantly during intraday hours. Moreover, this risk appears to have distinct characteristics: continuous risk, which unfolds daily and drives currency risk premia in the time series (e.g., dollar carry), and non-continuous risk, which occurs on "special" pre-scheduled days and drives currency risk premia in the cross-section (e.g., traditional carry).

Related Literature: Our paper relates to various strands of the literature. First, an extensive literature studies violations of UIP using both regression- as well as portfolio-based methods. In a regression setting Fama (1984) famously rejects the expectations hypothesis for currencies and coins the forward discount puzzle showing that high-interest rate currencies subsequently tend

to appreciate violating the UIP condition (see Engel (1996) and Engel (2014) for surveys on the literature on UIP deviations). In portfolio settings, Lustig and Verdelhan (2007) and Lustig, Roussanov, and Verdelhan (2011) argue that returns to the carry trade are compensation for risk. Lustig et al. (2014) describe the dollar carry strategy that compensates investors for taking on aggregate risk by shorting the dollar in bad times, when the U.S. price of risk is high. Hassan and Mano (2018) unify the existing methods by providing a framework that maps UIP violations to trading strategy returns.

Different than these papers, we are the first paper to focus on high-frequency data and systematically study UIP violations not only at high frequencies but also for very short maturity instruments. To the best of our knowledge, Lyons and Rose (1995) and Chaboud and Wright (2005) are the only other papers that study UIP violations at comparable frequencies. However, they only do so for a much smaller set of currencies (three and four, respectively) and a much shorter time period (ending in 1992 and 2002, respectively). Moreover, the former focuses on a period when the EMS was in place and studies the behaviour of "vulnerable" currencies in the context of devaluation risk for fixed exchange rates while the latter only considers regressions surrounding the interest payment in FX positions. In addition to studying the overnight non-rejection period, our focus is on the behaviour of the trading strategies during the intraday period that leads to violations of UIP.

Second, our paper is related to a literature that studies effects of macroeconomic or FOMC announcements. For equity markets, Lucca and Moench (2015) show that a sizable fraction of realised stock returns is earned on FOMC announcement days. Similarly, Savor and Wilson (2013) show that the average excess return on U.S. stocks is significantly higher on days when macroeconomic news is scheduled for announcement. The closest paper to ours is Mueller, Tahbaz-Salehi, and Vedolin (2017) who show that long FX positions earn significant positive returns on FOMC announcement days, with returns increasing in the interest rate differential vis-a-vis the U.S. dollar. We complement and extend their paper by documenting not only the importance of FOMC days but also highlight the relevance of macroeconomic announcements. In addition, we further consider not only individual currency excess returns but instead study a host of currency trading strategies that display different exposures to currency risk factors. Importantly, we highlight that while the currency strategies behave similarly during intraday and overnight periods, the results are vastly different when studying announcement vs. non-announcement days, thus highlighting also the importance of non-announcement days for understanding currency risk premia.

I. Market Conventions and UIP Tests in High Frequency

In this section, we first clarify the relevant terminology used in FX markets for short-term transactions. In addition, we recast regression- and portfolio-based methods to study UIP violations in high frequency.

A. Spot as Forward Trading

In financial markets, *spot* trading commonly refers to transactions with "immediate" delivery (as opposed to *forward* transactions where delivery happens at a pre-determined point in the future). However, settlement is usually delayed—in FX markets, this usually happens two business days following the spot trade—to give both parties enough time to settle their obligations given time zone differences and bank processing delays.[5] This means that an FX spot trade is not immediate but effectively a two-day (or multi-day) forward transaction.[6] In order to establish the exact settlement date, it is important to track business days in both jurisdictions of the currencies to be exchanged, i.e., what matters for settlement are the jurisdictions of the respective currencies and not where the counterparties are located.[7] For example, if the trade date is a Wednesday, the settlement date would normally be a Friday if Thursday and Friday are business days in both jurisdictions. However, if Friday is a holiday in one of the two countries, then settlement will happen on the following Monday, again assuming there is no holiday on this day in either country.

Spot trades are the most frequent transactions in the FX market and the prices are commonly used to calculate FX (excess) returns at different frequencies. While traders routinely take into account that spot transactions involve a two-day settlement lag when managing their currency positions, the settlement lag is largely ignored in academic research as it is irrelevant. Instead, it is generally assumed that spot rates describe the immediate rate of exchange between two currencies. As we focus on higher-frequency transactions, however, the institutional and settlement details become important and there is a need to be very precise with regards to the various rates that are available in the market.

[5] The exception to this rule is the Canadian dollar which settles one trading day after the transaction date.

[6] In addition to the transaction and settlement dates, the value date is important in financial markets. It is the future time at which the value of an account, transaction, or asset becomes effective. In FX markets, the settlement and value date coincide, whereas in bond markets for example, the settlement date must be a business day but the value date can fall on any date of the month from which accrued interest is calculated. In FX, settlement can only happen on what is called an FX trading day.

[7] Some currencies are not quoted directly against each other but against the U.S. dollar, implying that an FX trading day must be a business day in up to three jurisdictions.

B. Short-Dated FX Transactions

Denote by S_t the spot exchange rate expressed in units of U.S. dollar per foreign currency.[8] A decrease in S_t corresponds to an appreciation of the U.S. dollar relative to the foreign currency. The τ-day domestic and foreign interest rates are i_t^τ and $i_t^{\tau,*}$, respectively. Covered interest parity (CIP) ensures that τ-day outright FX forwards obey

$$F_t^\tau = S_t \left(\frac{1 + i_t^\tau}{1 + i_t^{\tau,*}} \right). \tag{1}$$

FX forwards are quoted in terms of forward points (FP_t^τ), the number of basis points (bps) added to (or subtracted from) the current spot rate to determine the forward rate for delivery on a specific value date $t + \tau$ in the future, i.e.,

$$F_t^\tau = S_t + FP_t^\tau \quad \text{or} \quad FP_t^\tau = S_t \left(\frac{i_t^\tau - i_t^{\tau,*}}{1 + i_t^{\tau,*}} \right). \tag{2}$$

If the domestic interest rate is higher than the foreign interest rate ($i_t^\tau > i_t^{\tau,*}$), we observe a forward premium and forward points are added. Conversely, forward points are subtracted when there is a forward discount ($i_t^{\tau,*} > i_t^\tau$). Either way, imposing equation (1) ensures arbitrage-free pricing for FX forwards. In order to manage FX positions and exposures, traders can use a number of short-dated FX swaps, i.e., agreements to simultaneously borrow one currency and lend another while exchanging the amounts at maturity:

- Overnight (ON): swap today (t) against tomorrow ($t + 1$) denoted F_t^{ON}.
- Tomorrow-Next (TN): forward swap agreed today (t) for tomorrow ($t + 1$) against the next day ($t + 2$) denoted F_t^{TN}.
- Spot-Next (SN): forward FX swap agreed today (t) for the spot date ($t + 2$) against the following day ($t + 3$) denoted F_t^{SN}.

As a rule, if a trader opens and closes a position during the same business day, the value date of the trades will be identical and the positions will net out during settlement at $t+2$ as intradaily interest is zero and only accrues if a position is held open through 17:00 New York time (see, e.g., Chaboud and Wright (2005)). A TN contract for example can then enable traders to avoid

[8] Note that throughout we follow the euro vs. U.S. dollar quoting convention (EURUSD) where the U.S. dollar (our domestic currency) is the "quote currency."

taking physical delivery of spot by simultaneously buying and selling a currency over consecutive business days once they hold an open position. The quoted TN rate adjusts the closing level of positions held at 17:00 ET by prevailing interest rate differentials. Depending on the cost of carry, a broker will adjust the trading account in that a long position in a higher yielding currency will earn a credit while a long position in a lower yielding currency will be charged a debit. Moreover, the contracts listed above allow traders to roll over their positions on a potentially daily basis if desired.

The quotation of FX forwards takes into account that spot transactions settle two business days after the transaction date. Any contracts that settle before or after the standard two-day lag require an adjustment for the interest rate differential in line with equation (1). In particular, this is the case for value today (TOD) and value tomorrow (TOM) trades that settle on the same or the next day, respectively. Thus, ON, TN and spot transactions allow to back out the exchange rate for a TOD trade for example. Define such a cash rate C_t using the logic for the forward rate used in equation (1):

$$S_t = C_t \left(\frac{1 + i_t^{2\text{d}}}{1 + i_t^{2\text{d},*}} \right) \quad \text{or expressed in logs} \quad c_t = s_t - i_t^{2\text{d}} + i_t^{2\text{d},*} = s_t - fp_t^{2\text{d}},$$

where $fp_t^{2\text{d}}$ denotes the (log) forward premium, the difference between the domestic and the foreign interest rate for the period from the transaction to the settlement date (usually two days). To back out $fp_t^{2\text{d}}$, we can use the ON and TN contracts that are quoted in terms of forward points. When combining a spot transaction with an ON and a TN transaction, the ON back leg nets out the TN front leg, and the TN back leg nets out the spot trade. The implied cash rate can then be calculated by taking the spot rate and subtracting two days worth of forward points, i.e., $C_t = S_t - FP_t^{\text{ON}} - FP_t^{\text{TN}}$, where FP_t^i refers to the pricing convention of ON and TN FX swaps as per equation (2).

Note, however, that in order to calculate short term currency swap rates F_t^{ON} and F_t^{TN}, we effectively have to discount backwards in time, while for F_t^{SN} we can directly use the expression in equation (1). This for example implies that if $i_t^{\text{TN}} > i_t^{\text{TN},*}$, forward points are subtracted from the spot rate. Conversely, if $i_t^{\text{TN}} < i_t^{\text{TN},*}$, forward points are instead added to the spot rate if FP_t^{TN} is quoted as in equation (2).

To visualise the timing of the FX and interest rate transactions, we provide a schematic overview in Figure A-1 in Appendix AI. There, we also include an example on how positions

are rolled in the FX market using data on the EURUSD exchange rate to illustrate the actual steps and explain the precise calculations.

C. High-Frequency UIP Regressions

We start with the forward premium puzzle that arises in standard Fama (1984) regressions testing the expectations hypothesis of forward FX rates (or studying violations of UIP using a regression approach). Replacing the forward rate in equation (1) with the expected spot rate we get:

$$\frac{E_t\big[S_{t+\tau}\big]}{S_t} = \left(\frac{1+i_t^{\tau}}{1+i_t^{\tau,*}}\right).$$

Delivery on a 1-month forward contract occurs on the calendar day in the next month that corresponds to the calendar day in the current month when the spot trade settles, i.e., at $t+2$ days.[9]

UIP regressions are regularly run taking a log linear approximation (lower case letters indicate logs) of $(1+i_t^{\tau})$ and $(1+i_t^{\tau,*})$ ignoring Jensen's inequality arising from the expectations operator,i.e.,

$$\begin{aligned} E_t[s_{t+\tau} - s_t] &= i_t^{\tau} - i_t^{\tau,*}, \\ s_{t+\tau} - s_t &= \alpha + \beta\big(i_t^{\tau} - i_t^{\tau,*}\big) + \varepsilon_{t+\tau}, \qquad (3) \\ &= \alpha + \beta\big(f_t^{\tau} - s_t\big) + \varepsilon_{t+\tau}, \qquad (4) \end{aligned}$$

where equation (3) follows by imposing rational expectations and equation (4) follows by imposing covered interest parity (CIP). Bekaert and Hodrick (1993) show that unless the forward rate is matched with the appropriate future spot rate by accounting for all the delivery rules, the calculation of the return on the forward contract is generally not correct and, hence, the regression is potentially biased. However, they also show that for regressions using monthly forward rates (as is usually done in the literature), the bias introduced by this measurement error is not driving the widely documented failure of UIP.

We deviate from the large existing literature by considering higher frequencies to run the regression and a focus on a daily horizon for the FX instruments. With such a short-dated view, it

[9] This only holds if this day next month is a business day. If that is not the case, delivery occurs on the following business day as long as it remains in the same month. Otherwise, delivery occurs on the first previous business day. One final exception is the so-called "end-to-end"-rule which applies when the value date falls on the last business day of the month. In this case, the corresponding forward value day will automatically be the last business day in the subsequent month (see, e.g., Bekaert and Hodrick (1993)).

is imperative to carefully measure FX returns, and to correctly line up forward and spot rates. To set up the regression and extract the one-day forward premium, we use the SN FX swap contracts:

$$\begin{aligned} s_{t+1} - s_t &= \alpha + \beta\big(i_t^{\text{SN}} - i_t^{\text{SN},*}\big) + \varepsilon_{t+\tau}, \\ &= \alpha + \beta\big(f_t^{\text{SN}} - s_t\big) + \varepsilon_{t+\tau}, \end{aligned} \tag{5}$$

where $s_{t+1} - s_t$ is the change in the spot rate from value date $t+2$ to value date $t+3$ and $i_t^{\text{SN}} - i_t^{\text{SN},*} = FP_t^{\text{SN}}$ are the spot-next forward points that capture the one-day interest rate differential for the same time period.[10] That is, regression (5) appropriately aligns the daily changes in the spot rate from t to $t+1$ with the corresponding interest rate differential for daily rates.

D. High-Frequency Portfolio Sorts

Fama (1984) regressions are not the only way to test for violations of UIP. A related failure is the well-known carry trade anomaly. While the forward premium puzzle is a fact about a regression coefficient, the carry trade is about a profitable trading strategy based on portfolio sorts. Hassan and Mano (2018) propose a comprehensive framework that allows to analytically relate regression-based and portfolio-based facts by recasting both the forward premium puzzle as well as the carry strategy in the context of trading strategies.

The traditional carry trade is implemented by lending in currencies that have high interest rates while borrowing in currencies that have low interest rates. Related, the dollar carry trade is implemented by going long all foreign currencies when the world average interest rate is high relative to the U.S. interest rate, and by going short all foreign currencies when it is low (see Lustig, Roussanov, and Verdelhan (2014)). Finally, the forward premium puzzle corresponds to a forward premium trading strategy that involves going long a currency when its interest rate exceeds its own long-run mean and going short otherwise.

