TESTING THE UNBIASED EXPECTATIONS HYPOTHESIS

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THESIS

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1. Introduction

The complex relationship between exchange rates and interest rates has long attracted the interest of academic researchers and practitioners in the financial world, generating extensive research and practical discussions. This multifaceted interaction is of utmost importance, affecting a wide range of individuals and organizations, from individual investors trying to navigate turbulent forex markets, to policymakers carefully crafting monetary policy, to global economists trying to decipher macroeconomic trends. The focus of this discussion is the unbiased expectations hypothesis (UEH), an influential theory that posits a direct correlation between expected exchange rate movements and the different interest rates observed in different countries.

The main objective of this dissertation is to analyze and explain the complex network of interactions that determine the relationship between exchange rates and interest rates, with particular emphasis on the unbiased expectations hypothesis. Through an exhaustive and careful analysis, our goal is to examine whether the empirical correlation observed between these two key variables is consistent with the theoretical postulates of UEH.

The UEH stipulates that the difference in interest rates between two countries will have an impact on the exchange rates between their respective currencies. To contextualize this premise, imagine an investor weighing options for investing in a

domestic or foreign currency. UEH argues that an investor should not make additional profits by switching between currencies, as any potential benefits from rising interest rates would be offset by an equivalent decline in exchange rates, and vice versa.

From a theoretical point of view, regression analysis will help us depict the important relationship between exchange rates and interest rate differentials. The theory should give a slope equal to one. However, empirical studies often show a slope that is either less than unity or negative in some cases. This apparent discrepancy, called the “forward premium puzzle,” suggests a scenario in which a growing differential between two countries' interest rates is simultaneously associated with a future exchange rate depreciation. This anomaly indicates that there are unidentified variables that have yet to be taken into account that are integral to fully unraveling the complex dynamics underlying the relationship between exchange rates and interest rates.

Our analysis will focus primarily on countries located in Asia and Europe for pre-Euro and post-Euro currency introduction, using them as case studies to confirm our findings and increase the reliability of our results.

An important objective is to investigate the usefulness of forward premiums as a predictive tool for forecasting spot exchange rate returns. The forward premium, defined as the mismatch between the forward exchange rate and the spot rate, has

traditionally been used as a measure of market expectations regarding future movements in exchange rates. We suggest that forward premiums can provide invaluable information about future trajectories of spot exchange rate fluctuations, thus serving as an important resource for both investors and policymakers.

2. Literature review

2.1 Exchange Rates, Interest Rates, and the Risk Premium

The publication "Exchange Rates, Interest Rates, and the Risk Premium" by Charles Engel (2016) investigates the uncovered interest parity puzzle in foreign exchange markets and the relationship between high interest rate countries and their expected returns on short-term deposits. The author documents the empirical regularities that high interest rate countries tend to have high expected returns on short-term deposits and that high real interest rate countries tend to have stronger currencies than can be accounted for by the path of expected real interest differentials under uncovered interest parity. The article also talks about how these findings challenge economic models in international finance and how there have been improvements in understanding investor behavior and macroeconomic relationships as a result of efforts to tackle these challenges. The author puts forward a model that could bring together these findings and suggests that there could be factors influencing the connection between interest rates and exchange rates.

This thesis examines the uncovered interest parity puzzle in foreign exchange markets, focusing on the empirical regularities that high interest rate countries tend to have high expected returns on short-term deposits and that high real interest rate countries tend to have stronger currencies. The study aims to reconcile these findings and propose a model that can account for the observed phenomena.

The first chapter introduces the uncovered interest parity puzzle and its significance in the field of international finance. It provides an overview of the empirical regularities that have been observed in foreign exchange markets and sets the stage for the subsequent analysis. The second chapter reviews existing literature on the uncovered interest parity puzzle and the relationship between interest rates and exchange rates. It discusses the challenges posed by the empirical findings to traditional economic models and the advances that have been made in modeling investor behavior and macroeconomic relationships. The methodology chapter outlines the approach taken in this study to analyze the uncovered interest parity puzzle. It details the data sources, statistical methods, and theoretical frameworks employed in the analysis. The empirical regularities and challenges chapter delves into the empirical regularities observed in foreign exchange markets, specifically the relationship between high interest rate countries and their expected returns on short term deposits, as well as the relationship between high real interest rate countries and the strength of their currencies. It discusses the challenges these findings pose

to traditional economic models in international finance. The fifth chapter proposes a model that might reconcile the findings discussed in the previous chapter. It explains the theoretical underpinnings of the model and how it addresses the challenges posed by the empirical regularities. The final chapter summarizes the findings of the study, drawing conclusions about the uncovered interest parity puzzle and the relationship between interest rates and exchange rates. It also discusses the implications of these findings for currency markets and future research.

2.2 Five Facts about the UIP Premium

The document "Five Facts about the UIP Premium" by Şebnem Kalemli-Özcan and Liliana Varela is a comprehensive study that investigates the Uncovered Interest Parity (UIP) deviations in relation to the U.S. dollar for 34 currencies of advanced economies and emerging markets. The authors document five novel facts about UIP deviations, providing a detailed analysis of the dynamics and factors influencing the UIP premium.

1. UIP Premium and Global Risk Aversion**:** The UIP premium co-moves with global risk aversion, as measured by the VIX, for all currencies. However, a negative co-movement between the UIP premium and capital inflows is observed only for emerging market currencies. This indicates that in times of global risk aversion, the UIP premium tends to increase, reflecting the higher risk associated with foreign exchange investments.
2. Co-movement Explained by Interest Rate Differentials and Exchange Rate Expectations: The movement of the UIP premium and the VIX can be understood by considering changes in interest rate differences in emerging markets and expected changes in exchange rates in economies. In emerging markets, the UIP premium is influenced by interest rate differences while in economies expected exchange rate changes have an impact on determining the UIP premium.
3. Country Risk and Policy Uncertainty**:** The level of country risk as indicated by policy uncertainty can explain both the correlation between capital inflows and the UIP premium and the positive correlation between the VIX and the UIP premium in emerging markets. This implies that policy

uncertainty plays a role in determining the UIP premium in emerging markets where policy decisions can greatly affect currency values and capital flows.

4. No Overshooting and Predictability Reversal Puzzles: The authors find that there are no overshooting and predictability reversal puzzles when using exchange rate expectations to calculate the UIP premium. This contrasts with previous literature that documented puzzling dynamics in exchange rate movements in response to interest rate differentials.
5. Fama Puzzle in Advanced Economies and Emerging Markets: The classical Fama Puzzle, which refers to the observation that high interest rate currencies do not depreciate as expected, disappears in advanced economies when expectations are considered. However, the puzzle remains for emerging markets. This implies that while global investors expect zero excess returns and earn positive returns in the short-run and negative returns in the long-run by investing in advanced country currencies, they always expect and earn positive excess returns from emerging market currencies.

The paper provides a thorough analysis of the UIP premium and its relationship with global risk aversion, interest rate differentials, exchange rate expectations, and policy uncertainty. The authors demonstrate that the UIP premium behaves differently in advanced economies and emerging markets, with policy uncertainty playing a significant role in determining the UIP premium in emerging markets.

2.3 The Forward Bias in the ECU: Peso Risks vs. Fads and Fashions Piet Sercu and Tom Vinaimont's study, published in the Journal of Banking & Finance in 2006, delves into the intriguing empirical phenomenon of the persistent forward bias in European Currency Unit (ECU) forward rates. This study challenges the Unbiased Expectations Hypothesis (UEH), offering an in-depth exploration of the ECU market's history and dynamics, focusing on both its private and official forms.

The methodology is anchored in a robust data-driven approach. The study utilizes weekly data spanning from October 1989 to February 1998, encompassing changes in exchange rates and forward premia for both private and official ECUs. Employing regression analyses in line with the Hansen and Hodrick (1980) framework, the research opts for Ordinary Least Squares (OLS) due to the near-unit root properties of the regressors. A key aspect of the methodology is the subdivision of data based on the discount of the private ECU relative to the official one, forming subsets with distinct slope coefficients. This enables an examination of the correlation between the forward bias and market perceptions. Additionally, the study conducts comparative analyses and robustness checks, including using seemingly unrelated regression (SURe) to account for cross-currency correlations.

