東海大學管理學院財務金融研究所

碩士論文

全球貨幣匯率之預期理論的檢驗

Examination of Expectation Hypothesis on Global Exchange Rate

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本人馮氏芳蘭(學號:G04440701.)已完全了解學術倫理之定義。僅此聲明，本人呈交之碩士論文絕無抄襲或由他人代筆之情事。若被揭露具有違背學術倫理之事實或可能，本人願自行擔負所有之法律責任。對於碩士學位因違背學術倫理而被取消之後果，本人也願一併概括承受。

立證人：馮氏芳蘭＿＿＿＿＿＿(簽名)

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Phung, Thi Phuong Lan.

摘要

相較過往文獻皆拒絕預期理論，因即期匯率變動是遠期匯率與即期匯率之差的不偏誤估計值，因此，本研究根據 Froot and Frankel（1989），將匯率與即期匯率之差的數值拆解成風險溢酬和預測誤差。本研究探討 2003 年至 2013 年期間，全球主要貨幣歐元、英鎊、澳幣、加幣和瑞士法郎等之匯率的期望假設的有效性。本文假設遠期利率是否能成為未來即期利率的無偏預測因子，並解釋期望假設被拒絕之原因。本研究將其分兩部分，分別為預測風險溢價和期望錯誤，而後對期望誤差的決定因素進行評估，並檢驗其是否在拒絕匯率的期望假說方面發揮作用。研究結果與過往文獻之結果是一致地，但不能將其歸因於風險溢價。此外，本文發現投資者行為的總體經濟驚喜和非理性是預期誤差的重要決定因素，而這些因素足夠解釋對期望假說的拒絕。

關鍵詞：風險溢價，理性預期，非理性預期，與時俱變風險溢價，匯率調查，匯率預測。

ABSTRACT

This paper reconsiders the inability of empirical research to account for the widespread finding that the forward exchange rate appears to be a biased predictor of spot rates with a time-varying risk premium. The study follows Froot and Frankel (1989) and others in using dataset on exchange rate expectations to decompose the bias into two components, the correlations of the forward discount with the risk premium and with forecast errors. This study tests validity of expectation hypothesis on major exchange rates, namely Euro dollar, British pound, Australian dollar, Canadian dollar, and Swiss Franc from the period of 2003 and 2013. Specially, we evaluate whether forward rates can be an unbiased predictor of future spot rates and explain why expectation hypothesis is rejected. In this work, we decompose the predictor to risk premium and expectation errors. The determinants of expectation errors are evaluated and tested whether they play a role in rejecting the expectation hypothesis of exchange rates. This is the same result that many authors have found with forward market data, but now it cannot be attributed to risk premium. Moreover, we found that macroeconomic surprises and irrationality from investors' behavior are important determinants of expectation errors. These factors are capable of explaining the rejection of the expectation hypothesis.

Keywords: Risk premium, rational expectation, irrational expectation, time-varying risk premium, survey of exchange rate, exchange rate forecasting.

CONTENTS

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CHAPTER 1 INTRODUCTION

In today's global economy, accuracy in forecasting the foreign exchange rate or at least predicting the trend correctly is of crucial importance for any future investment. The use of computational intelligence based techniques for forecasting has been proved extremely successful in recent times.

The foreign exchange market has experienced unprecedented growth over the last few decades. The exchange rates play an important role in controlling dynamics of the exchange market. As a result, the appropriate prediction of exchange rate is a crucial factor for the success of many businesses and fund managers. Although the market is well-known for its unpredictability and volatility, there exist a number of groups (like Banks, Agency and other) for predicting exchange rates using numerous techniques.

1.1 Background of currency market

Exchange rates prediction is one of the most challenging applications of modern time series forecasting. The rates are inherently noisy, non-stationary and deterministically chaotic. These characteristics suggest that there is no complete information that could be obtained from the past behavior of such markets to fully capture the dependency between the future rates and that of the past. One general assumption is made in such cases is that the historical data incorporate all those behavior. As a result, the historical data is the major player in the prediction process.

In the other hand, many entities have an interest in being able to forecast the direction of exchange rates. Whether you are a business or a trader, having an exchange rate forecast to guide your decision making can be very important to minimize risks and maximize returns.

There are numerous methods of forecasting exchange rates, likely because none of them have been shown to be superior to any other. As we know, currencies are affected by both fundamental and technical factors. Thus, there are 4 popular ways to forecasting the exchange rate such as: purchasing power parity (PPP), relative economic strength approach, economic model and time series model.

First, the purchasing power parity (PPP) is perhaps the most popular method due to its indoctrination in most economic textbooks. The PPP forecasting approach is based off of the theoretical Law of One Price, which states that identical goods in different countries should have identical prices. Based on this underlying principle, the PPP approach forecasts that the exchange rate will change to offset price changes due to inflation. One of the most well-known applications of the PPP method is illustrated by the Big Mac Index, compiled and published by *The Economist*. This light-hearted index attempts to measure whether a currency is undervalued or overvalued based on the price of Big Macs in various countries. Since Big Macs are nearly universal in all the countries they are sold, a comparison of their prices serves as the basis for the index.

Second, as the name may suggest, the relative economic strength approach looks at the strength of economic growth in different countries in order to forecast the direction of exchange rates. The rationale behind this approach is based on the idea that a strong economic environment and potentially high growth is more likely to attract investments from foreign investors. And, in order to purchase investments in the desired country, an investor would have to purchase the country's currency - creating increased demand that should cause the currency to appreciate. This approach doesn't just look at the relative economic strength between countries. It takes a more general view and looks at all investment flows. For instance, another factor that can draw investors to a certain country is interest rates. High interest rates will attract investors looking for the highest yield on their investments, causing demand for the currency to increase, which again would result in an appreciation of the currency. Conversely, low interest rates can also sometimes induce investors to avoid investing in a particular country or even borrow that country's currency at low interest rates to fund other investments. Many investors did this with the Japanese yen when the interest rates in Japan were at extreme lows. This strategy is commonly known as the carry-trade. Unlike the PPP approach, the relative economic strength approach doesn't forecast what the exchange rate should be. Rather, this approach gives the investor a general sense of whether a currency is going to appreciate or depreciate and an overall feel for the strength of the movement. This approach is typically used in combination with other forecasting methods to develop a more complete forecast.

Third, another common method used to forecast exchange rates involves gathering factors that you believe affect the movement of a certain currency and creating a model that relates these factors to the exchange rate. The factors used in econometric models are normally based on economic theory, but any variable can be added if it is believed to significantly influence the exchange rate. You can see that this method is probably the most complex and time-consuming approach of all the ones discussed so far. However, once the model is built, new data can be easily acquired and plugged into the model to generate quick forecasts.

Finally, the last approach is the time series model. This method is purely technical in nature and is not based on any economic theory. One of the more popular time series approaches is called the autoregressive moving average (ARMA) process. The rationale for using this method is based on the idea that past behavior and price patterns can be used to predict future price behavior and patterns. The data you need to use this approach is simply a time series of data that can then be entered into a computer program to estimate the parameters and essentially create a model for you.

Forecasting exchange rates is a very difficult task, and it is for this reason that many companies and investors simply hedge their currency risk. However, there are others who see value in forecasting exchange rates and want to understand the factors that affect their movements. In addition, dozens of studies in international macroeconomics report that the slope coefficient in a regression of the future change in the spot exchange rate on the forward premium, which we call the Bilson (1981) - Fama (1998) (BF) regression, is not only significantly less than one, but less than zero. Interpreting their results as implying a stable relationship in the data, researchers have concluded from this evidence that the forward rate is a biased predictor of future changes in the spot rate and that one can make predictable profits by betting against the forward rate (Obstfeld and Rogoff, 1996, p. 589). To account for these predictable profits, researchers have developed a variety of risk premium models based on the rational expectations hypothesis (REH). Fama (1984) shows that in order for these models to account for the negative slope coefficient, the risk premium needs not only be time-varying but highly variable. However, empirical studies generally find that REH models do not produce nearly enough variation in the premium without implausibly large estimates of the degree of risk aversion.