The trading strategies related to UIP violations are formed using a decomposition of the unconditional covariance of expected currency returns (or risk premia) with forward premia into a cross-currency ("static trade"), a between-time-and-currency ("dynamic trade"), and a cross-time ("dollar trade") component:

[10] An exception to this rule is the CAD, for which the settlement period is $t+1$. Correspondingly, we use tomorrow-next contracts for this currency.

$$\sum_{i,t}\left[\left(rx_{i,t+1}-\overline{rx}\right)\left(fp_{i,t}-\overline{fp}\right)\right]=\underbrace{\sum_{i,t}\left[rx_{i,t+1}\left(\overline{fp_i^e}-\overline{fp^e}\right)\right]}_{\text{Static Trade}}+$$
$$\underbrace{\sum_{i,t}\left[rx_{i,t+1}\left(fp_{i,t}-\overline{fp_t}-\left(\overline{fp_i^e}-\overline{fp^e}\right)\right)\right]}_{\text{Dynamic Trade}}+$$
$$\underbrace{\sum_{i,t}\left[rx_{i,t+1}\left(\overline{fp_t}-\overline{fp^e}\right)\right]}_{\text{Dollar Trade}}+\underbrace{\sum_{i,t}\left[\overline{rx}\left(\overline{fp^e}-\overline{fp}\right)\right]}_{\text{Constant}}, \tag{6}$$

where $rx_{i,t+1} = f_{it} - s_{i,t+1}$ is the log excess return on currency i between time t and $t+1$, $fp_{it} \equiv f_{it} - s_{it}$ is the forward premium (or the negative of the forward discount), $\overline{rx}$ is the mean currency return across currencies and time periods, $\overline{fp_t}$ is the average forward premium of all currencies at time t, $\overline{fp_i}$ is the currency-specific mean forward premium, and $\overline{fp}$ is the unconditional mean forward premium. The superscript e denotes investor's ex ante (i.e., at time 0) expectations.

The static trade represents a static version of the carry trade (SC) where the portfolio is long currencies that are expected to have high interest rates on average and short those that are expected to have low interest rates. The traditional carry trade (TC) is the sum of the static and the dynamic trade, while the return to the forward premium trade (FP) is the sum of the dynamic and the dollar trade, i.e., relation of the traditional carry and the forward premium trade is determined by the relative contribution of the dynamic trade (DT) as they share the between-time-and-currency part. The dollar trade is the dollar carry (DC) strategy proposed in Lustig, Roussanov, and Verdelhan (2014) and it is also a component of the forward premium trade.[11] By construction, the dollar and the carry trades are independent. In addition to the various strategies, we also consider returns to the dollar portfolio (DOL) that always goes long a basket of foreign

[11] To be precise, the dollar carry strategy in equation (9) uses the unconditional expectation of the average forward premium to decide on whether to go long or short the dollar portfolio. Results are materially the same when assuming that this unconditional expectation is equal to zero as in Lustig, Roussanov, and Verdelhan (2014).

currencies. In sum, we have:

$$\text{Traditional Carry: } \sum_{i,t} \left[rx_{i,t+1} \left(fp_{i,t} - \overline{fp_t} \right) \right] \tag{7}$$

$$\text{Static Carry: } \sum_{i,t} \left[rx_{i,t+1} \left(\overline{fp_i^e} - \overline{fp^e} \right) \right] \tag{8}$$

$$\text{Dollar Carry: } \sum_{i,t} \left[rx_{i,t+1} \left(\overline{fp_t} - \overline{fp^e} \right) \right] \tag{9}$$

$$\text{Forward Premium: } \sum_{i,t} \left[rx_{i,t+1} \left(fp_{i,t} - \overline{fp_i^e} \right) \right] \tag{10}$$

Note that the portfolio weights in equations (7) to (10) are linear and depend on deviations from means. The extant literature predominantly uses a very peculiar, if not ad hoc, weighing scheme by sorting currencies into buckets according to their interest rate differential and then going long high interest rate currencies in equal weights while shorting low interest currencies using equal weights at the same time. That is, the weights for the long and the short leg, respectively, add up to one while currencies in other buckets are assigned a weight of zero. To mimic the construction of carry portfolios, we apply a scaling factor c_t to the raw weights to ensure that the sum of the absolute weights in the long and short leg adds up to unity (as in Menkhoff et al. (2017)). As the components in equation (6) need to add up to the total covariance, we apply the scaling factor based on the traditional carry strategy to all other trading strategies listed in equations (7) to (10). Moreover, the returns to our dollar portfolio are the "unsigned" returns to the collar carry strategy where we use the absolute value of the weights in equation (9) and apply the scaling factor. That is, for any given day, the absolute returns to the dollar portfolio and the dollar carry strategy are equal.

The extant literature studies returns to the various trading strategies (in particular the traditional and dollar carry) predominantly based on monthly, quarterly, or lower frequency holding periods. We focus on much higher frequencies and consider daily close-to-close returns measured at 17:00 ET as well as returns split into overnight and intraday components. In order to account for the interest portion of these portfolio returns, we attribute the interest rate differential fully to the overnight component of trading returns for positions that are open at 17:00 ET on the previous day.

II. Data

We compile our data from multiple sources. Data on intraday foreign exchange rates are obtained from Refinitiv covering 25 years of high-frequency data from January 1999 to December 2023. We focus on the G9 currencies, i.e., the Australian dollar (AUD), the Canadian dollar (CAD), the euro (EUR), the Japanese yen (JPY), the New Zealand dollar (NZD), the Norwegian krone (NOK), the Swedish krona (SEK), the Swiss franc (CHF), and the British pound (GBP), all vis-à-vis the U.S. dollar.

We transform the tick-by-tick data from Refinitiv in the following way. We obtain the best bid and ask quote recorded to the nearest even second. After applying a number of filters to correct the data for outliers, the price at each five-minute tick is obtained by linearly interpolating from the average of the bid and ask quotes for the two closest ticks. If no quote was submitted during a specific interval, we fill the gap with the most recent available price.

Following previous studies (see, e.g., Andersen, Bollerslev, Diebold, and Vega (2003)) we exclude quotes that are submitted on days that are associated with low trading activity. For example. we remove all quotes on weekends between Friday 17:00 ET and Sunday 17:05 ET. Similarly, we drop quotes around fixed holidays, i.e., Christmas (24 to 26 December), New Year (31 December to 2 January), and 4 July, and around flexible holidays, such as Good Friday, Easter Monday, Memorial Day, Labor Day, and Thanksgiving (including the day after). In addition, we collect dates of country-specific holidays from Bloomberg in order to correctly align the days of interest accrual with the corresponding daily spot transactions. As a result, daily observations vary across currency pairs, ranging between 5,470 days for the yen to 5,877 days for the euro.

We supplement the high-frequency FX spot data with daily data from Bloomberg on short-term forward points with tomorrow-next (TN) and spot-next (SN) maturities. These short-term forward contracts exactly match the settlement period of a one-day spot trade, allowing us to align daily spot rate changes with daily forward discounts. Moreover, and in line with existing literature, we use forward rates from Datastream with one-month maturity for monthly UIP regressions. For additional robustness tests, we source deposit interest rates with maturities ranging between one day (tomorrow-next and spot-next, respectively) and one month (1M) from Datastream as well.[12]

Lastly, we collect information on announcements dates and times from Bloomberg's Economic Calendar. Following Savor and Wilson (2014), we primarily focus on central bank announcements

[12]We use historical monthly data on 1-month forwards during the period January 1994 to December 1998 to proxy the ex-ante expectations $\overline{fp}^e$ introduced in section D of the previous section.

as well as the main macroeconomic announcements related to labor market dynamics (e.g., U.S. non-farm payroll), inflation (e.g., CPI Ex. Food and Energy), and output (e.g., GDP QoQ or Industrial Production MoM).

III. Daily Regression-Based Tests

We begin by running conventional monthly UIP regressions, with the twist that we split returns into intraday (ID) and overnight (ON) components aggregated over the month. In line with how interest accrual is measured, we use 17:00 ET as the close of day to define daily log spot returns:

$$\Delta s_{t+1}^{\text{CTC}} = s_{t+1}^{17:00} - s_t^{17:00},$$

where $s_t^{17:00}$ is the log mid-price at the end of day t. We express returns in U.S. dollar (domestic) per foreign currency, i.e., a negative return observation implies an appreciation of the U.S. dollar appreciates against the foreign currency. Note that our choice of closing time differs from the "London fix" time at 16:00 GMT that is often used in studies using FX data.

To decompose the daily currency returns into an intraday and an overnight component, we take the perspective of a U.S. investor based in New York and define the beginning and ending of the intraday period as 7:00 ET and 17:00 ET on day t, respectively. In line with previous studies (e.g., Cespa, Gargano, Riddiough, and Sarno, 2022), we assume that these hours capture the most active trading period in the spot market for New York based market participants. The overnight window for day t covers the period between 17:00 ET on day $t-1$ until 7:00 ET on day t. This window thus comprises all opening times and some of the closing times of the major FX trading venues located outside of the U.S.[13] In addition, interest on FX positions is paid at 17:00 and is thus attributed to the overnight period.

More formally, we define the components as follows, ensuring that our intraday (ID) and overnight (ON) return measures exactly add up to the close-to-close returns (CTC):

$$\Delta s_t^{\text{ID}} = s_t^{17:00} - s_t^{7:00}. \qquad \Delta s_t^{\text{ON}} = s_t^{7:00} - s_{t-1}^{17:00}.$$

We also create monthly time series by aggregating all daily log returns within a month (i.e., $t \in m$) for a total of 300 monthly observations for the CTC, ID and ON returns, respectively:

[13] As FX markets trade around the clock, defining intraday vs. overnight periods is not straightforward. We use 7:00 ET as Krohn, Mueller, and Whelan (2024) for example show that volume starts to pick up around that time for many currencies with a local spike at 7:00 ET. However, our results are robust to moving the start of the intraday period back to 8:00 ET.

$$\Delta s_t^{\text{CTC,m}} = \sum_{t \in m} \Delta s_t^{\text{CTC}} \qquad \Delta s_t^{\text{ID,m}} = \sum_{t \in m} \Delta s_t^{\text{ID}} \qquad \Delta s_t^{\text{ON,m}} = \sum_{t \in m} \Delta s_t^{\text{ON}}$$

Lastly, we construct daily log excess return (rx) for a U.S. investor, who takes long positions in foreign currencies as

$$rx_{t+1}^k = \Delta s_t^k + s_t - f_t$$

where s_t and f_t refer to daily spot and short-term forward rates, and Δs_t^k are the returns during intraday period k, where $k \in \{CTC, ON, ID\}$.

A. Forward Premium Regressions

We start by re-examining the forward premium puzzle using the following fixed effects panel regression:

$$\Delta s_{t+1}^j = \beta(f_t^{\tau,j} - s_t^j) + \alpha_i + \kappa_t + \varepsilon_{t+1} \tag{11}$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, and $(f_t^{\tau,j} - s_t^j)$ refer to the forward discount with maturity τ =1M (Panel A) or τ =1D (Panel B) , α_i are currency fixed effects and κ_t are time-series fixed effects. The combination of included fixed effects varies across regression specifications, as indicated by the column headers.

[INSERT TABLE I HERE]

A positive coefficient under the null $H_0 : \beta = 1$ implies that the forward rate is an unbiased estimate of the future spot exchange rate. As rational agents drive the value of the forward rate to the price of the expected future exchange rate, speculation in the forward market becomes unprofitable. In contrast, if the forward rate is higher (lower) than the expected spot rate, market participants earn a premium from buying (selling) a currency in the forward market.

For each maturity τ and for each fixed effect specification, we estimate three separate versions of regression (11) using our monthly CTC, ID or ON return time series as the dependent variable on the left-hand side, respectively. The top panel in Figure 1 illustrates our first major finding, displaying the currency fixed effects estimates reported in columns denoted "Curr". The plot shows the estimated β-coefficients from the panel regression for the three return series along with the corresponding error bands. In line with previous papers, the coefficient based on CTC returns is negative (-0.5, grey bar) and far from unity. According to Fama (1984), such a result

is consistent with perfect risk-sharing and the existence of a time-varying risk premium; however, alternative channels can also explain this finding such as deviations from full information rational expectations (see, e.g., Froot and Ramadorai, 2005 and Stavrakeva and Tang, 2024) or imperfect risk-sharing, market segmentation and the role of financial intermediation (see, for example, Gabaix and Maggiori, 2015 and Chernov, Haddad, and Itskhoki, 2024).

Panel A in Figure 1 also shows a strong divergence in the relationship between the forward discount and returns for different periods of the day. The estimated β-coefficient is positive (0.89, blue bar) and not statistically different from unity for overnight hours (the p-value is 0.86), while during local trading hours in New York, the same β-coefficient is significantly negative with a point estimate of -1.31 (orange bar). Thus, the results suggest that the failure of the UIP relationship detected in conventional regressions is primarily due to exchange rate movements during the intraday period; whereas forward discounts and currency returns seem to be more aligned during the overnight hours.

[INSERT FIGURE 1 HERE]

In the bottom panel of Figure 1, we present the corresponding results for daily panel regressions, carefully matching up daily spot rate changes with short-term forward discounts (using tomorrow-next or spot-next contracts) as outlined in Section I. The divergence between overnight and intraday returns is now even more striking, with estimated β-coefficients equal to 1.32 and -1.28 for the respective windows. Both coefficients are significantly different from zero, and the discrepancy between overnight and intraday periods further suggests differing patterns in the time-varying risk premium over the course of the day.

Table I studies the robustness of this finding to the inclusion of time and currency+time fixed effects. We first note that across specifications, point estimates and statistical inference is very similar for both monthly and daily horizons demonstrating an important contribution of our paper: accounting for settlement conventions properly allows us to map a *vast* low frequency literature on UIP anomalies consistently to a high frequency setting. Focusing on the daily CTC specification in panel B, with time fixed effects the estimated $\beta = 0.46$ and we do not reject $H_0 : \beta = 1$ at conventional levels. Adding currency+time fixed effects this result becomes even more striking with an estimated $\beta = 1.05$ which is very close to the null which we clearly do not reject. This shows that unobservable factors in *both* the time-series and cross-sectional dimensions contribute towards the rejection of UIP. Next, we apply fixed effects to our overnight specification. Consistent

with observation that we do not observe a rejection overnight, the main result from figure 1 is unaffected. Finally, considering our intraday specification, adding time or currency+time fixed effects reduced the magnitude of the negative β estimates but we still strongly reject $H_0 : \beta = 1$ in both cases.