At the heart of the study are two contrasting explanations for the forward bias: rational 'peso risks' and psychological 'fads and fashions'. The results reveal a significant dependency of the Cumby–Obstfeld–Fama (COF) beta on the degree of market mistrust, particularly during periods of high mistrust or deep discounts. The analysis indicates that deep-discount coefficients systematically decrease with deeper discounts, signaling increased perceived risk. This pattern supports the theory that market sentiments, rather than fundamental risks, significantly influence forward rates. Interestingly, the study also finds that the deep-discount betas for the private ECU are more negative than for the official ECU, contradicting the peso-risk hypothesis and further supporting the fads and fashion's view. The post-1994 data particularly highlight this shift in market behavior and perceptions. Robustness checks using SURe align with the OLS findings, and the results are inconsistent with alternative hypotheses like Bansal's asymmetric risk premium theory and the Huisman et al. extreme support hypothesis.

2.4 The Forward Puzzle: Currency Regime and Currency Strength Paper by Piet Sercu and Fang Liu (2007) investigates the forward puzzle in currency markets, specifically analyzing how the choice of sample affects empirical evidence for various explanatory theories. It examines two key characteristics of exchange rates: the exchange rate regime and the base-currency strength, exploring their impacts on model nonlinearity, beta patterns, nonstationary of the forward premium, and the variable selection for loading expectations.

The methodology involves a detailed analysis of currency regimes and their strength. It employs cubic models to assess the nonlinearity in currency movements and the forward premium. The paper also explores the use of different regressors and their effectiveness in predicting currency movements. This includes decomposing the forward premium into short-term filtered components and long run trends to understand their impact on different currency regimes and strengths. The results of the paper are related to floating currencies, band regimes and non-stationarity. For floating currencies, the forward premium is found to be closer to a unit root, and the cubic models indicate a U-shaped pattern of the betas, supporting market friction or limits to arbitrage theories. However, the nonlinearity is insignificant, and the cubic models do not outperform linear models in terms of goodness-of-fit. Under band regimes, the forward premium is more stationary, and nonlinearity is more significant. Here, the cubic models notably outperform linear ones. However, strong currencies exhibit patterns opposite to weak currencies. For strong currencies, a clear U-shaped pattern supports market friction and limits to arbitrage theories, while for weak currencies, an inverse U-shaped pattern suggests a career-risk effect with significant nonlinearity. Addressing the issue of nonstationary forward premium, the study finds that the exchange rate regime and base-currency strength have similar impacts on the short-term filtered component as with the raw forward premium.

The research concludes that the short-term component is best for band-regime currencies and weak floaters, while the long-run trend is preferred by strong floaters. It suggests that market friction or limits to arbitrage theories are prominent for floaters and strong band-regime currencies.

2.5 Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis

Lars Peter Hansen and Robert J. Hodrick' s paper (1980) explores a fundamental question in international finance: whether forward exchange rates are optimal predictors of future spot rates. They critically evaluate the hypothesis that the expected rate of return to speculation in the forward foreign exchange market is zero, employing an innovative econometric methodology.

The methodology is a key strength of this study, with Hansen and Hodrick introducing a novel econometric technique that enhances estimation efficiency. This technique involves examining restrictions on a k-step-ahead forecasting equation and using data sampled more finely than the forecast interval. The approach encompasses both modern data from the period with flexible exchange rates and historical data from the 1920s, offering a broad and comprehensive analysis of currency market dynamics across different eras. The study likely employs advanced statistical models, such as time-series models, to analyze exchange rates and forward premiums.

The study finds significant deviations from the simple market efficiency hypothesis in both modern and historical contexts. This suggests that the expected rate of return in the forward foreign exchange market is not consistently zero, indicating market inefficiencies. Moreover, Hansen and Hodrick's analysis of both modern (1970s) and historical (1920s) data shows similar patterns of inefficiency, demonstrating that these market behaviors are not confined to a specific era. Furthermore, the paper's novel econometric approach is shown to be more efficient than traditional methods, providing more reliable and accurate results in assessing the efficiency of foreign exchange markets.

Hansen and Hodrick's study offer critical insights into the efficiency of foreign exchange markets, challenging long-held assumptions in the field of international finance. Their innovative approach to econometric analysis significantly contributes to our understanding of how forward exchange rates function as predictors of future spot rates. The study underscores the complexity of financial markets and the necessity for sophisticated analytical tools, questioning the conventional wisdom on market efficiency and the role of forward exchange rates. This research is a valuable contribution to the discourse on market behavior and efficiency in the field of international finance.

3. Methodology

In the first period, the focus is on the pre-Euro time where we are analyzing the situation in European Union countries that later adopted the Euro after January 1, 1999. This analysis employs a base currency for comparison as the US Dollar, UK Pound, Japanese Yen, German Mark, New Zealand Dollar, and Australian Dollar. This period provides a crucial backdrop for understanding the interplay between exchange rates, interest rates, and forward premiums in a diverse currency environment.

The second phase transitions to the post-Euro introduction period. Here, the Euro is treated as a consolidated entity for those countries that adopted it post-1999, with the German Mark being replaced by the Euro in the set of base currencies. This segment of the study expands to include various countries worldwide, offering a broader perspective on the global exchange rate system. This period will enable the research to assess how strong base currencies like the US Dollar, UK Pound, Japanese Yen, and Euro, as well as weaker bases such as the New Zealand and Australian Dollars, interact in the global market in terms of exchange rates and forward premiums.

Moreover, we have chosen 3-month interbank rates as the focal point of our analysis. This rate, a staple in the financial sector, offers a more immediate reflection of short-term interest rate fluctuations, in contrast to longer-duration rates that are subject to a range of economic influences. Crucially, the uniformity and widespread availability of these rates across various countries provide a robust and comparable dataset essential for our cross-country analysis.

The Unbiased Expectations Hypothesis (UEH) shows a relationship between expected exchange rate movements and the interest rate differentials of different countries, as represented by the formula (1) below. Under UEH, the forward exchange rate is expected to be an unbiased predictor of the future spot exchange rate, and changes in interest rates in different countries are believed to drive exchange rate movements.

[illegible] *(1 + [illegible]$_{[illegible],[illegible]}$ [illegible]$_{[illegible],[illegible]}$ = [illegible]h[illegible]

[illegible] [illegible]

Where:

�� ∗ 100%)   100%)

(1 +���� ��,�� �� ∗   (1)

• ��������������� ��������$_{��,��}$is expected forward rate of the spot exchange rate at time *t* which is predicting spot at time *t+1*.

• �������� ������ℎ�������� ��������$_{��}^{��}$ is the spot exchange rate of the testing country to the base country at time *t*.

• ����$_{��,��}$represents the interest rate of the testing country at time *t*. • ����$_{��,��}$represents the interest rate of the base country at time *t*. • D is the time to maturity of the forward contract in months.

The main four methods of our research are One-by-One regressions, Seemingly Unrelated Regressions, Panel Data Estimations, Transaction Costs and Overlapping Samples.

3.1 One-by-One Regressions

To empirically test the Unbiased Expectations Hypothesis (UEH), we first employed the method of one-by-one regression, a robust approach that allowed me to scrutinize the relationship between exchange rate movements and interest rate differentials as postulated by the hypothesis.

For a start, we firstly found our Forward Rates data as you can see above. After obtaining the forward rates, the next step is to calculate the Forward Premium, defined below in formula (2):

(2)

Additionally, we need calculate the Return on Spot Exchange Rate as follows in formula (3):

(3)

These calculations set the stage for the primary analysis of a regression of the

Return on Spot Exchange Rate against the Forward Premium where theoretically we expect (β) to be 1 as it shows that forward rates predict future spot exchange rates. The regression equation was specified as:

$$��������������������� ������������_{��+1} \sim �� + �� * ����_{��} + ��_{��} (4)$$

Where:

- $����_{��}$ is forward premium of the spot exchange rate at time *t* which is predicting spot at time *t+1*.
- $���������� ������������_{��+1}$ is the spot return of the testing country to the base country at time *t*.
- �� represents the coefficient of forward premium.
- �� is intercept and $��_{��}$ is error term.

To enhance the robustness of the analysis, we then shifted the base country for interest rates from the United States to other countries in the dataset. By employing this meticulous approach, our aim was to shed light on the validity of the UEH in explaining real-world exchange rate movements.

3.2 Panel Data Regression Using a Pooling Model

In the second method of the thesis, we employed a pooling model for panel data regression. This approach aggregates data from multiple countries into a single dataset, treating observations from different time periods and countries as if they come from the same population. The pooling model is particularly effective for examining the consistency of relationships across different countries and time periods. The panel data comprised observations from six base currencies: the United States Dollar), British Pound, Euro (Germany in pre-Euro), Japanese Yen, Australian Dollar, and New Zealand Dollar.

