International Journal of Finance & Economics

WILEY

RESEARCH ARTICLE OPEN ACCESS

Measuring Currency Risk Premium: The Case of Turkey

Idil Uz Akdogan[1] | Ferda Halicioglu[2] | Ishak Demir[3]

[1]School of Slavonic and East European Studies, University College London, London, UK | [2]Department of Peace Studies and International Development, University of Bradford, West Yorkshire, UK | [3]The World Federation of Exchanges, London, UK

Correspondence: Idil Uz Akdogan (i.akdogan@ucl.ac.uk)

Received: 26 April 2024 | **Revised:** 12 January 2025 | **Accepted:** 17 January 2025

Funding: The authors received no specific funding for this work.

Keywords: CBRT | currency return | foreign swap agreements | forward premium puzzle | missing risk premium | state-space modelling | uncovered interest parity

ABSTRACT

This study examines the determinants of a change in currency expectations for the Turkish Lira (TL) versus the US dollar with different maturities (1 month, 3 months and 1 year). The risk premium is estimated using the interest rate differential and a latent component called the *missing risk premium*. The empirical model is extended to break down the risk component by introducing other explanatory variables, such as currency swap agreements, credit default swap (CDS), foreign reserves and the volatility index (VIX). A *state-space* model is employed to explain the behaviour of an unobserved variable over the period between January 2005 and March 2023 with daily and weekly data frequencies. Our findings suggest that the uncovered interest parity (UIP) condition does not hold consistently in Turkey during this period. Deviations from UIP can be attributed to a time-varying risk premium as outlined in Fama's framework. Additionally, our analysis also shows that interest rates and swaps play a significant role in explaining the variations in the TL's risk premium. Moreover, we found a substantial increase in both the level and volatility of the missing risk premium for longer maturities after 2018. Incorporating observable variables substantially reduces both the magnitude and the *long-lasting impact* of the missing risk premium *shocks* on expectations. Overall, this study sheds light on the intricate relationship between monetary policy changes, exchange rates and risk premia in the context of an emerging market.

JEL Classification: E43, F31, E58, G18

1 | Introduction

Since 2018, the Turkish financial and economic system has been in turmoil. Domestic and international investors have lost their confidence in the currency, which eventually has led to instability and unpredictability for the Turkish Lira (TL). This period dramatically coincided with radical changes in the monetary policies conducted by the Central Bank of the Republic of Türkiye (CBRT). Such policy changes mainly stemmed from political pressures and raised concerns about the independence of the CBRT. Between 2018 and 2024, the governor of the CBRT changed six times. Furthermore, the disagreements regarding the interest rate policy, particularly the emergence of negative real interest rates, contributed to the loss of investor confidence in the financial markets.

In 2021, the Turkish Ministry of Finance and Treasury officially declared that Turkey had adopted heterodox economic policies. During this time, the persistent depreciation of the TL increased the volatility and uncertainty in the foreign exchange markets.

This paper was initially presented at the 30th Turkish Economics Association conference on economics, which was held from November 16 to 18, 2023, in Antalya. We sincerely acknowledge the contributions of the conference participants. We also would like to thank two anonymous referees of this journal for their attention, insight and valuable comments. We are solely responsible for all errors. The views expressed in this paper are of the authors and do not necessarily reflect those of the World Federation of Exchanges or its member institutions.

Notably, the currency depreciated by 40% from March 2018 to March 2019 and continued to depreciate further in 2021. In response, the CBRT reduced policy rates throughout the latter half of 2021. In the first quarter of 2022, the TL further depreciated by an average of 88% from the previous year.

The economic instability and uncertainty have further escalated due to the central bank's rapid depletion of foreign reserves ($1.35 billion direct forex intervention on 2–3 December 2021 and $7 billion interventions in December 2021 (CBRT 2022). Until June 2023, the CBRT implemented various measures to prevent the depreciation of the domestic currency. These measures included backdoor interventions in foreign exchange markets, boosting reserves through swaps, introducing deposit saving accounts linked to foreign exchange rates and imposing indirect restrictions on capital mobility. Therefore, the impact of Turkish non-conventional monetary policies on exchange rate predictability presents an interesting case study for empirical research.

The forward exchange rate can predict the future spot rate perfectly unless the risk premium exists. Excess currency returns have been studied extensively in the literature. Some of the key factors affecting risk premia (*excess currency returns*) are related to *carry trade* and others are related to various strategies that cause diversification of foreign currency portfolios. Forward contracts are considered a technical tool by which the central bank can drive the equilibrium exchange rate. Because central banks try to smooth exchange rate volatilities, they employ a variety of approaches for managing exchange rates (Zapatero and Reverter 2003). For example, the direct approach of changing interest rates and the indirect approach of buying/selling foreign reserves are considered standard methods to manage exchange rates. There are also other instruments such as quantitative easing (QE), which affects the long-term interest rates, and the use of options to implement currency stabilisation objectives through the hedges of investment banks[1]. Although there are various tools that the central bank uses for maintaining exchange rate stability, the effectiveness of policy is significantly reduced when the risk premium is high, and, more importantly, when it varies over time.

Interest rates alone are neither necessary nor sufficient to prevent a devaluation (Kraay 2003). Whether interest rates should be raised or lowered to stabilise the currency depends on the behaviour of risk premia. According to the efficient market hypothesis pioneered by Lucas (1972) and Sargent (1973), the investors' optimism and pessimism influence currency risk premia differently. For example, the *uncovered interest parity* (UIP) condition states that the high-interest currencies are expected to depreciate so that exchange rate changes reduce international disparities in total return. However, Fama's (1984) UIP puzzle suggests that high-interest currencies tend to appreciate in the short run and carry a positive return for holding bonds.

Central banks systematically tend to intervene in support of (against) undervalued (overvalued) currencies (see Fratzscher et al. 2018). However, their policy decisions may be considerably different during the period of crises. Central banks stabilise their currency by 'leaning against the wind' (LATW), which involves actions to move the exchange rate in the opposite direction from its current trend. The primary mechanism works through a risk-taking channel of monetary policy and financial stability. Agur and Demertzis (2013) argue that when a central bank faces a negative economic shock, the LATW approach requires cutting interest rates deeper upon impact than would be required without a financial objective. However, such a policy is not an easy choice to implement not only because it is hard to manage the size of the exchange rate movement, but mainly because of the complex relationship between interest rates and exchange rates.

Moreover, the determination of the exchange rate in imperfect financial markets differs from what the conventional open macroeconomic model approach suggests. Exchange rates frequently disconnect from macro fundamentals such as imports, exports, consumption and output. They may also exhibit limited responsiveness to traditional monetary policy instruments, making the domestic currencies more vulnerable to global shocks (including the interest rate and QE announcements). The impact of large-scale currency interventions reshapes the movement of exchange rates and the risk-taking behaviour of the agents. For example, Gabaix and Maggiori (2015) argue that active risk taking in currency markets is highly concentrated in a few large financial players with typical characteristics of being active investors that profit from medium-term imbalances in international financial markets, often by bearing the risks resulting from imbalances in currency demand due to both trade and financial flows. They also argue that these financial players share the characteristic of being subject to financial constraints that limit their ability to take positions based on their risk-bearing capacities and existing balance sheet risks.

This study aims to explain the risk-taking behaviour of investors by examining the *observed* and *unobserved* components of the excess currency returns in TL. The unobserved component is also called the 'missing risk premium'. It is often defined as a latent factor within the excess currency returns framework that captures dynamic and persistent influences on the risk premium, which are not directly observable in the data but significantly impact the exchange rate dynamics. The missing risk premium also reflects the underlying economic or financial uncertainties that cannot be fully explained by traditional predictors. Thus, this study extends beyond traditional predictors to explore how the Turkish foreign exchange market interacts with central bank policies. In particular, it highlights the role of the missing risk premium and various central bank intervention techniques such as currency swap activities and foreign reserve management as key explanatory variables. The study also includes other observable factors such as interest rate differentials, volatility and credit default risk. This expanded framework allows a deeper understanding of observable and unobservable influences on the TL returns. The research questions are as follows: (i) What are the determinants of risk premia? (ii) Are swap agreements increasing the volatility of currency risk premia or exchange rate returns? (iii) Do central bank interventions (reserve management and swap agreements) affect the missing component of risk premia?

The analysis uses traditional regression analysis of the ordinary least squares (OLS) and the state-space model (SSM) to explain the determinants of excess currency returns, thereby identifying the shocks influencing the *missing variable* *component*. Although this research is highly inspired by the study of Dahlquist and Pénasse (2022), it significantly differs from it by using data for the impact of determinants with different frequencies on the missing foreign exchange risk premium. Our intended contribution to the existing literature is as follows: (i) We use high-frequency (daily and weekly) data to measure the behaviour of the forward premium and risk premium in the emerging market context. (ii) We present comprehensive and robust empirical evidence for the impacts of swap activities, credit default swap (CDS) spreads, reserves and volatility index (VIX) on unexpected currency returns via OLS and SSM techniques. (iii) We also examine the variance decomposition of the unexpected currency return including all observable and unobservable variables to measure their attributions. (iv) Finally, this is the first study to measure the impact of the *missing risk premium* on exchange rates in Turkey, representing a good example of an emerging economy. Additionally, it creates an exciting opportunity for demonstrating how non-conventional monetary policies under the strict auspices of the central government can be implemented.

Our empirical results support the existence of a risk premium described by Fama (1984) and suggest that the UIP condition does not hold for the TL. The impact of the *missing risk premium* mimics the risk premium on exchange rates, particularly during high-uncertainty periods from 2008 to 2018. An unusual increase in both the level and volatility of the *missing risk premium* was observed after 2018, coinciding with the period when the CBRT shifted from traditional to heterodox monetary policies. These results suggest that the unconventional monetary policies implemented by the CBRT since 2018 may have contributed to a rise in the uncertainty surrounding future exchange rates in Turkey. Both interest rates and the swap agreements seem to be robust monetary policy tools in explaining the movement of currency risk premia. Their explanatory powers are greater than the CDS, VIX and reserves in determining the exchange rate predictability. The impact of a missing premium component on excess exchange returns lasts longer than other shocks. Nevertheless, the inclusion of observable factors serves to mitigate this influence. The variance decomposition analysis suggests that the interest rate differential explains most of the variations in unexpected currency returns.

The rest of this paper is organised as follows: Section 2 briefly reviews the relevant literature. Section 3 describes the theoretical framework. Section 4 explains the econometric methodology and data. Section 5 reveals and discusses the main findings, and Section 7 concludes with policy implications.

2 | A Brief Literature Review

The UIP condition originates from Fischer's (1907) research. It indicates that the divergence between real and nominal interest rates results from inflationary expectations. The study of Friedman (1953) showed for the first time that the inflation differentials between countries are the main determinants of the exchange rates in a flexible exchange rate system. Alternatively, the pioneering research of Mundell (1960) and Fleming (1962) describes the interest parity condition for exchange rate determination in an open macroeconomic model. This model was later extended into a dynamic exchange rate shooting model by Dornbusch (1976). Frankel (1979) also demonstrates that the exchange rate overshooting is proportional to the real interest rate differentials. The empirical studies of Hansen and Hodrick (1980) and Fama (1984) present the existence of the 'UIP puzzle', implying a negative relationship between future exchange changes and the current interest rate differential. Verdelhan (2010) attributes this anomaly to time-varying risk premia and expectational errors.

The literature review shows various approaches used in explaining the exchange rate risk premium. For example, the macroeconomic approach by Mark (1985) and Engel (2016) relates the risk premium to consumption growth, which is derived from a general equilibrium model of consumption-based asset pricing model (CAPM). In this approach, foreign currency is an important tool for smoothing consumption fluctuations over time. Alternatively, external and internal imbalances can be other macroeconomic variables that affect risk premia. As a result, currency excess returns are higher when the funding (investment) country is a net foreign creditor (debtor) and has a higher propensity to issue liabilities in domestic (foreign) currency (Della Corte, Riddiough, and Sarno 2016). According to Gabaix and Maggiori (2015), the relationship between net foreign assets and currency excess returns is used to identify the link between external imbalances and currency risk premia.

Moreover, the finance approach can also be used in studying risk premia. The advantage of this approach is that the short-term variables in the financial markets are used to determine the short-run behaviour of exchange rates. Like any other financial asset, the risk factor is an essential determinant of the exchange rate volatility. Eichengreen and Hausmann (1999), Eichengreen, Rose, and Wyplosz (1995) and Obstfeld and Rogoff (2000) sought to determine the role of risk factors in exchange rate volatility. Svensson (1992) and Fama (1976) argue that the risk premium is considered as compensation for foreign currency holders. In this respect, domestic households can diversify the risk by holding a portfolio of domestic bonds denominated in domestic currency and foreign bonds denominated in foreign currency. Hofmann, Shim, and Shin (2020) examine how the local currency bond credit risk premium fluctuates in tandem with the spot exchange rate so that the spot exchange rate takes on the attributes of a risk measure in emerging economies.

Expectations theory has been used as a workhorse for many policy discussions (Shiller, Campbell, and Schoenholtz 1983). Because expectations play a central role in determining exchange rates, little is known about the exact nature of those expectations (Takagi 1991). The problem arises due to its difficulty in measuring the expected exchange rate, which uses either the forward exchange rate or the ex post spot exchange rate as a proxy. Little evidence supports that expectations are formed rationally in the foreign exchange market, so the forward rate summarises all relevant information about the future spot rate (Hakkio 1981; Hartley 1983). Verdelhan (2010) argues that forward premium anomaly can be due to time-varying risk premia and expectational errors. The modern literature in financial economics has documented that significant and time-varying risk premia are pervasive across asset classes (Kremens and Martin 2019).

