Finance and Economics Discussion Series

Federal Reserve Board, Washington, D.C.
ISSN 1936-2854 (Print)
ISSN 2767-3898 (Online)

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2023-074

Please cite this paper as:
Kilic, Rehim (2023). "Uncovered interest rate, overshooting, and predictability reversal puzzles in an emerging economy," Finance and Economics Discussion Series 2023-074. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2023.074.

Uncovered interest rate, overshooting, and predictability reversal puzzles in an emerging economy

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First Draft: April 2022
This Draft: August 2023

Abstract

By using realized and survey-based expected exchange rate data, the paper presents five key findings regarding the Uncovered Interest rate Parity (UIP) and related puzzles in an Emerging Market (EM). First, Fama regressions, when not accounting for shifts in the UIP relationship, yield slopes that are statistically identical to one, irrespective of whether survey-based expected exchange rates or realized exchange rates are used. Second, caution is necessary however, as our analysis identifies three distinct sub-periods within each exchange rate measure, each exhibiting varying levels of puzzling behavior. Third, under realized exchange rates, expectation errors can introduce both downward and upward biases or no bias at all, depending on the sub-period. On the other hand, currency risk premiums consistently lead to a downward bias. Under expected exchange rates, currency risk premiums continue to exert a downward bias at varying degrees across sub-periods. Fourth, responses to interest rate differential shocks by expectation errors are pivotal in inducing both downward and upward biases or removing biases altogether when utilizing realized exchange rate data. Fifth, evidence concerning overshooting and reversal puzzles, as well as their link to the UIP puzzle, varies depending on the specific sub-period and the choice of exchange rate measurement, making it more intricate than the previous literature has documented.

JEL Classification: F31, F41, G11, G15.
Keywords: UIP Puzzle, FX Rate Overshooting Puzzle, Predictability Reversal Puzzle, Fama Regression, Expectations.

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1 Introduction

The Uncovered Interest Rate (UIP) parity condition states that a currency with a higher interest rate is expected to depreciate relative to a currency with a lower interest rate. Research, beginning with Hansen and Hodrick (1980) and Fama (1984), focusing on advanced economy (AE) currencies and utilizing ex-post realized exchange rates under full information rational expectations (FIRE), has shown a contrary outcome: currencies with high interest rates tend to appreciate, yielding realized excess returns over up to one-year investment horizons. This outcome leads to the well-known the UIP or Fama puzzle. Excellent discussions of the puzzle and the literature are given in Engel (1996), Sarno (2005), Engel (2014), and Engel (2016). Conversely, using expected exchange rates, several studies have reported more favorable evidence for UIP in AEs (see, Frankel and Froot, 1987; Chinn and Frankel, 1994, 2020; Bussiere et al., 2022). Additional studies on AEs, still using realized exchange rates, reveal other perplexing dynamics like the delayed overshooting and predictability reversal puzzles.[1]

Despite extensive research on AEs currencies, the UIP and related puzzles in emerging markets (EMs) remain understudied. We contribute to this literature by investigating the UIP, delayed overshooting, and predictability reversal puzzles, collectively referred to as "UIP puzzles" in the paper in a major EM currency by using both survey-based *ex ante* expected and *ex post* realized measures of exchange rate. Our empirical analysis yields five key findings regarding "UIP puzzles." First, we document that disregarding potential shifts in the UIP relationship over time and conducting Fama regressions can yield strong statistical support for UIP in the full-sample. Importantly, this evidence is not limited to survey-based data for the expectation of Turkish Lira (TRY) and US Dollar (USD) exchange rate but extends to realized data covering the period from April 2006 to February 2022.

Second, support for the UIP condition varies over time. Consequently, the UIP puzzle periodically emerges and disappears, with notable disparities between ex-ante and ex-post exchange rate measures. Third, examining the roles of expectation errors and currency risk premiums in the fluctuation of the UIP puzzle across sub-periods, we show that both expectation errors and the currency risk premiums contribute to shifts in the Fama regression slope when using realized exchange rate changes under the FIRE assumption, while the currency risk premium predominately drives slope shifts in survey-based data on expected exchange rate. Fourth, we demonstrate that variations in responses to interest rate differential shocks by expectation errors play a pivotal role in generating large negative, large positive or negligible correlations between the interest rate differential and expectation errors across sub-periods. Consequently,

[1] The delayed overshooting puzzle involves initial appreciation followed by depreciation after a positive shock to the interest rate differential Eichenbaum and Evans (1995). The predictability reversal puzzle shows that UIP deviations change direction; high interest rate currencies have positive excess returns in the near future due to initial appreciation but then experience predictable negative excess returns due to excessive depreciation (Bacchetta and Wincoop, 2010; Engel, 2016; Valchev, 2020).

these differences determine the direction and magnitude of bias in the regression slopes over time. Fifth, the evidence or absence thereof regarding delayed overshooting and predictability reversal puzzles as well as their connection the UIP puzzle are more nuanced than previously suggested in the literature. Let's delve into each of these findings.

Our first result that the UIP holds on average in the full-sample using both the change in the expected and realized exchange rates suggests two important points: (i) the supporting evidence for UIP from survey-based data is not unique to AEs and (ii) this evidence extends beyond survey-based data on exchange rate. Indeed, in contrast to a Fama slope that is statistically indistinguishable from one, expected excess currency returns consistently remain positive, with a statistically significant positive regression intercept under survey data. This happens because survey-based expected exchange rate changes do not, on average, perfectly offset interest rate differential, a phenomenon also observed by Kalemli-Özcan and Varela (2023) for their panel of EMs. This stands in contrast to the support for UIP from the Fama regression with ex-post exchange rate, which shows a small and negative average realized excess currency return in the full sample.

Our second finding underscores the need for caution when interpreting evidence from full-sample regressions. It highlights shifts in the Fama slope and consequently, excess return regressions over sub-periods when using both measures of exchange rates. Structural break tests identify three distinct UIP regression slope periods, labeled as 'early', 'middle', and 'late' periods for brevity.[2] The UIP regression slopes exhibit significant differences, particularly in the early and middle periods, between the two exchange rate measures. In the early period, the slope is strongly negative under the realized exchange rate, while it is positive and significantly above one in the middle period. Conversely, using the survey-based expected exchange rate, UIP holds in the early period but fails in the middle period with a slope indistinguishable from zero. Only in the late period do we find evidence for UIP with slopes statistically indistinguishable from one, using both expected and realized exchange rates. These findings underscore the need to explore Fama regression shifts, suggesting that the evidence in the full sample, even with survey-based exchange rate data, can result from averaging out opposite Fama regression slopes over different sub-periods and/or the dominance of a particular sub-period in the full sample.

The third finding in our study involves decomposing the Fama regression slope under real-

[2] These periods are 2006M4-2008M9, 2008M10-2013M8, and 2013M9-2022M2 under realized exchange rate, and 2006M4-2008M10, 2008M11-2015M11, and 2015M12-2022M2 under survey-based expected exchange rate. Although the early period overlaps between two exchange rates, they differ somewhat in the other two sub-periods. Overall, these periods roughly correspond to the period leading into the Global Financial Crisis (GFC) and the crisis period, the period of recovery and zero-lower-bound, and the recent period covering the COVID-induced global recession. In the context of Turkish economy, these periods roughly corresponds to the period of high interest rate period until the end of 2008, the low rate period between 2009 and 2016, and the post 2016 period with high and more volatile interest rate despite the Turkish government's mandate to keep the interest rates low. See, Gurkaynak et al. (2022) for an excellent discussion of the policy developments in Türkiye that covers largely our sample period.

ized exchange rate changes into expectation error and currency risk premium components and assessing the bias in the slope under expected exchange rate changes. Decomposition under realized exchange rates shows that both expectation error and the currency risk premium contribute to bias. Although the currency risk premium consistently pushes the slope towards zero, the expectation error term predominantly determines the direction and magnitude of the bias. For instance, it induces a significant negative bias in the early period when the Fama puzzle is present and a substantial upward bias in the middle period, despite the presence of a relatively large and statistically significant currency risk premium term pushing the slope towards zero.

In the late sub-period, neither the expectation error nor the currency risk premium terms introduce a meaningful bias, and the Fama slope is statistically indistinguishable from one. These results suggest that the full-sample slope being statistically indistinguishable from one when using realized exchange rates may be due to the dominance of the late sub-period and the averaging out of the large downward bias in the early period and the significant upward bias in the middle period. Examining bias in the Fama regression slope under survey-based data reveals that the currency risk premium term continues to induce a downward bias in the slope at varying degrees across sub-periods. This term generally pushes point estimates of the slope below one over sub-periods and in the full sample, although it remains statistically significant only in the middle and late sub-periods.

Our fourth result explains why the correlation between the interest rate differential and the expectation error changes in sign and magnitude across sub-periods with distinct UIP regression outcomes. We observe that the direction and size of the expectation error responses to a one percentage point interest rate differential shock vary significantly across periods characterized by large downward bias, large upward bias, and no bias. In the early period, where the UIP puzzle exists, a substantial and statistically significant negative expectation error response leads to a large negative correlation between the expectation error and the interest rate differential, resulting in a significant downward bias in the UIP regression. In the middle period, a similarly substantial response in the opposite direction contributes to a large positive correlation, driving the slope above unity. In the most recent period, similar to the full sample, the expectation error response to a one percent increase in the differential becomes statistically insignificant and economically small, leading to a minor correlation between the two and thus an insignificant bias. This finding demonstrates that the responsiveness of the expectation error to interest rate differential shocks determines the magnitude of the correlation between the expectation error and the interest rate differential, ultimately making the expectation error term dominant over the currency risk premium term in determining the bias's direction and size.

Our fifth finding reveals significant differences in responses to changes in expected and realized exchange rates following the same interest rate differential increase. The response dynamics of realized exchange rate changes and realized excess returns indicate that in samples where UIP holds with a slope statistically indistinguishable from one, none of these puzzles are present. This is the case in our full sample and the late period. In the early period, where UIP fails to hold with a large negative slope, both of these puzzles are present, consistent with previous literature on AEs. Interestingly, in the middle period, where the Fama slope is biased upward and above one, we find that the overshooting and excess return predictability reverse direction. Initially, the exchange rate appreciates more than the interest rate differential shock, followed by depreciation beyond the shock about one year into the future. This dynamic results in significant initial negative excess return predictability followed by positive predictability.

The response dynamics of survey-based changes in expected exchange rates and expected excess returns across different sub-periods reveal the presence of predictability reversal, even when overshooting is absent in both sub-periods and the full-sample period. To illustrate, in the early period and the full-sample period where the Fama slope is statistically indistinguishable from one, as well as in the late period where the slope is positive but below one, expected excess returns display a pattern of predictability. Initially, they tend to be predictably positive, followed by a phase of negative predictability, and ultimately returning to positive predictability. This pattern emerges because the expected exchange rate response, while somewhat persistent, is not substantial enough to counter the impact of the interest rate differential shock. Remarkably, in the middle period, where UIP fails with a Fama slope that is not statistically distinguishable from zero, expected excess returns still exhibit positive predictability initially, followed by a phase of negative predictability despite the absence of any overshooting.

The remainder of the paper is structured as follows. Section 2 summarizes the literature. Section 3 outlines the UIP condition and Fama and excess return regressions. Section 4 presents the data and summary statistics. Section 5 undertakes our empirical analysis of Fama and excess return regressions, the role of expectation error and currency risk premium in inducing Fama slope shifts and responses to interest rate differential shock by expectation errors over the full and sub-sample periods. Section 6 explores the delayed overshooting and predictability reversal puzzles. Section 7 concludes. Additional results are in Appendices.