The regression model was structured as follows:

���������� ������������ ��+1 ~ �� + �� * ���� �� + �� ��(5)

Where:

- ���������� ������������ ��+1 represents the dependent variable of Spot Exchange rate of the testing country to the base country at time *t+1*.
- ���� �� are the independent variable of the forward premiums of spot exchange rate of the testing country to the base country at time *t*.
- �� is the coefficient measuring the impact of the forward premium on spot exchange returns.
- �� is the constant term, and �� �� is the error term.

The pooling model assumes that this relationship is constant across all countries and time periods in the dataset. The pooling model in panel data regression provided an opportunity to test the UEH across a range of currencies and time periods, offering insights into the generalizability of the hypothesis.

3.3 Transaction Cost

The third method of the thesis introduces a transaction cost approach that directly incorporates forward premiums into the regression analysis. The objective is to understand how different levels of transaction costs, as implied by the currency's position in the discount tier, influence the relationship between forward premiums and subsequent spot exchange rate returns.

The top forward premiums are determined by their absolute values to account for the most significant market deviations, both positive and negative: 1. Calculating the absolute values of all forward premiums in the dataset.

2. . Ranking these absolute values to establish market discount tiers such as the top 1%, 5%, 10%, 20%, 40% and small rest 60%.

3. Creating binary indicators (������������������������%,��) that signals whether a forward premium falls into a specific top tier.

The inclusion of the top forward premiums in the regression is achieved by multiplying the actual (not absolute) forward premium value by the binary indicator. If the forward premium is within the top percentile, the indicator is 1;

otherwise, it is 0. This allows the regression to only consider the forward premiums that are significant in magnitude (both positive and negative) for each tier.

Our new model acknowledges that each beta represents the forward premium at different tiers of currency discounts, which indirectly serve as a proxy for transaction costs. The revised model is specified as:

���������� ��������������+1 ~ �� + ��������1%,�� *
����������1%,�� + ��������5%,�� * ����������5%,�� +
��������10%,�� * ����������10%,�� + ��������20%,�� *
����������20%,�� + ��������40%,�� * ����������40%,��
+ ������������60%,�� * ��������������60%,�� +
����(6)

Where:

- ���������� ��������������+1 represents the dependent variable of Spot Exchange rate of the testing country to the base country at time *t+1*.
- ������������%,�� are the independent variable of the forward premiums of spot exchange rate for the corresponding *topn%* currency discounts of the testing
  country to the base country at time *t* for n = 1%, 5%, 10%, 20%, 40%, and

60%.

• �� ��������%,�� are the coefficients measuring the impact of the forward premium on spot exchange returns, adjusted for the corresponding transaction cost tier. • �� is the constant term, and �� ��is the error term.

The model will analyze how transaction costs, inferred from currency discounts, affect the predictive power of forward premiums on spot exchange rates. The betas are expected to differ across discount tiers, reflecting the varying impact of transaction costs on the forward premium's predictive accuracy.

Our main hypotheses of the model are:

H1: To examine if higher transaction costs (implied by larger forward premiums at deeper discount tiers) lead to larger betas, indicating a deviation from the expected negative relationship in the UIP framework.

H2: To test whether increasing the stringency of the discount criteria (and thus the implied transaction costs) will lead to a decrease in the magnitude of the forward premium's impact on exchange rate returns.

H3: To determine the differential impact of transaction costs under conditions of confidence crisis and pure devaluation risk on the forward premiums' predictive power.

3.4 Seemingly Unrelated Regressions

Next method, which is called Seemingly Unrelated Regressions (SURe), is used when there are multiple regression equations with correlated error terms. These equations are 'seemingly unrelated' in the sense that they do not directly depend on each other, but they are connected through the correlation in their error terms. In the context of our model with return on spot exchange rates and forward premium, it can exploit the information in the cross-currency correlations of the residuals and can serve as a robustness check of our model. However, SURe can behave unpredictably if the regressors are close to the unit root (Piet Sercu, Tom Vinaimont). The general formula that we took into consideration is as follows:

��$_1$ 0 ... 0 ��$_1$
��$_1$
��$_1$
(��^{2} ⋮ ... 0 ⋮ ⋮ ⋱ ⋮ 0 0) ( ) + (���� + �� (7)
��$_{��}$ ... ��^{2} ⋮ ��^{2} ⋮
Where:) = (��$_{��}$ ��$_{��}$
0 ��$_2$ ��$_{��}$) =

• ��$_1$ through ��$_{��}$ is the return on spot exchange rate matrix of different countries • ��$_1$ through ��$_{��}$ is the forward premium matrix

• ��$_1$ through ��$_{��}$ is the matrix of coefficients for the forward premium for chosen countries

• ��$_1$ through ��$_{��}$ is the error term matrix.

We adapt the equation across 6 base countries.

3.5 Covariance Matrix method (Hansen & Hodrick, 1980)

Now we have changed the frequency of data to weekly data. The new regression will look like:

���������� ������������$_{��+��}$ ~ �� + �� ∗ ����$_{��}$ + ��$_{��,��}$(8)

Where:

• *k* is the 13 weeks ahead of prediction

• ���������� ������������$_{��+��}$ represents the dependent variable of weekly Spot Exchange rate of the testing country to the base country at time *t+k*. • ����$_{��}$ are the independent variable of the forward premiums of spot exchange rate of the testing country to the base country at time *t*.

• �� is the coefficient measuring the impact of the forward premium on spot exchange returns.

• �� is the constant term, and ��$_{��}$is the error term at time t and k steps weeks ahead prediction which is also called residual of the OLS regression.

From the regression above, we got �� on forward premiums, p-values and standard errors. However, the results are biased due to overlapping weekly sample on 3month (13 weeks) maturity interest rates. So, we need to find new standard errors and p values of the model which will be adjusted for the overlapping bias. Therefore, Hansen and Hodrick (1980) have presented the method for this issue of overlapping bias in weekly data for different maturity.

As they have shown, we need a consistent estimator for the asymptotic covariance matrix. Firstly, we have to find consistent estimators of residuals and forward premiums for j = -k+1,…,k+1 and since ���� is ergodic for j ≥ 0,

$$\hat{�}^{��}(��) = \frac{1}{��} \sum_{��=��+1}^{��} ����_{��}{}' * ����_{��-��} \rightarrow ��_{����}(��) \quad (9)$$

$$\hat{�}_{��}^{��}(��) = \frac{1}{��} \sum \; �\hat{�}\,�\,�\,{}'\,�\,�$$

$$\sum_{�=�+1}^{�} �̂_{�−�,�} ��_* \rightarrow ��_{��}(��) \quad (10)$$

�� is the OLS residual for observation t with sample size T. Using the facts where $��̂_{��,��}$ $'(-��)$ now we can obtain a consistent estimator that $��_{��}(��)= ��_{��}(-��)$ and $��_{����}(��)= ��_{����}$ of the asymptotic covariance matrix Θ.

Firstly, lest make our Forward Premium data into to matrix,

$$��� \; �_{��} = \begin{bmatrix} �_1 \\ ��� \\ \cdots \\ ��� \\ �_{��} \end{bmatrix} \quad (11)$$

$�_{��},$

And we can now form TxT symmetric matrix $\hat{\Omega}_{��}$ whose lower triangular representation is:

$$\begin{bmatrix} ��̂_{��}^{��}(0) & 0 & 0 & 0 & 0 & 0 & 0 \\ ��̂_{��}^{��}(1) & ��̂_{��}^{��}(0) & 0 & 0 & 0 & 0 & \\ & & \vdots & & & & \\ 0 & \ldots & 0 & ��̂_{��}^{��}(�� - 1) & \ldots & ��̂_{��}^{��}(1) & ��̂_{��}^{��}(0) \\ \vdots & \ldots & \ldots & 0 & 0 & 0 & 0 \; ��̂_{��}^{��}(�� - 1) \end{bmatrix}$$

… … … 0 0 0 0 … … … … 0 0 ⋮ … …
… … … 0 [

(12)

Next, we are sure that

$' * ����_{��,��})^{-1} = ��\hat{�}����$

$^{��}(0)^{-1}$(13) $�� * (����_{��,��}$

And

$����_{��,}$

$_{��})^{-1}$

$��-1$

$' *$

$(����_{��,��}$ (14)

$��=-��+1$

$�� = \sum ��\hat{�}����$

$^{��}(��) * ��\hat{�}��^{��}(��)$

So, now we can say that

$' * ����_{��,��})^{-1} *$ $' * ����_{��,��})^{-1} = \hat{\Theta}��$(15)

$����_{��,��}$

$�� * (����_{��,��}$ $(����_{��,��}$

$' * \hat{\Omega}�� * ����_{��,��} *$

is a consistent estimator for the asymptotic covariance matrix which will be variance of our OLS regression.