There are also country-specific studies that explain the impact of exchange rate risk on interest rates (Berument and Gunay 2003) and the impact of dollarisation (Eren, Basar, and Tosun 2022) in Turkey. There are also a few other studies on risk premia in Turkey. For example, Ozlu (2006) studied the impact of central bank interventions on risk premia with a daily frequency between November 1993 and December 2002. Korkmaz and Onay (2018) examined the determinants of currency risk premia in emerging market countries, including Turkey. Nevertheless, there are no studies on the missing risk premium in Turkey, and thus we believe that this paper will fill the gap in the literature with its current contribution.

3 | Theoretical Framework

The theoretical model explores the complex relationship between interest rate differentials and exchange rate fluctuations. Unlike the UIP condition, which assumes interest rates respond to currency fluctuations, our model is based on the pioneering work of Fama's (1984) assertion that exchange rates react to interest rate differentials and a time-varying premium.

We first specify the theoretical relationship between exchange rate changes and nominal interest rate differentials as follows:

$$E_t\left(e_{t+k} - e_t\right) = \left(i_{t,k} - i^*_{t,k}\right) = f_{t,k} - e_t = F^P_{t,k} \qquad (1)$$

where e_t is the log nominal exchange rate in units of domestic currency per US dollar at time t, e_{t+k} is a k-period forward of log nominal exchange rate, E_t is the expectation based on information at time t, $f_{t,k}$ is the forward exchange rate and $F^P_{t,k}$ represents the forward premium at k-maturity and $i_{t,k}$ is k-period interest rates. The left-hand side of the equation shows the change between dates t and $t+k$. $i_{t,k}$ and $i^*_{t,k}$ are interest rates on domestic and foreign deposits with k-maturity, respectively.

Expected exchange rate changes must equal interest differential under the UIP condition or forward premium[2] under the *covered interest parity* (CIP) condition. UIP serves as a theoretical baseline, assuming market efficiency and risk neutrality, where the forward exchange rate predicts the future spot exchange rate without bias. To evaluate Equation (1), the first step is to compute log exchange rate changes, $\Delta e_{t,k} = e_{t+k} - e_t$, where positive (negative) values represent depreciations (appreciations). Under risk neutrality and rational expectations, a currency's forward rate should be an unbiased predictor of future spot rates (Delcoure et al. 2003; Sarno, Schneider, and Wagner 2012, 279). In the context of risk neutrality and rational expectations, the forward rate of a currency is considered an unbiased estimator of the corresponding future spot exchange rate, $f_{t,k} = E\left(e_{t+k}\right)$, where, $f_{t,k}$ denotes the forward spot exchange rate for the k-period forward and $E\left(e_{t+k}\right)$ represents the expected spot rate at time t+k.

Subtracting the spot exchange rate from both sides of the equation and combining with Equation (1), we derive the forward premium, which can be expressed as follows:

$$\Delta e_{t,k} = \propto + \beta\left(i_{t,k} - i^*_{t,k}\right) + \varepsilon_{t,k} \qquad (2)$$

where $\varepsilon_{t,k}$ is a stochastic error term. Equation (2) indicates that when $\beta = 1$, the UIP condition holds, and the exchange rate is expected to depreciate (appreciate) in response to any increase (decrease) in the domestic interest rate. However, the empirical studies questioned the ability of the forward premium to predict the direction of the ex post spot exchange rate. They found that the estimated value of β was less than unity and often negative (see Hansen and Hodrick 1980; Fama 1984; Hodrick 1987; Froot and Thaler 2001; Engel 1996; Hai, Nelson, and Wu 1997; Burnside et al. 2006). This suggests that a positive interest differential tends to appreciate the domestic currency, underscoring the *forward premium puzzle* (Meredith and Ma 2002). However, observing the forward premium (or the interest rate differential) alone cannot identify the probability of a devaluation and its expected magnitude. The forward unbiasedness hypothesis (FUH) suggests that a currency's forward rates should form unbiased predictions of future spot rates due to a time-varying risk premium, which compensates both for currency risk and interest rate risk, $f_{t,k} = e_{t+k} + \lambda_{t,k}$ (Sarno, Schneider, and Wagner 2012). Omitting the time-varying risk premium, $\lambda_{t,k}$, results in a value of β below unity if the variance of the risk premium is greater than the variance of the expected depreciation and the risk premium's covariance with expected exchange rate changes is negative (Sarno, Schneider, and Wagner 2012, 282).

We then define the excess currency return as follows:

$$rx_{t,k} = \Delta e_{t,k} - F^P_{t,k} = e_{t+k} - f_{t,k} \qquad (3)$$

where $rx_{t,k}$ is used as a k-period maturity currency return. The derivation of risk premia, or currency excess returns, depends on the interest differential that represents the carry trade returns. The excess currency is equal to the depreciation of the domestic currency minus the interest rate differential price

$$rx_{t,k} = \Delta e_{t,k} - \left(i_{t,k} - i^*_{t,k}\right) \qquad (4)$$

When we subtract the interest rate differential from both sides in Equation (2), the left-hand side of the equation will be equal to Equation (4). Alternatively, this equation is often referred to as *Fama's return predictability regression*, and it is represented as follows:

$$rx_{t,k} = \propto + (1 - \beta)\left(i_{t,k} - i^*_{t,k}\right) + \varepsilon_{t,k} \qquad (5)$$

where the null hypothesis that the UIP condition is valid and holds if $\alpha = 0$, $\beta = 1$ and $\varepsilon_{t,k}$ is serially uncorrelated. We further assume that the investors are rational and the error term is orthogonal to all available information at t. Under these assumptions, the interest rate differential will be sufficient for explaining the currency risk premium, and when the expected value operator is introduced, Equation (5) will take the following form: $E_t\left(rx_{t+k}\right) = \propto + (\beta - 1)\left(i_{t,k} - i^*_{t,k}\right)$.

A typical procedure to capture the risk premium anomalies associates the currency risk premium with the interest rate differentials, see for example, Backus, Foresi, and Telmer (2001). We further expand our model by including additional predictor variables, y_t and η_t,

$$E_t\left(rx_{t,k}\right) = \propto + (\beta - 1)\left(i_{t,k} - i^*_{t,k}\right) + \gamma y_{t.k} + \eta_t \quad (6)$$

Equation (6) implies that the risk premium is not solely influenced by interest rate differential but also by two other factors. The first factor is the observed variables, $y_{t,k}$, which is an *additional predictor of currency returns*, and the second one is the potentially missing component of the *currency risk premium*, η_t, also called a *missing risk premium* (Dahlquist and Pénasse 2022). In this framework, the missing risk premium is defined as an unobservable component representing latent factors that influence the risk premium but are not directly observable in the data. These latent factors significantly impact exchange rate dynamics. To quantify the influence of these hidden factors on excess currency returns, η_t is modelled as a latent variable within the state-space framework. The explanatory variables/observable variables may include such currency *swap agreements*, the sovereign *CDS* spreads, which is the potential measure of sovereign default risk, the global VIX and *foreign reserves* depending on the data availability. It is further assumed that the additional predictor and the missing risk premium follow the mean-zero AR (1) process:

$$\left(i_{t+1,k} - i^*_{t+1,k}\right) = p_i\left(i_{t,k} - i^*_{t,k}\right) + \varepsilon^i_{t+1} \quad (7)$$

$$y_{t+1} = p_y y_t + \varepsilon^y_{t+1} \quad (8)$$

$$\eta_{t+1} = p_\eta \eta_t + \varepsilon^\eta_{t+1} \quad (9)$$

where the shocks ε^i_{t+1}, ε^y_{t+1} and ε^η_{t+1} are independently and identically distributed (IID) over time (but potentially cross-correlated), and where $-1 < p_i < 1$, $-1 < p_y < 1$ and $-1 < p_\eta < 1$. Finally, the zero-mean assumption does not entail loss of generality, as a non-zero mean would be incorporated into the constant term $\propto$.

4 | Empirical Model and Data

4.1 | SSM

The SSM deals with dynamic time-series problems that involve unobservable variables or parameters that describe the evolution of the underlying system (Commandeur and Koopman 2007). One of the SSM's advantages is that it enables an adaptive approach to calibrating parameters using maximum likelihood estimation, allowing the model to effectively handle time-varying coefficients with potential instability (Bhatta et al. 2022). This flexibility allows for practically analysing both linear and non-linear time series. The advantage of the signal extraction approach is that it enables empirically characterising the temporal behaviour of risk premia, even using only data on spot and forward exchange rates (Cheung 1993). The SSM has two components: the *signal* (observation/measurement) equation and the *state* (transition) equation. The SSM can be defined as follows:

$$Y_t = AX_t + v_t \quad (10)$$

$$X_t = BX_{t-1} + \varphi_t \quad (11)$$

where A and B are matrices of the underlying parameters of the model, Equation (10) represents the signal equation and Y_t is a vector of observed variables. Equation (11) is the transition equation for the state vector X_t, which includes both observed and potentially unobserved variables. Finally, v_t and φ_t are vectors of observation errors and state innovations, respectively. All error terms are IID over time but potentially correlated. It is assumed that all equations are affine and that the shocks are normally distributed. Furthermore, the SSM uses the Kalman filter and the estimation with maximum likelihood (Hamilton 1994; Dahlquist and Pénasse 2022).

We employ this framework to analyse our model and follow the approach adopted by Dahlquist and Pénasse (2022). The equations of the SSM are summarised as follows:

$$\begin{bmatrix} rx_t \\ i_t - i^*_t \\ y_t \end{bmatrix} = \begin{bmatrix} \beta - 1 & \gamma & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} i_t - i^*_t \\ y_t \\ \eta_t \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} i_t - i^*_t \\ y_t \\ \eta_t \end{bmatrix} = \begin{bmatrix} p_i & 0 & 0 \\ 0 & p_y & 0 \\ 0 & 0 & p_\eta \end{bmatrix} \begin{bmatrix} i_{t-1} - i^*_{t-1} \\ y_{t-1} \\ \eta_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon^i_t \\ \varepsilon^y_t \\ \varepsilon^\eta_t \end{bmatrix} \quad (13)$$

with

$$var\left(\begin{bmatrix} \varepsilon^i \\ \varepsilon^y \\ \varepsilon^\eta \end{bmatrix}\right) = \begin{bmatrix} \sigma^2_i & \sigma_{yi} & \sigma_{\eta i} \\ \sigma_{\gamma i} & \sigma^2_y & \sigma_{\eta y} \\ \sigma_{\eta i} & \sigma_{\eta y} & \sigma^2_\eta \end{bmatrix} \quad (14)$$

The above SSM system presents the signal equation incorporating the excess return, the interest differential and the explanatory variable. The state vector has the interest rate differential, the explanatory variable and the missing component, where $\chi_t = \left[i_t - i^*_t, y_t, \eta_t\right]$. The signal equation is given in Equation (7), and the dynamics of the state vector are provided in Equations (8–10). It is important to emphasise that there is no error in the signal equation so that it will allow us to model the co-movements between the missing premium and other explanatory variables in the vector $\varepsilon_t = \left[\varepsilon^i_t, \varepsilon^y_t, \varepsilon^\eta_t\right]$. Finally, Equation (14) presents the corresponding correlation between the shocks: σ_{yi}, $\sigma_{\eta i}$ and σ_η.

4.2 | Variables and Data Sources

Data from 1 January 2005 to 26 March 2023 are used for the empirical analysis. The definitions of variables and their respective data sources are presented in Table 1.

Summary descriptive statistics tables of the variables used in the empirical analysis are provided in Appendices 1 and 2 for daily and weekly frequencies, respectively. These tables also contain the summary unit root tests of the augmented Dickey–Fuller (ADF) statistics.

TABLE 1 | Empirical models variable definitions and data sources.

Variable name	Definition	Data source
Exchange rate	TL/US dollar nominal exchange rates	LSEG Workspace (refinitive)
Forward exchange rate	Forward exchange rates: Turkish Lira per US dollar	LSEG Workspace (refinitive)
	Overnight (O/N) forward	
	1-month forward	
	3-month forward	
	1-year forward	
Spot exchange rates	Turkish Lira per US dollar	LSEG Workspace (refinitive)
Interest rate differentials	Turkish and US deposit interest rates	
	Overnight differentials	LSEG Workspace (refinitive)
	1 month	
	3 months	
	1 year	
Forward premium		Own estimates
	Overnight	
	1 month	
	3 months	
	1 year	
Risk premium	It is calculated as the difference between the actual (ex post) spot exchange rate at a particular maturity and its forward rate.	Own estimates
	Overnight	
	1 month	
	3 months	
	1 year	
Swaps	Official swap actions in millions of US dollars	CBRT
CDS	5-year credit default swap premium for Turkey	LSEG Workspace (refinitive)
Reserves (foreign)	Gross foreign exchange reserves in millions of US dollars	CBRT
VIX	The volatility index measures expected price fluctuations in the S&P 500 options over the next 30 days.	CBOE

Note: All variables except interest rates are in natural logarithmic form.
Abbreviations: CBOE, Chicago Board Options Exchange; CBRT, Central Bank of the Republic of Türkiye.

5 | Estimations

5.1 | Expected Excess Returns

The models used in this study take the forward and risk premium as the dependent variables for different maturities. There is a strong correlation between various maturities and the change in long-term expectations after 2018, as the gap between short- and long-term maturities widened significantly after 2021 (see Appendix 3). Due to deterioration in expectations, we see similar behaviour in the risk premium as the 1-year maturity varies significantly from 1- to 3-month maturities (see Appendix 4). The correlation between the risk premium with 1- and 3-month maturity is around 0.55, whereas the correlation between the risk premium with 1-month and 1-year maturity is 0.26.