2 Literature

Our paper contributes to four strands of the literature. Our first contribution is to the large empirical UIP literature. Focusing mainly on the AEs' currencies, this literature shows that UIP does not hold with realized exchange rate under FIRE, but it holds when survey-based data on expected exchange rate is used.[3] Relative to this large literature, our findings in the full-sample

[3] In addition to FIRE, the empirical UIP literature, assumes that Covered Interest Parity (CIP) holds by equating the forward premium (the difference between forward rates and spot rates) to interest rate differential. This is the reason why the UIP puzzle is also known as the forward premium/discount puzzle, as the forward premium is associated with appreciations instead of depreciations.

show that Fama and excess return regressions can produce results that are in support of the UIP condition not only using by survey data on exchange rate but also using realized exchange rate. Our subsequent finding that such evidence may break in sub-sample periods under both measures of exchange rate change highlights that such supportive evidence for UIP reported in this paper and other papers in the literature might be an artifact of averaging out of large downward and upward biases across sub-periods in the full-sample and/or the dominance of a sub-period with nearly no-bias in the full-sample.

Our second contribution adds to the existing body of literature that highlights evidence of nonlinearity or shifts in the UIP relationship (see, Baillie and Kilic, 2006; Sarno etal., 2006; Baillie and Cho, 2014; Bussiere et al., 2022). While we do not formally explore threshold-type nonlinear effects in the UIP relationship as done by Baillie and Kilic (2006) and Sarno etal. (2006), our study demonstrates a similar phenomenon to the findings presented by Bussiere et al. (2022) for several AE currencies. Specifically, we observe that the Fama slope does not remain constant over time. Notably, in the late period, the regression slopes under realized and expected exchange rate changes align direction-wise, although they exhibit significant differences during the early and middle periods. Additionally, we find that the slope gradually approaches one in the latter part of the sample period under both measures of exchange rates. This tendency appears to contribute to the statistically indistinguishable unity slope observed in the full-sample period under both measures of exchange rates.

Our third contribution is to the part of the literature that interprets the failure of UIP as a result of deviations from FIRE and hence, identify expectation error as the key source of the downward bias in Fama regressions under realized exchange rate changes (e.g., Ito, 1990; Chinn and Frankel, 1994; Burnside, et al., 2007; Bacchetta et al., 2009; Gourinchas and Tornell, 2002; Stavrekeva and Tang, 2018; Candian and De Leo, 2022; Bussiere et al., 2022). Our results show that (i) both the expectation error and currency risk premium can induce bias in Fama regressions; (ii) expectation errors can induce both downward and upward bias or no-bias in Fama regressions using realized exchange rate changes, depending on the direction and strength of the correlation between expectation errors and the interest rate differential; (iii) the direction and the size of the bias are driven by the reactivity and response pattern of expectation error to shocks in the interest rate differential; and (iv) the currency risk premium term consistently pushes Fama slope downward even under survey-based expected exchange rate change. Our results reveal that regardless of its size or statistical significance, the expectation error term typically dominates and determines the ultimate direction and magnitude of the bias. For instance, it leads to a substantial negative bias in the early period when the UIP puzzle is prominent and a significant upward bias in the middle period, despite the presence of a relatively large and statistically significant currency risk premium term pushing the slope downward from one. In the late period, the expectation error term becomes negligibly small, resulting in no bias.

Our fourth contribution is to the overshooting and predictability reversal literature (e.g., Dornbusch, 1976; Eichenbaum and Evans, 1995; Bacchetta and Wincoop, 2010; Engel, 2016; Valchev, 2020; Kalemli-Özcan and Varela, 2023). This body of work, primarily focused on AE currencies, has demonstrated that that exchange rates often overshoot their equilibrium levels after an initial interest rate shock, giving rise to delayed overshooting and related predictability reversal puzzles. Our study aligns with this literature by confirming the presence of the overshooting and predictability reversal puzzles in the early period when the Fama puzzle is prevalent, under realized exchange rates. Importantly, we introduce an additional finding: whenever the Fama slope turns positive and exceeds one, we observe opposite form of overshooting and predictability reversal puzzles. In this scenario, the exchange rate initially overshoots immediately after the shock, experiences a sharp depreciation, and subsequently undershoots, leading to negative excess return predictability followed by positive predictability. Furthermore, our results demonstrate the disappearance of these puzzles in the late period when the Fama slope is statistically indistinguishable from one, and there is no statistically significant bias induced by expectation errors and currency risk premiums.

Our findings using the change in expected exchange rates reveal no overshooting as exchange rates are always expected to depreciate even in the middle period where the expected depreciation is usually positive but small and statistically insignificant in most months into the future. However, since the response by survey participants is on average muted relative to the size of the interest rate differential shock, there is small expected excess return predictability with reversal in the early and especially in the late and full-sample periods. These results exhibit both similarities and differences compared to the findings reported in Kalemli-Özcan and Varela (2023) for EM currencies. In contrast to the literature on AEs, Kalemli-Özcan and Varela (2023) find that in EMs, there is no delayed overshooting and the response of expected exchange rate change follows an inverse U-shaped pattern, leading to consistent positive expected excess return predictability without any reversal. Our results highlight that in the case of TRY, similar to Kalemli-Özcan and Varela (2023), there is no delayed overshooting. However, due to the subdued responses of survey participants, we observe predictability reversal, especially in the late and full-period samples. Additionally, our findings indicate that using realized exchange rate changes or expected changes from survey data may not always yield consistent results. This observation contrasts with the documented results from the panel of EM currencies reported in Kalemli-Özcan and Varela (2023).[4]

[4]While we do draw some comparisons to the findings of Kalemli-Özcan and Varela (2023), it's crucial to note several significant differences between our work and theirs: (i) the differences in the sample periods, (ii) source of survey data, (iii) econometric approaches as we rely on time series data on a single EM while they utilize panel data from a broader range of EMs; (iv) we explore shifts in the Fama and excess return regressions while they do not consider such shifts; and (v) finally we focus on the UIP and the related puzzles while their focus is on

3 UIP Condition and regressions using realized and expected exchange rate changes

Under UIP condition, the k-period ahead return on a 1 USD investment should be equal to the expected return on converting 1 USD into say TRY by using exchange rate S_t at date t and investing in a TRY denominated risk-free asset for k periods and then converting the proceeds back to dollar at a future expected exchange rate, $E_t S_{t+k}$. Mathematically, this textbook UIP condition is

$$(1 + i_t^{US}) = \frac{1}{E_t S_{t+k}}(1 + i_t)S_t, \tag{1}$$

where S_t is the local currency per USD (i.e., TRY per USD) and we measure i_t and i_t^{US} by both the local and the U.S. $k = 12$ month deposit rate. Ignoring the higher order terms and using the lowercase letters to denote logarithms and superscript 'e' for conditional expectation E_t, this condition alternatively states that the expected change in the log exchange rate over the investment horizon k equals to the interest rate differential between Türkiye and the USA,

$$s^e_{t+k} - s_t = i_{t,k} - i^{US}_{t,k}. \tag{2}$$

Any deviations from the UIP condition for a horizon k in Equation (2) can be considered as expected UIP premium or expected excess currency return,

$$\lambda^e_{t+k} = (i_t - i_t^{US}) - (s^e_{t+k} - s_t). \tag{3}$$

Clearly when $\lambda^e_{t+k} = 0$, the UIP condition in Equation (2) holds exactly as the interest rate differential and the expected exchange rate depreciation over k-period maturity or investment horizon offset each other and hence, the expected excess returns from investing in the TRY are zero. Adding and subtracting s_{t+k} to the left hand-side of Equation (2) and re-arranging the terms, we can re-write the UIP condition as follows

$$s_{t+k} - s_t = (i_t - i_t^{US}) + (s_{t+k} - s^e_{t+k}). \tag{4}$$

In this form, the equation indicates that the ex-post realized log exchange rate depreciation can be decomposed into two components, the interest rate differential and the exchange rate expectation (forecast) error. Assuming FIRE, so that the logarithm of the expected k-period ahead exchange rate equals to the future realized exchange rate plus a white-noise error term, (i.e., $s^e_{t+k} = s^{FIRE}_{t+k} = s_{t+k} + \zeta_{t+k}$), one can write the ex-post excess currency returns as

$$\lambda_{t+k} = (i_{t,k} - i^{US}_{t,k}) - (s_{t+k} - s_t). \tag{5}$$

the explanation of the UIP deviations in EMs and the role of policy uncertainty.

with $\lambda_{t+k} = -\zeta_{t+k}$. The literature following Hansen and Hodrick (1980) and Fama (1984), tests the UIP condition with ex-post (*realized*) exchange rate under the assumption of FIRE and estimates the following Fama or the UIP regression

$$s_{t+k} - s_t = \Delta s_{t+k} = \alpha + \beta(i_{t,k} - i_{t,k}^{US}) + u_{t+k}, \tag{6}$$

where the error term u_{t+k} includes the forecast/expectation error as well as any higher order terms from the approximation of the textbook form of the UIP condition stated in Equation (1). Under FIRE assumption, the error term is assumed to be uncorrelated with the interest rate differential with zero mean. By implication, imposing FIRE also means that expectation error term $(s_{t+k} - s_{t+k}^e)$, should be uncorrelated with the interest rate differential. If $\beta = 1$, interest rate differential and exchange rate changes offset each other and UIP condition holds on average. A stricter UIP condition (i.e., Equation (2) also implies $\alpha = 0$. If $\beta < 1$, the ex-post depreciation is lower than implied by the interest rate differential and hence, there exist ex-post excess returns. Equation (6) is equivalently re-written as follows,

$$\lambda_{t+k} = \alpha^* + \beta^*(i_{t,k} - i_{t,k}^{US}) + u_{t+k}^*, \tag{7}$$

to test whether excess returns are predictable or not.

In this equation, λ_{t+k} is given in Equation (5) is the ex-post deviation from UIP under FIRE and hence, the *realized* excess return in k period between time t and $t + k$. It can be shown that these two regression equations are equivalent and hence, $\beta^* = 1 - \beta$ and $\alpha^* = -\alpha$. If $\beta^* = 0$, then there is no predictable excess returns while if β^* is statistically different from zero, there are predictable excess returns on TRY. Specifically, $\beta^* > 0$ implies that the higher the interest rate differential between TRY and USD-denominated assets, the higher the excess return on TRY is.

Note also that if observations on s_{t+k}^e is available, an econometric specification of the following form

$$s_{t+k}^e - s_t = \Delta s_{t+k}^e = \alpha^{'} + \beta^{'}(i_{t,k} - i_{t,k}^{US}) + u_{t+k}^{'} \tag{8}$$

can be used to test the UIP condition stated in Equation (2) under the assumption that the error term $u_{t+k}^{'}$ is uncorrelated with the interest rate differential. In the above equation the superscript $'$ is used to indicate that the regression equation is based on the survey-based expected exchange rate data. In both forms of specifications in Equations (6) and (8) testing for slope is 1 ($\beta = 1$ or $\beta^{'} = 1$) and intercept is 0 ($\alpha = 0$ or $\alpha^{'} = 0$) allows us to test the strict form of UIP condition as stated in Equation (2). If $\alpha \neq 0$ or $\alpha^{'} \neq 0$, a test of $\beta = 1$ or $\beta^{'} = 1$ will test approximately the UIP condition above with some non-zero average constant excess return. As indicated by Bussiere et al. (2022), in this form, there is no need to impose

FIRE and hence, there is no assumption that the *ex ante* measure of exchange rate change is an unbiased measure of the *ex post* exchange rate change. In a similar fashion, the corresponding excess return regression in expectations is

$$\lambda^e_{t+k} = \alpha'^* + \beta'^*(i_{t,k} - i^{US}_{t,k}) + u'^*_{t+k}, \tag{9}$$

where λ^e_{t+k} is given by Equation (3) above and captures the expected UIP premium or expected excess return under a given measure of expected exchange rate change.