The forward-discount anomaly, as it is called, has led many researchers to appeal to behavioral-finance models in which a negative bias arises because market participants fall prey to systematic forecasting biases and technical trading. In these models, speculators could earn greater profits simply by betting against the forward rate, but they pass up this obvious opportunity. Such gross irrationality arises because speculators are assumed to underreact or overreact to news, underestimate or overestimate economic growth, or make use of chartists rules in a way that remains fixed over time.

Thus, in this paper, we evaluate whether forward rates can be an unbiased predictor of future spot rates. As we know, in currency and other asset markets, participants revise their forecasting strategies, at least from time to time, as their understanding of the market process develops, and as economic policy and other features of the social context within which they make their trading decisions also change. Such change would lead to shifts in the exchange-rate process. Therefore, through researching the affection of the economic factors to the foreign exchange rates we can explain why expectation hypothesis is rejected. Moreover, defining the determinants of expectation errors whether play a role in rejecting the expectation hypothesis of exchange rates.

1.2 Expectation hypothesis of currency

For decades, finance practitioners and academics have struggled to understand currency fluctuations. The difficulty of explaining and forecasting nominal exchange rates was systematically reported by Meese and Rogoff (1983), and it has continued to be difficult to find variables able to beat a random walk forecasting model for currencies (e.g., see Engel, Mark, and West, 2008). More recently, the literature on exchange rates has focused on a closely related issue, which is high returns to currency investment strategies such as carry and momentum. Analogous to the difficulty of finding definitive answers about the source of currency fluctuations, limited success has been attained in explaining the often high returns to these currency investment strategies in terms of compensation for systematic risk.

There are three main potential reasons for the rejection of the expectation hypothesis (EHs). First, the EHs are based on the assumption of rational expectations and unlimited arbitrage. It maybe that irrational investors make systematic forecast errors, and the ability of rational investors to profit from this situation is limited by their risk aversion. Second, the presence of time-varying risk premium means that standard tests of the EHs omit the variables capturing the risk premium. If these variables are correlated with interest rates, the estimated coefficients would be pulled away from those implied by the EHs. Third, the test themselves may lead to false rejections because of their poor properties in finite samples, which can be caused by highly persistent variables, peso problems, or learning. Bekaert et al.(1997,2001) and Valkanov (1998) analyze the poor finite sample behavior of expectation hypothesis of interest rates tests, and Baillie and Bollerslev (2000), Maynard and Phillips (1998), and Roll and Yan (2000) argue that poor small-sample behavior may explain the results expectation hypothesis of foreign exchange rate tests. These papers note that if standard tests are poorly behaved in small samples, inference based on standard asymptotic distribution theory is distorted, and alternative methods of inference are necessary.

1.3 Research objective

Empirical tests of forward foreign exchange rates as predictors of future exchange rates are too numerous to enumerate. The assumption that the forward exchange rate is an unbiased predictor of the future spot exchange rate is widely used in both theoritical and empirical studies. However, the forward rate unbiasedness hypothesis has been rejected in a large number of studies using data for many different countries and time periods (Engel, 1996; Froot and Thaler, 1990; Lewis, 1995). In the absence of further information, it is difficult to tell whether this finding is evidence of a time-varying exchange risk premium, as many authors claim, or whether investors' expectation themselves are subject to in-sample bias, as other argue.

The empirical literature on the term structure exchange rates suggests that the rejection of ***the unbiased expectations hypothesis (UEH)*** has been commonly attributed to either the existence of the time-varying term premium or irrationality, or some combination of the two. A number of studies attempt to explain the existence of the time-varying term premium. For example, Engle et al. (1987) propose a conditional variance model to explain excess return and claim that an ARCH-type model is an appropriate approach to modeling the time-varying risk premium. Lee (1995), Bekdache (2001), and Backus and Wright (2007) argue that the term premium should be explained by using macroeconomic variables and not by depending exclusively on asset return covariance. Recently, Jongen et al. (2011) investigate the time-varying term premium in a wide range of international markets and conclude that the time variation seems to arise from changing attitudes toward risk among market participants.

In addition to that a number of papers have attempted to use dataset as an independent source of information on investors' expectations. These studies have tended to find little evidence of a time-varying risk premium. But they have been confined to exchange rate for four foreign currencies (the Yen, Mark, Pound and Swiss Franc) against the dollar. These may be five of the least risky currencies in the world, by the measure of inflation variability, for example. Thus, in this study we will test validity of expectation hypothesis on major exchange rates, evaluate whether forward rates can be an unbiased predictor of future spot rates and explain why expectation hypothesis is rejected.

1.4 Structure of this research

The aim of the analysis presented in this paper is to determine whether the forward rate unbiasedness hypothesis has been rejected because market behavior is inconsistent with expectations (rational and irrational) or because there exists a time varying risk premium. This paper differs from the existing literature in several respects. First, the existing literature has generally examined the rational-expectations hypothesis or the hypothesis of a time-varying risk premium, but not both, especially irrational factors. Our investigation focuses on the relationship between the market's expectations and expectation errors. By constructing a sentiment index to proxy the deviations from expectation errors, this study shows that market expectations are systematically biased and deviate from rational expectations. As a result, the evidence indicates that part of the expectations error is attributable to irrational behavior.

Second, this study demonstrates that expectation errors comprise two components. This study identifies the sources of expectation errors and tests the significance of each element. In this way, agents' overreaction or underreaction can be explained partly by irrationality and partly by an unexpected regime change.

Third, this study investigates the variations in expectation errors in relation to market noise and macroeconomic surprises by testing the significance of (1) investor sentiments that measure the deviation of market behavior from rationality, and (2) unexpected macroeconomic shifts that represent the pseudo peso bias due to the limited information that generates persistent errors. A clear empirical significance is able to provide more concrete evidence of the economic behavior of expectation errors, in turn, a meaningful insight into the failure of the UEH.

The remainder of the paper is organized as follows. Chapter 1 introduces about the overview of predict the foreign exchange rates, the research objective, research suggestion and theories. Chapter 2 reviews the related literatures, data and provides appropriate interpretation. In chapter 3, we reproduce the standard regression test of forward discount bias into a component attributable to systematic expectation errors and a component attributable to the risk premium. In additional, we test the statistical significance of the component attributable to the risk premium and the component attributable to systematic expectation errors, respectively. After that, we analyze the expectation error by decomposing it into rationality and irrationality, examines the economic factors pertinent to explaining the expectation error. The final chapter is conclusion.

CHAPTER 2 LITERATURE REVIEW

The hypothesis that the forward rate is unbiased predictor of the future spot rate has been rejected in many empirical studies. The rejection of this hypothesis could occur because is inconsistent with rational-expectations or because there exists a risk premium. So in this paper, equations describing the forward premium and the change in the exchange rate are estimated jointly, and tests of both the rational and irrational expectations hypotheses are conducted. Empirical estimates, obtained using the dataset on the five foreign currencies.

2.1 Literature review

There is much empirical work on forward exchange rates as predictors of future spot exchange rates. For example, Hansen and Hodrick (1980), Bilson (1981), and the review article by Levich (1979). There is also a growing literature on whether forward rates contain variation in premiums. For example, Frankel (1982), Hsieh (1982) and Domowitz and Hakkio (1983). There is a general consensus that forward rates have little power to forecast changes in spot rates. There is less consensus on the existence of time varying premiums in forward rates. Frankel (1982) and Domowitz and Hakkio (1983) fail to identify such premiums, while Hsieh (1982) and Korajczyk (1983) find evidence consistent with time varying premiums.

Charles Engel (1995) summarized as: first, empirical tests routinely reject the null hypothesis that the forward rate is a conditionally unbiased predictor of future spot rates. Second, models of the risk premium have been unsuccessful at explaining the magnitude of this failure of unbiasedness. In that paper, some progress has been made toward understanding the empirical findings when one allows for peso problem, learning, and possibly a group of agents whose irrational expectations lead to speculative bubbles through a bandwagon effect. A likely outcome of future research is that risk premia, peso problem, learning, irrational speculative bubbles, as well as the effects of small transactions costs will be found to play a role in explaining forward rate bias.