The first-order autocorrelation (AC) function of expected excess returns (forward premium) and squared expected excess returns for weekly data are reported in Appendix 5. The null for the *Q*-test is rejected for all lags for both returns; thus, there is strong evidence of serial correlation. The positive results for the AC functions are consistent with the literature on the AC of asset returns (Campbell, Lo and MacKinlay 1996; Lo and MacKinlay 1988; 1990)[3]. The AC of the excess return series is higher than that of the squared excess return series, and they are consistently significantly positive for lags up to 36 lags at longer maturities. Although the ACs of the excess returns for overnight (O/N) rates only display less activity, the AC function of squared excess returns presents significant correlations up to an extended lag length. These are more evident for longer maturities.

Finally, as presented in Table 2, the leverage effect reports the correlation coefficient between squared excess returns at time t and excess returns at t−1 for different maturities. The results confirm that the leverage effect is positive for all other maturities except the O/N forward premium. The correlation for the daily excess returns is significantly greater at longer maturities.

TABLE 2 | Leverage effect.

	Daily	Weekly
O/N	0.008	−0.153
1M	0.966	0.642
3M	0.396	0.760
1Y	0.925	0.943

In other words, the positive excess returns are followed by a pick-up in volatility for longer maturities.

5.2 | Risk Premium

The following analysis stage tests the UIP condition to assess the efficiency of the foreign exchange markets in Turkey. Table 3 presents the OLS regression estimates for four different maturities (daily and weekly) based on the predictive regression for expected excess returns outlined in Equation (2). The results reveal that β-coefficient is statistically significant in only three estimations, which implies that the UIP condition does not hold for the Turkish case during the estimation period. These findings are consistent with prior empirical studies on Turkish data, such as Civcir (2003), Karahan and Çolak (2012) and Öge Güney (2018). The consistently small coefficients across regressions show that interest rate differentials alone are insufficient to explain exchange rate behaviour in Turkey, especially in the context of a volatile emerging market. This limitation of the UIP framework aligns with Fama's theory, which attributes such deviations to a

TABLE 3 | Predicting excess currency returns.

Frequency	Daily				Weekly			
Maturity	O/N	1M	3M	1Y	O/N[a]	1M	3M	1Y
α	0.00272 (0.0024)	0.01036*** (0.0017)	0.030754*** (0.0014)	0.0001 (0.0002)	−0.0010*** (0.0000)	0.001366 (0.0016)	0.004536 (0.0003)	0.08282 (0.0134)
β	0.0003 (0.0002)	−0.0003*** (0.0001)	−0.00022 (0.0008)	−0.0031*** (0.0003)	−0.0001** (0.0000)	0.0000 (0.0003)	−0.0001 (0.0008)	−0.0122 (0.0095)
R^2	0.0004	0.00099	0.00002	0.02205	0.007	0.000001	0.00002	0.00181
N	4163	4731	4686	4489	839	945	933	905

Note: Standard errors are in parenthesis.
[a]The coefficients are reported to estimate that the forward premium is the dependent variable.
***, ** and * refer to statistical significance at 1%, 5% and 10%, respectively.

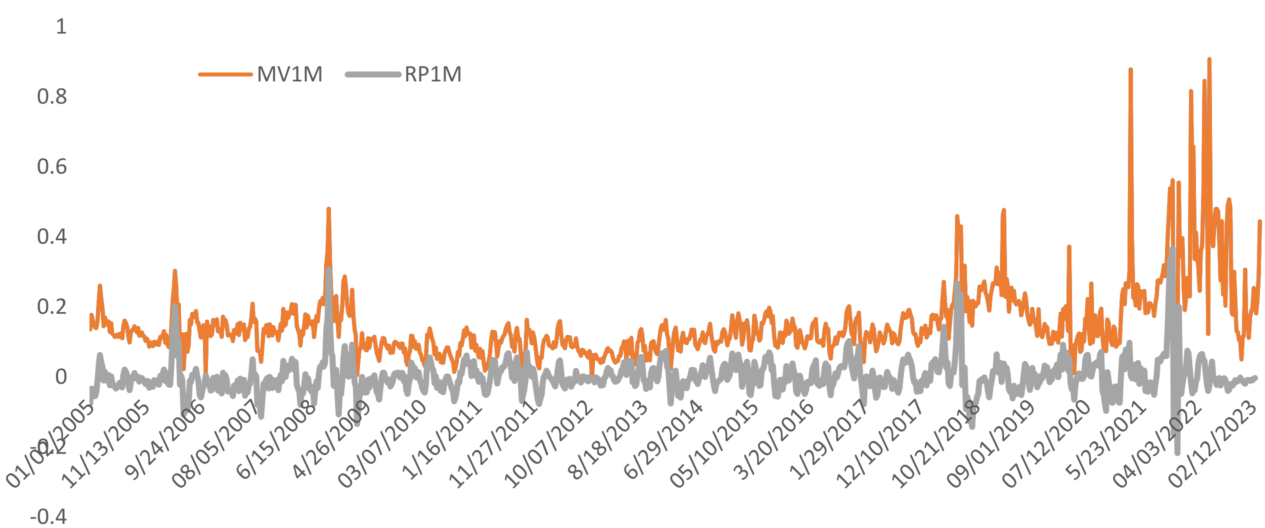


FIGURE 1 | The risk premium (RP) and the missing risk (MV) component: Fama model. The risk premium is calculated as the difference between the actual (ex post) spot exchange rate at a particular maturity and its forward rate, whereas the missing risk component based on Fama's model is represented by the interest rate differentials at a 1-month maturity as the explanatory variable. [Colour figure can be viewed at wileyonlinelibrary.com]

persistent and time-varying risk premium. Moreover, the small magnitudes of these coefficients raise concerns about the effectiveness of the OLS estimation method. Attempts to correct for serial correlation using the Cochrane–Orcut iterative approach did not significantly improve the results, and these outputs are omitted here for brevity.

Poor performance of the OLS estimates raises the necessity for alternative methods to estimate the expected excess returns and risk premia. Because measuring expectations is challenging, the risk premium can be calculated by taking the difference between the actual (ex post) spot exchange rate at a given maturity minus its forward exchange rate. Alternatively, Dahlquist and Pénasse (2022) calculated the excess return by subtracting the interest rate differential from the changes in exchange rates. Because Turkey's interest rate differential is not informative, we used the first alternative in calculating the risk premium. Subsequently, the SSM offers a flexible and robust framework for modelling complex systems. This approach accommodates systems with multiple components, non-linear dynamics and uncertainties. The SSM estimation results are explained in detail in Section 5.3; however, Figures 1 and 2 present the *risk premium* (RP) behaviour and *estimated missing risk* (MV) component over the selected period. A significant shift in the behaviour of missing variables has occurred since 2021.

Figure 1 presents the risk premium (the grey line) and the missing risk component (the orange line) derived from the basic Fama's model. The risk premium exhibits periods of sharp increases coinciding with significant economic and political events such as rising oil prices and a high current account deficit in 2006, the Great Financial Crisis in 2008 and the political turmoil in 2018 and 2021. The volatility of the missing variable during the period of turmoil is notably higher, with a standard deviation of 0.05 for the risk premium and 0.11 for the missing variable. Since 2018, there have been further fluctuations in excess returns and the missing variable. The unusual behaviour of the missing component since late 2018 aligns with radical changes in the Turkish monetary policy. These changes include shifts from traditional policies to unconventional measures such as large backdoor interventions, substantial foreign exchange swap agreements signed with China, Qatar, United Arab Emirates and South Korea and the exchange rate-protected time deposit scheme that was implemented in December 2021.

These unconventional monetary policy measures, as reflected in Figure 2, contributed to a sharply depreciated lira, soaring inflation and a loss of the central bank's control over long-term interest rates (Gürkaynak, Kısacıkoğlu, B, and Lee 2023). The significant reduction in Turkey's official reserves and its increased reliance on external financing further exacerbated economic uncertainty and risk.

In summary, while the blend of high economic uncertainty and weak monetary policy has amplified instability, the current weakness that is distinctively observed in the Turkish data made the predictions unstable and significantly unreliable after 2018. The CBRT has engaged in extensive foreign currency interventions since the 2018 currency crisis. The selling of nearly 199 billion US dollars in foreign currency between December 2021 and May 2023 and providing US dollar reserves to domestic banks through swap agreements aimed to stabilise the exchange rates and restore confidence in the financial market. However, these interventions address the mismatch between the Turkish banking sector's US dollar liabilities and assets. The CBRT's 2022 report highlights that swap transactions were crucial in managing this mismatch (CBRT 2022).

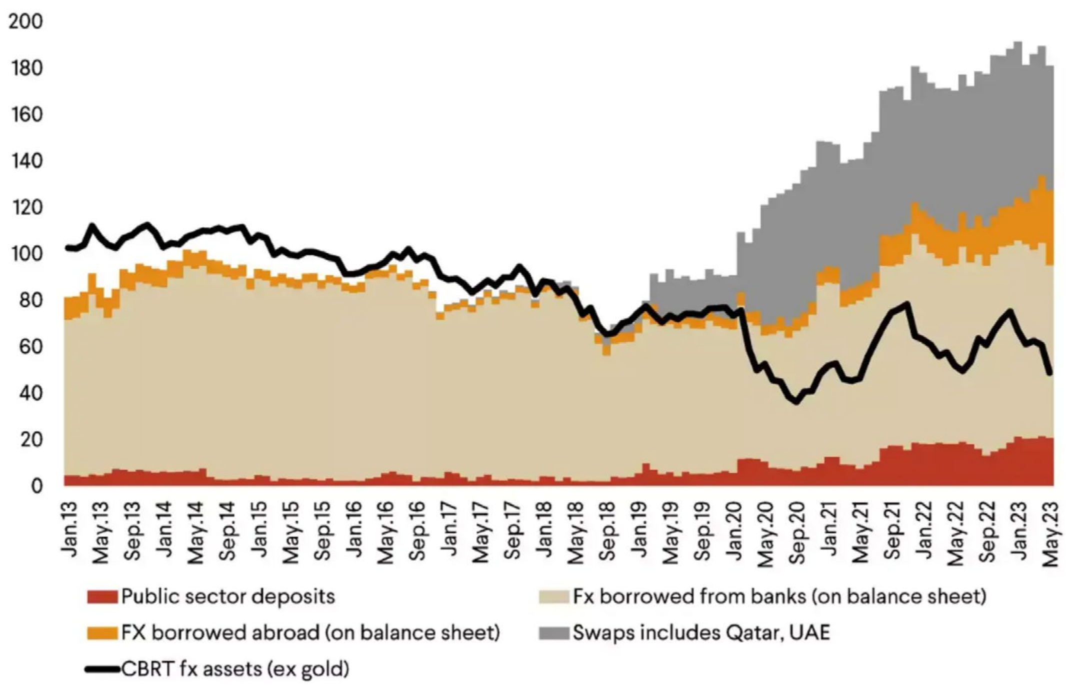


FIGURE 2 | FX liabilities of the Central Bank of the Republic of Türkiye (CBRT), USD billion. *Source:* Setser (2023). [Colour figure can be viewed at wileyonlinelibrary.com]

5.3 | SSM Estimations

The SSM was used to calculate expected excess returns for three maturities: 1 month, 3 months and 1 year, with daily and weekly frequencies[4]. The choice of using either forward premium or risk premium to measure expectations is an equally common practice. We opted for a forward premium (forward exchange rate minus spot exchange rate) with daily frequency and a risk premium (forward exchange rate minus future spot exchange rate) with a weekly frequency. This choice was made due to the better performance of forward premium, particularly at shorter maturities with using daily data. Additionally, the risk premium resulted in many missing observations, especially for longer maturities.

The basic model includes interest rate differential (IP) and the unobservable missing risk premium (MV) in the signal equation of the SSM specification. We also add other variables such as currency swap agreements of the central bank, the CDS spreads (which is the potential measure of sovereign default risk), foreign reserves and the CBOE VIX to capture the observable influence in our model. These variables allow us to assess the relative importance of observable factors in mitigating the influence of unobserved components. We tested our model by selecting various combinations of explanatory variables in respective equations. All explanatory variables in the signal equation have coefficients except the missing premium. According to Dahlquist and Pénasse (2022), no error term in the signal equation allows us to model the co-movements between missing premium, interest rate differential (IP) and other explanatory variables.

5.3.1 | Forward Risk Premium

Table 4 presents the estimation of the forward premium with a daily frequency. The columns are numbered depending on the observable variables used in the model. Model 1 reports the simple Fama model's coefficients, error terms and covariances. The official foreign reserves are omitted from the model due to the unavailability of data. Similarly, CDS is also excluded because of its high correlation with interest rate differentials. Model 2 includes interest rate differential and currency swaps. Model 3 contains interest rate differential, currency swaps and VIX as the observable variables in our model. The estimated β-coefficients for IP are consistent with the literature; they are all negative and small in magnitude (Civcir 2003; Karahan and Çolak 2012; Öge Güney 2018). The sign of the coefficient implies that the TL tends to appreciate against the US dollar when the domestic interest rate is relatively high. The absolute values of the IP coefficients remain relatively unchanged when swaps are added to the model.

The coefficient for currency swaps is significantly larger than for IP across all maturities, suggesting that swaps have a more substantial impact on explaining excess returns than interest rate differentials. This finding aligns with the post-2018 period, where unconventional monetary policies led to increased reliance on swaps to stabilise the lira. The magnitude of the swap coefficients also increases with maturity, indicating a growing effect of swap activity on longer-term excess returns.

The missing component (MV) coefficient shows a significant reduction when currency swaps and VIX are included in the model suggesting that these variables explain factors previously attributed to the missing component. In simpler terms, the model explains a more significant portion of the data variability when currency swaps and VIX are considered. The analysis of the estimated persistence parameters reveals that the missing component (MV) shock exhibits the highest persistence (i.e., $p_\eta > p_y > p_i$). This result implies that its impact on the excess return can last longer than the other shocks. The results highlight the importance of considering swap activity alongside traditional factors like interest rate differentials when explaining excess returns in the Turkish financial markets.