4 Data and summary statistics

Our measure of *ex ante* expectation of TRY-USD exchange rate is extracted from Central Bank of the Republic of Türkiye (CBRT)'s Electronic Data Delivery System (EDDS). The CBRT conducts a monthly survey of expectations of future TRY/USD exchange rate among the market participants in Türkiye. The survey is conducted first week of each month; and participants are the decision makers and financial professionals in the Interbank exchange rate market in Türkiye. A non-probability sampling method based on the voluntary participation of the market participants is used. Survey participants are asked to answer "what is your expectation of the US Dollar rate in the Interbank foreign exchange market by the end of the next 12-months?" Responses by each participant is recorded as the expected exchange rate of TRY/USD at 12-month horizon. We use survey average over the participants for each month as our measure of 12-month ahead expected exchange rate. The coverage period for the survey sample is between 04/2006 and 02/2022 with a total of 191 monthly data points. The number of participants varies over time and typically ranges between 40 and 100 with a sample average of 67 survey responses and roughly with a sample standard deviation of 12 monthly participants.

To measure *ex post* exchange rate between TRY and USD, we use end of the month mid-rate from Bloomberg Finance LP for the period 04/2006 and 02/2022. The implied forward exchange rate premium/discount used for robustness checks and in testing for Covered Interest Rate Parity (CIP) are also downloaded from Bloomberg Finance LP. We obtain 12-month deposit rates from Bloomberg Finance LP for the USA and from EDDS for Türkiye to measure the interest rate differential.

We provide the main summary statistics for changes in realized (Δs_t) and expected ($\Delta^e t + k$) exchange rates, expectation errors ($\eta t + k = s_{t+k} - s^e t + k$), as well as realized and expected UIP deviations or excess returns ($\lambda t + k$ and λ^e_{t+k}), along with the interest rate differential in Table 1. These statistics are presented for both the full-sample period and sub-sample periods identified through break point tests for the UIP regressions under each measure. (We refer to sub-sample period results in Section 5 for more detailed analysis but display them here to provide a comprehensive overview of the data across both the full sample period and sub-

Table 1: **Sample summary statistics in the full-sample and sub-samples**

		A. Periods under *Realized* exchange rate changes			
		2006M4-2022M2	2006M4-2008M9	2008M10-2013M8	2013M9-2022M2
Δs_{t+k}	Avg	12.364	-4.068	8.302	19.546
	Std	15.299	12.243	11.728	13.866
$i_t - i_t^{US}$	Avg	11.061	12.427	8.856	11.865
	Std	3.441	1.625	2.098	4.009
λ_{t+k}	Avg	-1.340	16.495	0.554	-7.681
	Std	14.530	16.495	10.369	12.278
η_{t+k}	Avg	-6.329	6.735	-3.621	-12.458
	Std	15.131	18.924	8.635	13.866
		B. Periods under *Expected* exchange rate changes			
		2006M4-2022M2	2006M4-2008M10	2008M11-2015M11	2015M12-2022M2
Δs^e_{t+k}	Avg	6.631	9.417	2.964	9.635
	Std	4.650	2.698	2.730	4.033
$i_t - i_t^{US}$	Avg	11.061	12.450	8.865	12.882
	Std	3.441	1.603	1.730	4.219
λ^e_{t+k}	Avg	4.393	3.033	5.901	3.246
	Std	3.572	2.493	3.161	3.765
η_{t+k}	Avg	-6.329	6.535	-5.980	-13.128
	Std	15.131	18.639	9.215	15.630

Sample averages (Avg) and standard deviations (Std) for realized and expected changes in exchange rates (Δs_{t+k}, and Δ^e_{t+k}, respectively), realized and expected excess returns (λ_{t+k} and λ^e_{t+k}, respectively), interest rate differential ($i_t - i_t^{US}$), and expectation error (η_{t+k}) over the full sample and sub-sample periods identified by break-point tests by using realized and expected exchange rates in UIP regressions (see, Section 5.2).

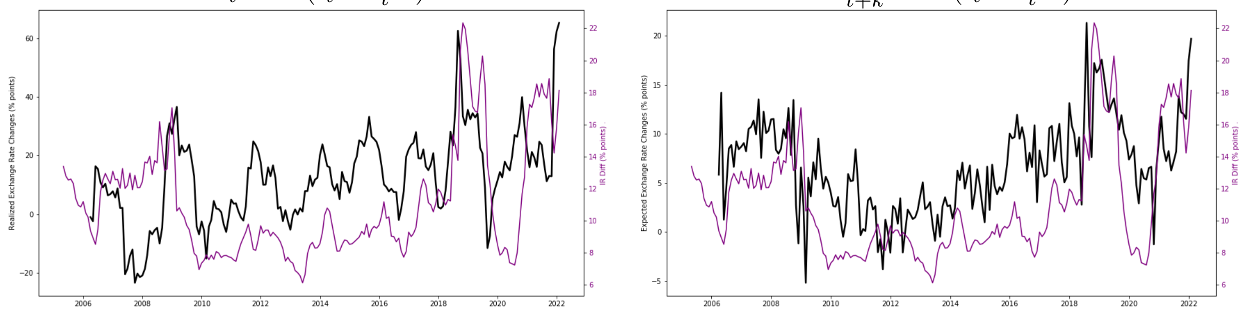
periods.) In addition to the tabular presentation, we offer visual representations of monthly 12-month log percentage changes in both realized and expected exchange rates, as well as 12-month interest differentials over time in Figure 1.

For a closer look at the full-sample period (2006M4-2022M2) in Table 1 and the time series plots in Figure 1, it becomes evident that, in line with the higher interest rates in Türkiye compared to the USA, the interest rate differential remained persistently positive, averaging 11.1 percentage points in our sample period. After the initial decline due to falling interest rates in Türkiye and gradual increase in the US prior to the Global Financial Crisis (GFC), the interest rate differential surged and reached levels exceeding 20 percentage points during the GFC. This increase was mainly driven by declines in the US interest rates while rates in Türkiye remained relatively high.

Following the GFC, during the recovery and the zero-lower bound era, the interest rate differential held steady between 5 and 10 percentage points. However, it reached new highs in 2018, driven by sharp increases in Turkish rates. While the differential briefly dipped into the 5 to 10 percentage point range in 2020 in response to rate declines in both countries due to the Global Covid-induced recession, it quickly climbed above 10 percentage points as Turkish rates started to rise more rapidly in late 2020 and throughout 2021. It's worth noting that despite the Turkish government's mandate to maintain low policy rates, interest rates in T"urkiye increased significantly during this period. For a comprehensive account of these key developments, you can refer to Gurkaynak et al. (2022).

Figure 1: Exchange Rate Depreciation and Interest Rate Differentials

Δs_t and $(i_t - i_t^{US})$ Δs^e_{t+k} and $(i_t - i_t^{US})$



This figure displays time series of percentage year-over-year change in *realized* and *expected* (black solid lines in each plot) exchange rate changes with interest rate differential (purple solid lines).

In our sample, realized exchange rate depreciation averaged approximately 12.4 percent year-over-year. In contrast, the survey-based measure of exchange rates indicated that Lira was expected to depreciate at a lower rate of 6.6 percentage points, with significantly less dispersion in these expectations. Inline with the sample statistics in Table 1, the plots for realized exchange rate changes in Figure 1 reveal significant swings in terms of both depreciation and appreciation. However, survey participants anticipated almost always a depreciation, but at much smaller magnitudes compared to the actual realization.

Upon closer inspection of the plots and eye-ball econometrics suggest that periods characterized by large spikes in the interest rate differential often coincide with episodes of substantial realized depreciation. However, the expected depreciation tends to be less aligned with such large swings in the interest rate differential.

It's important to emphasize the differences in the average magnitude of depreciation and the dispersion between expected and realized exchange rates. In line with these differences, average realized UIP deviations or excess returns are generally negative, while average expected UIP deviations are positive during our sample period, with much less variation than the ex-post deviations. In addition to these patterns holding true for the full sample, it's noteworthy that we also observe significant differences in sample averages and standard deviations across sub-periods under each measure of exchange rates, as well as between them. As we will note, these disparities provide valuable insights into the varying outcomes we uncover across the two measures of exchange rate changes in the subsequent sections of this paper.

5 The UIP puzzle in the full-sample and sub-period samples

5.1 Fama and excess return regressions in the full sample

Table 2 reports Fama and excess return regression results in the full sample. Columns (1) and (2) display the results using change in realized exchange rate under the FIRE assumption while columns (3) and (4) presents results using expected exchange rate, corresponding to regressions in Equations (6) and (7) and Equations (8) and (9), respectively.

In column (1) the results provide compelling evidence for the UIP with realized exchange rates in the full sample. Specifically, we cannot reject that the null hypothesis that the slope is equal to one ($H_0 : \beta = 1$), nor can we reject the joint hypothesis of a zero intercept and a unity slope ($H_0 : \alpha = 0, \beta = 1$ or).[5] This consistency with UIP is further supported by the observation that interest rate differentials fail to predict realized excess returns, as evident from the results in column (2).[6]

The results presented in columns (3) and (4) also offer support for UIP when using the survey expectations measure of exchange rate. Comparing the point estimates for the slope in columns (1) and (3) reveals that, with the expected exchange rate, the point estimate for the slope, although below one, is not statistically different from one, as indicated by a much narrower 95% confidence interval. Additionally, the Fama regression yields a considerably

[5]For simplicity, throughout the remainder of the paper, we use α and β to denote the intercept and slope in regressions, regardless of the exchange rate measure used.

[6]Results using forward premium data are similar and reported in Appendix B.

Table 2: **Fama and Excess Return Regressions**

	(1)	(2)	(3)	(4)
	Realized Exchange Rate		*Expected* Exchange Rate	
Intercept	-3.310	3.310	-2.809*	2.809*
	(5.489)	(5.489)	(1.489)	(1.489)
Slope	1.422**	-0.422	0.856***	0.144
	(0.553)	(0.555)	(0.123)	(.123)
95% Interval	[0.330, 2.513]	[-1.513, 0.670]	[0.614, 1.098]	[-0.098, 0.386]
p-value ($H_0 : \beta_1 = 1$)	0.447		0.243	
p-value ($H_0 : \alpha = 0, \beta = 1$)	0.73		0.000	
R^2	0.107	0.010	0.422	0.002

Table reports Fama (UIP) and excess return regressions results columns in (1) and (3) and (2) and (4), respectively. Interest rate differential is measured by the deposit rate differentials between T"urkiye and the USA. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

higher $R-$squared value in column(3) compared to column (1) (42% vs. 11%).

However, it's worth noting that we reject the joint null hypothesis of a zero intercept and a unity slope with the *ex ante* exchange rate change, a result that is not observed with *realized* exchange rate change. The presence of a statistically significant intercept term in column (3) also suggests positive average expected excess returns or deviations from UIP with the *ex ante* measure, while no such evidence is found with the *ex post* measure of exchange rate change.