In Table II we report the daily regression results at the individual currency level, as well as for the unconditional dollar portfolio (DOL) that goes long all foreign currencies in equal weights. For CTC returns (Panel A), β-coefficients are negative for seven currencies, but the null hypothesis cannot be rejected due to the massive standard errors. The point estimate for the slope coefficient is only positive for CAD, and JPY. Splitting the time series into an overnight and intraday component, the various regression results almost uniformly confirm those highlighted in Figure 1 as all point estimates for the slope coefficient are positive overnight and negative during the day (with the exception of JPY ID). Moreover, the null hypothesis $H_0 : \beta = 1$ can only be rejected for JPY for the overnight period but is strongly rejected for 7 out of 9 individual currency pairs during the day (the exceptions are CAD and again JPY).

[INSERT TABLE II HERE]

In addition to the strong pattern for the slope coefficient, Table II also highlights systematic differences of the intercepts between intraday and overnight hours. Overnight (Panel B), the intercept is negative for all currencies except NOK, ranging between -2.65 bps (GBP) and 0.24 bps (NOK), while during the day (Panel C), the intercept term is largely positive (exceptions are JPY and NOK), ranging between -1.03 bps (JPY), and 3.18 bps (CHF). For the dollar portfolio for example, the intercept switches from -1.19 bps (with a t-statistic of 2.95) to 1.59 bps (with a t-statistic of 3.28). The significant negative intercepts reflect the average appreciation of the U.S. dollar during the overnight period in the U.S. markets, whereas the positive intercepts in Panel C are reflecting the average depreciation of the U.S. dollar during the main trading hours in New York (see also Krohn, Mueller, and Whelan, 2024).

The corresponding regression results for the monthly data are qualitatively the same and are presented in the Online Appendix. Thus, the daily as well as the monthly regression results suggest that deviations from the expectation hypothesis are largely driven by return dynamics in play during U.S. trading hours. Moreover, the results point towards the existence of a risk premium that is only statistically different from zero during certain hours of the trading day. The results are also consistent with the view that rational agents' expectations about the future path

of the spot exchange rate are in line with the forward rate during overnight hours, but then deviate when trading in New York commences. The differences in expected and realized future spot rates generate room for a risk premium to be earned mainly during the day (in the U.S.).

B. Bootstrap Evidence

To further assess the statistical robustness of our findings, we conduct a block-bootstrapping exercise, where we randomly sample 5,000 combinations of days from the sample of ID (orange), and ON (blue) returns. The optimal block length is chosen following Patton, Politis, and White (2009), although we show in the Appendix that results are robust to alternative block lengths. For each sample, we estimate daily UIP panel regressions and plot the distribution of the slope coefficient, $\hat{\beta}$ in Figure 2.

[INSERT FIGURE 2 HERE]

We find that the empirical distributions of the coefficients from both intraday periods barely overlap. Coefficients for ON returns are centered around 1.32, and more than 95% of coefficient estimates are positive. In contrast, the distribution of slope coefficients for ID returns is notably shifted towards the left. It is centered around -1.28 whereby the vast majority of estimated slope coefficients has a negative sign. Moreover, as indicated by the blue and orange vertical dashed lines, the 95% confidence interval of both distributions do not overlap, building further confidence in the statistical differences between the estimates.[14] Overall, the bootstrapping exercise highlights the validity of the differences in UIP regression outcomes for different return windows measured over a 24-hour period.

C. UIP Regressions Over Time

Bussiére, Chinn, Ferrara, and Heipertz (2022) show that the conventional UIP relationship tends to hold during the period after the global financial crisis, while the negative slope coefficient in the UIP regressions is largely driven by pre-crisis dynamics. They label the change in the sign of the β-coefficient the "new Fama puzzle".

[INSERT FIGURE 3 HERE]

[14] We report in the appendix empirical distributions from the same bootstrap exercise for CTC returns, as well as the empirical distributions of p-values, assessing the null hypothesis $\beta = 1$.

Thus, in Figure 3 we apply a similar split to our baseline short-term UIP regressions with the first sub-period ranging from January 1999 to December 2008 (CTC^{99-08}) and the second from January 2009 to December 2023 (CTC^{09-23}). The CTC results (grey bars) in Figure 3 support the findings in Bussiére, Chinn, Ferrara, and Heipertz (2022) at the daily frequency, as the estimated β-coefficient turns positive for the most recent period after the financial crisis. However, error bands are large again and we cannot reject the null hypothesis for the pre-crisis period. Separating the overnight from the intraday returns, however, paints again a clearer picture as the expectations hypothesis can be strongly rejected for the intraday period (orange bars) whereas coefficient estimates are not significantly different during overnight period (blue bars).

The divergence between these two periods is stronger for the second sub-sample period, during which the estimated β-coefficient exceeds the value of 2 overnight but it is close to -1.5 during the day. The decomposition of CTC-returns into different components suggests that the new Fama puzzle might be particularly driven by the strong response of the exchange rate to the forward discount during the overnight hours.

D. Covered Interest Parity

The interest rate differentials used in setting up the UIP regression are generally measured without using actual interest rates but via the forward discount, i.e., the difference between forward and spot rates (see equation (4). In frictionless markets, the two measures must coincide as covered interest rate parity must hold. In reality, however, interest rate differentials measured using deposit rates may differ from forward discounts at any point in time. In Figure 4, we thus present the results of short-term UIP panel regressions when short-term deposit rates are used as regressors on the right-hand side (i.e., as suggested in equation (3)).

[INSERT FIGURE 4 HERE]

While the point estimates for the slope coefficient are slightly different, the results remain qualitatively the same. For CTC returns, the estimated β is close to zero with large error bands, for the overnight period the coefficient is closer to one and the null hypothesis cannot be rejected while during the intraday period the coefficient turns negative and we can reject the expectations hypothesis. That is, the main result with respect to the split between overnight and intraday returns is not driven by potential concerns about deviations from CIP.

IV. Daily Portfolio-Based Tests

We implement the trading strategies described in equations (7) to (10) at the daily frequency. In addition, we split the portfolio returns into overnight and intraday components. Panel A in Table III considers a close-to-close (CTC) return decomposition of that trading strategies and the components described in equation (6). The carry trade exhibits a statistically marginally significant average annual excess return of around 3.6% per year. This is in line with existing evidence for our sample period as returns for the carry trade are significantly lower than during the 1980s and 1990s. The decomposition in Panel A also highlights that virtually 100% of the carry return is due to the actual carry (i.e., the forward premium) and is not driven by an appreciation of high interest rate currencies.

[INSERT TABLE III HERE]

Moving across columns provides additional insights regarding the profitability of the other strategies. First, the biggest share of the carry returns comes from the static component (5.34%), while the re-balancing of currencies captured by the dynamics component in fact generates negative returns (−1.72%). For the forward premium and dollar carry trade we find that both trading strategies generate positive excess returns of 4.54% and 2.83%, respectively; however, in contrast to the carry trade, excess returns earned by both of these approaches are not statistically different from zero. Lastly, across the first five columns, excess returns are driven by the positive forward discount ($f_t - s_t$), while the spot component (Δs) is small and not distinguishable from zero. Measured CTC, returns to the dollar portfolio are essentially zero measured over the full sample period.

Panel B then provides an intraday decomposition of returns to all of the five strategies plus the dollar portfolio, reporting excess returns that are earned for holding foreign currency positions during the first hour after the cut-off point at 17:00 ET ($xret^{1H}$) and the spot returns during that hours (Δs^{1H}). The last two rows refer to the return components that are earned throughout the rest of the day, distinguishing between the overnight period that excludes the first hour (Δs^{ON-1H}) and intraday period (Δs^{ID}). First, excess returns held for just the first hour of the trading remain significant and positive at 0.78%. These excess returns are smaller compared to the CTC returns in Panel A, as spot returns asssociated with carry portfolios are strongly negative during the first hours of the trading day. Importantly, it is only due to subsequent return dynamics that occur during the rest of the day which make the carry trade an economically significant trading

approach. In fact, during the overnight period the spot carry component is -3.45% ($\Delta s^{1H} + \Delta s^{ON-1H}$), while it reverses to 3.44 (Δs^{ID}) during the intraday period. Second, similar trends can be observed for the other trading strategies. For example, over the entire overnight period the dollar carry and forward premium trade generate negative returns of -2.45% and -6.08%, while intraday spot returns amount to more than 4.57% and 5.25%, respectively. The returns to the dollar portfolio mirror the findings in Krohn et al. (2024), whereby foreign currencies appreciate against the dollar during the intraday period and depreciate overnight.

Overall, Table III adds new nuances to our understanding of the profit-generating process of well-known currency trading strategies. while the results highlight that excess returns to these strategies are largely driven by the forward discount, they highlight that an additional crucial component are systematic spot movements during the intraday hours. In fact, it appears that only during these hours spot returns diverge from the forward discount and sizeable risk-premia emerge during the second half of the trading day.

[INSERT FIGURE 5 HERE]

To visualize this point, Figure 5 plots the evolution of spot returns over the course of the trading day (solid line). The red-dashed line refers to the inverted forward discount, i.e., an overlap between the two lines implies zero excess returns and in the cross-section the forward discount is offset by spot return dynamics. Panels A through D present the average intraday evolution for the traditional and the static carry trade, the dollar carry trade and the forward premium trade, respectively. The shaded areas indicate the 95% range of intraday returns based on 10,000 bootstrapped samples with replacement. We include these to exemplify the variation in cumulative returns. Building upon the results III, Panel A suggests that risk premia earned by the carry trade are offset by about 20:00 ET and remain close to the forward discount until about 7:00 ET in the morning. Subsequently in the run-up to market opening in the U.S., spot returns start moving in favor of the carry trade profits and rever the negative overnight trend. Spot returns revert until zero by then end of the trading day. This pattern is largely mirrored for the static trade, with the important exception that spot returns actually turn positive in the last few hour before market closing. Lastly, for the Dollar trade, the spot component overshoots the level of the forward discount and the dollar appreciates by almost 6% within the first four hours of trading. Subsequently, we note a strong reversal and foreign currencies appreciate strongly up to 2% by the end of trading day. Again, the divergence from the forward discount appears during the

intraday period. Overall, the figure confirms the importance of intraday patterns in spot markets for currency strategies.

V. FOMC and Macroeconomic Announcements

In this section, we separate macro and monetary policy announcement days from the remaining days in our sample and study UIP violations again using regression- as well as portfolio-based approaches.

A. Regression-Based Tests

Having established a way to run daily regressions to test the expectations hypothesis, we can now further investigate how UIP deviations arise. In this section, we focus on the role of central bank and macroeconomic announcements, and on how large movements in time-varying risk premia on these days may impact the relationship between exchange rates and interest rates.

We focus on days of major U.S. announcements, i.e., we follow the literature and assess the marginal impact on the slope coefficient on days of FOMC announcements, non-farm payroll, CPI, and GDP announcements. To this end, we estimate the following augmented regressions

$$\Delta s_{t+1}^j = \alpha + \alpha^A \times \mathbb{1}^A + \beta(f_t^\tau - s_t^j) + \beta^A(f_t^\tau - s_t^j) \times \mathbb{1}^A + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, $(f_t^\tau - s_t^j)$ refers to the short-term forward discount with maturity $\tau = 1D$, and $\mathbb{1}^A$ is an indicator variable equal to one on the day before major U.S. announcement days, and zero otherwise. Results are reported in Table IV. For each of the three sub-period, the first column shows the estimation results when all four announcement types are considered (1,017 days), while the subsequent columns refer to subsets of the announcements.

[INSERT TABLE IV HERE]

Isolating FOMC announcement and days of major macroeconomic releases in a regression framework, which uses short-term forwards, we can precisely pin down the importance of news releases for UIP. In fact, for close-to-close returns, we find that the slope coefficient is positive on non-announcement days (0.19), while the marginal effect on announcement days, i.e., β^A, is -0.93. Even though we cannot reject the null hypotheses $H_0 : \beta = 1$ or $H_0 : \beta + \beta^A = 1$, the change in

sign of the point estimates suggests there are substantial differences in the UIP relationship across different types of days.

Moving onto the overnight and intraday periods, results from Table II carry over: UIP holds during the overnight period and it fails during the intraday hours. For instance, for the overnight period the p-value of testing the aggregate impact of the forward discount on spot returns, i.e., $\beta + \beta^A$, is 0.49 while it is only 0.01 during the intraday period, strongly rejecting the parity condition during these hours. While the slope coefficient is negative across all days, the rejection is particularly pronounced on announcement days, as indicated by the substantially lower value of β^A, which ranges between -0.40 and -3.48 across the three columns.

Overall, these results suggests that risk premia on announcement days are different than on non-announcement days. In a next step, we explore the implications of different risk premia dynamics across different types of days for the cross-section of currencies.

B. Portfolio-Based Tests

To further understand the impact of news releases and announcements on risk premia in the cross-section of currencies, Table V reports results of the high-frequency Hassan and Mano (2018) decomposition by isolating the importance of announcement days during our sample. Panel A reports results for currency excess returns for all days ("All"), FOMC days ("FOMC", 203 days), days with major U.S. macroeconomic releases ("Macro", 795 days), and all other days ("Other", 4991 days). All returns are expressed in annualized percentage and scaled by the number of days in each subsample, i.e., the rows "FOMC", "Macro" and "Other" equal the return values displayed in the row "All".

Starting with the traditional carry (TC), Table V suggests a significant proposition of the strategy's excess returns of 3.63% are earned on a limited number of days. In fact, 2.25% (i.e., $1.69\% + 0.57\%$), or 62%, are generated on FOMC and major U.S. announcement days, which only represent 17% of days in the entire sample. On the majority of other days (83% of the sample), the strategy only earns statistically insignificant 1.37%. Focusing on the sub-components—i.e., static carry and dynamic trade—the table shows that the returns are primarily driven by the static portfolio components of the carry trade. On FOMC and macro announcement days, the consistently low- and high-yielding currencies in total generate almost 5% annualized excess returns, while the significantly negative returns of the dynamic strategy, overall dampen the profitability of the carry trade.

For the dollar carry and forward premium trade, in contrast, we observe a different pattern. Excess returns on FOMC and Macro days are small and negative for both strategies, generating returns ranging between of 0.11% and −2.74%. On non-announcement days, the excess returns turn positive earning over 5% and 6%, respectively. Taken together, we note that even though all strategies earn positive returns during the intraday period, the profitability of the different strategies varies across different types of days.