5.3.2 | Risk Premium

Table 5 includes all observable and unobservable variables in the SSM. Because risk premium is defined as the future spot exchange rate minus the forward rate, positive signs are associated with increases in the risk premium, whereas negative signs indicate reductions. Interest differential coefficients in all regressions are negative, suggesting that a decrease in interest rates causes a more significant increase in future spot rates than forward rates. This result implies that the 'actual' depreciation is higher than the 'expected' depreciation, thereby increasing the risk premium. Nevertheless, the magnitude of the coefficient is still small in value, varying between −0.014 and −0.011.

The coefficients of the observable variables, such as currency swap deals and forex reserves, have negative signs. Because the primary purpose of a currency swap is to reduce risk and volatility in the foreign exchange market, the increase in swap agreements boosts the TL and reduces the risk premium. This behaviour appears specific to the TL during the period of unconventional monetary policies of the CBRT, where reliance on currency swaps became a dominant strategy to counteract macroeconomic instability.

Foreign reserves are another critical determinant of the risk premium. When central banks sell (buy) foreign currency and reduce (increase) their reserves, they cause appreciation (depreciation) of their national currencies. This situation leads to buying foreign reserves, as unsterilised intervention causes an expansionary policy, resulting in an initial jump in exchange rates followed by domestic currency depreciation (Uz Akdogan 2020). Since 2018, there have been record-low levels of reductions in the CBRT assets. The Turkish central bank's net foreign reserves fell below zero for the first time in 21 years (Reuters 2023). Our results show that any reduction in the central bank's foreign reserves causes an increase in the risk premium, that is, falling reserves cause higher actual depreciation than expected depreciation (Korkmaz and Onay 2018). Moreover, the coefficient of the foreign reserves becomes smaller when currency swaps and VIX are included in the model. Although swap deals theoretically impact the amount of gross foreign currency reserves in the balance sheet, the impact of their effects on risk premia varies as they affect expectations around central bank policies and interventions differently[5].

TABLE 4 | Estimation of the expected excess return (daily frequency).

	Maturity	O/N			1-month			3-month			1-year		
	Model	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Signal coefficients	IP	−0.010 (0.0000)	−0.010 (0.0000)	−0.012 (0.0000)	−0.010 (0.0000)	−0.011 (0.0000)	−0.012 (0.0000)	−0.010 (0.0000)	−0.012 (0.0000)	−0.013 (0.0000)	−0.010 (0.0000)	−0.011 (0.0000)	−0.012 (0.0000)
	Swaps		−0.190 (0.0000)	−0.219 (0.0000)		−0.233 (0.0000)	−0.231 (0.0000)		−0.197 (0.0000)	−0.195 (0.0000)		−0.241 (0.0000)	−0.230 (0.0000)
	VIX			−0.337 (0.0000)			−0.292 (0.0000)			−0.257 (0.0000)			−0.260 (0.0000)
State coefficients	MV	0.706 (0.0000)	0.721 (0.0000)	0.668 (0.0000)	0.706 (0.0000)	0.471 (0.0000)	0.239 (0.0000)	0.706 (0.0000)	0.556 (0.0000)	0.343 (0.0000)	0.706 (0.0000)	0.668 (0.0000)	0.258 (0.0000)
	IP	−0.415 (0.0000)	−0.418 (0.0000)	−0.434 (0.0000)	−0.415 (0.0000)	−0.387 (0.0000)	−0.396 (0.0000)	−0.415 (0.0000)	−0.393 (0.0000)	−0.401 (0.0000)	−0.415 (0.0000)	−0.380 (0.0000)	−0.404 (0.0000)
	Swaps		0.446 (0.0000)	0.427 (0.0000)		0.407 (0.0000)	0.402 (0.0000)		0.430 (0.0000)	0.425 (0.0000)		0.410 (0.0001)	0.408 (0.0000)
	VIX			0.165 (0.0000)			0.185 (0.0000)			0.212 (0.0000)			0.208 (0.0000)
State error	MV	−0.778 (0.0000)	−0.792 (0.0000)	−1.006 (0.0000)	−0.778 (0.0000)	−0.655 (0.0000)	−0.856 (0.0000)	−0.778 (0.0000)	−0.679 (0.0000)	−0.838 (0.0000)	−0.778 (0.0000)	−0.616 (0.0000)	−0.786 (0.0000)
	IP	−0.334 (0.0714)	−0.346 (0.0000)	−0.276 (0.0002)	−0.356 (0.0779)	−2.939 (0.0768)	−3.674 (0.5926)	−0.360 (0.0000)	−2.040 (0.0000)	−2.012 (0.0000)	−0.368 (0.0497)	−3.977 (1.8163)	−3.993 (0.7319)
	Swaps		−0.892 (0.0000)	−0.870 (0.0000)		−0.812 (0.0000)	−0.823 (0.0000)		−0.907 (0.0000)	−0.916 (0.0000)		−0.785 (0.0000)	−0.825 (0.0000)
	VIX			−0.066 (0.0000)				−0.258		−0.349 (0.0000)			−0.309 (0.0000)
	$\sigma^{\eta i}$	7.805 (0.0000)	7.871 (0.0000)	8.964 (0.0000)	7.805 (0.0000)	10.279 (0.0000)	10.809 (0.0000)	7.805 (0.0000)	8.295 (0.0000)	8.681 (0.0000)	7.805 (0.0000)	9.988 (0.0000)	10.784 (0.0000)
Log likelihood		−651.35	−710.13	−844.74	−717.40	−783.26	−359.15	−715.55	−808.63	−448.41	−659.32	−960.75	−510.92
AIC		0.32	0.35	0.41	0.30	0.33	0.16	0.30	0.34	0.19	0.31	0.46	0.25
N		4165	4165	4165	4759	4759	4759	4759	4759	4759	4251	4251	4251

Note: The maximum likelihood for the expected currency return estimates is used. The signal coefficients are represented in Equation (6), whereas state coefficients and variance of state errors are represented in Equation (13). $\sigma^{\eta i}$ is the covariance of errors in interest rate differential and missing variable in Equation (14). Standard errors are reported in parenthesis.

TABLE 5 | Estimation of the risk premium (weekly frequency).

	Maturity	1M								3M					1Y				
	Model	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**4**	**6**	**8**	**1**	**2**	**4**	**6**	**8**
Signal coefficients	IP	−0.014	−0.011	−0.011	−0.011	−0.011	−0.013	−0.013	−0.012	−0.012	−0.011	−0.012	−0.012	−0.011	−0.011	−0.012	−0.012	−0.012	−0.013
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	Swaps		−0.301			−0.288	−0.272	−0.265	−0.1964		−0.301		−0.313	−0.280		−0.300		−0.168	−0.238
			(0.0000)			(0.0000)	(0.0000)	(0.0000)	(0.0000)		(0.0000)		(0.0000)	(0.0000)		(0.0000)		(0.0000)	(0.0000)
	CDS			0.293		0.057		0.128	0.074										
				(0.0000)		(0.0000)		(0.0000)	(0.0000)										
	Reserves				−0.298		−0.127	−0.184	−0.185			−0.353	−0.152	−0.156			−0.300	−0.314	−0.287
					(0.0000)		(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)
	VIX								0.241					0.065					0.151
									(0.0000)					(0.0000)					(0.0000)
State coefficients	MV	0.911	0.578	0.551	0.672	0.675	0.475	0.488	0.475	0.927	0.578	0.572	0.582	0.567	0.467	0.470	0.470	0.467	0.484
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0101)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.7242)	(0.0000)	(0.0005)	(0.0000)	(0.0011)
	IP	−0.413	−0.670	−0.678	−0.671	−0.672	−0.690	−0.691	−0.682	−0.408	−0.670	−0.649	−0.652	−0.653	−0.682	−0.670	−0.670	−0.670	−0.679
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	Swaps		0.926			0.934	0.827	0.928	0.926		0.926		0.967	0.966		0.753		0.754	0.777
			(0.0000)			(0.0000)	(0.0000)	(0.0000)	(0.0000)		(0.0000)		(0.0000)	(0.0000)		(0.0000)		(0.0000)	(0.0000)
	CDS			0.305		0.901		0.899	0.899										
				(0.0000)		(0.0000)		(0.0000)	(0.0000)										
	Reserves				0.934		0.752	0.769	0.809			0.973	1.025	1.023			0.753	0.976	0.974
					(0.0000)		(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)
	VIX								0.236					0.941					0.948
									(0.0000)					(0.0001)					(0.0000)
State error	MV	−0.285	−0.526	−0.952	−0.646	−0.750	−0.588	−0.610	−0.633	−0.270	−0.626	−0.544	−0.581	−0.621	−0.119	−0.470	−0.470	−0.476	−0.562
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0235)	(0.0000)	(0.0000)	(0.0000)	(0.0008)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	IP	−1.377	−1.446	−1.402	−1.388	−1.391	−2.0655	−2.460	−1.469	−1.546	−1.448	−1.518	−1.531	−1.476	−1.527	−1.427	−1.427	−1.314	−1.365
		(0.0000)	(0.0000)	(0.3536)	(0.3316)	(0.0924)	(0.0000)	(0.0000)	(0.0005)	(0.004)	(0.0000)	(0.0307)	(0.0001)	(0.0023)	(0.0000)	(0.3780)	(0.0000)	(8.2405)	(0.1083)
	Swaps		1.411			1.812	1.792	1.781	1.785		1.411		1.121	0.852		1.681		1.850	1.785
			(0.0000)			(0.0000)	(0.0000)	(0.0000)	(0.0000)		(0.0001)		(0.0000)	(0.0000)		(0.0000)		(0.0000)	(0.0000)
	CDS			2.076		3.272		3.103	3.124										
				(0.0000)		(0.0000)		(0.0000)	(0.0000)										
	Reserves				1.742		3.223	1.668	1.671			1.243	1.610	1.591			1.681	1.394	1.337
					(0.0000)		(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)			(0.0000)	(0.0000)	(0.0000)
	VIX								0.210					3.084					2.425
									(0.0018)					(0.0000)					(0.0000)
Covariance	$\sigma^{\eta i}$	8.396	7.771	7.728	7.814	7.867	9.040	9.026	8.456	9.400	7.771	7.954	7.863	7.716	8.516	8.782	8.782	8.794	9.337
		(0.0576)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0010)	(0.0004)	(0.0003)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log likelihood		−404.2	−694.57	−777.19	−722.91	−736.61	−866.91	−916	−787.05	−409.3	−694.62	−693.82	−732.2	−734.13	−530.3	−626.41	−626.41	−690.94	−795.15
AIC		0.87	1.48	1.66	1.54	1.58	1.85	1.96	1.70	0.89	1.48	1.50	1.59	1.57	1.34	1.59	1.59	1.76	1.78
N		948	948	948	948	948	948	948	948	936	936	936	936	936	799	799	799	799	799

Note: The maximum likelihood method is used to estimate the expected currency returns. The signal coefficients are represented in Equation (6), whereas state coefficients and state errors are represented in Equation (13). $\sigma^{\eta i}$ is the covariance of errors in interest rate differential and missing variable in Equation (14). CDS is removed from the 1-month and 1-year equation due to the high correlation with interest rate differentials at those maturities. Standard errors are reported in parenthesis.

Alternatively, the sign of the coefficients for the VIX and CDS are both positive. This means that the increase in volatility and default risk increases the risk premium as high sovereign risk increases expectations for future devaluation and high volatility in the currency (Della Corte, Riddiough, and Sarno 2016). The econometric results are consistent with the literature that CDS has a time-varying impact on exchange rates, and the effect is relatively small (Omachel and Rudolf 2014; Hassan, Kayhan, and Bayat 2017). The empirical literature associated with Turkish data also presents results consistent with our findings. Hassan, Kayhan, and Bayat (2017) studied the causation linkage from CDS spreads to the value of the TL against the US dollar between 2009 and 2015. They suggested that CDS spread changes might be useful in predicting exchange rate instability. In a recent study by Yildirim (2020), the adverse country risk premium shock, partially measured by CDS spreads, led to a significant and persistent depreciation of the TL. Oner and Oner (2022) found that CDS premium had a high explanatory power to explain the changes in the BIST 100 index, USDTRY exchange rate and bond interest rates.

Overall, our results present that the explanatory coefficients in the signal equations are notably larger than the coefficient for the interest rate differential, underscoring the limited role of interest rate differentials in explaining the risk premium. Among the observable variables, currency swap deals have the highest explanatory power. However, their magnitude decreases slightly with the inclusion of variables such as VIX or CDS, particularly for 1-month maturity. This pattern indicates that while swaps dominate, other variables contribute to explaining the risk premium's variability.

5.3.2.1 | Persistence of Shocks. The state coefficients represent the persistence of shocks, which varies by maturity and frequency. The persistence of shocks for the interest rate differential and currency swaps is greater with weekly frequency. Meanwhile, the coefficient for the missing component is higher for the baseline model in both daily and weekly frequencies. A positive sign for the missing component and a negative for the interest differential indicate opposing dynamics. The state coefficient of the missing component impact (shock) is significantly reduced when observable variables are added. This promising result shows that the shocks of the unobserved part of the risk premium can be measured by including selected observed variables.

Furthermore, the coefficient of the missing component is reduced the most when we add currency swaps and foreign reserves into our model. Nevertheless, the fitness of the model improves significantly by even just including currency swaps as an explanatory variable. Adding other variables such as credit default and stock market risks slightly reduces the missing component. This reduction indicates that these observable factors help account for the variability previously attributed to the missing component, thereby mitigating the overall impact of latent risks.

5.3.2.2 | Impact on Volatility. Incorporating currency swaps into the model amplifies the standard error of the missing risk component. This finding implies that while observable variables explain some of the model's variation, they also introduce additional uncertainty, making the shocks associated with the missing risk premium more unpredictable. In line with Dahlquist and Pénasse (2022), our analysis reveals that interest rate differential shocks exhibit higher volatility than missing risk premium shocks. Because the CDS is used only for 1-month maturity, its volatility is significantly higher compared to other risk factor shocks.