Thus, we use this variance to find new standard error and p-value of the regression as follows.

$$����=\frac{\sqrt{\hat{\Theta}_{��}}}{\sqrt{��}} \quad (16)$$

$$��_{��������}=\frac{����}{��} \quad (17)$$

$$��_{����������}=2*����(-������(��_{��������}),\ ����=��) \quad (18)$$

Where:

- T is sample size.
- $\hat{\Theta}_{��}$ is found consistent estimator for the asymptotic covariance matrix or just variance.
- �� is obtained coefficient of forward premium from OLS regression.
- pt () is a function in R Language that is used to return the probability cumulative density of the student t-distribution.
- abs () is a function in R Language which gives absolute value. •

df = n is degrees of freedom from the OLS regression.

So, now we will have updated statistical results of the regression which will be adjusted for overlapping bias.

4. Data

The data was conveniently obtained using Excel add-ins provided by the

Refinitiv terminal in our laboratory at GSB. This daily data on interest rates and interbank rates for multiple maturities allows for a more detailed examination of the relationship between exchange rates and interest rates.

Table 1. Data Description

Aspect	Pre-Euro Period	Post-Euro Period
Data Source	Refinitiv Terminal (Excel add-ins)	
Number of Countries	15	36
Data Types	Daily Exchange, Interest, and Interbank Rates	
Timeframe	2/1/1975 - 31/12/1998	1/1/1999 - 1/9/2023
Rate Maturities	1-month, 3-month, 6-month, 12-month	
Variable Names	Interest: "RF COUNTRY GVT BMK BID YLD" Interbank: "INTERBANK COUNTRY - OFFERED/MIDDLE RATE"	
Data Transformations	Conversion to US Dollar base, Comparative analysis	
Total Sample Size	6261	6463
Observation Frequency	Monthly for 1-month, quarterly for 3-month, semiannual for 6-month, annual for 12-month rates	

For the empirical part, we collected mixed data covering 36 countries around the world after the introduction of the euro and data of 15 countries for 15 countries before the euro introduction as you can see in Table 1 above (see Appendix 1 for the full list). The United States served as the base country for the exchange rate data. This diversity of the countries shows that the dataset is comprehensive, each bringing its own economic characteristics and background.

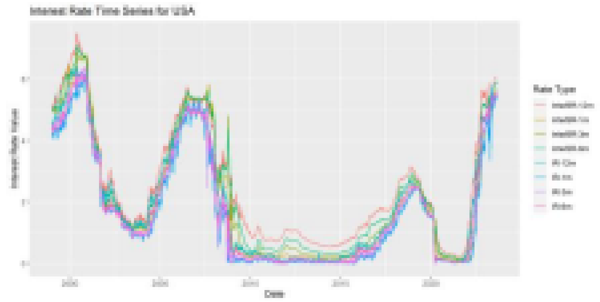
Moreover, to find the relationship between exchange rates and interest rates, we performed several transformations on the data set. Firstly, we converted the exchange rates to the base of US dollar currency. This step was necessary to ensure consistency of data across all countries. Additionally, to get an idea of other countries as a basis, we conducted further analysis by dividing the exchange rates of all other countries by a particular country as a base. This has helped us to understand how exchange rate fluctuations affect different countries relative to each other.

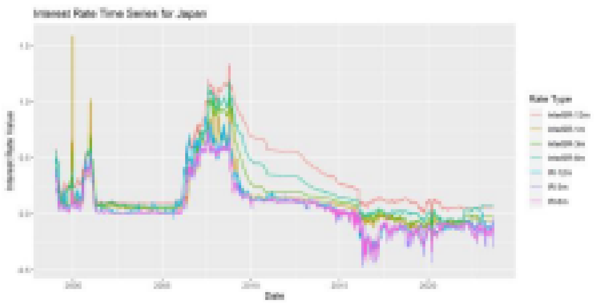
Furthermore, for the monthly data subset where we took 31 March for the 1- month rates and. Next, we have found other maturities for each country. We took the data of the last available day of the month. This was important because we need precise dates for different maturities of interest rates and interbank rates as it is affecting predictability of forward rates to spot rates.

5. Results

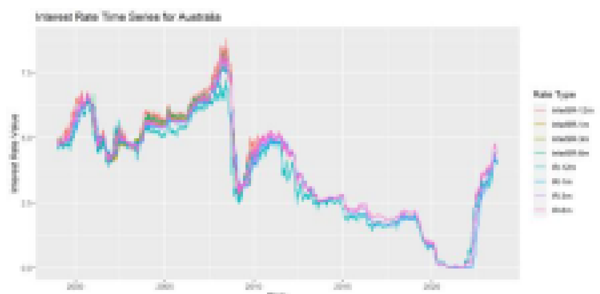
5.1 Time Series Plots of base currencies

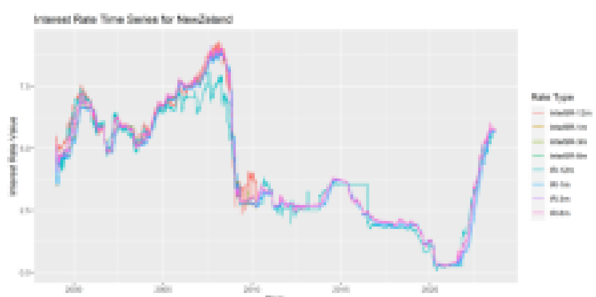
USA Japan



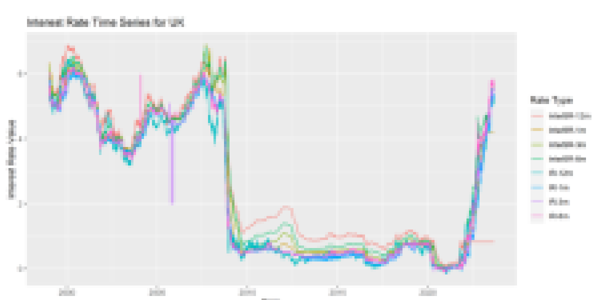


Australia New Zealand





UK EURO



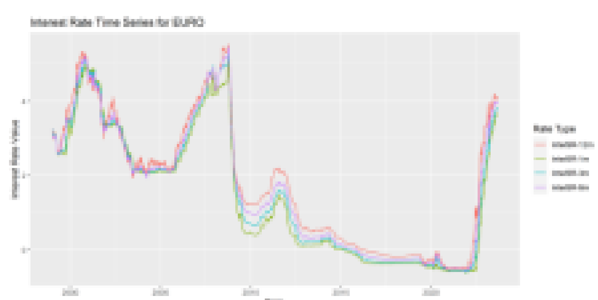


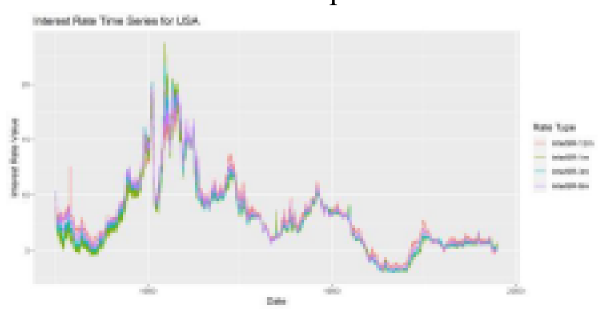
Figure 1. Interest Rates over time for post-Euro base currencies

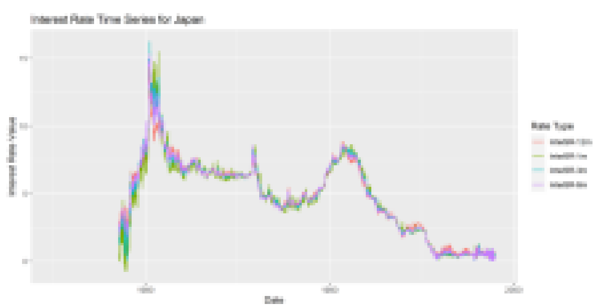
Across all regions as shown in Figure 1, we see that there is a general trend of rates peaking in the early 2000s, followed by a steep decline during the 2008 financial crisis, showcasing the synchronized global response to economic stress with aggressive rate cuts. Post-crisis, the InterBR-3M rates remain subdued, especially in Japan and the Euro area, reflecting persistent loose monetary policies to counteract deflationary pressures and stimulate economic growth. Notably, the Euro area and Japan display exceptionally prolonged periods of low rates, which could indicate long-term structural economic challenges and a reliance on unconventional monetary policy tools like negative interest rates or quantitative easing.