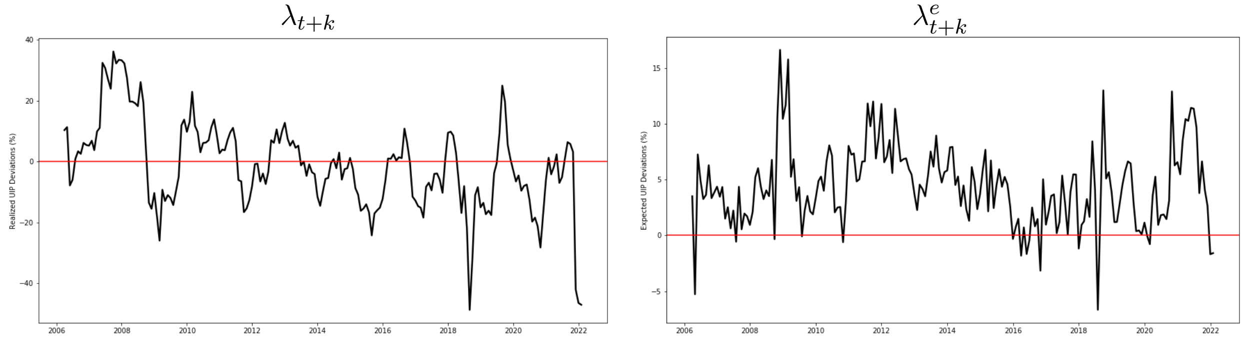
Fama and excess return regressions consistently demonstrate that, on average, UIP holds regardless of whether realized or expected exchange rates are used in the full sample. The evidence for UIP reported in Table 2 using realized exchange rate, however contrasts with the rejection of UIP in AEs as documented in the extensive literature on AEs. On the other hand, our results using expected exchange rates align more closely with the favorable evidence for UIP under survey-based data in AEs, as documented in papers such as Frankel and Froot (1987), Bacchetta et al. (2009), Chinn and Frankel (1994), Chinn and Frankel (2020), and Kalemli-Özcan and Varela (2023). It's worth noting, however, that our findings contrast with the negative findings for UIP reported by Kalemli-Özcan and Varela (2023) for EMs, where they demonstrated that UIP did not hold in a panel of 22 EM currencies, regardless of whether realized or expected exchange rates were considered.[7]

While it's essential to consider the differences in sample periods and regression methodologies employed by Kalemli-Özcan and Varela (2023), it's equally important not to interpret the findings in this study regarding TRY/USD as conclusive evidence of UIP. This caution is warranted when we examine the deviations from UIP under each exchange rate measure, as illustrated in Figure 2.

[7]In their study, UIP was not supported despite the positive Fama slope coefficient.

Upon closer inspection of the UIP deviations in Figure 2, it becomes apparent that the evidence from regressions, particularly those using expected exchange rates, does not align well with the persistently positive and substantial expected UIP deviations observed over time. These persistently positive expected excess returns contrast with the ex-post realized excess returns, which display episodes of both positive and negative excess returns. Indeed, when we calculate the average expected deviations in the full sample, we find it to be 4.4 percent, in stark contrast to the average realized UIP deviations of -1.3 percent as reported in Table 1. These disparities highlight the complexities surrounding UIP in the context of TRY/USD and calls for further examination of the evidence in the full-sample which we undertake in the following section.

Figure 2: Realized and expected UIP Deviations



This Figure displays *realized* (left) and *expected* (right) UIP deviation over time. The red line shows the zero-deviation under each measure of exchange rate.

5.2 Breaks in the Fama slope: the UIP puzzle on-and-off

Given the consistently positive expected Uncovered Interest Parity (UIP) deviations depicted in Figure 2 and the presence of periods where the interest rate differential undergoes significant fluctuations over time, accompanied by episodes of accelerated and prolonged depreciation of the TRY, as well as shorter episodes of appreciation, it is crucial to assess the robustness of the results obtained from the UIP regressions in the full sample.

As emphasized in Bussiere et al. (2022), UIP regressions represent a "nonstructural relationship," and as such, they may not hold consistently over time, especially in the face of changing policy regimes that can alter the relationship between exchange rate changes and interest rate differentials. Indeed, when we run rolling five-year Fama regressions and plot the estimated slopes along with their 95 percent confidence intervals over time, it becomes apparent that the evidence we observe in the full-sample period may not remain stable over time. This observation is consistent across both measures of exchange rate changes, as illustrated in Appendix C.

To formally assess breaks in the UIP regressions, we apply the sequential $n+1$ breaks vs. n test for structural breaks, as introduced by Bai (1997) and Bai (1998), with a maximum number of breaks set at $n_{max} = 2$. The test results, which are detailed in Appendix D reveal the presence of two breaks. The reported break dates identify three distinct periods with considerably narrow 95 percent confidence bands: 04/2006-09/2008, 10/2009-08/2013, and 08/2013-02/2022 with *ex post* exchange rate changes and 04/2006-10/2008, 10/2009-11/2015, and 12/2015-02/2022 with *ex ante* exchange rate changes. For the purpose of referencing, we label these sub-periods as the "early," "middle," and "late" sub-periods.

While it may be challenging to precisely identify specific events coinciding with these periods, we can broadly characterize them as follows. The "early" period roughly corresponds to the pre-and-during-global financial crisis (GFC) era, characterized by high interest rates in Türkiye. The "middle" period immediately follows the GFC and corresponds to a period when interest rates in Türkiye remained historically low. This resulted in interest rate differentials remaining relatively stable and below 10 percentage points. The "late" period corresponds to a time when interest rate differentials increased significantly due to higher rates in Türkiye compared to the US. This occurred despite the Turkish government's mandate to keep policy rates low, coinciding with an acceleration of overall depreciation in the Turkish Lira (TRY), as discussed in Gurkaynak et al. (2022).

The results of Fama regressions conducted across the identified sub-periods using both measures of exchange rate changes are presented in panels A and B of Table 3. Corresponding excess return regressions are reported in Table 4. These regression findings reveal that the disappearance of the Fama puzzle observed in the full sample, under both measures of exchange rates, does not persist consistently across all sub-periods.

The Fama slope estimates exhibit substantial variation and differ markedly over the early and middle sub-periods under both measures. For instance, the results reported in the first column of Panel A highlight three distinctive episodes for the slope.[8] In the early period, the Fama puzzle emerges with a slope of -2.432, accompanied by a statistically significant excess return regression slope. This negative slope in the Fama regression and the positive slope in the excess return regression align with the average realized appreciation of the TRY, which amounted to approximately 4 percent, despite the presence of a large interest rate differential exceeding 12 percent. This discrepancy results in a substantial and positive average realized excess return of more than 16 percent during this period (refer to Table 1 for additional details).

The compelling evidence indicating the failure of UIP in the first sub-sample stands in stark contrast to the results obtained using the expectation of the exchange rate. When utilizing the ex-ante measure, we arrive at an entirely different outcome: the slope becomes statistically

[8] Despite the slight differences in the middle and the recent sub-period samples between realized and expected exchange rates, results remain very similar if we were to estimate Fama regressions over the same sub-periods under any of the exchange rate measures. These results are available upon request.

Table 3: **Fama regressions over sub-samples**

	(1)	(2)	(3)
	A. *Realized* exchange rate		
	2006M4-2008M9	2008M10-2013M8	2013M9-2022M2
Intercept	26.152**	-26.351***	4.168
	(10.934)	(6.217)	(4.663)
Slope	-2.432***	3.913***	1.296***
	(0.654)	(0.619)	(0.406)
95% Interval	[-3.771, -1.092]	[2.672, 5.153]	[0.491, 2.101]
p-value ($H_0 : \beta_1 = 1$)	0.000	0.000	0.467
R^2	0.104	0.490	0.153
Sample	30	59	102
	B. *Expected* exchange rate		
	2006M4-2008M10	2008M11-2015M11	2015M12-2022M2
Intercept	0.619	2.291**	2.439**
	(2.357)	(1.119)	(1.143)
Slope	0.707***	0.076	0.559***
	(0.175)	(0.116)	(0.110)
95% Interval	[0.349, 1.064]	[-0.154, 0.306]	[0.338, 0.779]
$pv\, H_0 : \beta_1 = 1$	0.104	0.000	0.000
R^2	0.176	0.000	0.342
Sample	31	85	75

Panels A and B report Fama regression results over the identified periods by the break tests at 12-month horizon for *realized* and *expected* exchange rate changes. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 4: **Excess return regressions over sub-samples**

	(1)	(2)	(3)
	A. *Realized* exchange rate		
	2006M4-2008M9	2008M10-2013M8	2013M9-2022M2
Intercept	-26.152**	26.351***	-4.168
	(10.934)	(6.217)	(4.663)
Slope	3.432***	-2.913***	-0.296
	(0.654)	(0.619)	(0.406)
95% Interval	[2.092, 4.771]	[-4.153, -1.672]	[-1.101, 0.509]
R^2	0.188	0.347	0.009
	B. *Expected* exchange rate		
	2006M4-2008M10	2008M11-2015M11	2015M12-2022M2
Intercept	-0.619	-2.291**	-2.439**
	(2.357)	(1.119)	(1.143)
Slope	0.293	0.924***	0.441***
	(0.175)	(0.116)	(0.111)
95% Interval	[-0.064, 0.651]	[0.694, 1.154]	[0.221, 0.662]
R^2	0.036	0.256	0.245

Panels A and B report realized and expected excess return regression results over the identified periods by the break tests. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

indistinguishable from one, displaying an insignificant slope and intercept in the expected excess return regression. This is particularly noteworthy given the relatively similar sample averages observed for both interest rate differentials and the expected exchange rate changes, as reported in the second panel of Table 1.

The scatter plots depicting realized and expected exchange rate depreciation over interest rate differentials, along with the estimated slopes in Figure 3, vividly illustrate the contrasting outcomes between expected exchange rates and their realizations, particularly in the early period. Despite the wider range of fluctuations in the realized depreciation and appreciation of the TRY, survey participants consistently anticipate exchange rate depreciation, as evident in the plots in the first columns of Panel A and B in the Figure, during this early period.[9]

Upon closer examination of these plots, it becomes apparent that in the early period, in line with the positive interest rate differential, survey participants generally expect the TRY to depreciate on average. However, the realized exchange rate exhibits both depreciation and appreciation, resulting in an overall negative slope in the UIP regressions. This is accompanied by an average appreciation rate of over 4 percent, as indicated in Table 1.

It's worth noting that this period is unique in that it's the only sub-period where expec-

[9]These results observed in the early period parallel recent findings in AEs, where UIP is typically strongly rejected when using realized exchange rates but holds when using survey-based exchange rates, as demonstrated in recent studies such as Chinn and Frankel (2020) and Kalemli-Özcan and Varela (2023).

tation errors are, on average, positive and substantial. This suggests that, on average, survey participants in this initial period expected the TRY to depreciate more than what was realized. These disparities between survey participants' expectations and the actual realization of exchange rates are also reflected in the significantly positive realized excess returns on the TRY, averaging more than 16 percent, in contrast to the average expected excess return of 3 percent by survey participants (refer to Table 1 for additional details).