The relationship between swap activities and the latent risk premium highlights the dual-edged nature of such interventions by the CBRT. Although currency swaps effectively manage immediate currency pressures, they also signal underlying economic vulnerabilities and contribute to the unpredictability of the risk premium. The market might perceive large-scale swap agreements as indicators of deeper issues, leading to an increased risk premium and heightened volatility. Thus, while swaps stabilise the currency in the short term, they add complexity and long-term risks by increasing the standard error of the latent risk premium.

Finally, $\sigma^{\eta i}$ represents the correlation between interest differential shock and missing variable shocks. The shocks for missing risk premium and interest rate differential are positively related. The high coefficients signal that even though the interest rate differential has low explanatory power in explaining risk premium, its shock significantly impacts the risk premium shock. This result is corroborated when the variance decompositions are examined in the following section.

5.3.2.3 | Robustness Check. For the robustness test, we tested our model with monthly frequency. The goodness of the fit is significantly lower in monthly analysis compared to daily and weekly analysis (see Appendix 6). All coefficients have the same signs observed in higher frequencies. The absolute values of the observable variables' signal coefficients are significantly higher than other frequencies. One possible reason is that the higher frequency data better captures the short-term fluctuations in the selected variables. In addition to this, the missing risk premium is expected to have an important role, especially in very short periods, even before the expectations are shaped.

In monthly analysis, VIX has the highest coefficient compared to other observable variables. The persistence of the shocks for interest rate differential and currency swaps continues to increase for shorter maturities with less frequency analysis. Compared to other frequencies, the coefficient of the missing component reduces significantly, ensuring that the missing variable is more effective in higher-frequency analyses. The relationship between the missing variable and the observable variables is not as strong as we observed in higher frequencies.

Alternatively, we included additional observable variables to test the impact of external factors on risk premium. For example, we included the world currency variance risk premium (XVP) in the daily and weekly estimations (see Londono and Zhou (2017) for the calculation of XVP). The estimated coefficients are similar to those obtained when XVP was added to the existing observable variables. However, the AIC offers a better fit for the models using VIX instead of XVP, especially in the weekly estimations (see Appendix 7 for the results).

5.4 | Variance Decompositions

This section determines the fraction of the unexpected currency return that can be attributed to each component in the model. The error terms are derived from the observation equation of the SSM. These terms represent the unexplained part of the risk premium movement and are thus called the unexpected currency return. Subsequently, the observable variable shocks are derived from the error terms in the state equations of the SSM. We thereby decompose the unexpected currency return into observable variable shocks to explain what fraction of it is explained by the selected variables. The variance decomposition of the unexpected currency returns is calculated according to the following formula:

$$1 = \frac{\mathrm{Cov}\left(\varepsilon^{\eta}_{t+1}, \varepsilon^{rx}_{t+1}\right)}{\mathrm{Var}\left(\varepsilon^{rx}_{t+1}\right)} + \frac{\mathrm{Cov}\left(\varepsilon^{i}_{t+1}, \varepsilon^{rx}_{t+1}\right)}{\mathrm{Var}\left(\varepsilon^{rx}_{t+1}\right)} + \frac{\mathrm{Cov}\left(\varepsilon^{y}_{t+1}, \varepsilon^{rx}_{t+1}\right)}{\mathrm{Var}\left(\varepsilon^{rx}_{t+1}\right)} \tag{15}$$

The baseline model includes only the interest rate differential and the missing variable. The unexpected currency return, $\varepsilon^{\mathrm{rx}}$, is calculated from Equation (6), whereas the missing variable shock, ε^{η}, and interest differential shock, ε^{i}, are calculated from Equations (7) and (8), respectively. Alternatively, we use other $\varepsilon^{\mathrm{rx}}$, which includes all other observable variables in the signal equation and their shocks, ε^{y}, such as currency swaps, CDS, reserves and VIX calculated from Equation (8).

Table 6 presents the variance decomposition of the unexpected currency return for daily frequency[6]. The interest differential captures most of the variation in the unexpected currency return. In other words, although the impact of interest differential on the risk premium and the forward premium is small, its impact on the latent factor is colossal. Nevertheless, the fraction of the effect is significantly reduced when we introduce currency swaps, especially for the O/N and 3-month maturities. For example, the O/N interest rate differential accounts for 90% of the variance of unexpected return for the baseline model, yet it falls to 38% when currency swaps are added. Similarly, the 3-month interest differential accounts for 100% of the variance in the baseline model, but it is reduced to 85% when swaps are introduced. Nevertheless, the fraction of the impact of currency swaps is meagre for all maturities. Incorporating observable variables such as swaps into the model amplifies the standard error of the missing risk component.

Table 7 reports the variance decomposition for the unexpected currency return for weekly frequency when all other observable variables are added. The additional predictors explain only a tiny fraction of the unexpected currency return. The interest rate differential still explains the large fraction of the unexpected currency return. One possible explanation for this finding is the significant change in the CBRT policy that allowed the official rates to perseveringly deviate from the Taylor principle since 2018. When the monetary policy maintains low interest rates permanently, it lowers inflation and appreciates the domestic currency (Uribe 2022). Substantial evidence supports monetary policy decisions leading to higher uncertainty in Turkey's foreign exchange markets. For example, Gürkaynak, Kısacıkoğlu, B, and Lee (2023) argued that the so-called neo-Fisherian effect led the TL's exchange value into a free fall. Öge Güney (2023) also studied the impact of uncertainty in the interest rate on causing volatility in the exchange rate in Turkey. Cevik and Erduman (2020) analysed the immediate effect of the real exchange rate on monetary policy uncertainty. Finally, we also measured the explanatory variables' variance ratios to the risk premium variance (see Appendix 8). The relative variance of missing variables is significantly reduced as additional explanatory variables are introduced into the model.

6 | Policy Implications

The empirical findings of this study provide critical insights for policymakers and investors navigating the complex dynamics of the TL amidst the CBRT's evolving monetary policies. The analysis reveals that the missing risk component plays a significant role in explaining the variability of the TL's exchange rate, particularly in periods of heightened economic uncertainty. The latent risk premium, which reflects unobserved factors influencing the currency market, becomes especially pronounced when the interest rate differential is insufficient to fully capture the risk dynamics.

For policymakers, particularly within the CBRT, the study underscores the importance of maintaining a cautious approach to monetary policy interventions. The shift towards heterodox policies, characterised by aggressive use of currency swap deals

TABLE 6 | Variance decomposition of the unexpected currency return (daily).

Maturity	O/N		1M		3M		1Y	
Model	1	2	1	2	1	2	1	2
MV	0.341 (0.0008)	0.365 (0.0438)	0.343 (0.0011)	0.522 (0.0093)	0.321 (0.0013)	0.479 (0.0492)	0.302 (0.0024)	0.342 (0.0618)
IP	89.655 (0.1267)	37.608 (0.3746)	111.953 (0.1571)	105.023 (0.7837)	100.580 (0.1587)	85.445 (0.7932)	72.914 (0.1856)	69.078 (0.8674)
Swaps		2.816 (0.1133)		−0.084 (0.1037)		−0.093 (0.1115)		−0.039 (0.1126)
N	4166	553	4758	565	4758	585	4250	584

Note: Standard errors are reported in parenthesis.

TABLE 7 | Variance decomposition of the unexpected currency return (weekly).

Maturity	1M								3M					1Y				
Model	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**4**	**6**	**8**	**1**	**2**	**4**	**6**	**8**
MV	0.313 (0.0381)	0.998 (0.0141)	0.487 (0.0187)	0.441 (0.0830)	1.023 (0.0962)	1.509 (0.1420)	1.702 (0.1573)	1.439 (0.1354)	0.126 (0.0130)	0.656 (0.0979)	0.472 (0.0843)	0.645 (0.2025)	0.617 (0.1947)	0.545 (0.0080)	0.604 (0.1404)	0.543 (0.1012)	0.608 (0.3160)	0.582 (0.2584)
IP	122.511 (0.5805)	93.442 (1.1054)	51.002 (0.4329)	46.688 (0.3235)	91.359 (1.1078)	82.897 (1.0814)	77.276 (1.0610)	66.454 (1.0795)	54.108 (0.3469)	46.928 (1.1385)	24.130 (0.3062)	39.709 (1.0862)	35.812 (1.0818)	16.848 (0.4296)	−31.070 (1.1516)	8.623 (0.28139)	−26.502 (1.0710)	−22.797 (1.0878)
Swaps		0.015 (0.1283)			1.153 (0.1084)	2.236 (0.2104)	3.086 (0.2856)	2.618 (0.2463)		0.023 (0.0926)		0.024 (0.3641)	0.026 (0.3250)		0.059 (0.14629)		0.073 (0.5491)	0.070 (0.4187)
CDS			1.394 (0.0380)		0.813 (0.0765)		2.108 (0.1972)	1.805 (0.1698)										
Reserves				0.082 (0.0967)		0.090 (0.0085)	0.358 (0.0336)	0.390 (0.0367)			0.030 (0.1360)	0.068 (0.1171)	−0.024 (0.2228)			0.073 (0.1480)	0.080 (0.2965)	0.077 (0.2289)
VIX								1.208 (0.1137)					0.064 (0.2012)					−0.071 (0.2173)
N	947	112	791		113	113	113	113	946	104	935	105	105	798	64	798	65	65

Note: CDS is removed from the 1-month and 1-year equation due to the high correlation with interest rate differentials at those maturities. Standard errors are reported in parenthesis.

and other unconventional measures, has had a notable impact on the TL. Although these measures have provided short-term stabilisation, they have also contributed to an increase in the standard error of the missing risk component, indicating greater unpredictability in the currency's risk profile. Additionally, the persistence of this latent risk decreases when observable factors are included in the analysis, suggesting that a more transparent and consistent monetary policy framework could mitigate the long-term risks associated with these unobserved factors. Policymakers should therefore focus on enhancing the predictability and transparency of their actions, reducing reliance on ad hoc interventions that could exacerbate market uncertainty and undermine investor confidence.

For investors, the findings emphasise the need for heightened vigilance in managing exposure to the TL. The presence of a significant and volatile missing risk component indicates that the TL is subject to risks that are not fully captured by traditional economic indicators. Investors must therefore account for these latent risks in their decision-making processes, recognising that the CBRT's unconventional policy measures may introduce additional layers of uncertainty. In particular, the study highlights the critical role of swap activities in influencing the TL's exchange rate, with these interventions contributing to both immediate currency stabilisation and increased volatility in the risk premium. Investors should remain cautious about the potential for abrupt changes in the TL's value, particularly in an environment where the CBRT's policies might shift rapidly in response to political or economic pressures.

In summary, the policy implications of this study call for a consistent and transparent approach by the CBRT towards a monetary policy that reduces the unpredictability of the TL's risk profile. For investors, the key takeaway is the importance of incorporating the latent risk premium into their risk assessments, particularly in light of the CBRT's reliance on unconventional policy tools that can significantly impact the currency's stability.

7 | Conclusion

This study examines the behaviour of excess returns and risk premia in exchange rates for various maturities in Turkey. The analysis employs ex post data to capture the actual performance of risk premia by incorporating future spot rates rather than expected exchange rates. Our model posits that the risk premium in exchange rates depends not only on interest rate differentials but also on swap activities, foreign reserves, default risk, global uncertainty (VIX) and the unobserved missing risk premium.

Our findings indicate a significant increase in the level and the volatility of the latent risk premium in exchange rates since 2018. This period coincides with when the CBRT transitioned from traditional to heterodox monetary policies. Our results suggest that the unconventional monetary policies implemented by the CBRT have likely contributed to heightened uncertainty surrounding future exchange rates in Turkey. This heightened uncertainty is most prominently reflected in the increased missing risk premium, underscoring the limitations of traditional models in fully capturing the risks of holding TL assets, particularly for longer maturities.

The SSM estimations of Fama's excess returns in the exchange rate show that interest rate differentials influence currency excess returns negatively, implying a tendency for the TL to appreciate against the US dollar when domestic interest rates are relatively high. Notably, our results also show that swap activities exert a more significant impact on excess returns than interest rate differentials. Moreover, including currency swaps in the model leads to a noteworthy reduction in the lasting effect of the shocks associated with the latent component of the risk premium.

Further analyses using risk premium as the dependent variable unveil that interest rate increases, swap agreements and the central bank's foreign reserves contribute to a greater-than-expected appreciation in the exchange rate, thereby diminishing the risk premium. Conversely, heightened uncertainty (as measured by the VIX) and default risk elevate the risk premium. Notably, interest rate differential and swap activities exert the most substantial impact among the explanatory variables. Moreover, the incorporation of observables serves to mitigate the persistence of the missing risk premium shocks.

Overall, this study sheds light on the complex interplay between changes in monetary policy, exchange rate and risk premia in an emerging economy such as Turkey. The findings offer valuable insights for policymakers, investors and other market participants about the importance of missing risk premia in influencing exchange rate behaviour and the potential consequences of shifts in monetary policies on exchange rate dynamics. Although unconventional monetary policies may provide short-term stability, they could potentially introduce long-term risks, increasing the unpredictability of exchange rates. Finally, this study is also subject to limitations. It focused solely on the TL/US dollar exchange rate and used past data, and future research could expand missing risk premia in other major currencies using real-time data.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, Idil Uz Akdogan, upon reasonable request.

Endnotes

[1] For the use of options, see also Taylor (1995) and Filardo, Hubert, and Rungcharoenkitkul (2022).

[2] Premium is called when forward exchange rate is higher than current spot rate, and discount is used when forward exchange rate is less than current spot rate.