In Australia, New Zealand, the UK, and the USA, rates begin to recover post 2010, albeit with noticeable volatility, potentially illustrating the gradual unwinding of crisis-era policies as economic conditions improved. However, all six plots show a sharp dip around 2020, likely corresponding to the global economic impact of the COVID-19 pandemic, with central banks rapidly decreasing rates to near-zero levels to mitigate financial distress and support economic activity.

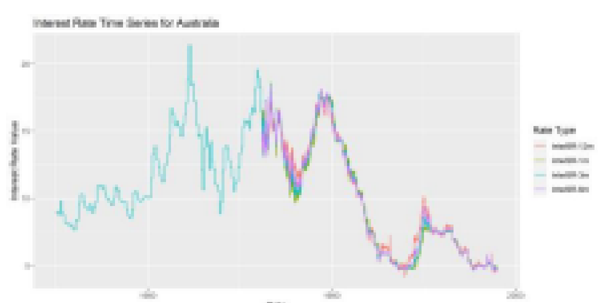
The 3-month interbank rate plots collectively underscore the interconnectedness of global economies, reflecting synchronized policy responses to global events. The time series for each region tells a story of economic resilience, crisis management, and the varying speeds of recovery, which are influenced by individual economic fundamentals, policy effectiveness, and external shocks. These plots are invaluable for comparing regional monetary policy stances over time and for understanding the global flow of capital in response to interest rate differentials.

USA Japan





Australia New Zealand



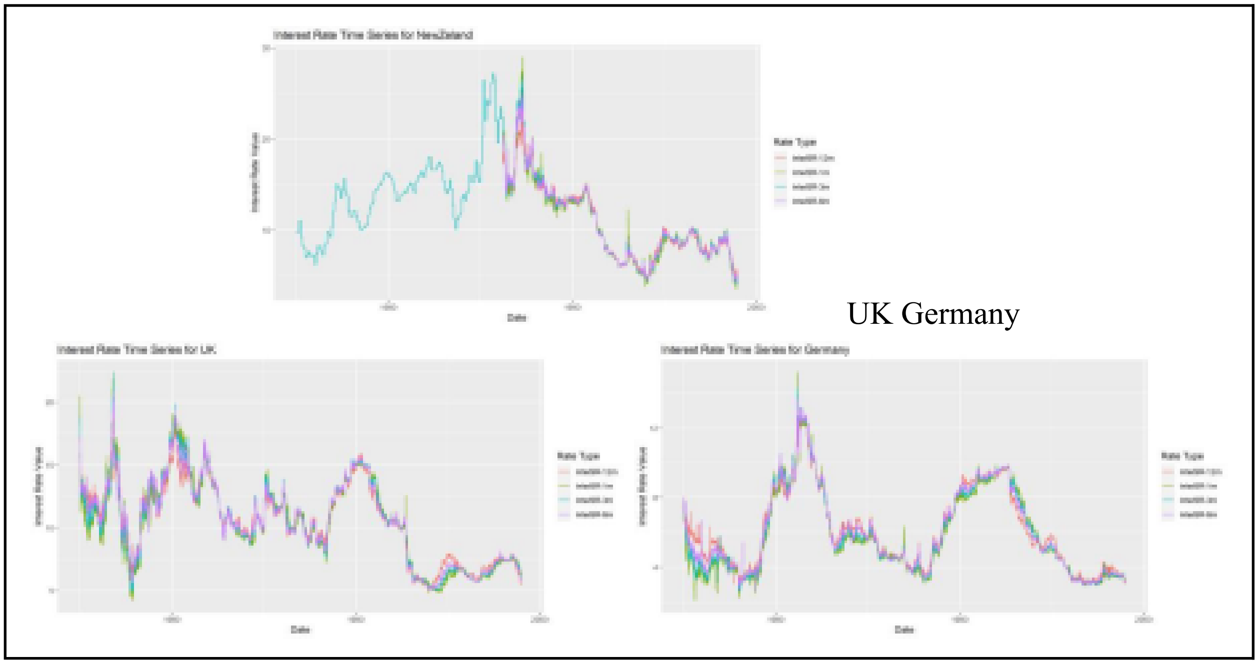


Figure 2. Interest Rates over time for pre-Euro base currencies

As we from the plots in Figure 2 above, the InterBR-3M rates experienced significant volatility, with peaks and troughs corresponding to periods of economic stress and prosperity, respectively. The early 1980s show relatively high rates across several countries, possibly indicative of the high-inflation environment of the time when central banks raised rates to combat inflation. The subsequent fluctuations can often be tied to global and country-specific economic events, such as the early 1990s recession, which led to lower rates to stimulate growth. A sharp spike is evident in

the early 1990s for countries like New Zealand, which may reflect a rapid tightening of monetary policy to control inflationary pressures.

By the late 1990s, the InterBR-3M rates generally trend downward across all countries, suggesting a global move towards lower inflation and the adoption of monetary policies aimed at fostering stable growth post-recession. It's also notable that Japan's rates remain lower than other countries for a prolonged period, likely due to Japan's unique economic situation with persistent deflationary pressures, leading to a prolonged period of low interest rates known as the "Lost Decade." The reliability of the graphs can be considered high, given that interbank rates are key economic indicators and are closely monitored by financial institutions worldwide.

5.2. One-by-One regressions

5.2.1 post-Euro data analysis

In this section, we analyze simple one-by-one regression for the 6 base currencies across our dataset. The timeframe for the post-Euro era was a full available time series from 1999 to 2023, 1st period from 1999 to 2010, and second from 2011 to 2023 to see different movements in timeframes. In addition, the timeframe for the pre-Euro era was from 1975 to 1999 to see how UEH works before Euro currency introduction.

Table 2. One-by-One Post-EURO Regression, USA Base

USA Base currency

Metric GBP EUR AUD JPY KZT NZD MXN �� ��̃ + - +* -*

��$_{��������}$ -0,297 0,962 1,296 -0,554 -0,983 0,930 0,723 0,173 0,021 19 16 3 3 ��$_1$-1,182 1,797 1,987 1,271 -1,430 1,381 0,508 0,486 0,264 21 14 2 3 ��$_2$-0,974 -1,749 -0,551 -0,876 -0,107 -1,301 5,521 -0,436 -0,545 11 23 2 1

Note:��$_{��������}$ is coefficient of full period sample, ��$_1$is for 1st period sample, ��$_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

First Period from 1999 to 2023. The coefficient of the forward premium (β) for the US base across various currencies shows a significant variation. For instance, the β for the UK is -0.297, and for Kazakhstan, it is -0.983. This suggests a weak predictive power of forward premiums on spot returns, as indicated by the generally low R^2 values. These findings echo the puzzles discussed in the literature where high-interest-rate countries do not always yield high returns, contradicting the traditional models (Engel, 2016). The mean and median β values across all 35 countries are not close to 1 (0.173 and 0.021, respectively), indicating a generally low predictability, which is consistent with the vast empirical literature on the forward premium anomaly (Engel, 2016). The predominance of negative β values (19 out of 35) also corroborates the challenges faced by the Unbiased Expectations Hypothesis (UEH) in explaining the empirical data (Sercu & Vinaimont, 2006).

Second Period 1999 to 2010. During the second period, we observe a remarkable increase in β values for some countries like the UK (β = -1.182) and Australia (β = 1.797), which suggests an improvement in the forward premium's ability to predict spot returns. This could be indicative of the period-specific effects that influence the forward premium's predictive power, as noted in the empirical works (Sercu & Vinaimont, 2006). The R^2 values, though improved, still indicate a moderate explanatory power for the forward premium. The mean β value across all 35 countries has increased to 0.486, with the median remaining stable, reflecting some improvement in predictability. However, the increase in countries with negative β to 21 illustrates the complexity and inconsistency of forward premiums as predictors across different markets and periods.