Some research papers (Jardet, 2008; Bekaert et al., 2001; Evans and Lewis, 1994) argue that relying on the time-varying term premium would not provide a full explanation for the failure of the UEH, since it fails to capture all of the empirical characteristics of the behavior of the term structure of foreign exchange market. In fact, a number of studies show that persistent expectation errors are observed, since economic agents tend to overreact or underreact to information when forming their expectations for projecting future movements in interest rates. For instance, Froot (1989) discovered that the expectations of short-term instruments systematically underreact to short rates, whereas the expectations of long-term instruments tend to overreact to long rates. The excess sensitivity hypothesis proposed by Mankiw and Summers (1984) claims that the long rate may respond "too much" to the short rate. Shiller (1979) examines the smoothing property of the UEH and finds that long rates are too volatile to be consistent with the theory. On the other hand, Ederington and Huang (1995) find that some short rates overreact and are referred to in the market as "myopic." By observing investors' behavior, Shefrin (2008) interprets the excess sensitivity of the long rate as the impact of market sentiment on the term structure.

Moreover, we can see that exchange rate expectations play an important role in the literature on exchange rate determination. Following early studies of Dominguez (1986) and Frankel and Froot (1987), many researchers have studied the nature of exchange rate expectations using dataset. Engel (1996) and Lewis (1995) summarize the literature on exchange rate expectations assuming rational expectations.

On the others hand, following Corte, Ramadoria and Sarno (2016) the currency volatility risk premium is the difference between expected future realized currency volatility and a model-free measure of implied volatility derived from currency options. A growing literature studies the variance or the volatility risk premium in different asset classes, including equity, bond, and foreign exchange (FX) markets. In general, this literature has shown that the volatility risk premium is on average negative: Expected volatility is higher than historical realized volatility and, because volatility is persistent, expected volatility is also generally higher than future realized volatility. In that paper, they discover a new currency strategy with high risk-adjusted returns, excellent diversification benefits relative to the set of previously discovered currency strategies, and unusual properties that provide clues to the underlying drivers of exchange rate movements.

Furthermore, Ammann and Buesser (2013), based on the theory of static replication of variance swaps they assess the sign and magnitude of variance risk premiums in foreign exchange markets. They find significantly negative risk premiums when realized variance is computed from intraday data with low frequency. As a likely consequence of microstructure effects however, the evidence is ambiguous when realized variance is based on high-frequency data. Common to all estimates, variance risk premiums are highly time-varying and inversely related to the risk-neutral expectation of future variance. When they test whether variance risk premiums can be attributed to classic risk factors or fear of jump risk, they find that conditional premiums remain significantly negative. However, they observe a strong relationship between the size of log variance risk premiums and the VIX, the TED spread and the general shape of the implied volatility function of the corresponding currency pair. Overall, they conclude that there is a separately priced variance risk factor which commands a highly time-varying premium.

On the other side, time series studies estimating multiple-period changes can use overlapping data in order to achieve greater efficiency (Gilbert, 1986). The overlapping of observations creates a moving average error term and thus ordinary least squares (OLS) parameter estimates would be inefficient and hypothesis tests biased (Hansen and Hodrick, 1980). Our paper seeks to improve econometric practice when dealing with overlapping data by using the method of Newey and West (1987) to accommodate the overlapping data problem. While others papers concentrate to study about how the risk premium affected to the future spot exchange rates, and ignore the influence of the rational and irrational factors on it. Thus, in the light of the empirical issues above, this paper extends the current literature by focusing on the investigation of the expectations error. By constructing a sentiment index to proxy the deviations from rational expectations, this study shows that market expectations are systematically biased and deviate from rational expectations. As a result, the evidence indicates that part of the expectations error is attributable to irrational behavior.

2.2 Data

Instead of using dataset as the others, in this paper we apply a new data set to the problem of exchange rate expectations and the risk premium. This data set is derived from DataStream, CME DataMine and Baker sentiment index database to test on the five foreign currencies (Euro dollar, British pound, Australian dollar, Canadian dollar, and Swiss Franc). The CME Group is the largest foreign currency futures market in the United States, and offers futures contracts on G10 currency pairs as well as emerging market currency pairs and e-micro products.

This study uses monthly Euro dollar futures rates from March 2003 to March 2013 to test the validity of the UEH, with the 212 monthly observations. This sample is collected from Datastream, Chicago Mercantile Exchange & Chicago Board of Trade (CME Group DataMine) and Baker sentiment index database. Not like the previous studies, instead of using dataset following the Froot (1989), Cavaglia et al.(1994) and Jognen et al., (2011), we use exchange-traded Eurodollar futures rates as alternatives .

Spot exchange rates and forward rates for five major currencies are taken from DataStream, future rates are taken from CME Group DataMine which is the Eurodollar futures rates. The Eurodollar futures rates are employed to measure the market's expectations of future rates, which is different from the dataset generally used in previous studies. In contrast to dataset, the forecasts from Eurodollar futures markets offer up-to-date information; futures market participants have a stronger incentive than economists to assess and use public information. As a result, these participants are considered to be a better group for representing the market consensus on future spot rates. All rates are U.S. dollars per unit of foreign currency. In addition, the sentiment index is taken from Baker sentiment index database such as demand for liquidity, inflation, industrial production index, M2 and yield spread.

CHAPTER 3 RESEARCH METHODOLOGY AND RESULT

This section presented extends the analysis of Frankel and Froot (1989) and using dataset on exchange rate expectations to decompose the bias into two components, the correlations of the forward discount with the risk premium and forecast errors.

3.1 The standard test of the forward discount bias

As we know, a forward discount, in a foreign exchange situation, is where the domestic current spot exchange rate is trading at a higher level then the current domestic futures spot rate for a maturity period. A forward discount is an indication by the market that the current domestic exchange rate is going to depreciate in value against another currency. A forward premium occurs when dealing with foreign exchange; it is a situation where the spot futures exchange rate, with respect to the domestic currency, is trading at a higher spot exchange rate then it is currently. A forward premium is frequently measured as the difference between the current spot rate and the forward rate, but any expected future exchange rate suffices.

Thus, to test whether the forward discount is an unbiased predictor of the future change in the spot exchange rate, the most popular regression is used following the equal (1)

$$\Delta \boldsymbol{s_{t+k}} = \boldsymbol{\alpha} + \boldsymbol{\beta f d_t^k} + \boldsymbol{\mu_{t+k}^k} \qquad \textbf{(1)}$$

Where Δs_{t+k} is the percentage depreciation of the currency (the change in the log of the spot price of foreign exchange) over k periods and fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate). Logs are used (a) to make the analysis independent of whether exchange rates are expressed as units of currency i per unit of currency j or units of j per unit of i, and (b) because some models for the premium.

Estimates of (1) tell us whether the current forward-spot differential, forward discount has power to predict the future change in the spot rate, Δs_{t+k}. Evidence that β is reliably non-zero means that the forward rate observed at t has information about the spot rate to be observed at t+k.

The expectations hypothesis under rational expectations implies that the forward premium is an efficient or unbiased forecast of the change in the future spot rate. Thus, the null hypothesis is that $\beta = 1$. Some authors include $\alpha = 0$ in the null hypothesis as well and the residual μ_{t+k}^{k} follows a random process. A constant is allowed to account either for a constant risk premium, or for the convexity term arising from Jensen's Inequality. The results of testing the joint hypothesis are reported in Table 1. Table 1 shows standard error, t-stastic, R square and presents the standard forward discount unbiasedness regressions for our sample periods.

Moreover, in the estimations, Hansen's (1982) generalized method of moments (GMM) standard errors are computed using the method of Newey and West (1987) to accommodate the overlapping data problem. We begin by reproducing the standard OLS regression results for (1) on sample periods that correspond precisely to those that we shall be using for the trading data and using GMM method to get the result of standard error.

The standard error of 3 months in Table 1 is smaller than the standard error of 6 months. Thus, in terms of standard error of forecast errors, the current spot rate which is predicted by 3 months is a better predictor of the 6 months. In addition, the coefficients of determination (R^2) in the both of situation for the regressions are small. It means that there is a little not to suite to use the forward exchange rates in order to forecast the future spot rates.

The common finding is acceptance of the null; with the β usually estimated to be closer to zero than to unity. But in the situation of null hypothesis is $\beta = 0$, the static results from Table 1 show that the null hypothesis is significantly rejected, especially in the 6 months with significance at 95% (EUR) and 99% (AUD).