[3] Campbell, Lo, and MacKinlay (1996) examined the AC of the stocks and found that the ACs of daily, weekly and monthly stock index returns are positive. Lo and Mackinlay (1990) found negative AC in individual stock returns, whereas weekly portfolio returns were strongly positively autocorrelated.

[4] Alternatively, we run the SSM for monthly frequency. Signs and the magnitude of the coefficients are very similar to weekly frequency. The results are not reported here as the log likelihood values are significantly higher for monthly frequency, yet they are available upon request. A positive value of β in the UIP meaning higher domestic interest rates leading to the expected future depreciation.

[5] We used both swaps and foreign reserves in the state space model as their correlation was below 0.50.

[6] In variance decomposition of the SSM with multiple equations, the sum can exceed 100% because error terms capture independent influences, not a single source of variation.

References

Agur, I., and M. Demertzis. 2013. "Leaning Against the Wind' and the Timing of Monetary Policy." IMF Working Papers, WP/13/86.

Backus, D. K., S. Foresi, and E. Telmer. 2001. "Affine Term Structure Models and the Forward Premium Anomaly." *Journal of Finance* 56, no. 1: 279–304.

Berument, H., and A. Gunay. 2003. "Exchange Rate Risk and Interest Rate: A Case for Turkey." *Open Economies Review* 14, no. 1: 19–27.

Bhatta, G. R., R. Nepal, K. Jayanthakumaran, and C. Harvie. 2022. "Impossible Trinity in a Small Open Economy: A State-Space Model Informed Policy Simulation." *Asian Development Policy Review* 10, no. 3: 200–225.

Burnside, C., M. Eichenbaum, I. Kleshchelski, and S. Rebelo. 2006. "Returns to Currency Speculation." National Bureau of Economic Research Working Papers. No. 12489.

Campbell, J. Y., A. W. Lo, and A. C. MacKinlay. 1996. *The Econometrics of Financial Markets*. Princeton: Princeton University Press.

CBRT. 2022. "Financial Stability Report." Financial Sector, November 2022.

Cevik, S., and Y. Erduman. 2020. "Measuring Monetary Policy Uncertainty and Its Effects on the Economy: The Case of Turkey." *Eastern European Economics* 58, no. 5: 436–454.

Cheung, Y. W. 1993. "Long Memory in Foreign Exchange Rates." *Journal of Business and Economic Statistics* 11, no. 1: 93–101.

Civcir, I. 2003. "The Monetary Models of the Turkish Lira/US Dollar Exchange Rate: Long-Run Relationships, Short-Run Dynamics." *Forecast* 41, no. 6: 43–69.

Commandeur, J. J., and S. J. Koopman. 2007. *An Introduction to State Space Time Series Analysis*. USA: Oxford, University Press.

Dahlquist, M., and J. Pénasse. 2022. "The Missing Risk Premium in Exchange Rates." *Journal of Financial Economics* 143: 697–715.

Delcoure, N., J. Barkoulas, C. F. Baum, and A. Chakraborty. 2003. "The Forward Rate Unbiasedness Hypothesis Reexamined: Evidence from a New Test." *Global Finance Journal* 14, no. 1: 83–93.

Della Corte, P., S. J. Riddiough, and L. Sarno. 2016. "Currency Premia and Global Imbalances." *Review of Financial Studies* 29, no. 8: 2161–2193.

Dornbusch, R. 1976. "Expectations and Exchange Rate Dynamics." *Journal of Political Economy* 84, no. 6: 1161–1176.

Eichengreen, B., and R. Hausmann. 1999. "Exchange Rates and Financial Fragility." National Bureau of Economic Research Working Papers, No. 7418.

Eichengreen, B., A. K. Rose, and C. Wyplosz. 1995. "Exchange Market Mayhem: The Antecedents and Aftermath of Speculative Attacks." *Economic Policy* 10, no. 21: 249–312.

Engel, C. 1996. "The Forward Discount Anomaly and the Risk Premium: A Survey of Recent Evidence." *Journal of Empirical Finance* 3, no. 2: 123–192.

Engel, C. 2016. "Exchange Rates, Interest Rates and the Risk Premium." *American Economic Review* 106, no. 2: 436–474.

Eren, M., S. Basar, and B. Tosun. 2022. "Dollarisation and Risk Premium in a Risky Country: An Investigation on Turkey." *Istanbul University of Journal of Economics* 72, no. 2: 625–651.

Fama, E. F. 1976. *Foundations of Finance*. New York: Basic Books Publishers.

Fama, E. F. 1984. "Forward and Spot Exchange Rates." *Journal of Monetary Economics* 14, no. 3: 319–338.

Filardo, A., P. Hubert, and P. Rungcharoenkitkul. 2022. "Monetary Policy Reaction Function and the Financial Cycle." *Journal of Banking and Finance* 142: 106536.

Fischer, I. 1907. *The Rate of Interest: Its Nature, Determination and Relation to Economic Phenomena*. New York: Macmillan.

Fleming, J. M. 1962. "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates." *IMF Staff Papers* 9: 369–379.

Frankel, J. A. 1979. "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Rates Differentials." *American Economic Review* 69, no. 4: 610–622.

Fratzscher, M., L. Mekhoff, L. S, and M. Schmeling. 2018. "Systematic Intervention and Currency Risk Premia." SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3119907.

Friedman, M. 1953. The Case for Flexible Exchange Rates." Essays in Economics, 157, University of Chicago, Chicago.

Froot, K., and R. H. Thaler. 2001. "Anomalies: Foreign Exchange." *Journal of Economic Perspectives* 4, no. 3: 179–192.

Gabaix, X., and M. Maggiori. 2015. "International Liquidity and Exchange Rate Dynamics." *Quarterly Journal of Economics* 130, no. 3: 1369–1420.

Gürkaynak, R. S., B. Kısacıkoğlu, B, and S. S. Lee. 2023. "Exchange Rate and Inflation Under Weak Monetary Policy: Turkey Verifies Theory." *Economic Policy* 38, no. 115: 519–560.

Hai, W., C. M. Nelson, and Y. Wu. 1997. "Understanding Spot and Forward Exchange Rate Regressions." *Journal of Applied Econometrics* 12, no. 1: 715–734.

Hakkio, C. S. 1981. "Expectations and the Forward Exchange Rate." *International Economic Review* 22, no. 3: 663–678.

Hamilton, J. D. 1994. "State Space Models." In *Handbook of Econometrics*, edited by R. F. Engle and D. L. McFadden, vol. 4. Amsterdam, Netherlands: Elsevier Science.

Hansen, L. P., and R. J. Hodrick. 1980. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis." *Journal of Political Economy* 88, no. 5: 829–853.

Hartley, P. R. 1983. "Rational Expectations and the Foreign Exchange Market." In *Exchange Rates and International Macroeconomics*, edited by J. A. Frenkel. Chicago, IL: University of Chicago Press.

Hassan, M. K., S. Kayhan, and T. Bayat. 2017. "Does Credit Default Swap Spread Affect the Value of the Turkish Lira Against the U.S. Dollar?" *Borsa Istanbul Review* 17, no. 1: 1–9.

Hodrick, R. 1987. *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets*. 1st ed. London: Routledge. https://doi.org/10.4324/9781315014593.

Hofmann, B., I. Shim, and H. S. Shin. 2020. "Bond Risk Premia and the Exchange Rate." BIS Working Papers, No. 775.

Karahan, Ö., and O. Çolak. 2012. "Does Uncovered Interest Rate Parity Hold in Turkey?" *International Journal of Economics and Financial Issues* 2, no. 4: 386–394.

Korkmaz, H. I., and Y. Onay. 2018. "The "Determinants of Currency Risk Premium in Emerging Market Countries." CBT Research Notes in Economics 1806. Research and Monetary Policy Department, Central Bank of the Republic of Turkey.

Kraay, A. 2003. "Do High Interest Rates Defend Currencies During Speculative Attacks?" *Journal of International Economics* 59, no. 2: 297–321.

Kremens, L., and I. Martin. 2019. "The Quanto Theory of Exchange Rates." *American Economic Review* 109, no. 3: 810–843.

Lo, A. W., and A. C. MacKinlay. 1988. "Stock Market Prices do not Follow Random Walks: Evidence from a Simple Specification Test." *Review of Financial Studies* 1, no. 1: 41–66.

Lo, A. W., and A. C. MacKinlay. 1990. "When are Contrarian Profits Due to Stock Market Overreaction." *Review of Financial Studies* 3, no. 2: 175–205.

Londono, J. M., and H. Zhou. 2017. "Variance Risk Premiums and the Forward Premium Puzzle." *Journal of Financial Economics* 124: 415–440.

Lucas, R. E. 1972. "Expectations and Neutrality of Money." *Journal of Economic Theory* 4, no. 2: 103–124.

Mark, N. C. 1985. "On Time Varying Risk Premia in the Foreign Exchange Market: An Econometric Analysis." *Journal of Monetary Economics* 16: 3–18.

Meredith, G. M., and Y. Ma. 2002. "The Forward Premium Puzzle Revisited." IMF Working Papers, No.2002/028.

Mundell, R. 1960. "The Monetary Dynamics of International Adjustments Under Fixed and Flexible Exchange Rates." *Quarterly Journal of Economics* 74, no. 2: 227–257.

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

Öge Güney, P. 2018. "Uncovered Interest Rate Parity: The Turkish Evidence." *Review of Middle East Economics and Finance* 14, no. 2: 20170025.

Öge Güney, P. 2023. "Interest Rate Uncertainty and Macroeconomics in Turkey." *Prague Economic Papers* 32, no. 2: 184–204.

Omachel, M., and M. Rudolf. 2014. "The Linkage Between Sovereign Defaults and Exchange Rate Shocks in the Eurozone: A Measure for Systemic Risk." SSRN e-Journal. https://doi.org/10.2139/ssrn.2513178.

Oner, H., and S. Oner. 2022. "How Does Credit Default Swap Premiums Affect the Turkish Financial Markets?" *Quarterly Journal of Econometrics Research* 8, no. 1: 11–22.

Ozlu, P. 2006. "Risk Premium and Central Bank Intervention." *Central Bank Review Research and Monetary Policy Department, Central Bank of the Republic of Turkey* 61, no. 1: 65–79.

Reuters. 2023. "Turkish Central Bank's Net Forex Reserves Negative for First Time Since 2002, May 26th."

Sargent, T. J. 1973. "Rational Expectations, the Real Interest Rate of Interest and the Natural Rate of Unemployment." *Brookings Papers on Economic Activity* No.2: 429–480.

Sarno, L., P. Schneider, and C. Wagner. 2012. "Properties of Foreign Exchange Risk Premiums." *Journal of Financial Economics* 105: 279–310.

Setser, B. W. 2023. "Turkey's Increasing Balance Sheet Risks." The Council on Foreign Relations (CFR) Blog. https://www.cfr.org/blog/turkeys-increasing-balance-sheet-risks.

Shiller, R. J., Y. Campbell, and K. L. Schoenholtz. 1983. "Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates." *Brookings Papers on Economic Activity* 1: 173–217.

Svensson, L. 1992. "Foreign Exchange Risk Premium in a Target Zone With Devaluation Risk." *Journal of International Economics* 33: 21–40.

Takagi, S. 1991. "Exchange Rate Expectations: A Survey of Studies." *IMF Staff Papers* 38, no. 1: 156–183.

Taylor, C. R. 1995. *Options and Currency Intervention*. London: Centre for the Study of Financial Innovation, October.

Uribe, M. 2022. "The Neo-Fisher Effect: Econometric Evidence From Empirical and Optimising Models." *American Economic Journal: Macroeconomics, American Economic Association* 14, no. 3: 133–162.

Uz Akdogan, I. 2020. "Understanding the Dynamics of Foreign Reserve Management: The Central Bank Intervention Policy and the Exchange Rate Fundamentals." *International Economics* 161: 41–55.

Verdelhan, A. 2010. "A Habit-Based Explanation of the Exchange Rate Risk Premium." *Journal of Finance* 65, no. 1: 123–146.

Yildirim, Z. 2020. "External and Domestic Shocks, Exchange Rate, Country Risk Premia and Macroeconomic Conditions in Turkey." *Istanbul Journal of Economics* 70: 73–111.

Zapatero, F., and L. F. Reverter. 2003. "Exchange Rate Intervention With Options." *Journal of International Money and Finance* 22: 289–306.