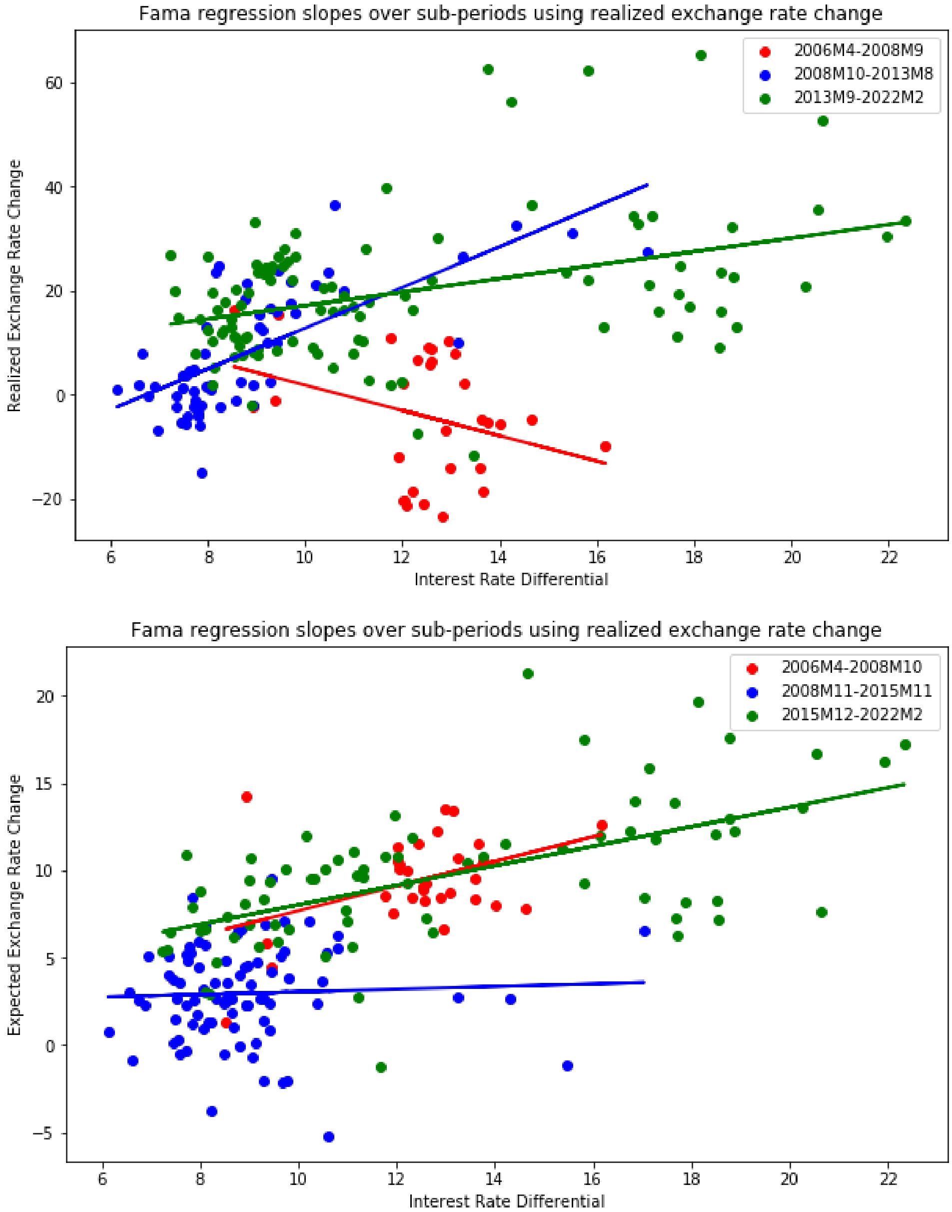
In the middle period, the slope using realized exchange rates not only turns positive but also surpasses one, becoming statistically significantly greater than one. The R-squared value sees a substantial increase in both the UIP regression and the corresponding excess return regression (as seen in column (2) in Panel A of Tables 3 and 4). Interestingly, the slope exceeding unity in the Fama regression and the statistically significant slope in the realized excess return regression highlight that a positive slope in the UIP regression does not immediately translate into strong evidence supporting the UIP condition under FIRE.

This middle period corresponds to an era where interest rates in Türkiye began to decline from their historically high levels and generally remained below 10 percentage points. It's worth noting that the larger-than-unity slope estimate may also be influenced by factors such as lower variability in the differential relative to the covariance between the differential and exchange rate changes. However, an examination of standard deviations over sub-periods does not suggest this as a major contributing factor during this period. Additionally, the reported high R-squared values in this period indicate a significant improvement in the fit of the Fama regressions and thus, a tighter correlation between realized exchange rate changes and interest rate differentials.

In the middle period under expected exchange rates, survey expectations appear to be somewhat disconnected from the interest rate differential, contrary to its realization. Excess return regressions suggest a strong positive relationship between the interest rate differential and expected excess returns, in contrast to the negative correlation observed with realized excess returns. This implies that even though participants expect higher positive excess returns on the TRY compared to the UIP condition (as they do not fully anticipate the realized depreciation), the exchange rate experiences significant depreciation in reality, eliminating such expected excess returns ex-post. This can be observed by examining the sample averages for realized and expected depreciation and the expectation error, as provided in Panel B of Table 1.

It's only in the late period that the slope estimates under both measures of exchange rates align in the same direction, albeit not necessarily in terms of magnitudes. This alignment is observed in the plots presented in the third column of Figure 3 and is further confirmed by the regression results in Table 3. The findings for this recent period generally align well with the results from the full sample period, as evident from the comparison of estimated Fama regression results for the late period sample in Table 3 and the results for the full sample in

Figure 3: Realized and expected exchange rate depreciation and Fama slope over the sub-periods



This figure displays realized (panel A) and expected (panel B) percentage exchange rate depreciation at 12-month horizon and the interest rate differential with the estimated slope from Fama regressions over sub-samples.

Table 2. Additionally, the comparison of displayed plots in the third and fourth columns in panels A and B of Figure 3 corroborates this alignment.

During the late period, interest rates in Türkiye first spiked above 25 percent and then gradually decreased during the COVID period in 2020, only to increase once again beyond 20 percent. This occurred despite the Turkish government's mandate to keep policy rates low.

Consequently, the interest rate differential surged, exceeding 20 percentage points, accompanied by significant depreciation rates in the TRY against the U.S. dollar. These substantial movements in the interest rate differential and the resulting accelerated depreciation rates, both in expectations and realization, appear to account for the stronger evidence supporting UIP and the alignment in the direction of depreciation, both in expectations and realizations of the TRY, during this period.

Similar to the full sample, in the late period, survey participants generally tend to predict the direction of exchange rate changes correctly, but they systematically under-predict the degree of realized depreciation. This is evident from the less-than-unity slope and the positive and statistically significant slope observed in the expected excess return regressions. It's also worth noting that the results for the late and full sample periods highlight the possibility that the full-sample results are primarily driven by the results for the late period, given that this sub-period sample dominates the full sample under both measures.

5.3 The Fama slope: downward bias, upward bias, and no-bias

The results from Fama regressions across sub-periods and in the full sample using realized exchange rate changes raise questions about the potential roles of expectation errors and the presence of currency risk premium in shaping these outcomes. Similarly, assuming that survey-based data reflects the market's expectation of the TRY/USD exchange rate, we may wonder whether the presence of currency risk premium could introduce still bias in the Fama slope when using expected exchange rate changes.

In the existing literature, particularly in the context of AEs currencies, investigations into the sources of bias in Fama regressions under realized exchange rate changes have produced mixed results. Some studies support the notion that the failure of the FIRE and systemic expectation errors contribute to the observed biases, while others propose that the presence of time-varying currency risk premium induces downward bias. For comprehensive reviews, please refer to the extensive literature on this topic, as summarized in Engel (1996), Sarno (2005), Engel (2014), and Engel (2016).

5.3.1 Bias in Fama slope under realized exchange rate

To gain insights into the roles of expectation errors and currency risk premium, we employ a decomposition of the asymptotic limit of the Fama slope to examine the roles of expectation errors and currency risk premium in both the full sample period and across sub-periods. Following the approach of Froot and Frankel (1989), we utilize this decomposition to study how expectation errors and currency risk premium influence the UIP regressions.

As elucidated by Froot and Frankel (1989), the asymptotic limit of the Fama slope can be expressed as:

$$\text{plim}\,\hat{\beta} = \frac{cov(\Delta s_{t+k}, i_t - i_t^{US})}{var(i_t - i_t^{US})}, \tag{10}$$

and by defining the forecast errors as:

$$\eta_{t+k} = s_{t+k} - s_{t+k}^e, \tag{11}$$

we can re-write plim $\hat{\beta}$ as

$$\text{plim}\,\hat{\beta} = 1 - b_{re} - b_{rp}, \tag{12}$$

where

$$b_{re} = -\frac{cov(\eta_{t+k}, i_t - i_t^{US})}{var(i_t - i_t^{US})}; \tag{13}$$

$$b_{rp} = \frac{var(\lambda_{t+k}^e) + cov(\Delta s_{t+k}^e, \lambda_{t+k}^e)}{var(i_t - i_t^{US})}. \tag{14}$$

Equation (12) shows the asymptotic bias, if any in the slope coefficient estimate in the UIP regressions under FIRE with *ex post* exchange rate changes, can be decomposed into two parts: b_{re} and b_{rp}. The first part, b_{re} represents the covariance between the interest rate differential and the expectation error, η_{t+k}, and captures whether survey participants' systematic expectation errors induce any bias in the UIP regression slope. The slope coefficient would be biased downward if $b_{re} > 0$ and hence, $cov(\eta_{t+k}, (i_t - i_t^{US})) < 0$. The second term b_{rp} is considered to be a currency risk premium term by Froot and Frankel (1989) and is a function of volatility of the expected excess return, λ_{t+k}^e, and its covariance with the expected exchange rate change Δs_{t+k}^e. The slope coefficient would be downward biased if $b_{rp} > 0$ which implies existence of time-varying expected UIP deviations or expected excess returns (risk premium) or non-zero covariance of expected excess returns with expected exchange rate changes.[10]

The expression for r_{re} in Equation (13) implies that we can use the negative of the slope from the regression

$$s_{t+k} - s_{t+k}^e = \gamma_0 + \gamma_1(i_t - i_t^{US}) + \nu_t, \tag{15}$$

and estimate and test the significance of b_{re} term. Although the expression for b_{rp} term is relatively more involved, one can show that it can also be estimated by running the expected excess return regression in Equation (9) as discussed below (section 5.3.2). Using the survey data, we compute b_{re} and r_{rp} and underlying components and report results for the whole sample and sub-samples in Table 5.[11]

In the early period, where UIP fails with a large and negative slope, both b_{re} and b_{rp} terms

[10]This decomposition presumes that Covered Interest Parity (CIP) (i.e., $f_{k,t} - s_t = (i_{k,t} - i_{k,t}^{US}) + \varepsilon_t$ where $f_{k,t} - s_t$ is the k-period forward premium or discount) holds on average in the data and hence, any deviation from CIP is zero. Investigating the CIP by using forward discount/premium data show that CIP holds in the

Table 5: **Bias in Fama regression slope using realized exchange rate change**

	(1)	(2)	(3)	(4)
	Early	Middle	Late	Full S.
	2006M4-2008M9	2008M10-2013M8	2013M9-2022M2	2006M4-2022M2
A. Bias decomposition between b_{re} and b_{rp}				
b_{re}	4.381**	-2.233***	-0.551	-0.637
	(1.988)	(0.537)	(0.660)	(0.581)
b_{rp}	0.326*	0.805***	0.280**	0.144
	(0.175)	(0.120)	(0.130)	(0.123)
Implied β	-3.756	2.428	1.271	1.493
$\hat{\beta}$	-2.432	3.913	1.296	1.422
B. Sample components of b_{re} and b_{rp}				
$cov(\eta_{t+k}, (i_t - i_t^*))$	-11.567	9.829	8.859	7.926
$var(i_t - i_t^{US})$	2.640	4.402	16.074	12.442
$var(\lambda_{t+k}^e)$	6.026	12.933	11.950	12.758
$cov(\Delta s_{t+k}^e, \lambda_{t+k}^e)$	-5.165	-9.391	-7.449	-10.970

Panel A reports b_{re}, b_{rp}, and the implied UIP Regression slope coefficient as decomposed following Froot and Frankel (1989) based on survey expected exchange rate between TRY and USD at 12M horizon over sub-samples and the full sample. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$. Reported standard errors in parentheses for b_{re} term are based on a regression of 12-month ahead forecast errors on interest rate differential. Standard errors for b_{rp} are based on the regression of expected excess return on interest rate differential. Panel B report components of b_{re} and b_{rp}. $\hat{\beta}$ re-produces slope coefficients reported in Tables 2 and 3 under realized exchange rate change.

appear to significantly contribute to the downward bias observed in the Fama slope. Although the b_{rp} term is statistically significant at the 10 percent level, its magnitude is considerably smaller compared to the b_{re} term. During this period, survey participants consistently anticipated the depreciation of TRY against the USD for any given interest rate differential. However, this anticipation did not align with the overall realized appreciation and periods characterized by both large depreciation and appreciation (refer to the scatter plots displayed in panels A and B in Figure 3, as well as Table 1 for additional context). The results for the early period suggest that in samples where Fama regressions indicate a failure of the UIP condition with a slope less than one, it is plausible that the combined influence of expectation errors and the presence of a currency risk premium can lead to a substantial downward bias in the slope estimate.