Returns to the dollar portfolio are high and significant for macro and FOMC announcement days, totalling over 5.7% per annum versus a total of almost −5.5% on non-announcement days. The results suggest that a smart investor would create novel strategy combining for example the dollar carry strategy on non-announcement days with a long position in the dollar portfolio on announcements days. Abstracting from transaction costs, this "adjusted-dollar carry" strategy generates 11.36% (5.65% + 2.06% + 3.65%) per annum with a t-statistic of 3.3.

[INSERT TABLE V HERE]

Lastly, Figure 6 provides insights into the intraday dynamics of the strategies' spot component. Panel A presents the intraday components for all days, while Panels B and C focus solely on FOMC and macroeconomic announcement days, respectively. Panel D covers all other days, during which neither of the two types of announcements occur.

[INSERT FIGURE 6 HERE]

Panel A highlights the differences between overnight and intraday returns, with all strategies generating negative returns during the early part of the day. Specifically, the dollar carry spot returns drop to −6% during the first few hours of the trading day, only beginning to recover slowly thereafter. In contrast, all currencies generate positive returns during the intraday hours, with static carry closing the day with the highest returns, followed by the dollar carry and the dollar portfolio.

Regarding announcement days, Panels B and C suggest that intraday returns are generally flatter during the overnight period. For example, on FOMC days, overnight returns never fall below −1% and are even positive for the static carry. The flatter return pattern could be indicative of the generally lower average trading volume in the run-up to major announcements, as market participants await the outcome of monetary policy decisions or news releases. Additionally, both panels emphasize the importance of announcements, particularly for the static trade and the dollar

portfolio. Static carry returns (light green line) clearly depict a jump at 14:00 ET in Panel B and at 8:30 ET in Panel C, followed by further increases for the rest of the trading day. Overall, the panels highlight the importance of intraday trading hours for the profitability of some currency trading strategies, as returns tend to be close to zero or negative during the overnight hours of the average day but turn positive during the day, in particular when major news are released.

VI. Conclusion

We document that high-frequency deviations from uncovered interest parity are driven by intraday spot return dynamics. On average, the U.S. dollar appreciates sufficiently during the overnight period, offsetting the forward discount as predicted by theory. However, it diverges during intraday hours, undergoing a sharp depreciation, which leads to the failure of UIP.

Using short-term forward points and accounting for settlement conventions in the foreign exchange market, we show how the slope coefficient of conventional UIP regressions switches from a positive value of 1.32 during the overnight hours, to -1.28 during the intraday period for the panel of G9 currencies vis-à vis the U.S. dollar. This pattern is a robust feature of the data, with our sample spanning over 25 years of high-frequency data and currencies that collectively represent more than 75% of the daily average trading volume.

Furthermore, we exploit the large cross-section of high-frequency returns and assess the implications of intraday UIP deviations for trading strategies. Decomposing high-frequency portfolio returns, we document that for compensation to the carry strategy is almost exclusively coming from intraday returns, as the profits earned from entering forward positions in U.S. dollar (i.e., the forward discount) are offset by overnight spot return movements. For example, annualized average excess returns to the traditional carry trade during our sample period are 3.63%, with 3.44% coming from intraday spot returns.

Lastly, we divide the sample into subsets of days designed to capture currency risk exposure to news (FOMC and macro announcement days). Although these days account for only 15% of our sample, nearly two-thirds of the excess returns from the traditional carry trade are earned during this small subset of days. The same is not true, however, for the dollar carry as well as the forward premium trade that exhibit negative excess returns on FOMC and macro announcement days. In contrast to the carry portfolio, returns to these portfolios are exclusively earned on non-announcement days.

Overall, our findings provide compelling evidence that the origins of UIP violations are com-

pensation for risk, which investors are primarily exposed to during intraday hours. However, we also find that while exposure to risk diverge significantly on days when central bank or macroeconomic news is released (news days) versus all other days. This suggests that different dimensions of currency risk (time-series and the cross-section components) are exposed to different sources of risk, and both need to be accounted for in understanding the origins of UIP violations.

VII. Tables

Table I. UIP Regressions: Currency and Time Fixed Effects

The table reports results to the regression

$$\Delta s_{t+1}^{j} = \beta(f_t^{\tau,j} - s_t^{j}) + \alpha_i + \kappa_t + \varepsilon_{t+1}$$

where $\Delta s_{t+1}^{j} = s_{t+1}^{j} - s_t^{j}$ refers to the log spot return of currency j, and $(f_t^{\tau,j} - s_t^{j})$ refer to the forward discount with maturity τ =1M (Panel A) or τ =1D (Panel B) , α_i are currency fixed effects and κ_t are time-series fixed effects. The combination of included fixed effects varies across regression specifications, as indicated by the column headers. Numbers in round parentheses refer to t-statistics based on or Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2023.

Panel A: Monthly Regressions

	CTC			ON			ID		
	Curr	Time	Curr + Time	Curr	Time	Curr + Time	Curr	Time	Curr + Time
$f_t - s_t$	-0.42	0.20	1.03	0.89	0.92	1.61	-1.31	-0.72	-0.59
	(-0.44)	(0.33)	(1.02)	(1.45)	(1.79)	(2.10)	(-2.16)	(-2.94)	(-1.23)
p-val	[0.14]	[0.19]	[0.98]	[0.86]	[0.88]	[0.43]	[0.00]	[0.00]	[0.00]
adj R^2	-0.00	0.55	0.55	0.01	0.39	0.40	0.01	0.55	0.56

Panel B: Daily Regressions

	CTC			ON			ID		
	Curr	Time	Curr + Time	Curr	Time	Curr + Time	Curr	Time	Curr + Time
$f_t - s_t$	0.04	0.46	1.05	1.32	1.10	1.31	-1.28	-0.64	-0.26
	(0.06)	(1.07)	(2.08)	(3.02)	(3.18)	(3.40)	(-2.36)	(-2.29)	(-0.81)
p-val	[0.16]	[0.21]	[0.92]	[0.47]	[0.78]	[0.42]	[0.00]	[0.00]	[0.00]
adj R^2	-0.00	0.50	0.50	0.00	0.42	0.42	0.00	0.55	0.55

Table II
Daily UIP Regressions and Intraday Returns

This table reports results of the following regression

$$\Delta s_{t+1}^j = \alpha + \beta(f_t^{\tau,j} - s_t^j) + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, and $(f_t^{\tau,j} - s_t^j)$ refer to the short-term forward discount with maturity τ =1D. Panel A, B, and C refer to close-to-close, overnight, and intraday returns, respectively. For the definitions of overnight and intraday returns see Note 1. Numbers in round parentheses refer to t-statistics based on Newey and West (1987) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2023.

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK
Panel A: Close-to-Close									
α	0.41	0.38	0.68	0.31	-0.15	-2.29	-0.42	-0.32	-0.23
	(0.36)	(0.57)	(0.58)	(0.34)	(-0.20)	(-2.26)	(-0.43)	(-0.26)	(-0.24)
β	-0.14	1.62	-0.02	-0.26	-2.29	2.48	-0.92	-1.22	-0.49
	(-0.10)	(0.78)	(-0.02)	(-0.22)	(-1.41)	(3.12)	(-0.92)	(-0.95)	(-0.42)
p-val	[0.40]	[0.76]	[0.37]	[0.28]	[0.04]	[0.06]	[0.06]	[0.08]	[0.20]
$\bar{R}^2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	5676	5804	5774	5876	5796	5469	5756	5632	5737
Panel B: Overnight									
α	-0.63	-0.65	-2.14	-2.31	-2.54	-0.90	-0.64	-1.90	-2.02
	(-0.80)	(-1.66)	(-3.09)	(-4.37)	(-4.92)	(-1.19)	(-1.01)	(-1.97)	(-3.10)
β	1.20	1.80	0.77	1.83	1.25	2.27	1.27	0.24	1.06
	(1.33)	(1.75)	(1.28)	(2.57)	(1.26)	(3.61)	(2.03)	(0.25)	(1.30)
p-val	[0.82]	[0.44]	[0.71]	[0.24]	[0.80]	[0.04]	[0.67]	[0.43]	[0.94]
$\bar{R}^2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	5676	5804	5774	5876	5796	5469	5756	5632	5737
Panel C: Intraday									
α	1.04	1.03	2.81	2.62	2.39	-1.39	0.23	1.59	1.79
	(1.34)	(1.81)	(3.07)	(3.68)	(4.02)	(-1.97)	(0.29)	(1.97)	(2.17)
β	-1.34	-0.18	-0.79	-2.09	-3.55	0.21	-2.18	-1.46	-1.55
	(-1.52)	(-0.09)	(-0.87)	(-2.04)	(-2.75)	(0.39)	(-2.92)	(-1.73)	(-1.79)
p-val	[0.01]	[0.54]	[0.05]	[0.00]	[0.00]	[0.14]	[0.00]	[0.00]	[0.00]
$\bar{R}^2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	5676	5804	5774	5876	5796	5469	5756	5632	5737

Table III

Intraday Returns and Cross-Sectional Currency Strategies

This table reports annualized average returns to the different currency strategies obtained from the Hassan and Mano (2018) decomposition. Results in Panel A are based on close-to-close returns, distinguishing between excess returns (rx), forward discount ($f_t - s_t$) and spot returns (Δs). Panel B shows results for a decomposition reporting excess returns when short- and long-positions are closed after the entire overnight periods (rx^{1H}), after the first hour of trading (rx^{1H}), and the spot returns during the first hour, the rest of the ON period and during the ID hours (Δs^{1H}, Δs^{ON-1H} and Δs^{ID}). The columns refer to different trading strategies, i.e., traditional carry ("TC"), static carry ("SC"), dollar carry ("DC"), forward premium ("FP"), the dynamic trade ("DT"), and the dollar portfolio ("DOL"). and the dollar carry trade by Lustig et al. (2014). Numbers in parentheses show t-statistics. The sample period is January 1999 to December 2023.

Panel A: Close-to-Close

	TC	SC	DC	FP	DT	DOL
xret	3.63	5.34	4.54	2.83	-1.72	0.16
	(1.96)	(1.60)	(1.33)	(0.64)	(-0.66)	(0.05)
$f_t - s_t$	3.63	2.40	2.42	3.66	1.23	-0.34
	(103.32)	(366.77)	(67.14)	(61.33)	(34.55)	(-7.12)
Δs	-0.00	2.94	2.12	-0.83	-2.95	0.50
	(-0.00)	(0.88)	(0.62)	(-0.19)	(-1.13)	(0.15)

Panel B: Intraday Decomposition

	TC	SC	DC	FP	DT	DOL
xret^{ON}	0.18	2.58	-0.02	-2.42	-2.40	-6.90
	(0.13)	(1.09)	(-0.01)	(-0.84)	(-1.33)	(-3.22)
xret^{1H}	0.78	-0.25	0.42	1.46	1.04	-0.34
	(2.24)	(-0.55)	(1.09)	(2.76)	(3.19)	(-7.13)
Δs^{1H}	-2.85	-2.65	-2.01	-2.20	-0.20	-0.00
	(-8.18)	(-5.74)	(-5.20)	(-4.18)	(-0.60)	(-3.32)
Δs^{ON-1H}	-0.60	2.84	-0.44	-3.88	-3.44	-0.00
	(-0.44)	(1.20)	(-0.21)	(-1.35)	(-1.90)	(-1.54)
Δs^{ON}	-3.45	0.18	-2.45	-6.08	-3.63	-6.56
	(-2.52)	(0.08)	(-1.14)	(-2.10)	(-2.02)	(-3.07)
Δs^{ID}	3.44	2.76	4.57	5.25	0.68	7.05
	(2.83)	(1.15)	(1.71)	(1.54)	(0.35)	(2.64)

Table IV
UIP Regressions and Major U.S. Announcements

This table reports results of the following regression

$$\Delta s_{t+1}^j = \alpha + \alpha^A \times \mathbb{1}^A + \beta(f_t^j - s_t^j) + \beta^A(f_t^j - s_t^j) \times \mathbb{1}^A + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, $(f_t^\tau - s_t^j)$ refers to the short-term forward discount with maturity τ =1D, and $\mathbb{1}^A$ is an indicator variable equal to one on the day before major U.S. announcement days, and zero otherwise. Major U.S. macroeconomic announcements include FOMC rate decisions (FOMC), change in nonfarm payrolls (NFP), consumer price index excluding food and energy (CPI), and annualised gross domestic product (GDP). Numbers in round parentheses refer to Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show p-values from Wald-tests with either the null hypothesis $H_0 : \beta = 1$ or $H_0 : \beta + \beta^A = 1$. The sample period is January 1999 to December 2023.

	Close-to-Close			Overnight			Intraday		
	All Ann.	FOMC	Macro	All Ann.	FOMC	Macro	All Ann.	FOMC	Macro
α	-0.99	-0.31	-0.69	-1.82	-1.58	-1.62	0.83	1.27	0.93
	(-1.41)	(-0.47)	(-1.00)	(-3.98)	(-3.81)	(-3.63)	(1.59)	(2.48)	(1.78)
α^A	(6.93)	(14.44)	(6.15)	(2.58)	(5.70)	(1.63)	(4.34)	(8.74)	(4.52)
	(3.54)	(3.17)	(2.90)	(2.37)	(2.63)	(1.39)	(2.62)	(2.05)	(2.44)
β	0.19	0.12	0.14	1.35	1.31	1.36	-1.16	-1.19	-1.22
	(0.26)	(0.18)	(0.19)	(2.82)	(2.97)	(2.91)	(-2.05)	(-2.16)	(-2.19)
β^A	-0.93	-3.07	-0.71	-0.20	0.41	-0.31	-0.74	-3.48	-0.40
	(-0.62)	(-0.82)	(-0.45)	(-0.20)	(0.19)	(-0.30)	(-0.64)	(-0.99)	(-0.32)
p-val$^\beta$	[0.28]	[0.21]	[0.24]	[0.47]	[0.48]	[0.44]	[0.00]	[0.00]	[0.00]
p-val$^{\beta+\beta^A}$	[0.22]	[0.29]	[0.30]	[0.86]	[0.73]	[0.96]	[0.01]	[0.10]	[0.04]

Table V

UIP HM Decomposition and U.S. Announcement Days

This table reports annualized average excess returns (Panel A) and spot returns split by pre- (Panel B) and post-announcement (Panel C) hours, to the different strategies of the decomposition, introduced by Hassan and Mano (2018). Returns are reported when the strategies are implemented every day (i.e., "All". 5989 days), only on FOMC days ("FOMC", 203 days), only on the major U.S. macroeconomic announcement days ("Macro", 795 days) and only on all the other days ("Other", 4991 days). The columns refer to different trading strategies, i.e., traditional carry ("TC"), static carry ("SC"), dollar carry ("DC"), forward premium ("FP"), the dynamic trade ("DT"), and the dollar portfolio ("DOL"). Returns are annualized, expressed in percentage, and scaled by the number of days for each row. Numbers in parentheses show t-statistics. The sample period is January 1999 to December 2023.