Appendix 1

Summary Statistics (Daily Frequency)

		Daily									
		N	**ADF**	**Mean**	**Median**	**Maximum**	**Minimum**	**SD**	**Skewness**	**Kurtosis**	**JB**
Exchange rate	xr	4760	2.15	1.04	0.75	2.95	0.14	0.77	0.94	2.84	699.24***
Forwards	xrf_{on}	4165	1.89	1.13	0.92	2.95	0.14	0.77	0.79	2.60	455.82***
	xrf_{1M}	4759	2.20	1.05	0.76	2.99	0.15	0.77	0.95	2.87	713.79***
	xrf_{3M}	4759	2.35	1.07	0.77	3.10	0.17	0.78	0.97	2.91	742.70***
	xrf_{1Y}	4251	1.92	1.24	0.97	3.34	0.25	0.83	0.92	2.87	600.05***
Interest rate differentials	$i_{on}-i^*_{on}$	4755	2.95**	10.25	9.88	22.02	0.83	3.81	0.67	3.16	360.72***
	$i_{1M}-i^*_{1M}$	4755	4.28***	11.79	10.18	84.56	2.93	7.08	3.46	21.32	75,948.82***
	$i_{3M}-i^*_{3M}$	4755	2.18	12.02	10.24	67.15	2.92	7.03	2.75	13.87	29,427.95***
	$i_{1Y}-i^*_{1Y}$	4755	1.16	12.89	10.35	58.24	3.16	7.90	2.37	10.10	14,430.99***
Forward premium	$xrf_{on}-xr$	4165	9.45***	−0.01	0.00	0.30	−0.32	0.03	−0.96	22.33	65,452.24***
	$xrf_{1M}-xr$	4759	10.04***	0.01	0.01	0.33	−0.30	0.03	−0.73	21.48	68,128.08***
	$xrf_{3M}-xr$	4759	−7.30***	0.03	0.02	0.37	−0.28	0.03	0.21	14.82	27,726.64***
	$xrf_{1Y}-xr$	4251	2.33	0.12	0.10	0.56	−0.15	0.08	1.73	6.79	4659.32***
Risk premium	$xr_{t+1}-xrf_{on}$	4164	−9.06***	0.01	0.00	0.33	−0.26	0.03	1.26	19.05	45,786.04***
	$xrt+30-xrf_{1M}$	4729	−8.24***	0.01	0.00	0.53	−0.22	0.07	1.61	9.66	10,797.54***
	$xrt+90-xrf_{3M}$	4669	−5.25***	0.03	0.01	0.62	−0.32	0.11	1.12	5.63	2326.24***
	$xrt+365-xrf_{1Y}$	3886	2.62*	0.14	0.12	0.79	−0.39	0.19	0.61	4.19	471.52***
Observables											
Swaps		566	2.02	10.68	10.70	10.84	10.46	0.07	−0.37	2.39	21.81***
CDS		3978	2.46	5.59	5.54	6.81	4.70	0.45	0.50	2.50	209.84***
Reserves		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
VIX		4599	6.54***	2.89	2.83	4.42	2.21	0.38	0.84	3.69	629.24***

Note: ***, **, * refer to statistical significance at 1%, 5% and 10%, respectively.

Appendix 2

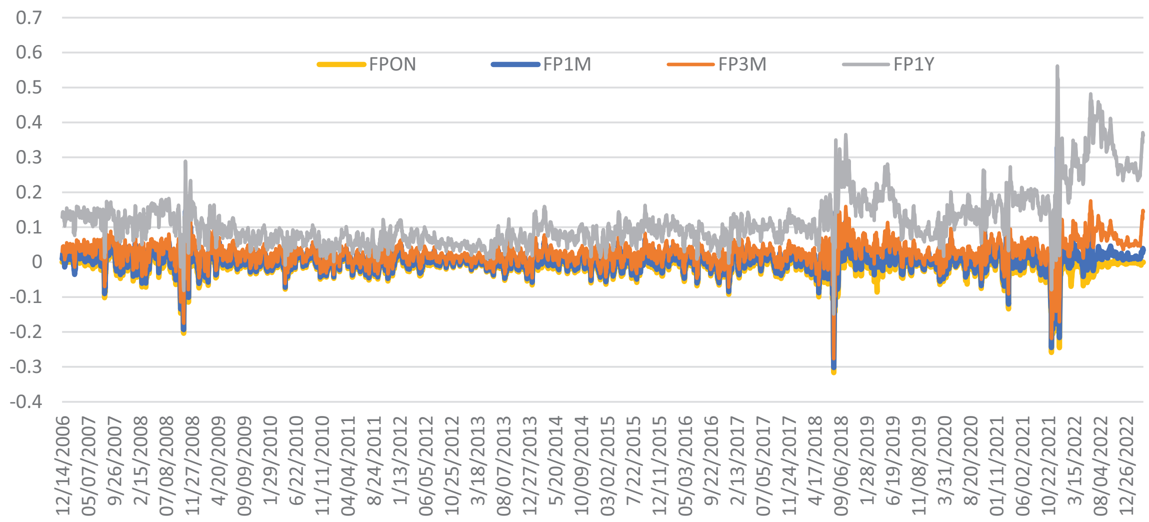
Summary Statistics (Weekly Frequency)

		Weekly									
		N.	**ADF**	**Mean**	**Median**	**Maximum**	**Minimum**	**SD**	**Skewness**	**Kurtosis**	**JB**
Exchange rate	xr	952	2.51	1.04	0.75	2.95	0.14	0.77	0.94	2.85	140.37***
Forwards	xrf_{on}	839	2.23	1.13	0.94	2.95	0.14	0.77	0.79	2.62	92.35***
	xrf_{1M}	952	2.51	1.05	0.76	2.99	0.15	0.77	0.95	2.87	142.73***
	xrf_{3M}	948	2.59	1.07	0.77	3.10	0.17	0.78	0.96	2.90	146.44***
	xrf_{1Y}	851	2.26	1.24	0.97	3.33	0.25	0.83	0.92	2.87	120.27***
Interest rate differentials	$i_{on}-i^*_{on}$	951	−2.30	10.26	9.87	21.58	−0.10	3.83	0.67	3.22	72.34***
	$i_{1M}-i^*_{1M}$	951	−2.09	11.79	10.19	73.52	−0.17	7.13	3.55	22.82	17,563.51***
	$i_{3M}-i^*_{3M}$	951	−1.62	12.00	10.24	67.15	−0.32	6.98	2.70	13.62	5631.83***
	$i_{1Y}-i^*_{1Y}$	951	−1.89	12.84	10.34	56.55	−0.97	7.84	2.34	9.95	2786.24***
Forward premium	$xrf_{on}-xr$	839	−5.55***	0.00	0.00	0.00	−0.01	0.00	−0.45	12.28	3038.65***
	$xrf_{1M}-xr$	952	1.99	0.01	0.01	0.05	−0.06	0.01	1.10	26.03	21,226.02***
	$xrf_{3M}-xr$	948	3.37**	0.03	0.03	0.22	−0.06	0.02	2.36	14.16	5798.54***
	$xrf_{1Y}-xr$	851	0.84	0.12	0.10	0.44	0.04	0.07	1.94	7.12	1136.00***
Risk premium	$xr_{t+1}-xrf_{on}$	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	$xrt+30-xrf_{1M}$	948	−9.07***	0.00	−0.01	0.37	−0.22	0.05	2.05	15.17	6514.18***
	$xrt+90-xrf_{3M}$	936	−5.82***	0.00	−0.01	0.57	−0.26	0.09	1.37	7.91	1233.32***
	$xrt+365-xrf_{1Y}$	803	3.50***	0.05	0.04	0.64	−0.39	0.17	0.61	4.05	87.33***
Observables											
Swaps		117	1.98	10.68	10.70	10.84	10.47	0.07	−0.38	2.48	4.12***
CDS		796	2.50	5.60	5.54	6.77	4.74	0.45	0.51	2.50	42.54***
Reserves		951	2.94**	25.05	25.06	25.47	24.24	0.27	−0.69	3.16	77.57***
VIX		952	−5.20***	2.90	2.83	4.42	2.23	0.38	0.85	3.68	132.84***

Note: ***, **, * refer to statistical significance at 1%, 5% and 10%, respectively.

Appendix 3

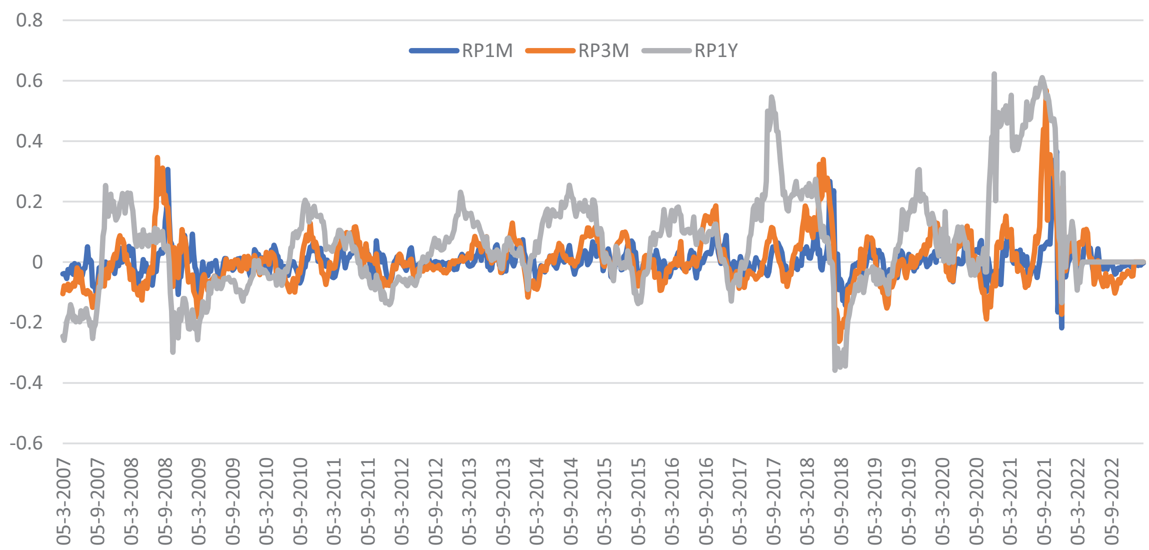
Forward Premium by Maturity



Forward premium by maturity obtained by daily frequency from 14 December 2006 to 31 March 2023.

Appendix 4

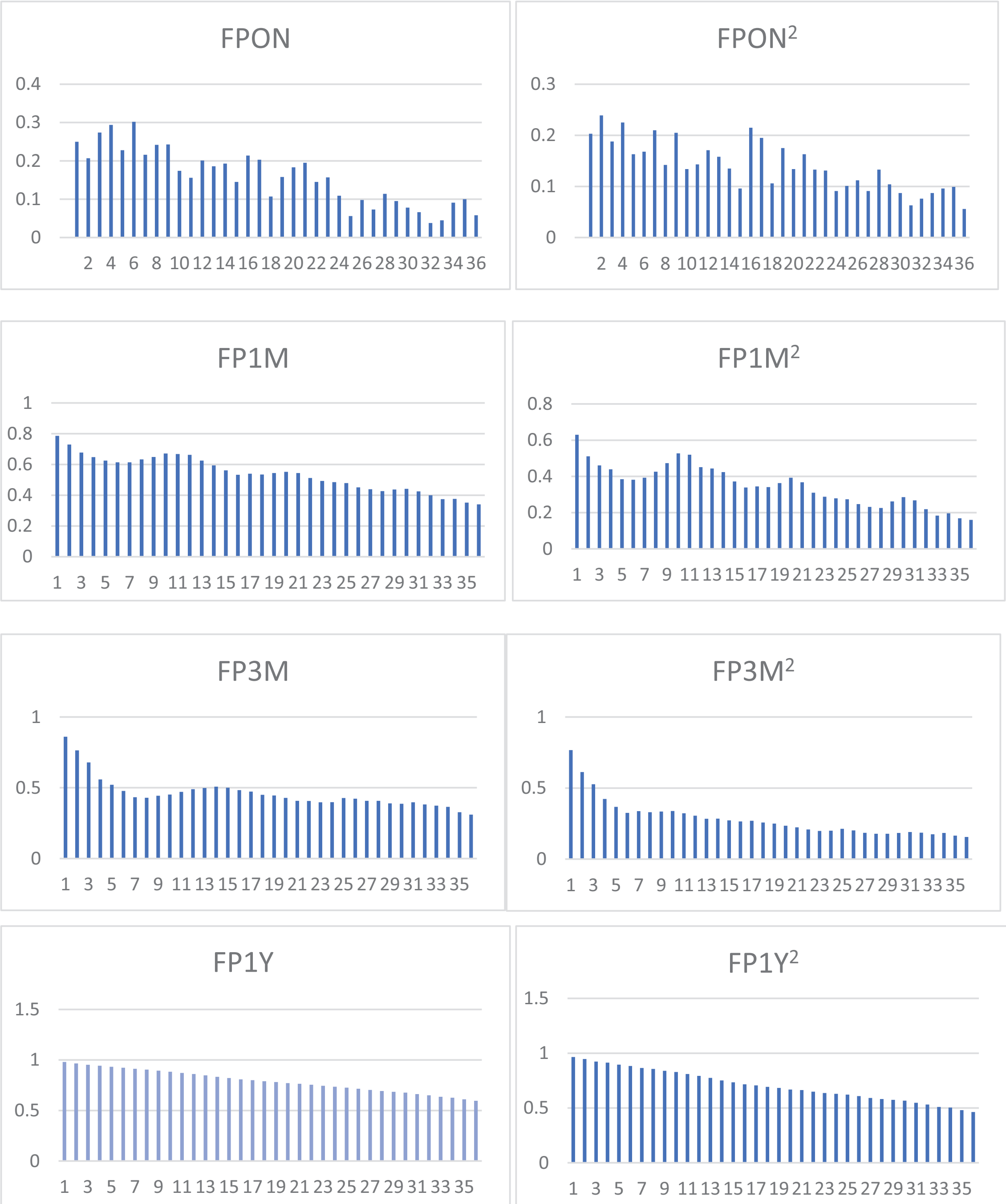
Risk Premium by Maturity



The risk premium by maturity is obtained for weekly data from 5 March 2007 to 26 February 2023.

Appendix 5

Autocorrelation Function of Expected Excess Returns and Squared Expected Excess Returns



In the above graphs, FP represents the forward premium or expected excess returns, O/N is overnight, 1M is 1-month, 3M is 3-month and 1Y is 1-year periods, respectively. The variable upper subscript 2 indicates the variable in question is squared.