One possible explanation for the negative forward bias is the existence of a time-varying risk premium in exchange rates. If foreign exchange market participants are risk averse, they would demand higher rate of return to be compensated for holding open positions in a risky foreign exchange market. In order for this omitted variable to cause the slope coefficient in the BF regression to be negative, the risk premium needs not only be time-varying but negatively correlated with the interest rate differential as shown by Fama (1984). This finding is most often taken to be evidence that most of the variation in the forward discount constitutes a time-varying risk premium, defined by:

$$\boldsymbol{rp_t^k = fd_t^k - \Delta s_{t+k}^e} \qquad (2)$$

Where fd_t^k is the current k-period forward discount and Δs_{t+k}^e is defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t.

There is ample evidence to reject unbiasedness. Most of the coefficients are significantly greater than one and positive. The F-test also indicate that the unbiasedness hypothesis fails in some of the data sets. The results of previous research overwhelmingly suggest rejection of the null hypothesis across the full spectrum of forward rate – see the surveys on the efficiency of the foreign exchange market by Levich (1985) and Hodrick (1987).

Overall, the analysis from Table 1 provides summary statistics for the forward discount and expected annualized exchange rate depreciation across forecast horizons and across currencies. It suggests that the expected short-term depreciations is smaller than the expected long-term depreciation. The slope of the equation is positive, most of them is greater than 1. Thus, it notes that in general the expected rates of depreciation and the forward discount are of the same sign. Consequently, the currencies that were expected to depreciate were at a forward discount. As others have found, the evidence presented suggests a fairly consistent rejection of the null hypothesis that the forward discount is an unbiased predictor of the future change in the exchange rate.

Table 1: Test of Forward Discount Unbiasedness OLS Regression

	Panel A: 3 months					
	β	t: β =0	t: β =1	R^2	F-test (α=0, β =1)	F probability
GBP	-0.32 (0.85)	-0.37	-1.50	0.001	1.19	0.30
CHF	-0.45 (1.24)	-0.35	-1.11	0.001	0.79	0.45
EUR	1.45 (1.10)	1.80*	0.56	0.027	0.31	0.74
CAD	1.04 (1.68)	0.64	0.02	0.003	1.39	0.25
AUD	1.24 (0.60)	1.95*	0.38	0.031	3.62*	0.03
	Panel B: 6 months					
	β	t: β =0	t: β =1	R^2	F-test (α=0, β =1)	F probability
GBP	1.47 (2.06)	1.42	0.46	0.017	0.15	0.86
CHF	0.57 (1.50)	0.54	-0.40	0.002	0.87	0.42
EUR	2.37 (1.40)	2.56**	1.48	0.052	1.45	0.24
CAD	2.28 (1.95)	1.70*	0.95	0.024	3.12*	0.05
AUD	2.33 (1.03)	2.65***	1.52	0.056	6.52*	0.00

Notes: The table shows the results of the joint hypothesis based on Eq. (1). $\Delta s_{t+k} = \alpha + \beta f d_t^k + \mu_{t+k}^k$, where $\Delta s_{t+k}$is the percentage depreciation of the currency (the change in the log of the spot price of foreign exchange) over k periods and fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate). The null hypothesis is that β=1, and the residual μ_{t+k}^k follows a random process. F-test if the F-statistic for testing the joint hypothesis $\alpha = 0\ and\ \beta$=1. An asterisk indicates that the coefficient is significantly different from zero at the 5% level. Method of Moments standard errors are in parentheses. * Represents significance at the 10 percent level, ** and *** represent significance at the 5 percent and 1 percent levels, respectively.

3.2 Expectation errors versus Risk premium

With the assumption that the expected future spot rate in the forward rate is efficient or rational. The probability limit of the coefficient β in (1) is:

$$\beta = \frac{cov\left(\mu_{t+k}^{k}, fd_t^k\right) + cov(\Delta s_{t+k}^{e}, fd_t^k)}{var(fd_t^k)} \quad (3)$$

where: μ_{t+k}^{k} is market participants' expectational error, and Δs_{t+k}^{e} is the market expectation.

We use the definition of the risk premium:

$$rp_t^k = fd_t^k - \Delta s_{t+k}^{e}$$

And we rewrite β as equal to 1 (the null hypothesis) minus a term arising from any failure of rational expectations, minus another term arising from the risk premium:

$$\beta = 1 - b_{re} - b_{rp} \quad (4)$$

where:

$$b_{re} = \frac{-cov\left(\mu_{t+k}^{k}, fd_t^k\right)}{var(fd_t^k)}; \quad (4.1)$$

$$b_{rp} = \frac{var(rp_t^k) + cov(\Delta s_{t+k}^{e}, rp_t^k)}{var(fd_t^k)} \quad (4.2)$$

With the help of collected data, both terms are observable. By inspection, b_{re} =0 if there are no systematic prediction errors in the sample, and b_{rp}=0 if there is no risk premium (or, somewhat more weakly, if the risk premium is uncorrelated with the forward discount).

The result of the decomposition are reported in Table 2. We can see that b_{re} in two situations are negative, meanwhile b_{rp} are positive in the most of cases. It leads to the value of b in all cases are positive, imply in (4) that the effect of the survey risk premium is to push the estimate of the standard coefficient b in the direction above one, particularly in the case of 6 months. In sum, the risk premium appears to have little economic importance for the bias of the forward discount.

Table 2: Components of the failure of the unbiasedness hypothesis

	3 months			6 months		
	The failure of rational expectation (1)	Existence of risk premium (2)	Implied regression coefficient (1-(1)-(2))	The failure of rational expectation (3)	Existence of risk premium (4)	Implied regression coefficient (1-(3)-(4))
	b_{re}	b_{rp}	β	b_{re}	b_{rp}	β
GBP	-0.05	-0.34	1.39	-0.13	-0.26	1.39
CHF	0.22	-0.45	1.23	0.17	-0.27	1.11
EUR	-0.03	0.60	0.43	-0.11	0.28	0.83
CAD	-0.23	0.51	0.72	-0.28	0.17	1.11
AUD	-0.12	0.22	0.90	-0.41	0.06	1.35

Notes: The table show the results based on the Eq (4) β = 1 – $b_{re} - b_{rp}$; Eq (4.1) $b_{re} = \frac{-cov(\mu_{t+k}^k, fd_t^k)}{var(fd_t^k)}$; and Eq (4.2) $b_{rp} = \frac{var(rp_t^k)+cov(\Delta s_{t+k}^e, rp_t^k)}{var(fd_t^k)}$ where b_{re} is rational expectations, b_{rp} is risk premium, μ_{t+k}^k is market participants' expectational error, while , rp_t^k is risk premium which defined as $rp_t^k = fd_t^k - \Delta s_{t+k}^e$, where fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate) and Δs_{t+k}^e is the market expectation and defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t.

The result can be exploited to decompose the forward discount bias into portions attributable to irrational behavior of economic agents or to the existence of time-varying rick premia. MacDonald and Torrance (1989), and Taylor (1989), for instance. As in Froot and Frankel (1989), data availability forces us to assume that the mean survey response is a proxy for the single expectation that is homogeneously held by investors. Thus, throughout our analysis we suggest what additional assumptions we need to impose to allow for the possibility of measurement errors in the dataset.

To assess whether the bias is due to expectation errors or a time-varying risk premium, one can regress the expected depreciation. Analogously to the standard regression equation, we regress our measure of expectation against the forward discount:

$$\Delta s_{t+k}^e = \alpha_2 + \beta_2 fd_t^k + \epsilon_t^k \tag{5}$$

where Δs_{t+k}^e is defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t and fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate).

Conditional on the hypothesis that the foreign exchange market is efficient or rational, the existence of time-varying premia has been documented in the literature by Hansen and Hodrick (1980) and Korajczyk (1985). Alternative methodologies to measure time-varying premia have been explored in the literature. First, models that are based strictly on the time series properties of spot and forward exchange rates. Korajczyk (1985) noted that the variability of risk premia in theory can be related to variations in expected real interest rates. A second approach is to employ some measurement of market fundamentals in an attempt to test specific theories of the risk premium. Frankel (1982) and Frankel and Engel (1984) examined an asset market equilibrium model based on assets demands derived from a 2-period mean-variance maximization problem. The third approach for assessing the risk premium interpretation (the existence of time-varying risk premia) attempts to measure expected depreciation directly, thereby, avoiding reliance on inferences from realized depreciations – see Frankel and Froot (1987b) and Froot and Frankel (1989), for instance. This would not tell us about the economic determinants of risk premia, but it could tell us about the importance of risk and market inefficiency in explaining the forward discount bias.