In the middle period, where the Fama slope is large and exceeds one, two statistically significant sources of bias emerge, each exerting influence in opposite directions. The expectation error term, b_{re}, is notably large and negative, thereby inducing an upward bias in the Fama slope. Conversely, the currency risk premium term, b_{rp}, is positive and substantial, which tends to induce a downward bias. During this period, survey participants' expectations appear to be somewhat disconnected from the interest rate differential, as evident from the scatter plot in column (2) of Panel B in Figure 3. This disconnect, coupled with the stronger correlation between realized exchange rate changes and the interest rate differential, results in a robust association between expectation errors and the interest rate differential. Consequently, this contributes to an upward bias in the UIP regression slope. Notably, the expectation error term is considerably larger in magnitude compared to the risk premium term, thus leading to an overall bias in the upward direction. This upward bias is responsible for pushing the Fama regression slope above one during this period.

The results for the late sub-period in column (3) show that the b_{re} term is not statistically significant but the risk premium term b_{rp} is at 5 percent level. This indicates that expectation errors do not play a role in inducing a downward bias in the Fama slope. If anything, they appear to introduce an upward bias or an adjustment toward the point estimates reported in Tables 2 and 3. Although risk premium term is positive and thus introduces a downward bias in the slope, its' magnitude is not large enough to move the slope far away from the neighborhood of one, at least in a statistical sense. In the full sample, both sources of bias become statistically insignificant. This occurs as the impact of the downward bias observed in the early period and the upward bias in the middle period average out over the full sample. Given that the late period dominates in the full sample, there is no statistically meaningful bias in the Fama slope

data both in the full sample and in the sub-periods (see, Appendix A).

[11]Note that we lose 12 monthly observations across each sample period due to aligning expectation errors with the corresponding realized and expected exchange rate changes. This leads different implied slopes than the estimated slopes reported in Tables 2 and 3. It worth pointing that consistent with the asymptotic theory, these difference become negligibly small as sample size increases in the recent sub-period and in the full sample.

attributable to either expectation errors or the currency risk premium, or both.

Our analysis under realized exchange rates reveals that in the early sub-period where UIP fails, expectation errors are the key factor. In the sub-period with a Fama slope above one, both expectation errors and the currency risk premium introduce biases, but in opposite directions. This occurs when survey expected exchange rates aren't closely tied to interest rate differentials, leading to UIP failure using expected exchange rates. Our results show that both upward and downward biases in Fama regression slopes under FIRE using realized exchange rates are primarily driven by expectation errors, with the currency risk premium also playing a role. Unlike findings in AEs, our results indicate that both expectation errors and a time-varying currency risk premium are generally significant in causing disparities between the UIP implied slope and the estimated slope under FIRE. These biases become negligible only when survey expected and realized exchange rates align direction-wise and correlate closely with interest rate differentials.

5.3.2 Bias in Fama slope under expected exchange rate

To provide insights into the second question that to what degree the presence of an 'expected' currency risk premium matters in Fama regressions using survey-based ex-ante exchange rate, first note that the asymptotic limit of the slope in Fama regression (i.e., Eqn. 8) can be written as

$$\text{plim}\,\hat{\beta} = 1 - \frac{cov(i_t - i_t^{US}, \lambda_{t+k}^e)}{var(i_t - i_t^{US})}. \tag{16}$$

The estimate of the second term can be obtained from the expected excess return regression in Eqn. 9. Note also that we can write the second term by substituting the expression for the interest rate differential $i_t - i_t^{US}$ in Equation (3) and re-arranging,

$$\frac{cov(i_t - i_t^{US}, \lambda_{t+k}^e)}{var(i_t - i_t^{US})} = \frac{var(\lambda_{t+k}^e) + cov(\Delta s_{t+k}^e, \lambda_{t+k}^e)}{var(i_t - i_t^{US})} = b_{rp} \tag{17}$$

This equation shows that the bias term is equivalent to the risk premium term in Eqn. (12).

As presented in Table 6 for the sub-periods (refer also 2 for the full sample and Table 4), there exists a downward bias in Fama regressions when using expected exchange rate changes across all sub-periods. However, this bias is notably significant in magnitude only during the middle and late periods. In the middle period, the bias is substantial enough to render the slope statistically indistinguishable from zero, resulting in the failure of the UIP. In the late period, although the estimated b_{rp} term remains sizable, it does not reach a magnitude significant enough to drive the regression slope towards zero statistically. Thus, UIP still does not hold, as expected exchange rate changes are not large enough to offset the considerable variability observed in the interest rate differential during this period.

Table 6: **Bias in Fama regression slope using expected exchange rate change**

	(1)	(2)	(3)	(4)
	Early	Middle	Late	Full S.
	2006M4-2008M10	2008M11-2015M11	2015M12-2022M2	2006M4-2022M2
	A. Bias term b_{rp}			
b_{rp}	0.293	0.924***	0.441***	0.144
	(0.175)	(0.116)	(0.111)	(0.123)
Implied β^a	0.707	0.076	0.559	0.856
	B. Sample components of b_{rp}			
$cov(\lambda^e_{t+k}, (i_t - i^*_t))$	0.754	2.766	7.855	1.788
$var(i_t - i^{US}_t)$	2.569	2.994	17.798	12.442

Panel A of the table reports b_{rp}, and the implied UIP regression slope coefficient over sub-samples and the full sample. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$. Standard errors for b_{rp} are based on the regression of expected excess return on interest rate differential. Panel B report components of b_{rp}. $\hat{\beta}$ re-produces slope coefficients reported in Tables 2 and 3 under expected exchange rate changes.

In the full sample period, the presence of a currency risk premium creates a wedge between the UIP-implied slope and the estimated slope, causing a downward bias. However, this term is not substantial enough to induce a statistically significant downward bias, mainly because the early and late periods tend to counterbalance the pronounced impact of the currency risk premium observed in the middle period.

5.4 Fama slope bias and expectation error response to an interest rate differential shock

The documented variation in the sign and magnitude of the expectation error term and consequently, the variation in the bias in the Fama slope over time under realized exchange rate change prompts an intriguing question: Do disparities in both the direction and extent of responses exhibited by expectation errors to the same interest rate differential shock across distinct time periods with varying Fama slopes play a role in the strength of this bias? Furthermore, does this dynamic contribute to the emergence and subsequent disappearance of the UIP puzzle over time?

To delve into this inquiry, we employ the following local projection-based regressions, similar to the approach outlined in Candian and De Leo (2022):

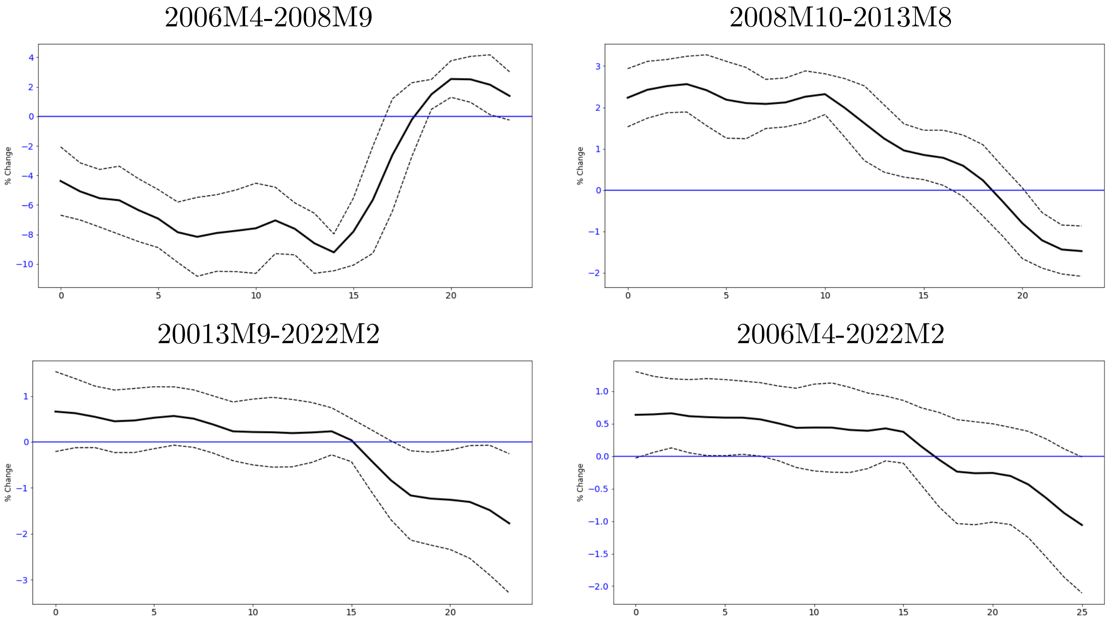
$$\eta_{t+k+j} = \alpha_j + \beta_j(i_t - i^{US}_t) + \varepsilon_{t+k+j} \tag{18}$$

where $j = 0, 1, 2, 3, \cdots, J = 24$-month ahead expectation error $\eta_{t+k+j}\} = s_{t+k+j} - s^e_{t+k+j}$ over horizon k.[12]

[12]Considering our constrained sample sizes, particularly within sub-samples, we employ Equation (18) without

Figure 4 displays the response of expectation errors to a one-percentage-point interest rate shock across sub-periods and the entire sample duration. These responses exhibit notable disparities among sub-periods. In the early period, where UIP fails under ex-ante exchange rates but holds with expected exchange rates[13] the expectation error response is significantly negative and of substantial magnitude. In simpler terms, the expectation error decreases considerably less than the one-percent increase in the interest rate differential. This phenomenon underscores the disparity between survey participants' exchange rate expectations and the actual outcomes. The negative and substantial covariance reported in Panel B of Table 5 confirms this response, contributing to the substantial b_{re} term. Notably, the plot for the early period in Figure 4 reveals that this response remains negative and statistically significant for more than 12 months into the future.

Figure 4: Response of expectation error to an interest rate differential shock



This figure shows the response of expectation error to a positive shock to interest rate differential over sub-sample periods and the full-sample from 'static' local projection regressions as in Equation 18. The dashed lines shows 95 percent confidence intervals, estimated by using Newey-West standard errors with a bandwidth lag $j + 1$ for horizon j.

In the middle period, characterized by a UIP regression slope above one when considering realized exchange rates, but UIP failing with expected exchange rates, the expectation error

incorporating autoregressive or lagged interest rate differential terms. Integrating these terms would introduce dynamics into the regressions, but due to the limited sample sizes, it often results in responses that are challenging to decipher. We also refrain from using the Newey-West estimator for small sample sub-periods but employ it with $j + 1$ lags for the full sample and later sub-periods.

[13]Results are qualitatively very similar for the sub-periods identified under expected exchange rate changes and are available upon request.

response shows an almost inverse pattern compared to the initial period. This response is statistically significant and remains consistently above zero for more than 12 months into the future. The primary distinction is that the response's absolute magnitude is smaller during this period. This substantial and positive response is reflected in the positive covariance between the interest rate differential and expectation error in Panel B of Table 5. It results in a negative b_{re} term, contributing to an upward bias in the Fama regression slope, despite the relatively large positive r_{rp} term for this period.

In the late sub-period and full-sample where UIP holds with a slope that is statistically indistinguishable from unity when using realized exchange rate changes, the responses of expectation error remain statistically indistinguishable from zero. This is corroborated by the small b_{re} term reported in Table 5.

This analysis confirms that the response of expectation errors to an interest rate shock establishes a persistent negative link between the interest rate differential and the expectation error, consequently inducing a downward bias in the Fama slope. The results also demonstrate that in periods where expectation errors remain consistently positive and large in response to a positive shock in the interest rate differential, the UIP regression slope may surpass unity, even in the presence of a relatively substantial downward bias term due to the currency risk premium. This represents a distinct type of bias compared to the commonly documented downward bias in the literature.

6 Overshooting and reversal puzzles

Considering the documented shifts in the Fama slope and the resulting fluctuations in evidence for UIP over time, we inquire whether related UIP puzzles, specifically the delayed overshooting and predictability reversal puzzles found in the literature on AEs currencies, exhibit similar patterns of emergence and disappearance. Firstly, we investigate the presence of these puzzles in the case of TRY/USD. Secondly, we explore the extent to which these puzzles appear and vanish during periods of Fama slope shifts, both under realized and expected exchange rate changes.