Panel A: Excess Returns

	TC	SC	DC	FP	DT	DOL
All	3.63	5.34	4.54	2.83	-1.72	0.16
	(1.96)	(1.60)	(1.33)	(0.64)	(-0.66)	(0.05)
FOMC	0.57	1.60	0.11	-0.91	-1.02	2.06
	(1.56)	(2.90)	(0.14)	(-1.00)	(-2.59)	(2.58)
Macro	1.70	3.22	-1.24	-2.76	-1.52	3.65
	(2.73)	(3.30)	(-0.86)	(-1.65)	(-2.21)	(2.52)
Other	1.37	0.57	5.65	6.45	0.80	-5.47
	(0.81)	(0.18)	(1.90)	(1.62)	(0.32)	(-1.84)

Panel B: Spot Returns

	TC	SC	DC	FP	DT	DOL
All	-0.00	2.94	2.12	-0.83	-2.95	0.50
	(-0.00)	(0.88)	(0.62)	(-0.19)	(-1.13)	(0.15)
FOMC	0.46	1.52	0.04	-1.02	-1.06	2.07
	(1.24)	(2.76)	(0.05)	(-1.12)	(-2.69)	(2.60)
Macro	1.21	2.91	-1.60	-3.30	-1.69	3.71
	(1.94)	(2.98)	(-1.11)	(-1.98)	(-2.47)	(2.57)
Other	-1.65	-1.43	3.66	3.44	-0.22	-5.21
	(-0.97)	(-0.45)	(1.23)	(0.86)	(-0.09)	(-1.75)

VIII. Figures

Figure 1. UIP Regressions and Intraday Returns.
The figure shows the estimated β-coefficient from the panel regressions

$$\Delta s^j_{t+1} = \alpha + \beta(f^\tau_t - s^j_t) + \varepsilon^j_{t+1}$$

where $\Delta s^j_{t+1} = s^j_{t+1} - s^j_t$ refers to the log spot return of currency j, and $(f^\tau_t - s^j_t)$ refer to the forward discount with maturity τ, respectively. In the top panel, τ refers to one-month (1M), while in the bottom panel τ refers to one-day (1D). For the definitions of overnight and intraday returns see Note 1. Error bars refer to 90% confidence intervals, based on Driscoll and Kraay (1998) adjusted standard errors. The sample period is January 1999 to December 2023.

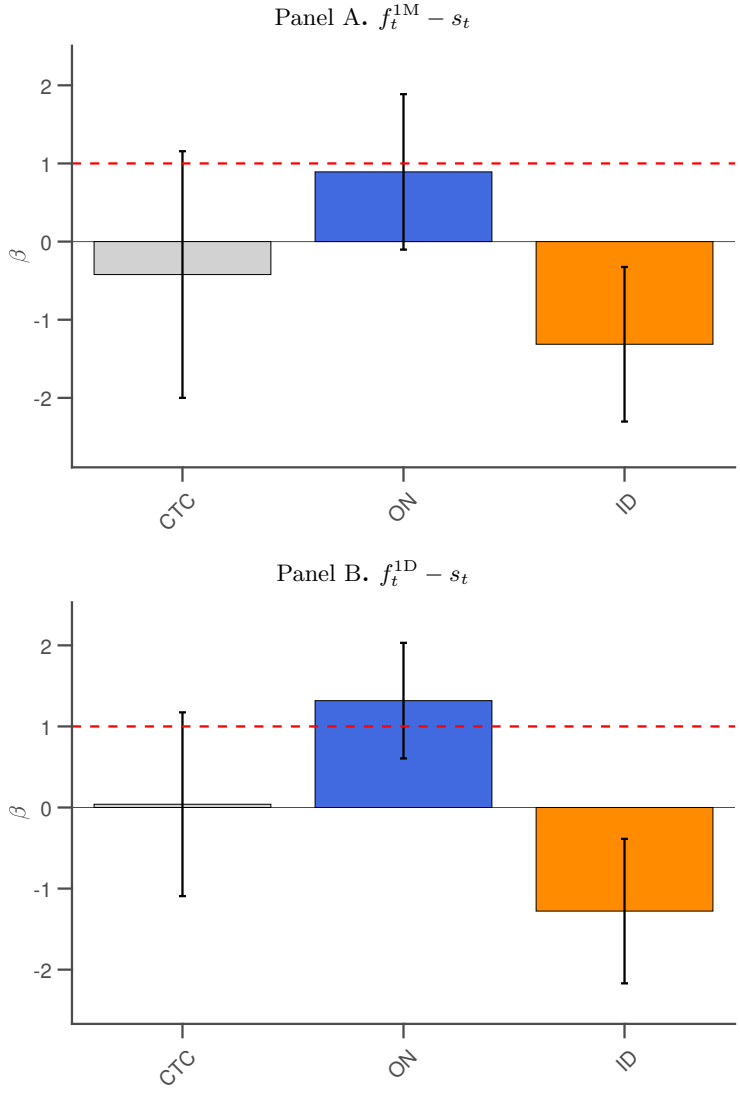


Figure 2.

UIP and Intraday Returns: Bootstrapped ON and ID Slope Coefficients.

The figure shows the distribution of the estimated slope coefficient from a UIP panel regression based on returns during overnight (ON, blue) or intraday (ID, orange) periods, using a block bootstrap sampling of 5,000. Each histogram is normalized such that the area sums up to 1. Vertical blue and oranged dashed lines indicate 95% confidence intervals. The vertical black lines with β^{ON} and β^{ID} indicate the magnitude of coefficients from panel regression from the entire sample. The sample period is January 1999 to December 2023.

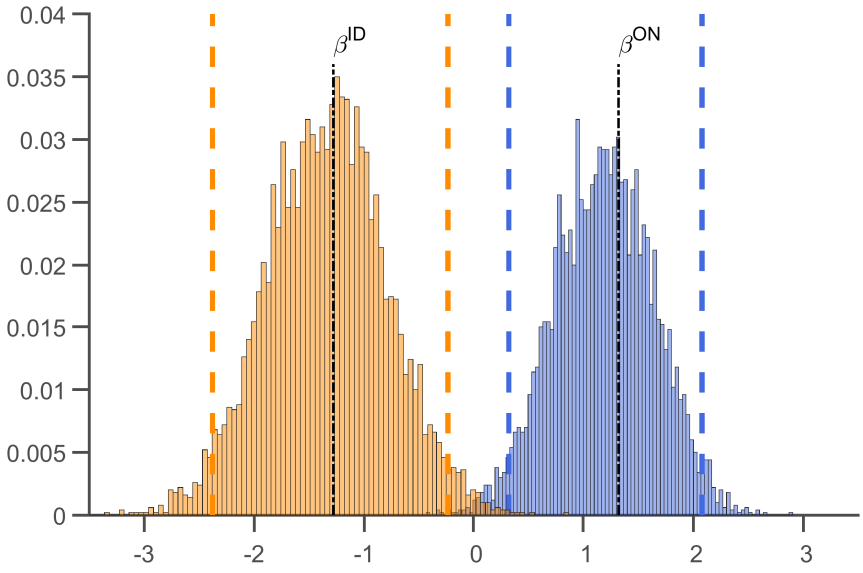


Figure 3. New Fama Puzzle: Intraday Returns and UIP.
The figure shows the estimated β-coefficient from the panel regressions

$$\Delta s^j_{t+1} = \alpha + \beta(f^\tau_t - s^j_t) + \varepsilon^j_{t+1}$$

where $\Delta s^j_{t+1} = s^j_{t+1} - s^j_t$ refers to the log spot return of currency j, and $(f^\tau_t - s^j_t)$ refer to the forward discount with maturity τ =1D, respectively. For the definitions of overnight and intraday returns see Note 1. Error bars refer to 90% confidence intervals, based on Driscoll and Kraay (1998) adjusted standard errors. For each intraday period, the sample is divided into two sub-samples, January 1999 to December 2008 (e.g., CTC^{99-08}) and January 2009 to December 2023 (e.g., CTC^{09-23}).

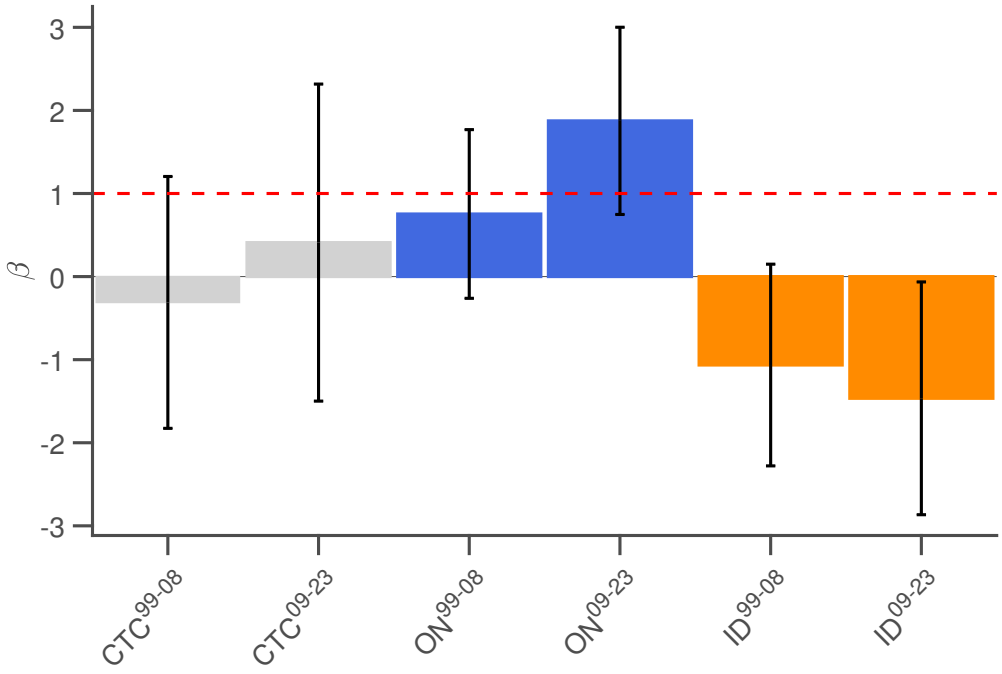


Figure 4. Intraday Returns, UIP, and CIP Deviations.
The figure shows the estimated β-coefficient from the panel regressions

$$\Delta s_{t+1}^{j} = \alpha + \beta(i_t^{\tau} - i_t^{j,*}) + \varepsilon_{t+1}^{j}$$

where $\Delta s_{t+1}^{j} = s_{t+1}^{j} - s_t^{j}$ refers to the log spot return of currency j, and $(i_t^{\tau} - i_t^{j,*})$ refer to the differential of deposit rates with maturity τ =1D, respectively. For the definitions of overnight and intraday returns see Note 1. Error bars refer to 90% confidence intervals, based on Driscoll and Kraay (1998) adjusted standard errors. The sample period is January 1999 to December 2023.

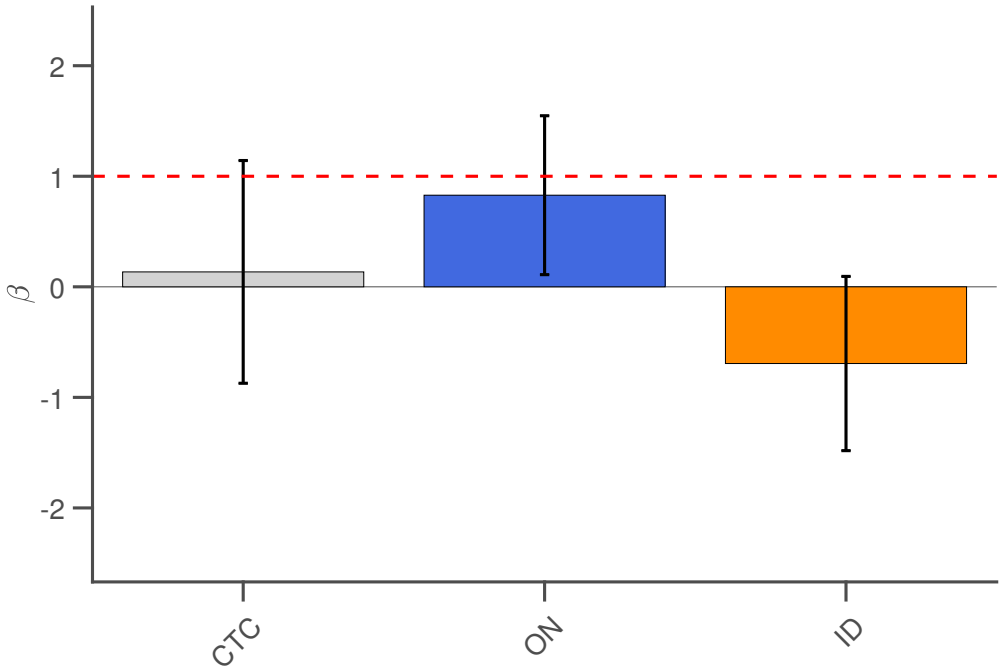
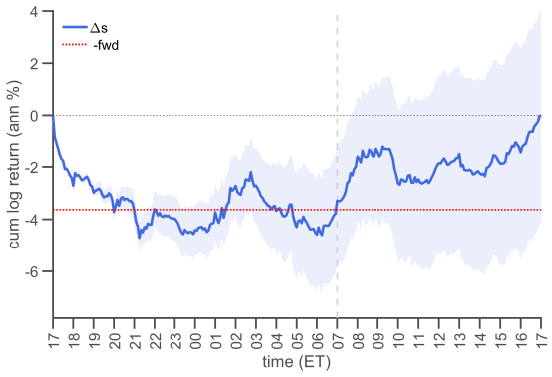


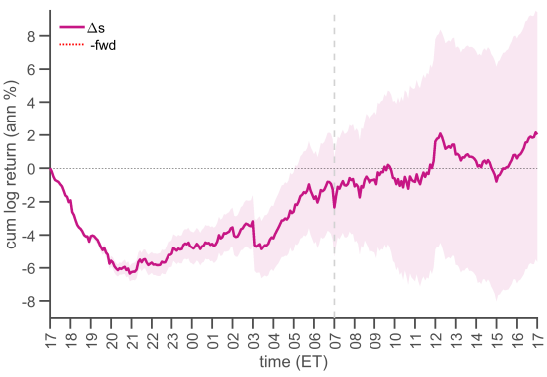
Figure 5. Intraday Returns

This figure shows intraday returns for different currency trading strategies, following the return decomposition in Hassan and Mano (2018). The panels show intraday spot return dynamics for traditional carry ("TC"), static carry ("SC"), dollar carry ("DC"), forward premium ("FP"), and the dynamic trade ("DT"). The red-dashed line refers to the inverted average daily forward discount. The gray-dashed line indicates the start of the intraday period at 8:00 ET. The shaded areas indicate the dispersion of intraday returns based on 10,000 bootstrap samples (with replacement), whereby the bottom (upper) limits refers 5% lowest (highest) average returns. The sample period is January 1999 to December 2023.