The null hypothesis that the correlation of the risk premium with the forward discount is zero implies that β_2=1. Under the null hypothesis, there are two possible interpretions of the error term: any time-varying risk premium that is not correlated with the forward discount, and random measurement error in the dataset.

Table 3 reports the OLS regression of (5). In some respects the data provide evidence in favor of perfect substitutability of assets denominated in different currencies. Contrary to the hypothesis of a risk premium that is correlated with the forward discount, all but two of the estimates of B_2 are statistically indistinguishable from one. In the CAD and AUD data sets of 6-month which aggregate across time horizons, the estimates are 0.92 and 0.98, respectively. Expectations seem to move very strongly with the forward rate.

Here we get different answers depending on whether we look at the 3-month results or the 6-month results (see Table 3). Overall, there is more evidence to support the existence of a risk premium. At the 3- month horizon, one rejects the null hypothesis β_2=1 when the intercepts are not constrained. For example, one rejects that all the variation in the forward discount is due to variation in expectations. Thus, there is some evidence of a time-varying risk premium, unlike in the narrower five-currency sample of Froot and Frankel (1989).

So that, a finding of β_2=1 would imply that the results in the Table 3 is reject the null hypothesis. Thus, at least some of the variation in the forward discount must be due to expected depreciation. In other words, one can reject the hypothesis that all of the variation in the forward discount is due to a time-varying risk premium.

The regression is also capable of shedding light on a claim set forth by Fama(1984) and Hodrick and Srivastava (1986) (FHS) that expected depreciation is less variable than the exchange risk premium. The FHS claim is:

$$\mathrm{var}(\Delta \mathrm{s}_{t,t+k}^{e}) < var(rp_{t,t+k})$$

To see the relevance of the regression results for this claim, note that (3) can be rewritten as:

$$\mathrm{var}(\Delta \mathrm{s}_{t,t+k}^{e}) < \ var\big(fd_{t,t+k}\big) + \mathrm{var}(\Delta \mathrm{s}_{t,t+k}^{e}) - 2 * \mathrm{cov}(fd_{t,t+k}, \Delta \mathrm{s}_{t,t+k}^{e})$$

Rearranging,

$$\frac{1}{2} \geq \frac{\mathrm{cov}(fd_{t,t+k}, \Delta \mathrm{s}_{t,t+k}^{e})}{var\big(fd_{t,t+k}\big)}$$

Assuming that the measurement error is uncorrelated with the forward discount, then the probability limit of the regression estimate is the same as the expression in the RHS of (4). Hence, if one can reject the null hypothesis that $\beta_2 \leq 0.5$, then one is rejecting the FHS hypothesis that the variation in the expectation of depreciation is less than the variation in the risk premium.

Under the null hypothesis that there is no time-varying risk premium and the regression error ϵ_t^k in (5) is random measurement error, we can use the R square from the regressions to obtain an estimate of the relative importance of the measurement error component in the dataset. The R square statistics in Table 3 are relatively low, suggesting that measurement error is relatively big. This suggests that the dataset are not a better measure of investors' expectations than are the ex post exchange rate change.

Table 3: Test of perfect substitutability OLS regressions

Panel A: 3 months						
	β_2	t:β_2=0.5	t: β_2=1	R^2	F-test (α_2=0, β_2=1)	F probability
GBP	1.37 (0.44)	3.00***	1.27	0.16	1.00	0.37
CHF	1.32 (0.34)	1.74*	0.68	0.06	1.79	0.17
EUR	0.45 (0.29)	-0.20	-2.21**	0.03	3.38*	0.04
CAD	0.75 (0.51)	0.45	-0.47	0.02	0.22	0.80
AUD	0.91 (0.40)	2.39**	-0.51	0.19	0.88	0.42
Panel B: 6 months						
	β_2	t:β_2=0.5	t: β_2=1	R^2	F-test (α_2=0, β_2=1)	F probability
GBP	1.27 (0.23)	4.02***	1.42	0.27	1.20	0.31
CHF	1.19 (0.18)	2.74***	0.75	0.16	1.95	0.15
EUR	0.74 (0.19)	1.22	-1.36	0.11	1.79	0.17
CAD	0.92 (0.23)	1.45	-0.27	0.08	0.13	0.88
AUD	0.98 0.28	3.34***	-0.11	0.28	0.63	0.54

Notes: The table shows the results of the joint hypothesis based on Eq. (2). $\Delta s_{t+k}^{e} = \alpha_2 + \beta_2 fd_t^k + \epsilon_t^k$ where Δs_{t+k}^{e} is defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t and fd_t^k is the current k-period forward discount (the log of the forward rate minus the log of the spot rate). The null hypothesis is β_2 =1 and and the residual ϵ_t^k follows a random process. F-test if the F-statistic for testing the joint hypothesis α_2=0, β_2=1. An asterisk indicates that the coefficient is significantly different from zero at the 5% level. Method of Moments standard errors are in parentheses. * Represents significance at the 10 percent level, ** and *** represent significance at the 5 percent and 1 percent levels, respectively.

3.3 Test of the rational expectations and risk premium hypothesis

In the previous section we formally tested the hypothesis that there exists no time-varying risk premium that could explain the findings of bias in the forward discount. In this section we formally test the hypothesis that there exist systematic expectation errors that can explain those findings.

3.3.1 Test of excessive speculation

In order to examine the role of systematic forecast errors in explaining the forward bias, we estimate the regression of forecast errors, on the forward premium following Froot and Frankel (1989) methodology, that is:

$$\Delta s_{t+k}^{e} - \Delta s_{t+k} = \alpha + d\Delta s_{t+k}^{e} + \vartheta_{t+k}^{k} \qquad \textbf{(6)}$$

Where the ϑ_{t+k}^{k} is the random measurement error in the dataset or regression errors. If forecast errors are uncorrelated with the forward premium d will equal to 0. Under the null hypothesis of rational expectations both coefficients should equal zero: $\alpha=0$, $d=0$. This test is also known as forecast errors "orthogonality test" – expectation errors should be orthogonal to the information set available at the time the expectations are formed when agents use all available information efficiently.

In fact, we are unable to reject the hypothesis that all of the bias is due to systematic forecast errors and none due to a time-varying risk premium. Froot and Frankel (1989) attribute this finding to irrationality that stems from the presence of heterogeneous traders in the market. More recent study by Bacchetta et al. (2009) has strengthen their argument by providing additional evidence of systematic expectation errors across different financial markets, such as the foreign exchange (FX), bond, and stock markets. Using dataset, they find that forecast errors are also predicable with the same sign and magnitude as excess returns in all three markets. However, Cavaglia et al. (1994) point out that in the pooled regression estimation the slope coefficient of one could result from mixing one group of countries where the risk premium is negatively correlated with the forward premium, with another group of countries where the correlation is positive. Thus, pooling data across countries might lead to conclude that risk premium is invariant over time or does not play any role for the forward premium bias. Examining a set of 10 developed-countries currency markets, Cavaglia et al. (1994) are able to show the existence of a time varying risk premium for some developed countries currency markets when the data are not pooled across countries. Frankel and Chinn (1993) and Chinn and Frankel (2000) also find some evidence that the bias in the forward rate is attributable to both the existence of a time-varying risk premium and systematic expectation errors in a larger set of dataset, but mostly over long forecast horizons. However, all these studies report that the magnitude of forecast errors is much larger than that of a time-varying risk premium.

Table 4 summarizes the test results for each currency separately as well as pooled regression estimates across all currencies. The rejections against the null hypothesis that the slope coefficient is equal to zero occurs at the 1% level for the CHF. Meanwhile, the rejections against the null hypothesis that the slope coefficient is equal to one occurs at the most of currencies in 6-month. On the other hand, exception CHF, the estimate of the slope coefficient for the others currencies in 3-month and 6-month both are not statistically different from zero. The point estimate of b_{rp} from the pooled regression model is statistically significant at the 1% level and the null hypothesis of $\alpha=0$, $d=0$ is easily rejected. Thus, it shows that the slope coefficient estimate for the CHF over the full sample is still insignificantly different from unity. Moreover, the hypothesis of perfect substitutability is rejected for the other currencies, so it implies that there is some evidence of a time varying risk premium.