Third Period 2011 to 2023. The most recent period reveals a mixture of positive and negative β values with the UK exhibiting a β of -0.974, EURO at -1.749, Japan at -0.876, and New Zealand at -1.301. The overall low R^2 values indicate that other factors besides forward premiums are at play in predicting spot exchange rate movements, aligning with the literature that points to the difficulty of finding economic models that account for the observed relationships (Engel, 2016). The decrease in the mean β value to 0.436 and median increase to 0.545 suggests a marginal decline in predictive power, further emphasizing the complexities in exchange rate dynamics and the limitations of the UEH (Engel, 2016).

Table 3. One-by-One Post-EURO Regression, Japan Base

Japan Base currency

Metric	*GBP*	*EUR*	*AUD*	*KZT*	*NZD*	*MXN*	*USD*	��	��̃	+	-	+*	-*
����������	-1,199	-0,399	-1,795	-1,467	-1,427	0,423	-0,507	-0,699	-0,531	10	25	1	0
��$_1$	-1,136	1,710	-10,98	-1,652	-3,249	0,815	1,289	-0,525	0,413	19	16	2	2
��$_2$	1,577	0,778	-2,546	-1,269	-1,712	1,957	-0,904	-0,851	-0,861	12	22	0	1

Note:����������� is coefficient of full period sample, ��$_1$is for 1st period sample, ��$_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

During First Period (1999 to 2023) period, the negative β for the UK (β = -1.199) with Japan as the base currency suggests that forward premiums were not effective predictors of future spot rate movements, likely due to the influence of carry trade activities where investors borrow in low-yield currencies such as the yen to invest in higher-yielding ones. This misalignment with the UEH is consistent with the complexities highlighted in the empirical literature (Sercu & Vinaimont, 2006). The modest β for the Euro (0.399) reflects some predictability, which might be influenced by the macroeconomic policies affecting stronger currencies (Engel, 2016). The overall negative mean β (-0.699) and 25 negative β values indicate that, especially for weak currencies, forward premiums did not reliably predict future spot exchange rates.

In the second (1999 to 2010) period, results show a stark divergence in β coefficients. Australia's extremely negative β (-10.977) could reflect the effects of unwinding carry trade, a phenomenon that often affects weak currencies offering high interest rates and subject to speculative flows (Engel, 2016). Positive β values for strong currencies like the Euro (1.710) suggests some level of forward premium predictability in this period, although the mean β value (-0.525) and 16 negative β values suggest that predictability was not consistent across all currencies.

In the most recent (2011 to 2023) period, for strong currencies like the UK (1.577) and the Euro (0.778), positive β values suggest that forward premiums might have provided some predictive insight into expected spot exchange rate movements when Japan is used as the base currency. Yet, with a mean β of -0.861 and 22 negative β values, the results indicate mixed predictability, highlighting the challenges of the forward premium puzzle and the complexities of currency market dynamics, especially in the context of carry trades and speculative activities involving weak currencies (Engel, 2016). This underscores the complex nature of using forward premiums to forecast spot exchange rates and the limitations of the UEH, particularly when Japan serves as the base currency in a financial environment influenced by its distinct low-interest-rate policy.

Table 4. One-by-One Post-EURO Regression, Australia Base

Australia Base currency

Metric	***GBP***	***EUR***	***JPY***	***KZT***	***NZD***	***MXN***	***USD***	��	��̃	+	-	+*	-*
���������	0,818	0,955	-2,219	-1,398	-1,851	1,137	1,069	0,230	0,162	21	14	2	1
��$_1$	3,382	2,351	-12,04	-4,660	-0,902	1,220	1,561	-1,865	0,071	18	17	1	6
��$_2$	-0,271	-0,588	-2,692	-0,844	-3,319	1,600	-0,561	-0,159	-0,444	11	23	2	0

Note:��������� is coefficient of full period sample, ��$_1$is for 1st period sample, ��$_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

For the full period (1999 to 2023), The β coefficient for the Euro (0.955) suggests a modest predictive power of forward premiums when Australia is used as the base currency. This aligns with the literature that describes market friction and limits to arbitrage as possible explanations for the forward puzzle (Liu & Sercu, 2007). A high negative β for New Zealand (-1.851) illustrates the career-risk effect, where portfolio managers may shun assets signaling danger, like a strong forward discount (Liu & Sercu, 2007). The positive β for the UK (0.818) could suggest that strong currencies might be more predictable due to macroeconomic stability and effective central bank policies, as discussed by Sercu & Vinaimont (2006). The relatively balanced number of positive (21) and negative (14) β values across currencies indicates an uncertain and variable predictive capability of forward premiums.

For the first subperiod (1999 to 2010), the significantly positive β values for the UK (3.382) and the Euro (2.351) during this period suggest that forward premiums had a stronger relationship with spot rate movements for these currencies. In contrast, the negative β for New Zealand (-0.902) reflects the ongoing difficulties in predicting movements for currencies targeted by carry trades (Liu & Sercu, 2007) . The mean β (1.865) and the almost equal distribution of positive and negative β values suggest that the predictability of forward premiums continued to be inconsistent, which is emblematic of the forward puzzle where the Fama regression slope often deviates from unity (Engel, 2016; Liu & Sercu, 2007).

For the last period (2011 to 2023), it exhibits a reversal from previous trends, with a negative β for the UK (-0.271) and a high negative β for New Zealand (3.319), suggesting a shift in market dynamics or the influence of external economic factors (Liu & Sercu, 2007). The mean β is negative (-0.159), and the majority of negative β values (23 out of 34) point to a weakened predictive power of forward premiums, consistent with the challenges of modeling exchange rate movements as described in the forward premium puzzle (Engel, 2016).

Across all periods, the analysis indicates that the relationship between forward premiums and spot exchange rates is complex and time-variant, especially from the perspective of Australia as the base currency. While there are moments of predictability, particularly with strong currencies, weak currencies such as New Zealand's display significant volatility in their β coefficients, highlighting the impact of speculative activities and the limitations of the UEH. This nuanced view is

corroborated by empirical findings on the forward premium puzzle, market frictions, limits to arbitrage, and the career-risk hypothesis (Engel, 2016; Sercu &

Vinaimont, 2006; Liu & Sercu, 2007).

Table 5. One-by-One Post-EURO Regression, New Zealand Base

New Zealand Base currency

Metric	*GBP*	*EUR*	*AUD*	*JPY*	*KZT*	*MXN*	*USD*	��	��̃	+	-	+*	-*
����������	-0,225	-3,385	-1,943	-1,814	-1,434	1,366	0,892	-0,490	-0,601	11	24	2	3
$��_1$	1,103	-4,179	-0,965	-3,800	-5,386	1,350	1,423	-1,302	-0,970	10	25	2	5
$��_2$	-1,689	-4,921	-3,431	-1,742	-0,245	1,949	-1,293	-1,185	-1,132	9	25	0	2

Note:���������� is coefficient of full period sample, $��_1$ is for 1st period sample, $��_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

For the full Period (1999 to 2023), the β coefficient for the USA (0.892) is significantly high, which may suggest a strong predictive power of forward premiums from the New Zealand perspective. This could be explained by the combination of market frictions and limits to arbitrage (Liu & Sercu, 2007) which can be particularly pronounced when dealing with 'strong' currencies like the Euro. The negative β for Australia (-1.943) reflects the complexities associated with 'weak' currencies, which may include the carry trade dynamics where New Zealand's higher interest rates make it a candidate for carry funding currencies (Liu & Sercu, 2007). The presence of both positive (11) and negative (24) β values across the board indicates an uncertain predictive capability of forward premiums in this period.

In the second period (1999 to 2010), the β for the UK (1.1031) remains positive, indicating some level of predictability. However, the negative β for

Australia (-0.9645) persists, emphasizing the ongoing challenge of predicting movements for weak currencies within the carry trade context. This period's mean β (-1.302) and the relatively balanced distribution of positive (10) and negative (25) β values suggest that the predictability of forward premiums was inconsistent and aligns with the broader empirical findings that question the UEH's assumptions (Engel, 2016).

In the last period (2011 to 2023), a high negative β for Australia (3.3431) deviates from previous trends, suggesting a change in the relationship between forward premiums and spot exchange rates. This could reflect a shift in the global economic environment or the impact of external economic factors such as monetary policies and market sentiments that influence exchange rates (Liu & Sercu, 2007). The mean β is positive (-1.185) with more positive β values (19) than negative ones (16), indicating a potential improvement in the predictive power of forward premiums for this period.