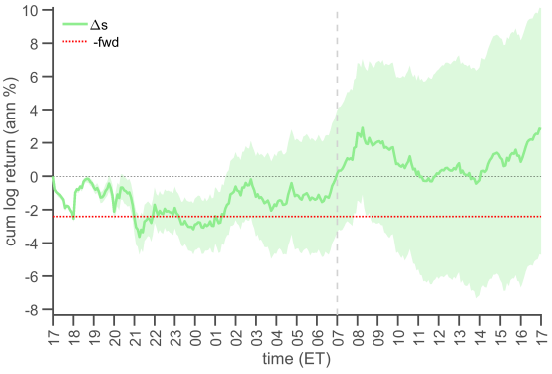
Panel A. Traditional Carry



Panel B. Dollar-Carry



Panel C. Static Carry



Panel D. Forward Premium

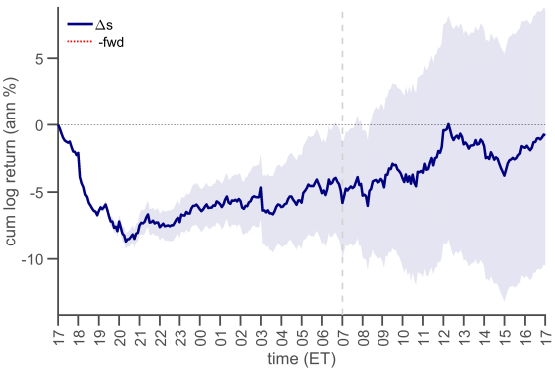
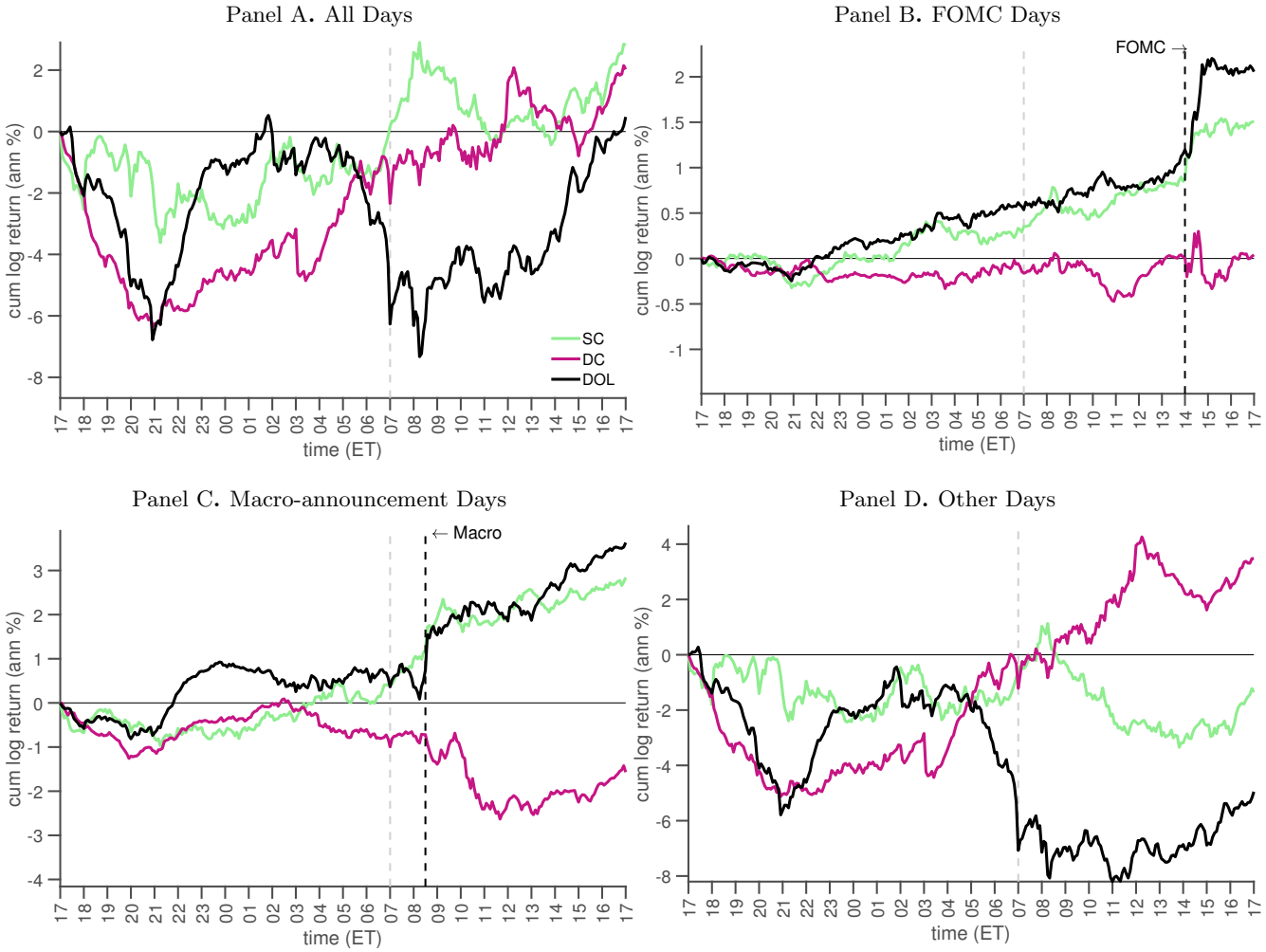


Figure 6. Intraday Currency Portfolio Returns and Major U.S. Announcements This figure shows intraday returns for different currency trading strategies, following the return decomposition in Hassan and Mano (2018), for all days (Panel A), FOMC days (Panel B), macroeconomic announcement days (Panel C), and all other days. The panels show intraday spot return dynamics for the static carry ("SC") and dollar carry ("DC") trading strategies, and for the dollar portfolio ("DOL"). The grey-dashed line indicates the start of the intraday period. The black-dashed lines in Panel B and C indicate the time of FOMC (14:00 ET) and macroeconomic (8:30 ET) announcements. The sample period is January 1999 to December 2023.



References

Ai, Hengjie, and Ravi Bansal, 2018, Risk preferences and the macroeconomic announcement premium, *Econometrica* 86, 1383–1430.

Andersen, Torben G., Tim Bollerslev, Francis X. Diebold, and Clara Vega, 2003, Micro effects of macro announcements: Real-time price discovery in foreign exchange, *American Economic Review* 93, 38–62.

Bekaert, Geert, and Robert J. Hodrick, 1993, On biases in the measurement of foreign exchange risk premiums, *Journal of International Money and Finance* 12, 115–138.

Bussiére, Matthieu, Menzie Chinn, Laurent Ferrara, and Jonas Heipertz, 2022, The New Fama Puzzle, *IMF Economic Review* 70, 451–486.

Cespa, Giovanni, Antonio Gargano, Steven J. Riddiough, and Lucio Sarno, 2022, Foreign exchange volume, *The Review of Financial Studies* 35, 2386–2427.

Chaboud, Alan P., and Jonathan H. Wright, 2005, Uncovered interest parity: It works, but not for long, *Journal of International Economics* 66, 349–362.

Chernov, Mikhail, Valentin Haddad, and Oleg Itskhoki, 2024, What do financial markets say about the exchange rate?, Working Paper, UCLA.

Driscoll, John C., and Aart C. Kraay, 1998, Consistent covariance matrix estimation with spatially dependent panel data, *Review of Economics and Statistics* 80, 549–560.

Dubinsky, Andreaw, and Michael Johannes, 2006, Earning announcements and equity options, Working Paper, Columbia University.

Engel, Charles, 1996, The forward discount anomaly and the risk premium: A survey of recent evidence, *Journal of Empirical Finance* 3, 123–192.

Engel, Charles, 2014, Exchange rates and interest parity, in Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, volume 4 of *Handbook of International Economics*, 453–522 (Elsevier).

Fama, Eugene F., 1984, Forward and spot exchange rates, *Journal of Monetary Economics* 14, 319–338.

Froot, Kenneth A., and Tarun Ramadorai, 2005, Currency returns, intrinsic value, and institutional-investor flows, *The Journal of Finance* 60, 1535–1566.

Gabaix, Xavier, and Matteo Maggiori, 2015, International liquidity and exchange rate dynamics, *Quarterly Journal of Economics* 130, 1369–1420.

Hassan, Tarek A., and Rui C. Mano, 2018, Forward and spot exchange rates in a multi-currency world, *The Quarterly Journal of Economics* 134, 397–450.

Kim, Don H., and Jonathan H. Wright, 2014, Jumps in bond yields at known times, NBER Working Paper 20711.

Krohn, Ingomar, Philippe Mueller, and Paul Whelan, 2024, Foreign exchange fixings and returns around the clock, *The Journal of Finance* 79, 541–578.

Lucca, David O., and Emanuel Moench, 2015, The pre-FOMC announcement drift, *The Journal of Finance* 70, 329–371.

Lustig, Hanno, Nikolai Roussanov, and Adrien Verdelhan, 2011, Common risk factors in currency markets, *The Review of Financial Studies* 24, 3731–3777.

Lustig, Hanno, Nikolai Roussanov, and Adrien Verdelhan, 2014, Countercyclical currency risk premia, *Journal of Financial Economics* 111, 527–553.

Lustig, Hanno, and Adrien Verdelhan, 2007, The cross-section of foreign currency risk premia and consumption growth risk, *American Economic Review* 97, 89–117.

Lyons, Richard K., and Andrew K. Rose, 1995, Explaining forward exchange bias...intraday, *The Journal of Finance* 50, 1321–1329.

Menkhoff, Lukas, Lucio Sarno, Maik Schmeling, and Andreas Schrimpf, 2017, Currency value, *The Review of Financial Studies* 30, 416–441.

Mueller, Philippe, Alireza Tahbaz-Salehi, and Andrea Vedolin, 2017, Exchange rates and monetary policy uncertainty, *The Journal of Finance* 72, 1213–1252.

Newey, Whitney K, and Kenneth D. West, 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703–708.

Patton, Andrew, Dimitris N. Politis, and Halbert White, 2009, Correction to "Automatic block-length selection for the dependent bootstrap" by D. Politis and H. White, *Econometric Reviews* 28, 372–375.

Piazzesi, Monika, 2005, Bond yields and the federal reserve, *Journal of Political Economy* 113, 311–344.

Savor, Pavel, and Mungo Wilson, 2013, How much do investors care about macroeconomic risk? evidence from scheduled economic announcements, *Journal of Financial and Quantitative Analysis* 48, 343–375.

Savor, Pavel, and Mungo Wilson, 2014, Asset pricing: A tale of two days, *Journal of Financial Economics* 113, 171–201.

Stavrakeva, Vania, and Jenny Tang, 2024, A fundamental connection: Exchange rates and macroeconomic expectations, *forthcoming, Review of Economics and Statistics* .

AI. Examples

The timing for the various short-dated FX and interest rate transactions is discussed in detail in Section B. In this section, we provide a visual overview in Figure A-1.

[INSERT FIGURE A-1 AND TABLE A-I HERE]

Furthermore, Table A-I contains actual data on the EURUSD FX pair collected from Bloomberg between 15 and 19 May 2023. This allows to illustrate the specific calculations required to calculate the cost of rolling over an FX position. Imagine that on Tuesday, 16 May, the EURUSD spot rate is trading at 1.086/0865. To buy 100 EUR spot, a trader then pays 108.65 USD with settlement on Thursday, 18 May, i.e., two days later. However, instead of accepting delivery at this date, the trader could sell 100 EUR in a TN transaction F_t^{TN} the following day, Wednesday, 17 May. In the front leg of the swap (effective on 18 May), the trader will sell 100 EUR (offsetting the open spot position to be settled) at the TN rate and in the back leg of the swap (effective on Friday, 19 May), the trader will buy back 100 EUR at the spot rate. On 17 May, the TN rate is quoted in swap points as 0.577/0.622, which translates into a EURUSD forward rate equal to 1.08386/08426, while the new prevailing spot rate is 1.0838/0842. The cost of rolling over the position is thus 108.42-108.386 = 3.4 cents or 3.4 basis points.[15]

[15]Note that the example is chosen such that there is no "weekend seasonality" effect. Whenever instruments span a weekend or a holiday, the implied interest covers not one but two or more days. Given the quoting conventions, this results in a "seasonality" effect in the quotes as they spike on a weekly basis. This does not, however, mean that interest rates jump around.

AJ. Appendix: Figures

Figure A-1. Short Maturity Trading in FX and Deposit Rates

This figure illustrates the timing of transaction and settlement dates for short term deposit rates (i_t^{ON}, i_t^{TN}, i_t^{SN}), spot transactions (S_t) and forwards (F_t^{ON}, F_t^{TN}, F_t^{SN}). For example, in the case of FX forwards (swaps) we have Overnight (ON): swap today (t) against tomorrow ($t+1$) denoted F_t^{ON}. Tomorrow-Next (TN): forward swap agreed today (t) for tomorrow ($t+1$) against the next day ($t+2$) denoted F_t^{TN}. Spot (S): is effectively a forward contact agreed today (t) for settlement in two days ($t+2$) where the underlying is the cash rate C_t (see discussion in Section B). Spot-Next (SN): forward FX swap agreed today (t) for the spot date ($t+2$) against the following day ($t+3$) denoted F_t^{SN}. An ON trade allows a trader to swap foreign for domestic currencies (or vice-versa) overnight. TN and SN trades allow traders to manage open currency positions.