Appendix 6

Estimation of the Forward Premium (Monthly Frequency)

	Maturity	1-month								3-months								1-year				
	Model	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Signal coefficients	IP	−0.012 (0.0000)	−0.024 (0.0002)	−0.019 (0.0002)	−0.019 (0.0002)	−0.020 (0.0000)	−0.020 (0.0043)	−0.027 (0.0002)	−0.027 (0.0002)	−0.012 (0.0000)	−0.024 (0.0002)	−0.019 (0.0001)	−0.017 (0.0004)	−0.017 (0.0002)	−0.017 (0.0002)	−0.027 (0.0002)	−0.028 (0.0001)	−0.015 (0.0000)	−0.024 (0.0002)	−0.017 (0.0003)	−0.017 (0.0007)	−0.027 (0.0002)
	Swaps		−0.868 (0.0001)			−0.529 (0.0030)	−0.523 (0.1406)	−0.444 (0.0003)	−0.444 (0.0005)		−0.867 (0.0002)			−0.542 (0.0002)	−0.522 (0.0007)	−0.445 (0.0006)	−0.487 (0.0000)		−0.868 (0.0283)		−0.506 (0.0002)	−0.681 (0.0001)
	CDS			0.5922 (0.0004)		0.1549 (0.0002)		0.3058 (0.0000)	0.2224 (0.0004)			0.5592 (0.0001)		0.3504 (0.0023)		0.3058 (0.0001)	0.5282 (0.0002)					
	Reserves				−0.590 (0.0000)		−0.178 (0.0003)	−0.119 (0.0001)	−0.129 (0.0000)				−0.598 (0.0001)		−0.427 (0.0003)	−0.119 (0.0000)	−0.518 (0.0001)			−0.590 (0.0002)	−0.387 (0.0000)	−0.463 (0.0001)
	VIX								1.1830 (0.0001)								0.2475 (0.0001)					0.8535 (0.0001)
State coefficients	MV	1.701 (0.0000)	0.501 (0.0000)	0.337 (0.0002)	0.366 (0.0007)	0.369 (0.0056)	0.355 (0.0059)	0.379 (0.0003)	0.372 (0.0008)	1.701 (0.0000)	0.500 (0.0000)	0.274 (0.0001)	0.252 (0.0001)	0.242 (0.0057)	0.238 (0.0012)	0.379 (0.0003)	0.386 (0.0008)	1.326 (0.0003)	0.500 (0.0011)	0.251 (0.0002)	0.464 (0.0004)	0.371 (0.0001)
	IP	−0.422 (0.0000)	−0.616 (0.0000)	−0.717 (0.0000)	−0.716 (0.0000)	−0.724 (0.0001)	0.671 (0.0010)	−0.580 (0.0001)	−0.591 (0.0000)	−0.422 (0.0000)	−0.596 (0.0002)	−0.633 (0.0000)	−0.716 (0.0001)	−0.720 (0.0001)	−0.721 (0.0001)	−0.580 (0.0001)	−0.467 (0.0000)	−0.306 (0.0000)	−0.604 (0.0196)	−0.716 (0.0001)	−0.564 (0.0000)	−0.472 (0.0000)
	Swaps		0.873 (0.0002)	0.976 (0.0002)	0.975 (0.0002)	0.975 (0.0008)	0.974 (0.0028)	0.977 (0.0002)	0.977 (0.0112)		0.873 (0.0000)		0.976 (0.0001)	0.985 (0.0040)	0.984 (0.0120)		0.941 (0.0004)		0.873 (0.0002)		0.912 (0.0003)	0.936 (0.0002)
	CDS					0.632 (0.0156)		0.937 (0.0007)	0.927 (0.0383)			0.974 (0.0003)		0.974 (0.0000)		0.937 (0.0006)	0.997 (0.0003)					
	Reserves						0.671 (0.0010)	0.996 (0.0003)	0.996 (0.0112)						0.974 (0.0125)	0.996 (0.0007)	0.984 (0.0003)			0.9753 (0.0003)	0.9827 (0.0005)	0.9830 (0.0006)
	VIX								0.8414 (0.0296)								0.1266 (0.0176)					0.9966 (0.0005)
State error	MV	−0.120 (0.0000)	−0.614 (0.0000)	−0.820 (0.0002)	−0.824 (0.0006)	−0.796 (0.0150)	−0.803 (0.0068)	−0.819 (0.0001)	−0.820 (0.0005)	−0.120 (0.0000)	−0.617 (0.0001)	−0.568 (0.0002)	−0.592 (0.0003)	−0.654 (0.0200)	−0.695 (0.0000)	−0.818 (0.0001)	−0.896 (0.0014)	−0.112 (0.0000)	−0.615 (0.0006)	−0.638 (0.0001)	−0.607 (0.0003)	−0.914 (0.0003)
	IP	−0.566 (0.1939)	−1.535 (0.0325)	−1.456 (0.1385)	−1.435 (0.4324)	−1.445 (0.4075)	−1.533 (0.5241)	−1.535 (0.0194)	−1.535 (0.1484)	−0.569 (0.0124)	−1.848 (0.0007)	−1.518 (0.0225)	−1.431 (1.4312)	−2.927 (0.5558)	−2.918 (0.5014)	−1.553 (0.0847)	−1.745 (0.3185)	−0.630 (0.0937)	−1.453 (0.2225)	−1.435 (0.5428)	−1.593 (0.1265)	−1.814 (0.2368)
	Swaps		1.265 (0.0002)			2.019 (0.0090)	2.003 (0.6040)	2.024 (0.0001)	2.022 (0.0019)		1.246 (0.0003)			1.560 (0.0008)	1.492 (0.0004)		1.640 (0.0008)		1.257 (0.0003)		1.739 (0.0004)	1.508 (0.0002)
	CDS			1.963 (0.0015)		3.255 (0.0013)		2.589 (0.0006)	2.595 (0.0012)			1.655 (0.0000)		1.816 (0.0789)		2.589 (0.0006)	1.294 (0.0007)					
	Reserves				1.942 (0.0004)		3.200 (0.0001)	3.755 (0.0006)	3.752 (0.0012)				1.641 (0.0007)		1.764 (0.0002)	3.755 (0.0008)	1.485 (0.0003)			1.883 (0.0010)	1.488 (0.0004)	1.469 (0.0002)
	VIX								−0.6993 (0.0049)								−0.6859 (0.0221)					−1.4185 (0.0001)
Covariance	$\sigma^{\eta i}$	7.733 (0.0215)	12.104 (0.0934)	8.949 (0.1049)	8.921 (0.0923)	9.572 (0.0016)	9.575 (1.5381)	11.893 (0.0899)	12.121 (0.0936)	7.751 (0.0180)	12.218 (0.1151)	9.564 (0.0726)	8.875 (0.2452)	9.034 (0.8404)	9.101 (0.8158)	11.888 (0.0755)	14.800 (0.0700)	8.912 (0.0138)	12.252 (0.1148)	9.917 (0.1871)	15.445 (0.6557)	14.226 (0.1167)
Log likelihood		−136.43	−278.71	−286.41	−283.45	−298.22	−300.40	−292.90	−301.17	−136.88	−273.79	−246.02	−267.98	−279.46	−283.37	−293.31	−277.25	−108.54	−247.39	−254.40	−227.84	−241.72
AIC		1.30	2.63	2.70	2.67	2.83	2.85	2.81	2.91	1.30	2.58	2.33	2.53	2.66	2.70	2.82	2.70	1.17	2.62	2.69	2.45	2.62
N		219	219	219	219	219	219	219	219	219	219	219	219	219	219	219	219	196	196	196	196	196

Note: The maximum likelihood method is used to estimate the expected currency returns. The signal coefficients are represented in Equation (6), whereas state coefficients and state errors are represented in Equation (13). $\sigma^{\eta i}$ is the covariance of errors in interest rate differential and missing variable in Equation (14). CDS is removed from the 1-year equation due to the high correlation with interest rate differentials. Standard errors are reported in parenthesis.

Appendix 7

Robustness Test Results

	Frequency	Daily				Weekly					
	Maturity	1-month		3-months		1-month		3-months		1-year	
	Model	1	2	1	2	1	2	1	2	1	2
Signal coefficients	IP	−0.012 (0.0000)	−0.012 (0.0000)	−0.013 (0.0000)	−0.013 (0.0000)	−0.012 (0.0000)	−0.013 (0.0000)	−0.011 (0.0000)	−0.011 (0.0000)	−0.016 (0.0000)	−0.016 (0.0000)
	Swaps	−0.229 (0.0000)	−0.233 (0.0000)	−0.194 (0.0000)	−0.196 (0.0000)	−0.1731 (0.0000)	−0.202 (0.0000)	−0.281 (0.0000)	−0.260 (0.0000)	−0.281 (0.0000)	−0.281 (0.0000)
	CDS				−0.262 (0.0000)	0.076 (0.0000)	0.074 (0.0000)				
	Reserves					−0.189 (0.0000)	−0.184 (0.0000)	−0.164 (0.0000)	−0.158 (0.0000)	−0.297 (0.0000)	−0.298 (0.0000)
	VIX		−0.300 (0.0000)				0.240 (0.0000)		0.067 (0.0000)		0.375 (0.0000)
	XVP	−0.260 (0.0000)	−0.21 (0.0000)	−0.264 (0.0000)	−0.195 (0.0000)	0.144 (0.0000)	0.141 (0.0000)	0.064 (0.0000)	0.223 (0.0000)	0.392 (0.0000)	0.204 (0.0000)
State coefficients	MV	0.257 (0.0000)	0.234 (0.0000)	0.345 (0.0000)	0.336 (0.0000)	0.473 (0.0000)	0.475 (0.0000)	0.602 (0.0000)	0.565 (0.0000)	0.488 (0.0000)	0.484 (0.0000)
	IP	−0.403 (0.0000)	−0.393 (0.0000)	−0.400 (0.0000)	−0.400 (0.0000)	−0.678 (0.0000)	−0.685 (0.0000)	−0.653 (0.0000)	−0.656 (0.0000)	−0.700 (0.0000)	−0.703 (0.0000)
	Swaps	0.404 (0.0000)	0.402 (0.0000)	0.425 (0.0000)	0.424 (0.0000)	0.927 (0.0000)	0.925 (0.0000)	0.966 (0.0000)	0.964 (0.0000)	0.872 (0.0000)	0.869 (0.0000)
	CDS					0.893 (0.0000)	0.898 (0.0000)				
	Reserves					0.809 (0.0000)	0.809 (0.0000)	1.023 (0.0000)	1.020 (0.0000)	0.975 (0.0000)	0.975 (0.0000)
	VIX		0.182 (0.0000)		0.209 (0.0000)		0.237 (0.0000)		0.942 (0.0001)		0.948 (0.0000)
	XVP	0.206 (0.0000)	0.249 (0.0000)	0.209 (0.0000)	0.266 (0.0000)	0.050 (0.0007)	0.035 (0.0022)	0.942 (0.0001)	0.266 (0.0000)	0.948 (0.0000)	0.310 (0.0000)

	Frequency	Daily				Weekly					
	Maturity	1-month		3-months		1-month		3-months		1-year	
	Model	1	2	1	2	1	2	1	2	1	2
State error	MV	−0.773 (0.0000)	−0.944 (0.0000)	−0.828 (0.0000)	−0.913 (0.0000)	−0.618 (0.0000)	−0.635 (0.0000)	−0.620 (0.0000)	−0.723 (0.0000)	−0.540 (0.0000)	−0.534 (0.0000)
	IP	−3.141 (0.5065)	−3.067 (0.3271)	−2.022 (0.0220)	−2.105 (0.0000)	−1.511 (0.0534)	−1.466 (0.0000)	−1.503 (0.0045)	−1.478 (0.0007)	−1.343 (0.2024)	−1.406 (0.1565)
	Swaps	−0.828 (0.0000)	−0.815 (0.0000)	−0.919 (0.0000)	−0.910 (0.0000)	1.804 (0.0000)	1.780 (0.0000)	0.885 (0.0000)	0.889 (0.0000)	0.799 (0.0002)	0.801 (0.0000)
	CDS					3.139 (0.0000)	3.120 (0.0000)				
	Reserves					1.686 (0.0000)	1.668 (0.0000)	1.575 (0.0000)	1.568 (0.0000)	1.330 (0.0000)	1.332 (0.0000)
	VIX		−0.301 (0.0000)		−0.342 (0.0000)		0.206 (0.0000)		3.059 (0.0000)		2.308 (0.0000)
	XVP	−0.412 (0.0000)	−0.486 (0.0000)	−0.486 (0.0000)	−0.561 (0.0000)	−0.146 (0.0000)	−0.089 (0.0004)	3.041 (0.0000)	0.190 (0.0000)	2.275 (0.0000)	1.117 (0.0000)
Covariance	$\sigma^{\eta i}$	10.798 (0.0000)	10.769 (0.0000)	8.681 (0.0000)	8.673 (0.0000)	8.176 (0.0000)	8.587 (0.0000)	7.715 (0.0004)	7.824 (0.0002)	11.207 (0.0001)	11.532 (0.0005)
Log likelihood		−501.54	−306.31	−452.69	−392.27	−748.65	−800.41	−722.886	−724.576	−992.39	−1007.61
AIC		0.22	0.14	0.20	0.17	1.62	1.73	1.58	1.59	2.52	2.57
N		4759	4759	4759	4759	948	948	936	936	799	799

Note: The maximum likelihood for the expected currency return estimates is used. The signal coefficients are represented in Equation (6), whereas state coefficients and variance of state errors are represented in Equation (13). $\sigma^{\eta i}$ is the covariance of errors in interest rate differentialand missing variable in Equation (14). Standard errors are reported in parenthesis. The O/N and 1-year maturity estimations for the daily frequency estimations are excluded as there is a high correlation between XVP and interest differentials for those maturities.

Appendix 8

Variance Ratios

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
MV	5.535	3.687	6.942	4.402	3.517	4.927	4.329	1.777
IP	6.999	6.935	6.935	6.999	6.999	6.999	6.999	3.124
Swaps		0.782			0.789	0.789	0.789	0.352
CDS			14.874				15.012	6.700
RES				5.436	5.486	5.486	5.486	2.449
VIX								3.317
N	113	113	113	113	113	113	113	113

Note: It shows the explanatory variables' variance ratios to the risk premium variance. Missing variables are obtained from the state space model, representing the unexplained component of the risk premium. Recently, we examined the behaviour risk premium concerning different explanatory variables for the same period for comparison.