Table 6. One-by-One Post-EURO Regression, EURO Base

Euro Base currency

Metric	*GBP*	*AUD*	*JPY*	*KZT*	*NZD*	*MXN*	*USD*	**	*̃*	+	-	+*	-*
**����������	-1,331	0,828	-0,556	-1,134	-3,130	1,584	0,775	0,728	0,517	24	11	6	0
**$_1$	0,127	1,906	1,547	-4,344	-4,111	1,870	1,612	2,241	1,547	27	8	7	1
**$_2$	-4,655	-0,482	0,465	-0,535	-4,331	0,891	-1,811	-0,583	0,085	18	16	0	2

Note:���������� is coefficient of full period sample, ��$_1$ is for 1st period sample, ��$_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

For the full period (1999 to 2023), the β for Australia (0.828) suggests a modest relationship between forward premiums and spot exchange rates, indicative of market friction or limits to arbitrage effects in currency markets (Liu & Sercu, 2007). New Zealand's significantly high β (-3.130) might reflect the career-risk effect in which investors are wary of assets with signals like a strong forward discount, especially when considering 'weak' currencies within a floating rate system against the USD (Liu & Sercu, 2007). The overall mean β (0.728) with a greater number of positive β values (24) than negative ones (11) suggest a generally positive but varied predictive capability of forward premiums during this period.

In the second (1999 to 2010), the β for the UK (0.127) is nearly zero, indicating a lack of predictive power of forward premiums for this strong currency, challenging the traditional UEH expectations (Liu & Sercu, 2007). The negative β for New Zealand (-4.111) is particularly striking and may reflect an amplified version of the phenomena observed in the first period, where weak currencies exhibit

behaviors that defy standard economic models (Engel, 2016). The mean β (2.241) with a significant number of positive β values (27) suggests an overall tendency for forward premiums to predict spot returns, although the presence of 8 negative β values indicates that this predictability is not uniform.

In the last period (2011 to 2023), a positive β for Mexico (0.891) suggests a change in the dynamics of how forward premiums predict spot exchange rates for strong currencies. This period's mean β (-0.583) with a majority of positive β values (18) compared to negative ones (16) could point towards an improvement in the predictive power of forward premiums for the Euro as a base currency. However, the results still indicate mixed predictability, aligning with the broader empirical findings that question the UEH's assumptions and highlight the forward premium puzzle (Engel, 2016; Liu & Sercu, 2007).

Table 7. One-by-One Post-EURO Regression, UK Base

UK Base currency

Metric	***EUR***	***AUD***	***JPY***	***KZT***	***NZD***	***MXN***	***USD***	**��**	**��̃**	**+**	**-**	**+***	**-***
��$_{��������}$	-1,228	0,923	-1,498	-1,146	-0,016	0,938	-0,552	-0,322	-0,454	10	25	3	1
��$_1$	0,568	3,565	-1,444	-4,859	1,034	0,904	-1,527	-0,378	-0,493	15	20	2	3
��$_2$	-4,598	-0,163	1,538	0,533	-1,153	1,460	-0,914	-0,086	0,334	21	13	1	1

Note:��$_{��������}$ is coefficient of full period sample, ��$_1$is for 1st period sample, ��$_2$ is for 2nd period sample, +/- is positive/negative count, +*/-* is significance of (+/-) count at 0.1 SL

The full period (1999 to 2023), the β for Australia (0.923) suggests that forward premiums offer some predictive power of future spot exchange rate movements. However, the negative β for New Zealand (-0.016) indicates almost no relationship, which could be consistent with the career-risk hypothesis where investors might avoid assets with strong forward discounts (Liu & Sercu, 2007).

The mean β (-0.322) with more negative (25) than positive (10) β values across countries indicates a predominantly weak predictive capability of forward premiums during this period.

The first sub-period (1999 to 2010) shows that the positive β for Australia (3.565) suggests a strong relationship between forward premiums and spot rate movements, which could be influenced by factors such as market frictions and limits to arbitrage (Liu & Sercu, 2007). The negative β for New Zealand (-1.151) continues to reflect the challenges in predicting movements for weak currencies within the carry trade context. The mean β (-0.378) with an equal distribution of positive and negative β values (15 positive and 20 negative) suggests that the predictability of forward premiums remained inconsistent, which is emblematic of the forward premium puzzle where the Fama regression slope often deviates from unity (Engel, 2016).

Last sub-period (2011 to 2023), shows that a negative β for Australia (-0.163) contrasts sharply with the previous period, indicating a shift in the predictive relationship. The mean β (-0.086) with more positive β values (21) than negative ones (13) indicate a general improvement in the predictive power of forward

premiums for the UK as a base currency during this period. However, the results still show mixed predictability, aligning with the broader empirical findings that challenge the UEH's assumptions and highlight the forward premium puzzle (Engel, 2016; Liu & Sercu, 2007).

Table 8. Summary statistics of other interest and interbank rates for different maturities

Base	**��**	**��̃**	+	-	+*	-*
3m Interest Rate						
USA	0,167	0,163	19	13	1	1
Japan	-0,273	-0,362	12	20	0	0
Australia	0,328	0,346	20	12	1	0
New Zealand	-0,899	-0,660	9	23	1	2
UK	0,329	0,056	19	13	2	2
1m Interbank Rate						
USA	0,182	0,186	20	14	4	3
Japan	-0,854	-0,641	9	25	1	2
Australia	0,071	0,170	18	16	2	2
New Zealand	-0,604	-0,856	10	24	3	5
EURO	0,727	0,676	24	10	4	2
UK	0,001	-0,108	15	19	4	3
6m Interbank Rate						
USA	0,367	-0,255	14	20	3	1
Japan	-0,819	-0,563	15	19	0	1
Australia	-0,584	-0,984	15	19	1	2
New Zealand	-3,061	-2,857	7	27	1	6
EURO	0,712	0,320	20	14	3	3
UK	-2,166	-2,993	7	27	2	1
1y Interbank Rate						
USA	-0,075	-0,204	14	20	4	2
Japan	-0,573	-0,187	10	24	0	1
Australia	-0,519	-0,467	13	21	1	4
New Zealand	-1,141	-1,013	6	28	0	7
EURO	0,213	0,186	19	15	3	3
UK	-1,030	-1,264	6	28	1	5

Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

When examining weak currencies like the New Zealand (NZD) and Australian dollars (AUD), the results suggest these tend to deviate from the UET, especially for longer maturities. For instance, the AUD shows a moderately positive mean coefficient (0.328) at the 3-month interest rate, suggesting some predictive power of the forward premium. However, the NZD displays a significant negative beta (e.g., -3.061 at the 6-month interbank rate), indicating a potential risk for carry trades as the actual spot return may not align with what the forward rate predicts.

In contrast, strong currencies such as the US dollar (USD), Euro (EUR), British pound (GBP), and Japanese yen (JPY) present a mixed picture. The EUR's strong positive mean coefficient (0.727 at the 1-month interbank rate) suggests a closer alignment with the UET, implying that the forward rate is a good predictor of future spot returns. However, the GBP and JPY show significant negative coefficients at different maturities (GBP at 6-month interbank rate: -2.166), challenging the theory's reliability.

The results suggest carry trades, which involve capitalizing on the interest rate differentials between currencies, could be subject to unexpected risks. While the predictive power of the forward premium might hold for some currencies and short term maturities, significant negative coefficients for others, particularly in longer maturities, imply that the market may anticipate currency depreciations that are not reflected in the forward rates.

5.2.2 Pre-Euro data analysis

Table 9. One-by-One Pre-EURO Regression

<u>*Full period from 4/1/1975 to 31/12/1998*</u>

USA Base DEM GBP JPY AUD NZD [illegible] [illegible] + - +* -* *β* <u>0,295 0,893 3,225 0,374 1,216 0,493 0,374 10 3 2 1</u> *Japan Base DEM USD GBP AUD NZD* [illegible] [illegible] + - +* -* *β* <u>1,256 3,208 4,858 0,685 0,127 0,668 0,256 8 5 3 0</u> *Australia Base DEM USD GBP JPY NZD* [illegible] [illegible] + - +* -* *β* -0,897 0,329 0,283 0,717 0,596 -0,327 -0,174 5 8 0 2 *New Zealand Base DEM USD GBP JPY AUD* [illegible] [illegible] + - +* -*

β -0,556 1,180 -0,237 -0,006 0,482 -0,414 -0,426 2 11 1 2 *Germany Base USD GBP JPY AUD NZD* + - +* -* β 0,253 0,261 1,144 -0,948 -0,454 -0,252 -0,368 4 9 0 3

UK Base DEM USD JPY AUD NZD + - +* -* β 0,256 0,902 5,023 0,234 -0,202 0,511 0,234 9 4 1 1 Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

The USA β with respect to the German Mark (0.295) and Australian Dollar (0.374) are closer to 0, suggesting a weaker predictive power of forward premiums. However, the Japanese Yen (3.225) shows a very high β, suggesting an unusual relationship where forward premiums might be significantly over or underestimating future spot returns. As the base changes to Japan, the β for the German Mark (1.256) and the US Dollar (3.208) are notably high, again indicating a potentially non standard relationship.