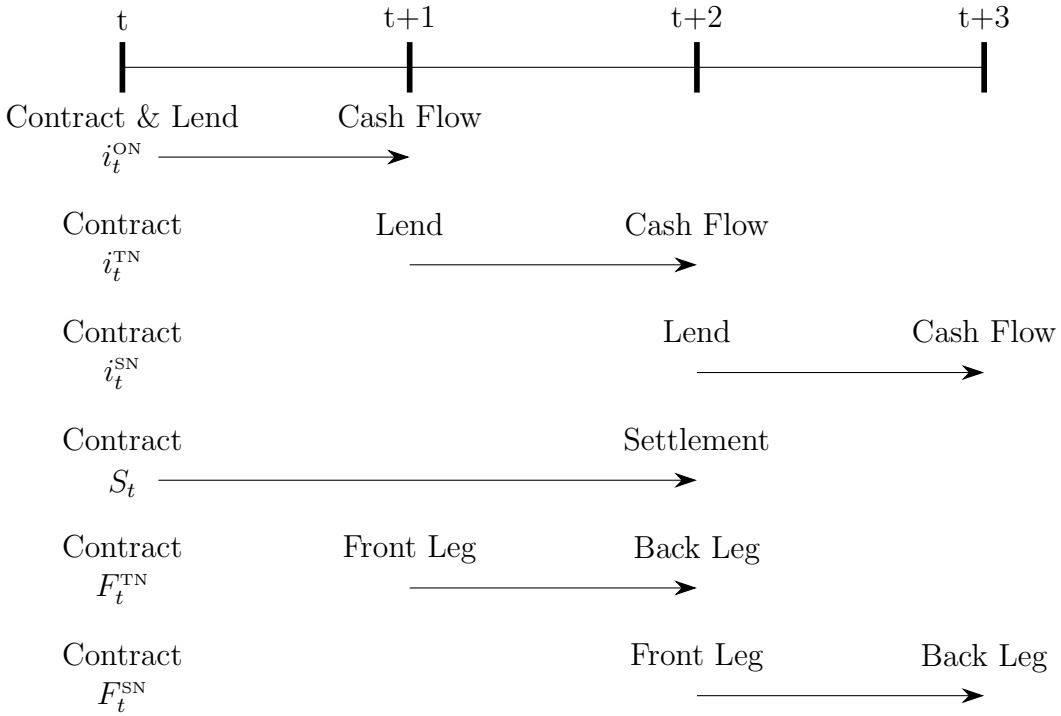
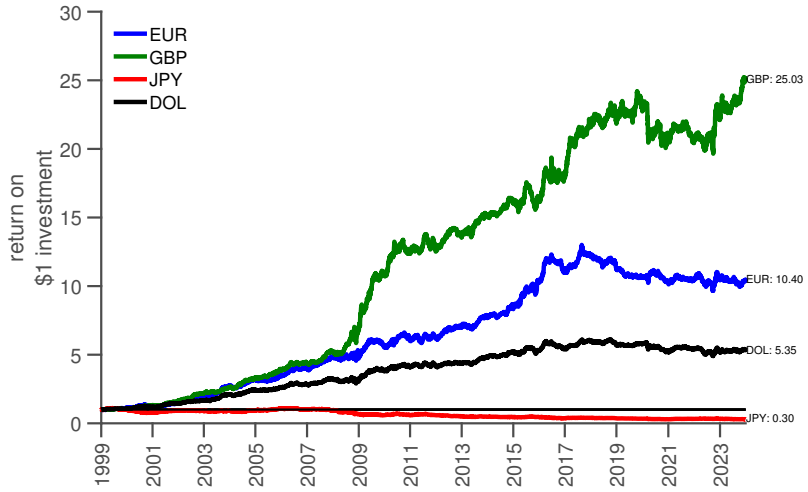


Figure A-2. Intraday Returns: Total return indices and year-over-year performance. The panels show the performance of a trading strategy where an investor takes a long position in the U.S. dollar during the overnight and a short position intraday period. The top panels show the total return indices for the three major currencies (EUR, GBP, JPY) and the dollar portfolio (DOL) with an initial investment of one U.S. dollar. The bottom panels show the total returns by year for the dollar portfolio. The sample period is January 1999 to December 2023.

Panel A. Total Return Index: DOL + G3



Panel B. YbY-Performance: DOL

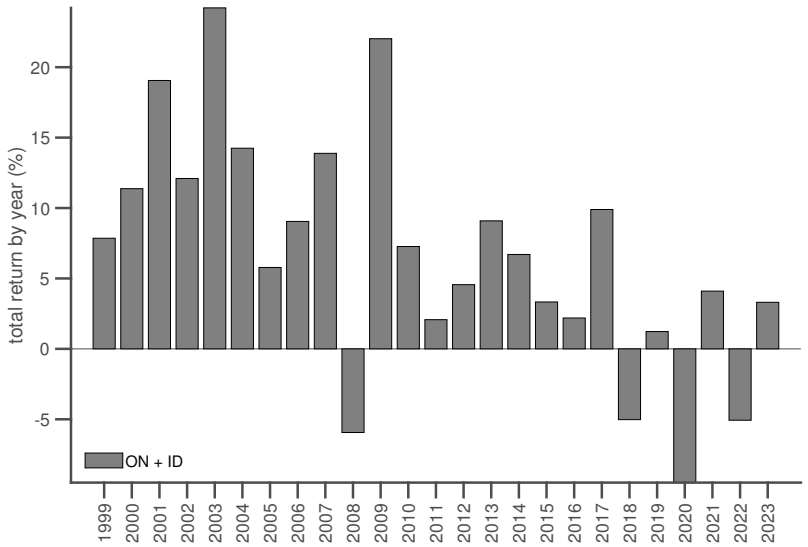


Figure A-3. UIP and Intraday Returns: Bootstrapped Slope Coefficients
The figure shows the distribution of the estimated slope coefficient from a UIP panel regression using a block bootstrap sampling of 5,000. Panel A, C, D show the distribution of β-coefficients based on close-to-close, overnight, and intraday returns. Each histogram is normalized such that the area sums up to 1. Vertical dashed lines indicate 95% confidence intervals. Panel B, D, F show the distribution of the corresponding p-values obtained from a Wald test with the null hypothesis that the slope coefficient is equal to unity. Values are displayed as cumulative distribution function to indicate the proportion of times the p-values is lower than the critical value. The vertical dashed line refers to the p-value of 10%. The sample period is January 1999 to December 2023.

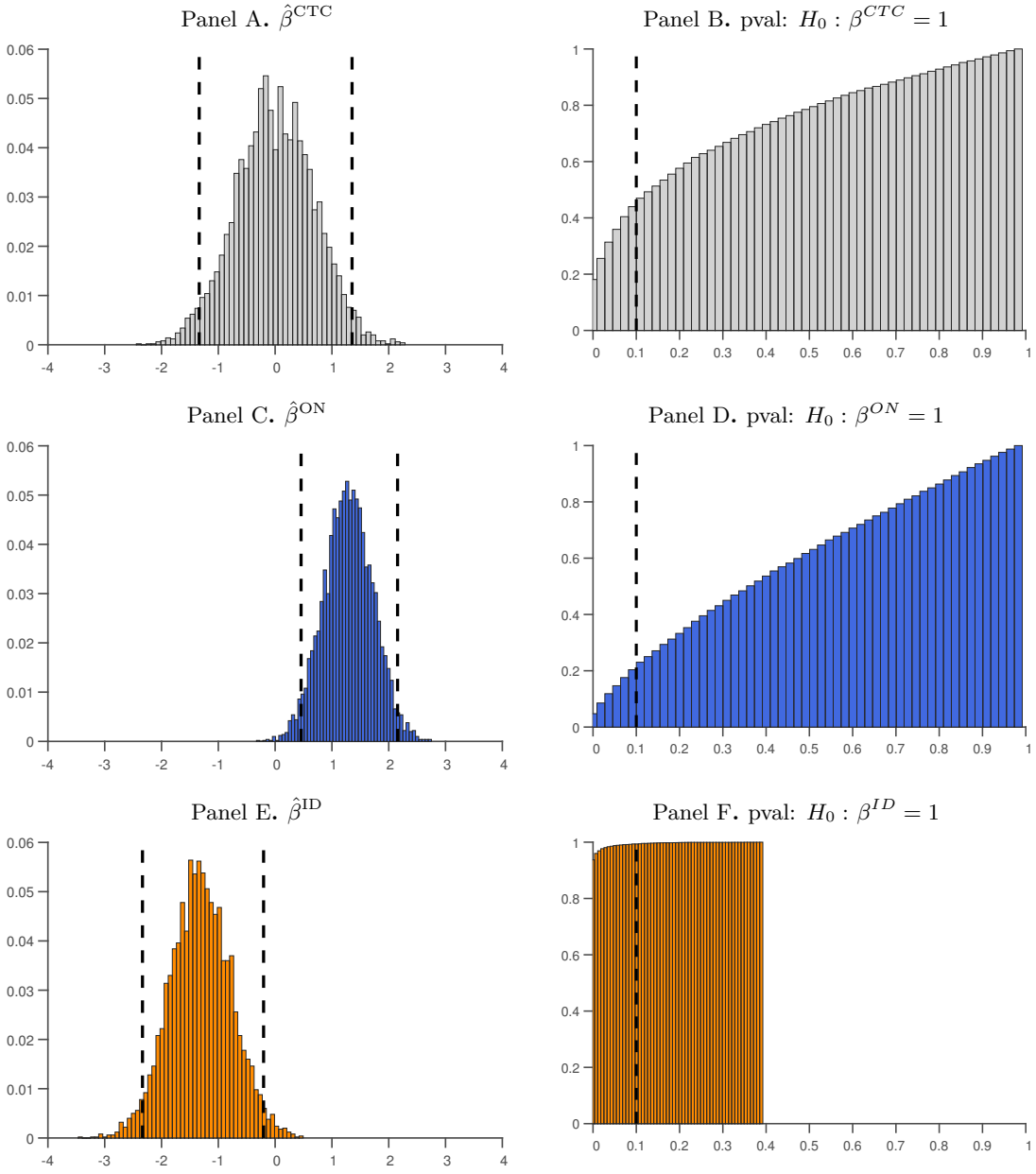
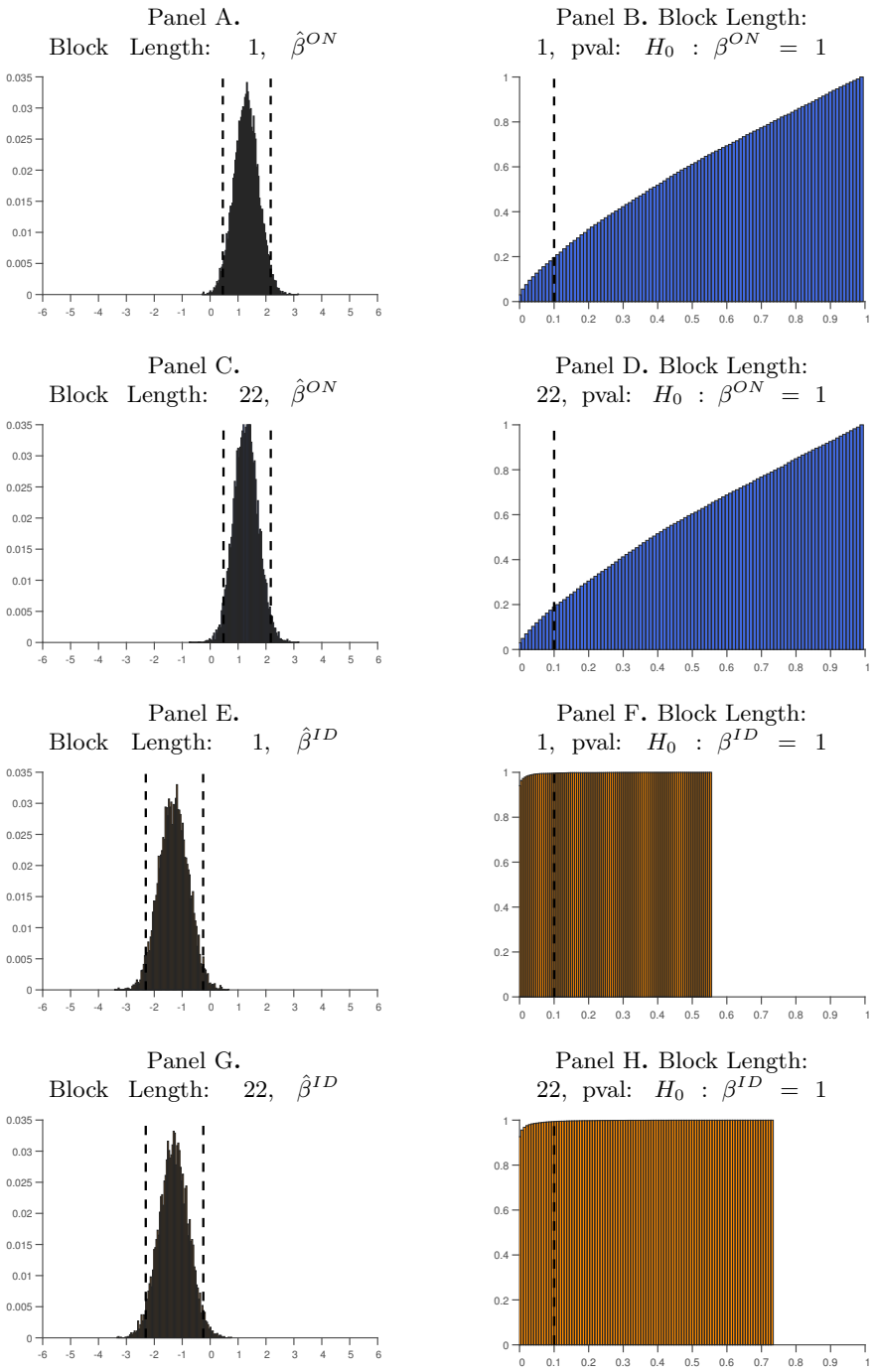


Figure A-4. UIP and Intraday Returns: Bootstrapped Slope Coefficients and Alternative Block Length

The figure shows the distribution of the estimated slope coefficient from a UIP panel regression using a block bootstrap sampling of 10,000 and for different block size length. Panel A and E (C and G) show the distribution of β-coefficients based on overnight, and intraday returns for a chosen block length o 1 day (22 days). Panel B and D (F and H) show the distribution of the corresponding p-values obtained from a Wald test with the null hypothesis that the slope coefficient is equal to unity. Values are displayed as cumulative distribution function to indicate the proportion of times the p-values is lower than the critical value. The vertical dashed line refers to the p-value of 10%. The sample period is January 1999 to December 2023.