To address these questions, we once again estimate the following local projection-based predictive regressions:

$$y_{t+k+j} = \alpha_j + \beta_j(i_t - i_t^{US}) + \varepsilon_{t+k+j} \tag{19}$$

where the left-hand side variables are $j = 0, 1, 2, 3, \cdots, J = 24$-month ahead realized and expected exchange rate changes (Δs_{t+k+j}, Δs^e_{t+k+j}), expected excess returns λ^e_{t+k}), and the realized excess returns under FIRE (λ_{t+k}).[14] In these regressions, the coefficient of interest is

[14]Research on delayed overshooting and predictability reversal often relies on VAR analysis with global assump-

β_j, representing the response of the left-hand side variable to interest rate differential shock at j month ahead over a horizon of $k-$month. These $j-$month ahead regressions allow us to estimate and trace responses of *ex ante* and *ex post* exchange rate changes, and excess returns to a positive shock to interest rate differential over time both in the full and sub-samples where the UIP puzzle appears and disappears.

The overshooting and the predictability reversal literature primarily focuses on the AEs and relies on realized exchange rates. As documented by Dornbusch (1976), Eichenbaum and Evans (1995) and more recently by Bacchetta and Wincoop (2010), the delayed overshooting puzzle indicates that a positive shock to domestic interest rate increases the interest rate differential, initially causing an appreciation followed by a delayed depreciation. This nearly U-shaped dynamics is found to hold for the AE *realized* exchange rates. Linked to the Fama puzzle, the predictability reversal puzzle suggests that deviations from UIP condition or excess returns switch direction. High-interest rate currencies initially exhibit positive excess returns as they appreciate, but over time, these returns turn negative due to eventual depreciation.

In this section, we delve into these puzzles by using local-projection type regressions as outlined in Equation (19) across the full sample and sub-samples identified by the break tests from Fama regressions under both measures of exchange rates. Kalemli-Özcan and Varela (2023) explored these puzzles in a panel of 22 EM currencies for the period 1996M11-2018M12, using survey-based expected exchange rates. In contrast to the findings in the overshooting literature, they reported an inverted U-shaped dynamic in the response of expected exchange rate changes in their EMs panel. In line with this finding, they did not find evidence for delayed overshooting and predictability reversal puzzles but reported persistent UIP deviations as expected exchange rate response to interest rate shock remained below the size of the shock.

6.1 Puzzles under realized exchange rate

Figure 5 plots the response of realized exchange rate to a one percentage point interest rate differential shock on the left panel, and the response of the *realized* UIP deviation to the same shock on the right panel over the sub-periods and the in the full-sample. In the early period consistent with findings in the overshooting literature, we observe a roughly U-shaped response dynamic, particularly within the first 18 months into the future. Similar to AEs currencies, in this early period where UIP fails to hold, an interest rate differential shock initially leads to an appreciation, followed by a delayed depreciation (see Dornbusch, 1976; Eichenbaum and Evans, 1995; Bacchetta and Wincoop, 2010). Since the magnitudes of both depreciation and subsequent appreciation exceed the one-percentage-point shock in the interest rate differential, UIP fails,

tions. Local projections offer an advantage by identifying responses without such assumptions. Plagborg-Møller and Wolf (2021) found that local projections and VAR methods produce equivalent results, while Kalemli-Özcan and Varela (2023) applies a similar approach in a panel data context.

resulting in *realized* excess returns, as shown in the right plot. Notably, *realized* UIP deviations remain positive more than 12 months into the future, even though the shock is transitory. As the realized exchange rate eventually depreciates by more than the one-percentage-point shock, the realized excess return turns negative and remains statistically below zero, reaching this state around the 20th month. This dynamic aligns with the predictability reversal puzzle documented in AEs under realized exchange rates.

Panel B of Figure 5 showcases response plots that depict an almost inverted-S-shaped pattern in the behavior of realized exchange rates during the period between 2008M10 and 2013M8. Following an initial substantial depreciation, the realized exchange rate exhibits an appreciating trend. Since both the extent of the initial depreciation and the subsequent appreciation are much greater than the shock, the slope of the UIP regression surpasses one. This results in a predictably large negative realized excess return initially, followed by a statistically significant positive excess return emerging after the 10th month onward. This dynamic presents a predictability reversal puzzle as well, although its nature is the opposite of the one documented in the literature and the earlier period in Panel A.

In Panels C and D of the figure, the response plots reveal that the realized exchange rate depreciates in sync with the one-percentage-point shock in the interest rate differential in the late sub-sample and the full sample. This response dynamic quickly becomes statistically and economically indistinguishable from zero, leading to the disappearance of the UIP puzzle. In line with this robust evidence for UIP, the realized excess return response remains indistinguishable from zero over time, as displayed in the right-hand plots for the late sub-period and the full sample.

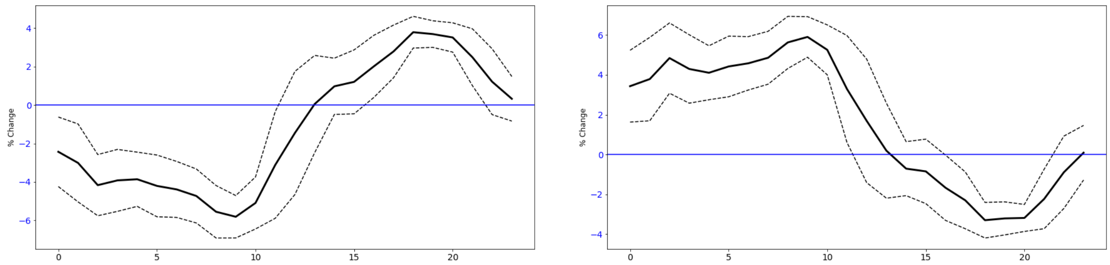
6.2 Puzzles under expected exchange rate

In Figure 6, we depict the response of the expected exchange rate change to a one-percentage-point interest rate differential shock in the left panels, and the response of the expected UIP deviation to the same shock in the right panels. In the early sub-sample, we do not observe the U-shaped or inverted U-shaped response dynamics reported for EMs currencies with expected exchange rates in Kalemli-Özcan and Varela (2023). The expected exchange rate depreciates to a similar extent as the interest rate differential, with the size of depreciation diminishing and becoming statistically insignificant. Consequently, UIP holds on average, with expected excess returns remaining unpredictable for most months into the future.

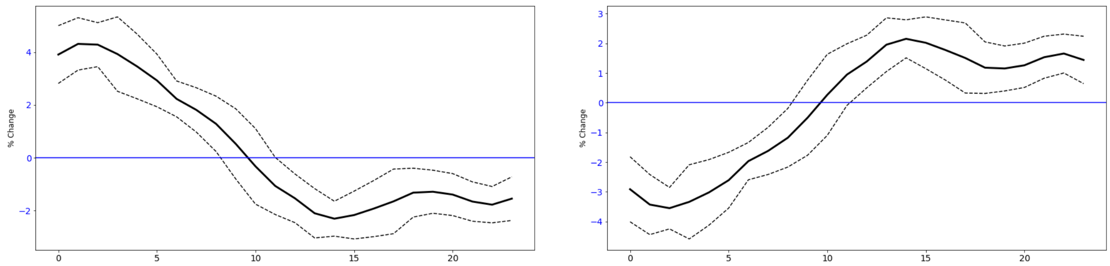
In Panel B of Figure 6, during the sub-period between 2008M11 and 2015M11, the response plots clearly illustrate that changes in expected exchange rates are largely unresponsive to shocks in the interest rate differential, except for a brief period after the fourth month into the future. Even then, the extent of depreciation is much smaller than the shock to the interest rate differential. This muted response by market participants' expectations results in an initial

Figure 5: Response of *realized* exchange rate and excess return to an interest rate differential shock

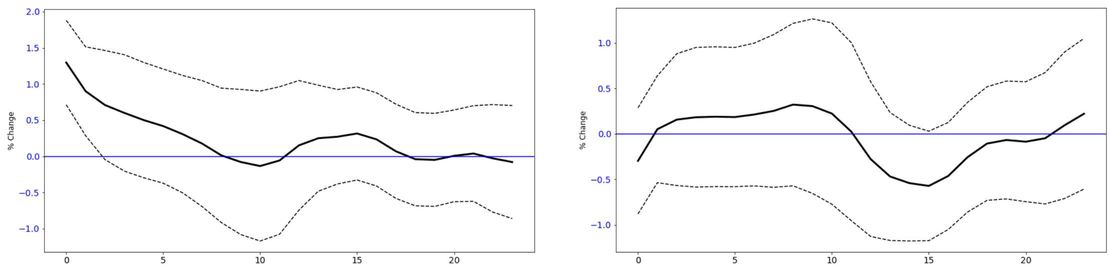
Panel A. 2006M4-2008M9



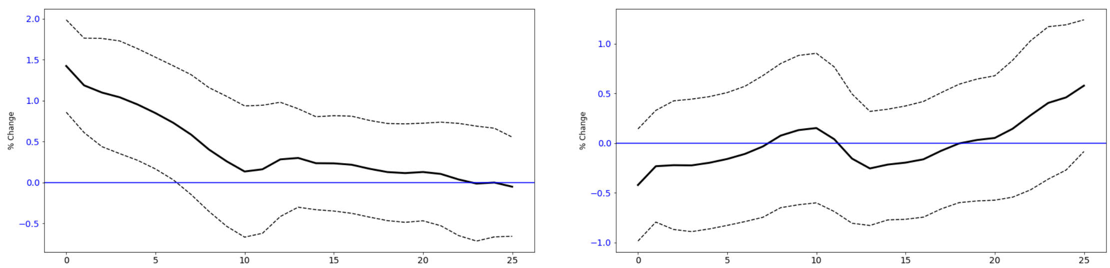
Panel B. 2008M10-2013M8



Panel C. 20013M9-2022M2



Panel D. 2006M4-2022M2

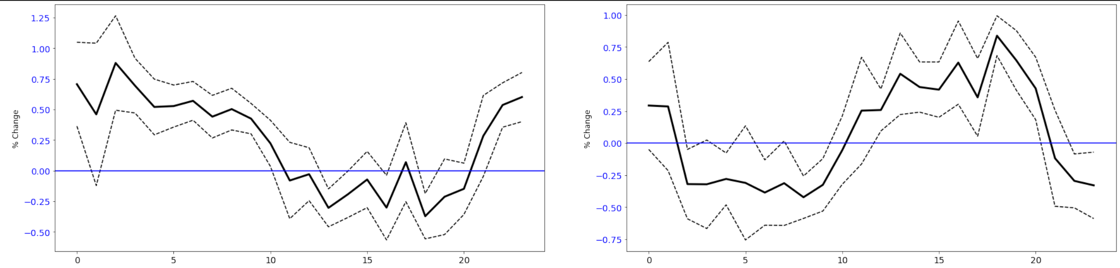


This figure shows the response of realized exchange rate change and UIP deviation to a positive shock to interest rate differential over sub-sample periods and the full-sample from static local projection regressions as in Equation 19. The dashed lines shows 95 percent confidence intervals, estimated by using Newey-West standard errors with a bandwidth lag $j+1$ for horizon j.