Table 4: Test of excessive speculation regressions

Panel A: 3 months						
	d	t:d=0	t:d=1	R^2	F-test (α=0, d=0)	F probability
GBP	0.49	1.27	-1.34	0.01	2.65	0.07
	(0.34)					
CHF	0.67	2.74***	-1.36	0.06	4.51*	0.01
	(0.27)					
EUR	0.47	1.62	1.80*	0.02	1.79	0.17
	(0.44)					
CAD	0.27	1.02	-2.78***	0.01	2.28	0.11
	(0.20)					
AUD	0.41	1.36	-1.93*	0.02	5.41*	0.01
	(0.20)					
Panel B: 6 months						
	d	t:d=0	t:d=1	R^2	F-test (α=0, d=0)	F probability
GBP	-0.16	-0.27	-1.96**	0.0006	2.56	0.08
	(0.78)					
CHF	0.35	0.98	-1.87**	0.0081	1.94	0.15
	(0.33)					
EUR	-0.06	-0.14	-2.56**	0.0002	0.64	0.53
	(0.45)					
CAD	0.15	0.36	-2.10**	0.0011	2.98*	0.05
	(0.25)					
AUD	-0.10	-0.21	-2.31**	0.0004	5.93*	0.00
	(0.40)					

Notes: The table shows the results of the joint hypothesis based on Eq. (3). $\Delta s^e_{t+k} - \Delta s_{t+k} = \alpha + d\Delta s^e_{t+k} + \vartheta^k_{t+k}$ where Δs^e_{t+k} is defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t and $\Delta s_{t+k}$is the percentage depreciation of the currency (the change in the log of the spot price of foreign exchange) over k periods. The null hypothesis is α=0, d=0 and and the residual ϑ^k_{t+k} follows a random process. F-test if the F-statistic for testing the joint hypothesis α=0, d=0. An asterisk indicates that the coefficient is significantly different from zero at the 5% level. Method of Moments standard errors are in parentheses. * Represents significance at the 10 percent level, ** and *** represent significance at the 5 percent and 1 percent levels, respectively.

3.3.2 Another test of excessive speculation

Another test of rational expectations, which is free of the problem of measurement error, is to replace Δs_{t+k}^{e} on the right-hand side of (6) with the forward discount fd_t^k. The null hypothesis of rational expectations implies that a=d=0 in regressions of the following form:

$$\boldsymbol{\Delta s_{t+k}^{e} - \Delta s_{t+k} = \alpha + d fd_t^k + \vartheta_{t+k}^{k}} \qquad \textbf{(7)}$$

Table 5 reports regression of the forecast error on the 3-month and 6-month ahead forward discount from equation (7) via OLS for each currency individually. We now see that the data continue to reject statistically the null hypothesis for the forecast horizons for individual currencies relative to the U.S dollar, for example GBP (5%) and EUR (10%). According to Froot and Frankel (1989), they reject d=0 in favor of the alternative of excessive speculation. (because the measurement error has been purged, the levels of significance are necessarily lower than those of Table 4). This can be put as: in one of these cases we can not reject the hypothesis that all of the forward bias is due to systematic expectation errors and none is due to a time-varying risk premium. The point estimate of b_{re} from the pooled regression model is statistically significant at the 1% level and the null hypothesis of a=d= 0 is easily rejected. This provides a strong evidence of correlations between the forward premium and expectation errors.

Overall, the main conclusion arising form Table 4 and Table 5 is that deviations from the unbiasedness hypothesis for the examined currencies seems to be mainly due to systematic forecast errors when estimated for the full sample and, especially, when the currencies are stacked together in a pooled regression model. By relaxing the assumption that the risk premium coefficient is the same across currencies and performing the analysis for individual currency markets, we are able to uncover some evidence of the existence of a time-varying risk premium and its correlation with the forward premium. Although the magnitude of the bias attributable to expectation errors is estimated to be much larger than the one due to a time-varying risk premium.

However, there is still a question mark over our conclusions based on figures in Tables 5 and 6 as well as Froot and Frankel’s (1989) and other researcher’s empirical findings due to the common practice among the researchers of ignoring the issue of temporal instability of the data. The vast majority of empirical studies that show the supposed predictability of currency returns are based on estimating time-invariant linear regression models which assume that the process generating each series is stable in a sample that involves two decades of data or more. However, when the return history used in estimating the beta is that long, regime changes can influence the resultant slope coefficient estimate and ignoring this problem will lead to misleading statistical inference.

Table 5: Test of rational expectations OLS regressions

Panel A: 3 months					
	d	t:d=0	R^2	F-test (t:α=0,d=0)	F probability
GBP	-0.71 (0.49)	-1.11	0.0102	2.45	0.09
CHF	1.77 (1.37)	1.34	0.0148	1.62	0.20
EUR	-1.00 (0.98)	-1.24	0.0127	1.24	0.29
CAD	-0.29 (1.80)	-0.18	0.0003	1.77	0.18
AUD	-0.33 (0.50)	-0.51	0.0022	4.56*	0.01
Panel B: 6 months					
	d	t:d=0	R^2	F-test (t:α=0,d=0)	F probability
GBP	-1.82 (0.99)	-2.08**	0.0351	4.78*	0.01
CHF	0.62 (1.52)	0.59	0.0029	1.62	0.20
EUR	-1.63 (1.37)	1.79*	0.0262	2.25	0.11
CAD	-1.36 (1.99)	-1.02	0.0087	3.46*	0.03
AUD	-1.35 (1.00)	-1.54	0.0195	7.20*	0.00

Notes: The table shows the results of the joint hypothesis based on Eq. (4).$\Delta s^e_{t+k} - \Delta s_{t+k} = \alpha + dfd^k_t + \vartheta^k_{t+k}$ where Δs^e_{t+k} is defined as the log of future price of exchange over k period minus the log of spot price of exchange at time t, $\Delta s_{t+k}$is the percentage depreciation of the currency (the change in the log of the spot price of foreign exchange) over k periods and fd^k_t is the current k-period forward discount (the log of the forward rate minus the log of the spot rate).. The null hypothesis is α=0, d=0 and and the residual ϑ^k_{t+k} follows a random process. F-test if the F-statistic for testing the joint hypothesis α=0, d=0. An asterisk indicates that the coefficient is significantly different from zero at the 5% level. Method of Moments standard errors are in parentheses. * Represents significance at the 10 percent level, ** and *** represent significance at the 5 percent and 1 percent levels, respectively.

3.4 Economic determinants of the expectation error

As mention above, the expectation errors are decomposed into: rational and irrational components. Next, we are turning to the examination of market irrationality, whether the null hypothesis that a change in sentiment explain the change in the expectation error.

On the basis of Eq. (4.1), we can test whether is significantly different from zero and examine the result that irrationality contributes to the expectation error. To this end, we need a proxy to measure deviations from rational expectations. One plausible approach to capturing irrationality is to use information that significantly represents investor sentiments, since they capture the overall attitude of investors and highlight the excess of optimism or pessimism held by agents. Investor sentiment is the state of mind of investors, or a crowd psychology (Shiller, 2000), as revealed through the activity and price/interest rate movements in bond markets. When the market becomes more intensely sentimental, investors' expectations, especially for noise traders, are more likely to depart from rationality. As stated in Eq. (4.1), if this element is correlated with the forward premium, we expect to observe a non-zero B_{rp}, contributing to B_{re}, which in turn rejects the UEH hypothesis.