AK. Appendix: Tables

Table A-I

Spot, Swap Points, Short Term Forwards, and Deposit Rates

	Euro spot			Swap points (TN)			Swap points (SN)		
	mid	bid	ask	mid	bid	ask	mid	bid	ask
05/19/2023	1.0805	1.0795	1.0814	0.5893	0.5740	0.6050	0.5900	0.5650	0.6150
05/18/2023	1.0770	1.0769	1.0772	1.7540	1.7290	1.7790	0.5905	0.5680	0.6130
05/17/2023	1.0840	1.0838	1.0842	0.5935	0.5830	0.6040	1.7750	1.7500	1.8000
05/16/2023	1.0862	1.0860	1.0865	0.5997	0.5770	0.6220	0.6000	0.5800	0.6200
05/15/2023	1.0874	1.0873	1.0875	0.5935	0.5850	0.6020	0.6000	0.5750	0.6250

	Forward rates (TN)			Forward rates (SN)		
	mid	bid	ask	mid	bid	ask
05/19/2023	1.0805	1.0796	1.0815	1.0805	1.0796	1.0815
05/18/2023	1.0772	1.0771	1.0774	1.0771	1.0770	1.0773
05/17/2023	1.0840	1.0839	1.0843	1.0841	1.0840	1.0844
05/16/2023	1.0863	1.0861	1.0866	1.0863	1.0861	1.0866
05/15/2023	1.0875	1.0874	1.0876	1.0875	1.0874	1.0876

	$i^{EU,TN}$ ann (%)			$i^{EU,SN}$ ann (%)			$i^{US,TN}$ ann (%)			$i^{US,SN}$ ann (%)		
	mid	bid	ask	mid	bid	ask	mid	bid	ask	mid	bid	ask
05/19/2023	3.2200	3.1200	3.3200	3.2250	3.1500	3.3000	5.0726	5.0226	5.1226	5.1300	5.0800	5.1800
05/18/2023	3.2200	3.1200	3.3200	3.2250	3.1500	3.3000	5.0703	5.0203	5.1203	5.1850	5.0200	5.3500
05/17/2023	3.2200	3.1200	3.3200	3.2250	3.1500	3.3000	5.1100	5.0600	5.1600	5.1300	5.0800	5.1800
05/16/2023	3.2200	3.1200	3.3200	3.2250	3.1500	3.3000	5.0709	5.0209	5.1209	5.1300	5.0800	5.1800
05/15/2023	3.2200	3.1200	3.3200	3.2250	3.1500	3.3000	5.1100	5.0600	5.1600	5.1300	5.0800	5.1800

Table A-II
Statistical Properties: Intraday Returns

This table reports the fraction of return observations that are positive, the p-value from a two-sided test of observing returns in one direction under the null hypothesis of a random walk, as well as mean, median, z-stat, standard deviation, skewness, and kurtosis. The z-stat refers to a non-parametric test assessing if the median is different from zero. Currencies are denominated in U.S. dollar. Returns are expressed in basis points. See The sample period is January 1999 to December 2023.

	Frac > 0	p-val	Mean	t-stat	Std. Dev.	Skew	Kurt
Panel A: Overnight							
AUD	0.51	0.22	-1.13	-1.62	55.43	-0.98	17.82
CAD	0.50	0.50	-0.74	-1.95	29.92	-0.32	8.72
CHF	0.47	0.00	-1.46	-2.58	44.75	4.78	198.29
EUR	0.48	0.00	-1.71	-3.59	37.66	-0.23	6.17
GBP	0.48	0.00	-2.51	-4.94	40.32	-1.78	35.57
JPY	0.50	0.91	0.71	1.26	44.73	0.28	11.66
NOK	0.49	0.15	-1.08	-1.64	52.16	-0.23	8.66
NZD	0.50	0.50	-1.52	-2.10	57.38	-0.74	10.25
SEK	0.49	0.24	-1.64	-2.59	50.11	-0.83	14.56
DOL	0.48	0.02	-1.18	-2.88	32.39	-0.20	6.44
Panel B: Intraday							
AUD	0.52	0.01	1.59	2.33	53.88	-0.30	12.05
CAD	0.51	0.05	1.01	1.75	45.78	-0.04	6.17
CHF	0.51	0.02	2.47	4.02	48.57	0.24	6.61
EUR	0.52	0.01	2.03	3.44	46.73	0.15	6.41
GBP	0.53	0.00	2.62	4.83	43.02	0.11	7.11
JPY	0.47	0.00	-1.20	-2.20	43.42	0.16	8.58
NOK	0.51	0.33	0.75	1.01	58.59	-0.43	13.96
NZD	0.52	0.01	2.38	3.44	54.71	-0.06	7.16
SEK	0.51	0.14	1.53	2.16	55.85	0.03	6.48
DOL	0.52	0.00	1.50	3.06	38.79	0.15	6.71

Table A-III
Monthly UIP Regressions and Intraday Returns

This table reports results of the following regression

$$\Delta s_{t+1}^j = \alpha + \beta(f_t^{\tau,j} - s_t^j) + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, and $(f_t^{\tau,j} - s_t^j)$ refer to the short-term forward discount with maturity τ =1M. Panel A, B, and C refer to close-to-close, overnight, and intraday returns, respectively. Numbers in round parentheses refer to t-statistics based on Newey and West (1987) or Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2023.

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	DOL	PANEL
Panel A: Close-to-Close											
α	-3.46	5.20	22.92	18.82	-0.40	-26.93	-8.84	17.31	2.53	7.40	4.96
	(-0.18)	(0.37)	(0.85)	(0.95)	(-0.02)	(-1.05)	(-0.51)	(0.59)	(0.11)	(0.49)	(0.33)
β	-0.89	-0.09	-0.08	-1.68	-1.22	0.91	-0.32	0.02	-1.35	-1.15	-0.42
	(-0.73)	(-0.03)	(-0.06)	(-1.35)	(-0.98)	(0.87)	(-0.22)	(0.01)	(-1.01)	(-0.98)	(-0.44)
p-val	[0.12]	[0.68]	[0.40]	[0.03]	[0.08]	[0.93]	[0.36]	[0.61]	[0.08]	[0.07]	[0.14]
$\bar{R}^2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	299	299	299	299	299	299	299	299	299	299	2691
Panel B: Overnight											
α	-15.44	-15.49	-46.28	-43.15	-49.38	-5.70	-13.93	-19.10	-34.91	-25.28	-26.67
	(-0.96)	(-1.71)	(-2.47)	(-3.57)	(-3.84)	(-0.32)	(-0.98)	(-0.73)	(-2.67)	(-2.90)	(-3.00)
β	0.66	0.56	1.00	1.12	1.58	1.09	1.45	0.75	-0.10	0.54	0.89
	(0.79)	(0.34)	(1.05)	(1.30)	(1.74)	(1.23)	(1.48)	(0.49)	(-0.12)	(0.72)	(1.47)
p-val	[0.68]	[0.79]	[1.00]	[0.89]	[0.52]	[0.92]	[0.65]	[0.87]	[0.19]	[0.55]	[0.86]
$\bar{R}^2$	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
N	299	299	299	299	299	299	299	299	299	299	2691
Panel C: Intraday											
α	11.98	20.69	69.20	61.97	48.98	-21.23	5.09	36.41	37.44	32.68	31.63
	(0.98)	(1.60)	(3.03)	(4.15)	(4.21)	(-1.26)	(0.31)	(2.39)	(1.82)	(3.01)	(2.94)
β	-1.54	-0.65	-1.08	-2.79	-2.81	-0.18	-1.77	-0.73	-1.25	-1.69	-1.31
	(-2.06)	(-0.23)	(-1.17)	(-2.84)	(-3.45)	(-0.27)	(-1.88)	(-1.00)	(-1.04)	(-2.00)	(-2.18)
p-val	[0.00]	[0.55]	[0.03]	[0.00]	[0.00]	[0.09]	[0.00]	[0.02]	[0.06]	[0.00]	[0.00]
$\bar{R}^2$	0.01	0.00	0.00	0.02	0.02	0.00	0.01	0.00	0.00	0.01	0.01
N	299	299	299	299	299	299	299	299	299	299	2691

Table A-IV

UIP Regressions and Intraday Returns, by week

The table reports results of the following regressions

$$\Delta s_{t+1}^j = \sum_i \alpha_i \times \mathbb{1}^{wk} + \sum_i \beta_i (f_t^\tau - s_t^j) \times \mathbb{1}^{wk} + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, and $(f_t^\tau - s_t^j)$ refers to the forward discount with maturity $\tau = 1D$, and $\mathbb{1}^{wkd}$ is an indicator variable for each week of the month. Numbers in round parentheses refer to t-statistics based on Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2023.

	Week 1	Week 2	Week 3	Week 4
Panel A: Close-to-Close				
α_i	-0.21	0.46	-0.63	1.82
	(-0.17)	(0.25)	(-0.34)	(0.95)
β_i	-0.87	0.17	1.70	-0.47
	(-0.67)	(0.14)	(1.39)	(-0.42)
p-val	[0.15]	[0.52]	[0.57]	[0.18]
$\bar{R}^2$		0.00		
N		51520		
Panel B: Overnight				
α_i	-2.46	1.36	0.60	2.73
	(-3.56)	(1.23)	(0.49)	(2.44)
β_i	0.91	1.98	1.65	0.68
	(1.17)	(2.47)	(1.74)	(0.89)
p-val	[0.91]	[0.22]	[0.49]	[0.67]
$\bar{R}^2$		0.00		
N		51520		
Panel C: Intraday				
α_i	2.25	-0.90	-1.23	-0.91
	(2.29)	(-0.65)	(-0.90)	(-0.64)
β_i	-1.78	-1.81	0.05	-1.14
	(-1.55)	(-1.95)	(0.06)	(-1.50)
p-val	[0.02]	[0.00]	[0.26]	[0.01]
$\bar{R}^2$		0.00		
N		51520		

Table A-V
UIP Regressions and Intraday Returns, by quarter

The table reports results of the following regressions

$$\Delta s_{t+1}^j = \sum_i \alpha_i \times \mathbb{1}^{qtr} + \sum_i \beta_i (f_t^\tau - s_t^j) \times \mathbb{1}^{qtr} + \varepsilon_{t+1}^j$$

where $\Delta s_{t+1}^j = s_{t+1}^j - s_t^j$ refers to the log spot return of currency j, and $(f_t^\tau - s_t^j)$ refers to the forward discount with maturity $\tau = 1D$, and $\mathbb{1}^{qtr}$ is an indicator variable for each quarter from Q1 to Q4. Numbers in round parentheses refer to t-statistics based on Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2020.

	Q1	Q2	Q3	Q4
Panel A: Close-to-Close				
α_i	-0.47	1.52	-0.54	1.63
	(-0.36)	(0.80)	(-0.30)	(0.86)
β_i	-0.77	-1.80	1.09	1.27
	(-0.61)	(-1.68)	(0.90)	(1.15)
p-val	[0.16]	[0.01]	[0.94]	[0.81]
$\bar{R}^2$		0.00		
N		51520		
Panel B: Overnight				
α_i	-2.69	1.66	0.33	3.24
	(-3.51)	(1.47)	(0.30)	(2.79)
β_i	0.86	0.32	2.20	1.74
	(1.16)	(0.45)	(2.87)	(2.26)
p-val	[0.85]	[0.33]	[0.12]	[0.34]
$\bar{R}^2$		0.00		
N		51520		
Panel C: Intraday				
α_i	2.22	-0.15	-0.87	-1.61
	(2.14)	(-0.10)	(-0.62)	(-1.06)
β_i	-1.63	-2.12	-1.11	-0.48
	(-1.76)	(-2.50)	(-1.30)	(-0.50)
p-val	[0.00]	[0.00]	[0.01]	[0.12]
$\bar{R}^2$		0.00		
N		51520		

Table A-VI
UIP Regressions and Intraday Returns, by Accrual Days

The table reports results of the following regressions

$$\Delta s_{t+1}^{j} = \sum_{i} \alpha_i \times \mathbb{1}^{Acc} + \sum_{i} \beta_i (f_t^{\tau} - s_t^{j}) \times \mathbb{1}^{Acc} + \varepsilon_{t+1}^{j}$$

where $\Delta s_{t+1}^{j} = s_{t+1}^{j} - s_t^{j}$ refers to the log spot return of currency j, and $(f_t^{\tau} - s_t^{j})$ refers to the forward discount with maturity $\tau = 1D$, and $\mathbb{1}^{Acc}$ is an indicator variable distinguishing between interest accrual days of one day versus days with more than one days of interest rate accrual. Numbers in round parentheses refer to t-statistics based on Driscoll and Kraay (1998) adjusted standard errors. Numbers in squared parentheses show the p-value based on a Wald-test with the null hypothesis $H_0 : \beta = 1$. The sample period is January 1999 to December 2020.

	Int. Acc. = 1	Int. Acc. > 1
Panel A: Close-to-Close		
α_i	0.67	-2.11
	(0.91)	(-1.42)
β_i	-0.17	1.21
	(-0.24)	(0.78)
p-val	[0.10]	[0.89]
$\bar{R}^2$	0.00	
N	51520	
Panel B: Overnight		
α_i	-0.90	-2.08
	(-1.97)	(-2.31)
β_i	1.08	2.65
	(2.41)	(2.41)
p-val	[0.85]	[0.13]
$\bar{R}^2$	0.00	
N	51520	
Panel C: Intraday		
α_i	1.56	-0.03
	(2.81)	(-0.03)
β_i	-1.25	-1.44
	(-2.33)	(-1.20)
p-val	[0.00]	[0.04]
$\bar{R}^2$	0.00	
N	51520	