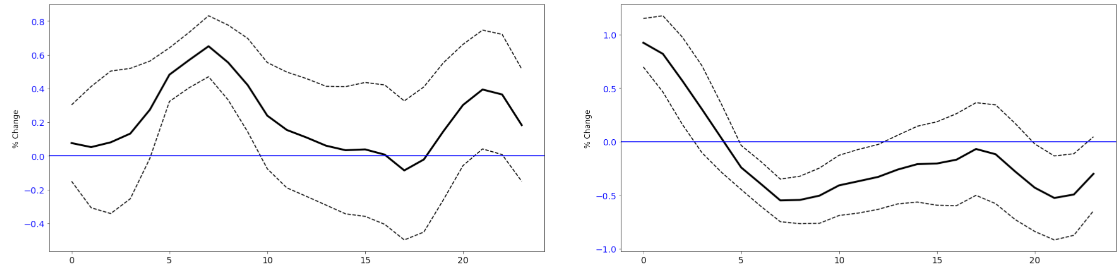
positive predictability of expected excess returns, followed by small but statistically significant negative predictability after the fifth month into the future.

Figure 6: Response of *expected* exchange rate and excess return to an interest rate differential shock

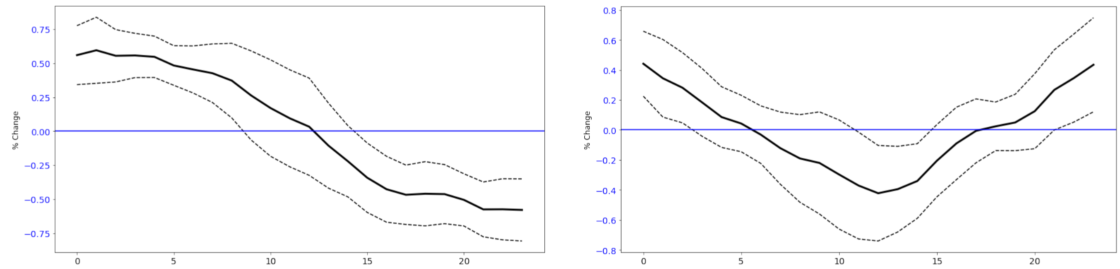
Panel A. 2006M4-2008M10



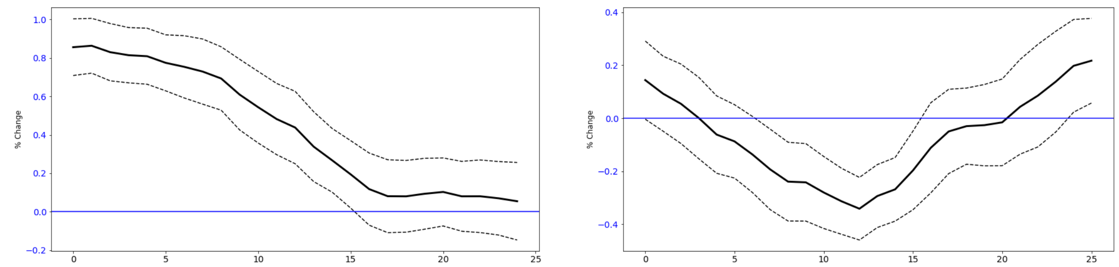
Panel B. 2008M10-2015M11



Panel C. 20015M12-2022M2



Panel D. 2006M4-2022M2



This figure shows the response of expected exchange rate and expected UIP deviation to a positive shock to interest rate differential over sub-sample periods and the full-sample period from 'static' local projection regressions as in Equation 19. The dashed lines shows 95 percent confidence intervals, estimated by using Newey-West standard errors with a bandwidth lag $j+1$ for horizon j.

Overall, this lack of response by the expected exchange rate contrasts with the more pronounced response observed in its realization, as displayed in Panel B of Figure 5. This disparity in responses between expected exchange rates and their realization contributes to a substantial positive expectation error response and an upward bias in the Fama regression using realized exchange rates during the middle period, which largely overlaps between the two measures of exchange rates.

In the late sub-period spanning from 2015M12 to 2022M2, the expected exchange rate responds by depreciating. However, the magnitude of this depreciation falls short of matching the shock to the interest rate differential. In response to a one-percentage-point interest rate differential shock, the exchange rate is expected to initially depreciate and then begin appreciating, roughly 12 months into the future. Since both the initial depreciation and eventual appreciation are considerably smaller than the shock itself, the left plot in Panel C of the figure shows a small but positive initial predictable expected excess return. This is followed by a negative predictability, eventually giving way to a positive predictability around the 20th month into the future. This response pattern resembles a U-shaped dynamic, akin to the evidence documented in the literature on AEs under realized exchange rates.

A similar response pattern in the full sample by the change in expected exchange rates leads to a comparable U-shaped response, albeit with a smaller overall magnitude in expected excess returns. This can be observed from the plots in Panel D of the figure. These observations highlight that the predictability reversal puzzle may emerge even if the Fama slope is positive and close to one, as long as the response by the change in expected exchange rates is not substantial enough to fully offset the shock to the interest rate differential.

7 Conclusions

This paper presents new findings regarding the UIP puzzle and related issues. We provide strong statistical evidence supporting UIP, not only with survey-based expected exchange rates but also with ex-post realized exchange rates in the full sample. However, this evidence is not consistently robust over time, as the UIP puzzle exhibits an intermittent pattern under both exchange rate measures. We identify that both expectation errors and currency risk premiums contribute to the deviation of the Fama regression slope from the UIP implied value of one, with expectation errors playing a significant role in UIP regressions using realized exchange rate changes. Fama regressions using survey-based exchange rate data can also be biased due to the presence of currency risk premiums, particularly in certain sub-periods. We highlight that the varying responses of expectation errors to interest rate differential shocks are key in characterizing the correlation between interest rate differentials and expectation errors, leading to the shifting UIP regression slopes. The presence of overshooting and predictability reversal puzzles varies depending on the exchange rate measure and time period, indicating a more complex relationship than previously thought.

Our findings emphasize the importance of considering shifts in the UIP relationship irrespective of exchange rate measure used and suggest caution when relying on results derived from survey data to support the UIP. Additionally, the variations in UIP puzzles across different sub-periods suggest the need to explore the underlying reasons behind these dynamics, which are left for future research.

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Table 7: **CIP Regressions**

	(1)	(2)	(3)	(4)
Early	Middle	Recent	Full S.	
Intercept	11.139***	-2.119**	0.087	-2.350
	(2.924)	(1.057)	(2.249)	(1.749)
IR Differential	0.546**	1.145***	1.230***	1.405***
	(0.247)	(0.109)	(0.157)	(0.135)
95% Interval	[0.040, 1.052]	[0.927, 1.362]	[0.919, 1.541]	[1.138, 1.672]
Sample Size	30	59	102	191
R^2	0.184	0.715	0.628	0.668

Table reports CIP Regression results. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Appendices

A CIP Regressions

Tests of UIP condition with interest rate differentials presumes holding of Covered Interest Parity (CIP) condition,

$$f_{k,t} - s_t = (i_{k,t} - i_{k,t}^{US})$$

where $f_{k,t} - s_t$ is the where $f_{k,t} - s_t$ is the k-period forward premium or discount. A simple test of CIP can be conducted by running the CIP regression,

$$f_{k,t} - s_t = \beta_0 + \beta_1(i_{k,t} - i_{k,t}^{US}) + \varepsilon_t$$

and testing $\beta_1 = 1$. Note that one can also consider the joint hypothesis $\beta_0 = 0$, $\beta_1 = 1$ if the interest is to conduct an exact testing of CIP condition. Table 7 reports results from the CIP regression above. Reported results provide statistically significant evidence in favor of CIP with a slope statistically indistinguishable from unity at both the full sample and across sub-periods.

B Testing UIP with forward premium

This appendix presents supplementary results from Fama regressions utilizing forward premium data to complement the findings reported in the main paper. Reported results in Table 8 show that evidence with forward discount/premium data is generally in line with the evidence reported in the main text, using interest rate differentials. However, there are some discrepancies in terms of the estimated Fama slope magnitudes.

One notable distinction is observed in the case of expected exchange rate changes, where the slope never becomes statistically indistinguishable from unity, both in the full sample period

Table 8: **Fama Regressions with Forward Premium/discount**

	(1)	(2)	(3)	(4)
	A. Realized Exchange Rate Changes			
	2006M4-2008M9	2008M10-2013M8	2013M9-2022M2	2005M4-2022M2
Intercept	-9.342	-14.329***	1.700	0.770
	(16.062)	(4.396)	(3.549)	(4.413)
Forward Premium	0.326	2.816***	1.230***	0.888**
	(0.781)	(0.368)	(0.243)	(0.426)
95% Interval	[-1.266, 1.918]	[2.079, 3.553]	[0.748, 1.713]	[0.048, 1.728]
Sample Size	33	58	101	191
R^2	0.005	0.465	0.319	0.120
	B. Expected Exchange Rate Changes			
Early	Middle	Recent	Full S.	
	2006M4-2008M10	2008M11-2015M11	2015M12-2022M2	2005M4-2022M2
Intercept	4.610**	1.529	3.993***	-0.456
	(2.240)	(1.503)	(1.038)	(0.916)
Forward Premium	0.271**	0.171	0.345***	0.543***
	(0.110)	(0.167)	(0.066)	(0.056)
95% Interval	[0.047, 0.495]	[-0.161, 0.502]	[0.214, 0.476]	[0.432, 0.654]
Sample Size	31	85	75	191
R^2	0.051	0.025	0.270	0.486

Table reports Fama regression results under forward premium/discount. Standard errors are based on Newey-West HAC standard errors with a lag order of 12. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

and during the sub-periods where the slope is statistically significant. Results with realized exchange rate changes closely resemble those with interest rate differentials in the full sample, as well as in the middle and recent sub-periods, with the exception that the slope in the initial sub-period is now statistically insignificant, as opposed to being negative.

C Rolling UIP Regression Slopes

In this Appendix, we present rolling five-year Fama regressions, where each slope coefficient estimate and confidence interval is based on five years of monthly observations. The window moves one month after each regression until the end of the sample period. Figure 7 displays the estimated slope and 95 percent confidence intervals over time.[15] The results from the rolling regressions reveal two noteworthy findings. First, the evidence we reported in the full sample may not hold consistently under both measures of exchange rate change. Second, the evolution of the Fama slope varies significantly over time between ex-ante and ex-post exchange rate changes, particularly before late 2018.

[15]The results with three-and four-year rolling windows are qualitatively similar and can be obtained upon request.

The plots indicate that with ex-post exchange rate changes, the Fama slope initially remains statistically indistinguishable from zero until around 2013. It then not only rises above zero but also surpasses unity significantly between 2013 and 2018 before gradually approaching unity, with much tighter 95 percent confidence intervals around one. In contrast, when considering ex-ante exchange rate changes, the slope is statistically indistinguishable from unity until approximately 2013. It subsequently declines toward zero and remains statistically indistinguishable from zero until mid-2017. After around 2018, it becomes positive but remains smaller than unity.

Figure 7: Rolling 5-year fixed sample and expanding sample (recursive) estimates for the slope coefficient in Fama regressions

The figure displays the rolling slope coefficient with 95% confidence intervals with a fixed 5-year sample window size. The 95% confidence are are based on Newey-West standard error estimates with lag length of 12. Horizontal zero- and unity-slope lines are displayed as relevant with red and light blue grayish colors.

D Break Tests

Table 9: **Bai (1997) and Bai-Perron (1998)sequential structural break tests**

A. Break Tests and dates: *realized* exchange rate changes		
		12-month
Test Stat	$F(1\|0)$	99.61***
	$F(2\|1)$	25.32***
Break Date(s)		2008M9
		[2008M8, 2008M10]
		2013M8
		[2013M4, 2013M12]
B. Break Tests and dates: *expected* exchange rate changes		
		12-month
Test Stat	$F(1\|0)$	17.13***
	$F(2\|1)$	67.66***
Break Date(s)		2008M10
		[2008M9, 2008M11]
		2015M11
		[2015M10, 2015M12]

Panels A and B report Bai (1997) and Bai-Perron (1998) Sequential n breaks vs. n test for structural breaks with a maximum break number of $n_{max} = 2$ with estimated unknown break dates and 95% confidence intervals, with *realized* and *expected* exchange rate changes. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.