Since there is no consensus in the literature as to how to measure investor sentiment, the sentiment index in this paper comprises both "direct" and "indirect" sentiment measures. Direct sentiment measures use dataset from institutions such as the American Association of Individual Investors (AAII) and Market Vane to directly measure the sentiment of market participants. Indirect sentiment measures are extracted from the financial markets, which assess market sentiment through the trading activities in financial markets. Baker and Wurgler (2006) propose an indirect sentiment index by using the principal component analysis (PCA) for several major financial variables. The AAII surveys individual investors weekly with respect to their outlook, asking them to state whether they believe that over the next six months, the stock market will be bullish, bearish, or neutral. The bullish consensus of Market Vane is the degree of bullish sentiment for a particular asset, such as gold, commodities, or the S&P 500 index. Market Vane tracks the buy/sell recommendations of leading advisers in the futures market for that specific asset. Market Vane collects the bullish consensus for Eurodollar futures (Eurodollar Consensus). The index price of the Eurodollar futures is equal to 100 less the futures rate. Arising Eurodollar Consensus implies rising Eurodollar futures expectations and, equivalently, declining Eurodollar futures rate expectations. A positive net position in Eurodollar futures published by the Commodity Futures Trading Commission (CFTC) is regarded as a bearish indicator for future rates. The index constructed by Baker and Wurgler (2006) is based on the first principal component from the principal component analysis (PCA) for the following six variables: NYSE turnover, closed-end fund discount, number of IPOs, first-day return on IPOs, the equity share in the new issues, and the dividend premium.

To deal with the possibility that sentiment proxies may contain rational assessments of the future interest rate, we need to extract the error beliefs in the sentiment variables. After regressing each sentiment variable on a set of rational predictors of the future interest rate, the residuals in the regression tend to be cleaner proxies for the belief errors in investor sentiment. The rational predictors of the future interest rate in the regression we use include: (1) monetary policy (i.e., measured by money growth or the M2 growth rate), (2) the growth rate of the industrial production index, (3) demand for liquidity (i.e., the difference between the one-year USD swap interest rate and the Treasury yield), (4) term spread (i.e., the difference between the 5-year T-bond rate and the 6-month T-bill rate), and (5) the inflation rate (see Bekaert et al., 2001; Bartolini et al., 2002;Deuskar et al., 2008).

Following Baker and Wurgler (2006) and Ho and Hung (2009), we apply the PCA and construct a composite sentiment index comprising (1) the residuals in the bullish consensus for Eurodollar futures (Eurodollar Consensus); (2) the residuals in the net position in Eurodollar futures (CFTC); (3) the residuals in the AAII bearish percentage; and (4) the residuals in the Baker sentiment index. We define Sent in Eq. (8), an investor sentiment index, as the first principal component estimated by the PCA. The Sent in our measure is able to capture the common component of the four proxies and incorporates the fact that some proxies may reveal the same sentiment.

$$\mathbf{SENT = -0.82*S - 0.004*RIPO - 0.02*PDND + 0.002*NIPO - 0.02*CEFD - 0.08} \qquad \mathbf{(8)}$$

The first principal component, $Sent_t$, explains 45% of the total sample variance, so we claim that one factor captures much of the common variation. The higher the values of $Sent_t$ are, the more excessive the pessimism expressed in the markets.

3.5 Model specification for estimating the expectation error.

In light of the arguments presented above, the determinants of the expectation error can be appropriately linked to: (1) unexpected macroeconomic surprises that capture the pseudo peso bias; (2) deviations from rational expectations measured by investor sentiment; and (3) the first-order autoregressive component, a lagged expectation error that takes care of the persistence in the expectation error. To estimate the expectation error in relation to economic factors, we use the following repression model:

$$\mathbf{EP_t = \alpha + \beta_m * Surprise_t + \beta_t * Sent_t + \mu_{t+j}} \quad \mathbf{(9)}$$

Where EP_t is defined as the expectation error. The surprise term captures information associated with the peso bias. As a result, $Surprise_t$ is defined as a vector of the unexpected macroeconomic variables, including (1) monetary policy (measure by money growth or the M2 growth rate), (2) the growth rate of the industrial production index, (3) demand for liquidity (the difference between the one-year USD swap interest rate and the Treasury yield), (4) term spread (The difference between the 5-year T-Bond rate and the 6-month T-Bill rate), and (5) the inflation rate (see Bekaert et al., 2001; Bartolini et al., 2002; Deuskar et al., 2008) . There are good reasons to use these surprise variables to explain the peso bias. The $Sent_t$ denotes as the sentiment index.

The sentiment proxy is the monthly Baker and Wurgler Sentiment Index (Baker). Baker and Wurgler (2006) constructed first principal component from six sentiment proxies and their lags. First, all of these variables are directly linked to interest rate movements. Uncertain movements in these variables are bound to create an expectation error. In particular, regardless of whether the uncertainty comes from default risk, liquidity risk, or inflation risk, frequent shocks involving these risks are likely to disturb the probability distribution of interest rates that investors use to form their expectations when making financial decisions. Second, information about the new stochastic process for the interest rate is limited and/or may be revealed gradually, because agents learn about the interest rate process only by using past information, and the ex post distribution may not agree with the ex ante distribution even based on rational expectations. With the limited information available to agents, it is assumed that the pseudo peso bias is closely tied to the unexpected components of macroeconomic variables. In fact, the unobserved regime changes or policy innovations can lead to surprises in macroeconomic fundamentals. Therefore, the pseudo peso bias can then be examined by testing the significance in relation to the surprises in macroeconomic a variable.

As mentioned above, the expectation errors are decomposed into rational and irrational components. Three streams of previous literature explain the sources of rational factors. The first stream of rational variables includes the variables governed by peso problems and learning behavior. Peso problems arise from infrequent discrete shifts in economic determinants causing asset price behavior to differ from conventional rational expectation. It is reasonable to assume that experience leads market participants to rationally predict future interest rates. When rare events occur, their expectations about future interest rates generate expectation errors. The learning behavior of market participants also creates expectation errors because they gradually absorb and adjust their expectation when the rare events occur.

Second, expectation errors can arise from prediction of rates using equilibrium interest rate models, which are formulated with assumptions of economic variables, and derive a process for short-term interest rates. Inconsistency between the assumptions behind these models, in regard to what economic variables evolve and the actual movement of the variables could cause incorrect estimation of future interest rates. When these models are adopted for estimating future interest rates, systematic expectation errors between ex post realized rate and expected future interest rates may be generated.

The third stream of literature relates to incorrect estimation of macroeconomic variables where certain variables govern the interest rate changes. As pointed by Bartolini et al. (2002), Benkert (2004), Deuskar et al. (2008), default spread, inflation, and money supply, and yield spread affect interest rate movements. Unexpected changes or shocks in inflation, for example, can create erroneous estimations in interest rates. Fama (2006) discusses the phenomenon of downward movement for US 1 year interest rates for the period between 1981 and 2004, as the result of permanent shocks. Certainly, an unexpected change in interest rates may arise from the phenomenon of peso problem, the learning behavior of market participant, incorrect model estimation, and so on.

Apart from rational variables, irrational components can impact expectation errors, for example, when investors trade fixed-income securities by extrapolating the trend or predict continuity of interest rates. Trend-chasing investors typically produce continuous errors across time, often resulting in persistently high number of correlated lags.

To obtain a suitable proxy for rational variables including peso problems, investor learning behavior, and incorrect estimation of macroeconomic variables, we use so-called macroeconomic surprises, defined as a vector of the unexpected relevant macroeconomic variables. There are three reasons that these surprise variables capture all rational variables. First, since macroeconomic variables are directly linked to interest rate movements, uncertain movements in these variables are bound to create an expectation error. In particular, uncertainty about economic variables is likely to disturb the probability distribution of interest rates that investors use to form their expectations when making financial decisions.

Second, information about the new stochastic process for interest rates is limited and/or may be revealed gradually, because agents learn about interest rate processes only from past information, and the ex post distribution may not agree with the ex ante distribution even based on rational expectations. With limited information available to agents, it is assumed that peso problems, learning behavior, and incorrect estimation of economic variables are closely tied to the unexpected components of macroeconomic variables. In fact, unobserved regime changes or policy innovations can lead to surprises in macroeconomic fundamentals. Therefore, peso problems can be examined by testing their significance in relation to surprises resulting from macroeconomic variables.

Following Bartolini et al. (2002), Benkert (2004), and Deuskar et al. (2008), we use default spread, inflation, money supply, the growth rate of the industrial production index and yield spread as economic variables. Default spread (*DEF*) is obtained from the difference between 3-month LIBOR and Treasury bill rate, the so-called TED spread. This spread is often used as an indicator of market default in practice. Inflation (*INF*) affects the rate change in the way that higher inflation triggers higher nominal interest rates. Money supply (*M2*) is often used by central banks to control circulation of currency and inflation. This is done by changing interest rates. The yield spread (*YIS*), obtained from the difference between 5-year and 1-year rates represents the market forecast of future interest rates.

To measure the irrational variables, we follow Brown and Cliff (2004), and Baker and Wurgler (2006). Brown and Cliff (2004) provide a list of direct and indirect sources of sentiment proxies. The former is obtained from surveys, and the latter is derived from market trading activities. The direct sentiment proxies considered in this study are AAII, the Michigan consumer index, and the dataset from Market Vane. Another sentiment proxy is the monthly Baker and Wurgler Sentiment Index (Baker).

Table 6 reports the estimates of the determinants of the expectation error equation. The regression results for 3- and 6-month forecast horizons. As can be seen, the surprises extracted from term spreads, volatility, monetary policy and the inflation rate are all statistically significant, implying that these surprises successfully explain the expectation error. This means that the limited information and the peso problem result in an inconsistency between the ex post and the ex ante formation of expectation.

On the other hand, the null hypothesis that whether a change in sentiment explain the change in the expectation error. The evidence from Table 6 suggests that the influence of surprise sectors are more pronounced for the 6-month forecast horizon compared with the 3-month forecast horizon. Moreover, the R- squared values are between 0.08 and 0.51, where the higher the forecast horizon the higher the value of R-squared.

As can be seen, the null hypothesis is significantly rejected in 3-month at 10% and 1% level, meanwhile in 6-month with the high level at 1%. Particularly, inflation and M2 surprises are significant for nearly all cases at 1% level. In addition, default spread, inflation surprises and sentiment are negatively related to expectation errors whereas industrial production index and term spread surprises are positively related. As we know, default spread is an acceptable measure of the aggregate liquidity variable as well as the default risk of consistent bank in U.S dollar fixing. Incorrect estimation of this variable can affect the estimation of general interest rate level. However, yield spread is an indicator of economic conditions as well as the direction of expected future interest rates. Hence, an erroneous prediction of yield spread leads to invalid expectations about future interest rates, contributing to expectation errors. Especially, the result of M2 surprise variable coefficient is nearly equal to zero, it suggests that when it doesn't joint significantly related to expectation errors. Nevertheless, the industrial production index indicate the measures the amount of output from the manufacturing, mining, electric and gas industries. Subsequently, the coefficient of industrial production index surprise variable is greater than one, it indicates that the an increase of the economic lead to an increase in the expectation errors.

All in all, a negative coefficient indicates that a bullishness consensus in expected future rate spurs the expected future rate, producing negative expectation errors. The ex post realized rate is consequently less than the expected future rates. Conversely, a bearishness consensus may trigger a decline in the expected future rate, which causes the ex post realized rate to surpass the expected future rates and results in a positive expectation error.

Irrespective of forecast horizons, expectation errors for long-term securities appear to be governed more by investor sentiment than short-term securities. One possible interpretation is that long-term securities prices are more sensitive to change in interest rates than short-term prices, and hence are more likely to be affected by irrational investor sentiment. Another interpretation relates to Fama (2006) who indicates swings of spot rates for short-term forecast horizons are driven by slow mean reversion, but spot rates for long-term forecast horizons are driven by permanent shocks to the long-term expected spot rate. As seen in Table 6, even short- or long-term changes of spot rates are affected by several series of macroeconomic surprises. When surprises occur, irrational investor behavior also affects expectation errors, leading to a predictive divergence from the slope of the term structure. Long-term securities, however, are more vulnerable to these shocks and are more closely related to investor behavior.

Table 6: Estimates of the economic determinants of the expectation error.

Panel A: 3months								
	Demand for liquidity	Inflation	Industrial production index	M2	Sentiment	Term spread	Lag error	R square
GBP	-0.058	-0.007	1.745	0.000	-0.050	0.002	0.002	0.119
	-2.136**	-0.539	1.954 *	0.486	-1.067	0.101		
CHF	0.009	-0.002	0.903	(0.000)	0.014	0.012	0.002	0.083
	0.523	-0.284	1.644	-1.710*	0.470	1.164		
EUR	0.010	-0.010	2.567	0.000	0.019	0.019	0.003	0.123
	0.443	-0.916	3.367***	0.772	0.488	1.278		
CAD	-0.009	0.001	1.526	0.00	-0.029	0.002	0.005	0.122
	-0.610	0.135	3.253***	-0.166*	-1.179	0.235		
AUD	-0.005	-0.004	1.833	0.000	-0.028	0.008	0.012	0.094
	-0.277	-0.43)	2.869***	0.130	-0.835	0.657		

-Continue on the next page-

Panel B: 6 months								
	Demand for liquidity	Inflation	Industrial production index	M2	Sentiment	Term spread	Lag error	R square
GBP	-0.192	-0.107	1.142	0.000	-0.002	0.027	0.004	0.499
	-4.299***	-6.879***	0.968	4.815***	-0.047	1.563		
CHF	-0.017	-0.032	-0.307	0.000	0.026	0.028	0.007	0.096
	-0.528	-2.857***	-0.363	-0.657	0.817	2.267**		
EUR	-0.076	-0.064	0.475	0.000	0.063	0.028	0.006	0.220
	-1.818*	-4.393***	0.433	2.935***	1.560	1.733 *		
CAD	-0.032	-0.039	1.011	0.000	-0.025	-0.004	0.011	0.291
	-1.268	-4.462***	1.542	2.142**	-1.048	-0.374		
AUD	0.003	-0.073	1.441	0.000	-0.033	0.006	0.025	0.341
	0.085	-6.176***	1.598	2.328 **	-0.980	0.467		

Notes: The table shows the results of the joint hypothesis based on Eq. (9). $\Delta EP_t = \alpha + \beta_m * \Delta Surprise_t + \beta_t * \Delta Sent_t + \mu_{t+j}$ where ΔEP_t is defined as the different of the change of expectation errors at time t, $\Delta Surprise_t$ is the vector of unexpected changes in macroeconomic variables, including term spreads, the default spread, the growth of industrial production index, the money growth rate, and the inflation rate, $\Delta Sent_t$ is the change in sentiment. The null hypothesis is α=0, β_m =0 and β_t =0 and the residual μ_{t+j} follows a random process. F-test if the F-statistic for testing the joint hypothesis α=0, d=0. * Represents significance at the 10 percent level, ** and *** represent significance at the 5 percent and 1 percent levels, respectively.

CHAPTER 4: CONCLUSION

In this paper, we show that the forward discount puzzle stems not from the presence of irrational market participants, but from the practice among researchers of ignoring the problem of temporal instability. We point out that correlations between the future change in the spot exchange rate and the forward premium are likely to be temporally unstable. They depend on how market participant form their market expectations about future returns, that is, on their forecasting strategies.

This study’s result indicate that correlation between the future change in the exchange rate and today’s forward premium is not negative as is widely believed. Rather, the bias is sometimes positive, sometimes negative, and sometimes zero. This implies that successive speculation in the foreign exchange market is not as simple as suggested by the voluminous literature on international finance. Indeed, the "predictable" profits cannot be made by simply betting against the forward rate. Although, this rule delivers profits in some subperiods for some currencies, it stops being profitable at moments of time that cannot before seen. No one can precisely specify ahead of time when the correlation might be negative and for how long, so no one can know in advance when it might be profitable to bet against or with the forward rate. In order for investors to systematically make money by taking either short or long positions in the forward exchange market based on the value of the forward premium, they would need to anticipate when the structural change will occur, otherwise it will not lead to significant money making opportunities.

The results reveal a close and robust relationship between the risk premium and the forward premium. This, plus the finding that the forecast of the change in the exchange rate bears little relationship to the forward premium. This study also finds that irrational behavior contribute to the expectation error. The evidence from significance testing by using sentiment to explain the expectation error provides a distinct insight for explaining the failure of the UEH in the U.S. market, which cannot be fully captured by either the term premium and/or the peso problem. This study also finds that the expectation error is persistent, implying that there are obstacles to arbitragers’ ability to help biased expectations revert to rational levels.

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