With Germany as the base, most β values are positive but less than 1, except for the Japanese Yen (1.144), implying a stronger relationship. The UK as Base Currency β for Japan (5.023) stands out as extremely high, suggesting an atypical predictive relationship.

Carry trades would likely have been influenced by these relationships, especially considering the high β values for currencies like the Japanese Yen. Traders would need to consider the possibility of the forward premium not accurately predicting future spot returns, potentially leading to unexpected gains or losses. The results suggests that the forward premium's ability to predict future spot returns varied widely before the introduction of the Euro.

5.3 Panel Data Estimations

5.3.1 Post Euro Data analysis

Table 9. PLM Regression for Full Post EURO period (1999-2023)

1Month USD JPY AUD NZD EUR GBP �� ��̃ + - +* -*

β1 -0,18 -0,30 -0,27 -0,38 -0,14 -0,26 -0,25 -0,26 0 6 0 5 *β2* -0,28 - - - -0,23 - -0,25 -0,25 0 2 0 2 *β3* -0,31 - - - -0,23 - -0,27 -0,27 0 2 0 2

3Month USD JPY AUD NZD EUR GBP �� ��̃ + - +* -*

β1 -0,20 -0,35 -0,30 -0,42 -0,18 -0,35 -0,30 -0,30 0 6 0 6 *β2* -0,30 - - - -0,28 - -0,29 -0,29 0 2 0 2 *β3* -0,33 - - - -0,28 - -0,31 -0,31 0 2 0 2

6Month USD JPY AUD NZD EUR GBP �� ��̃ + - +* -*

β1 -0,60 -0,79 -0,98 -1,39 -0,71 -1,20 -0,94 -0,94 0 6 0 6 *β2* -0,92 - - - -1,07 - -0,99 -0,99 0 2 0 2 *β3* -0,96 - - - -1,07 - -1,02 -1,02 0 2 0 2

12Month USD JPY AUD NZD EUR GBP �� ��̃ + - +* -*

β1 -0,22 -0,35 -0,38 -0,48 -0,24 -0,44 -0,35 -0,35 0 6 0 6 *β2* -0,29 -0,39 -0,44 -0,56 -0,32 -0,51 -0,42 -0,42 0 6 0 6 *β3* -0,30 -0,40 -0,33 -0,51 -0,32 -0,51 -0,39 -0,39 0 6 0 6 Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

The Panel Data regression for the table above considers the full timeframe from 1999 until 2023, which were divided by different maturities of interbank rates across 6 base countries. The three different betas are taken from three different regression models where �1 is from Spot Return on Forward Premium, �2 is from Spot Return on Forward Premium + GDP, and �3 is from Spot Return on Forward

Premium + GDP + VIX.

The coefficient of each maturity is negative indicating the inverse relationship between forward premium and future spot exchange return. By analyzing the pattern of mean and median statistics, as the maturity of the Interbank rate increases, the beta results are moving further away from the ideal coefficient of 1 (in the case of 1-, 3- and 6-month rates). Even though the coefficients are negative, most of them are significant for 10% significance level (their respective p-values are lower or equal to 10%). In fact, all the coefficients are significant if we do not account for the missing values.

If we move forward by analyzing base countries, EURO and USA have closer to ideal coefficients than other countries. Weaker currencies like NZD and AUD have the lowest coefficients across different maturities.

Table 10. PLM Regression for 1st Post EURO sub-period (1999-2010)

1Month USD JPY AUD NZD EUR GBP ** ~ + - +* -* *β1* 0,12 0,18 -0,03 -0,16 0,24 0,08 0,07 0,08 4 2 0 0 *β2* 0,03 - - - 0,11 - 0,07

0,07 2 0 0 0 *β3* 0,05 - - - 0,13 - 0,09 0,09 2 0 0 0 *3Month USD JPY AUD NZD EUR GBP* ** ~ + - +* -* *β1* 0,15 0,14 -0,08 -0,20 0,20

-0,04 0,03 0,03 3 3 0 0 *β2* 0,04 0,02 -0,18 -0,32 0,05 -0,16 -0,09 -0,09 3 3 0 1 *β3* 0,05 0,02 -0,06 -0,22 0,06 -0,21 -0,06 -0,06 3 3 0 0

6Month USD JPY AUD NZD EUR GBP ** ~ + - +* -* *β1* 0,22 0,42 -0,82 -0,96 0,23 -0,48 -0,23 -0,23 3 3 0 2 *β2* -0,18 - - - -0,23 -

-0,20 -0,20 0 2 0 0 *β3* -0,22 - - - -0,23 - -0,23 -0,23 0 2 0 0

12Month USD JPY AUD NZD EUR GBP ** ~ + - +* -* *β1* 0,04 -0,07 -0,27 -0,30 0,09 -0,18 -0,11 -0,11 2 4 0 2 *β2* -0,03 -0,08 -0,35

-0,38 0,00 -0,23 -0,18 -0,18 1 5 0 3 *β3* -0,04 -0,09 -0,22 -0,29 -0,02 -0,25 -0,15 -0,15 0 6 0 3 *Note: +/- is positive/negative count* *and +*/-* is significance of (+/-) count at 0.1 SL*

The next table describes the coefficients as well as the summary statistics for the first sub-period from 1999 to 2010. Here, unlike the table for the full Post EURO period, some of the coefficients are positive indicating that there might be a positive relationship between forward premium and future spot exchange returns.

The previous trend is consistent with this sub-period since AUD and NZD have the lowest beta coefficients across all maturities, while USD, EUR and JPY (except for 12M maturity) tend to have the highest (even positive) coefficients.

The mean and median values are consistent and low across different lags and countries, which indicates that the average forward premium is not large enough to suggest a strong predictive power over spot returns. The presence of more negative observations in certain rows, like the most values of mean and median, implies that the forward premium more frequently predicted a depreciation rather than an appreciation of the spot rate.

Table 11. PLM Regression for 2nd Post EURO sub-period (2011 – 2023)

1Month USD JPY AUD NZD EUR GBP �� ��̃ + - +* -* *β1* -0,75 -0,90 -0,74 -0,84 -0,74 -0,68 -0,77 -0,75 0 6 0 6

β2 -0,78 - - - -0,74 - -0,76 -0,76 0 2 0 2 *β3* -0,78 - - - -0,74 - -0,76 -0,76 0 2 0 2 *3Month USD JPY AUD NZD EUR GBP* �� ��̃ + -

+* -* *β1* -0,80 -0,93 -0,76 -0,84 -0,75 -0,67 -0,79 -0,79 0 6 0 6 *β2* -0,81 - - - -0,75 - -0,78 -0,78 0 2 0 2 *β3* -0,79 - - - -0,74 - -0,76 -0,76 0 2 0

2 *6Month USD JPY AUD NZD EUR GBP* �� ��̃ + - +* -* *β1* -2,03 -2,14 -1,83 -2,14 -2,16 -1,90 -2,04 -2,04 0 6 0 6 *β2* -2,09 - - - -2,19 -

-2,14 -2,14 0 2 0 2 *β3* -1,95 - - - -2,20 - -2,07 -2,07 0 2 0 2 *12Month USD JPY AUD NZD EUR GBP* **��** �� + - +* -* *β1* -0,82 -1,02 -0,83

-0,89 -0,92 -0,86 -0,89 -0,89 0 6 0 6 *β2* -0,83 -1,06 -0,85 -0,92 -0,92 -0,87 -0,91 -0,91 0 6 0 6 *β3* -0,79 -1,02 -0,72 -0,85 -0,92 -0,89 -0,86

-0,86 0 6 0 6 Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

For the second sub-period from 2011 to 2023, the panel data analysis indicates a strong and statistically significant negative relationship between forward premiums and spot returns. The coefficients are consistently negative across all lags and countries, with more pronounced negative values for longer lags (6-month and 12-month). This suggests that the forward premium puzzle not only persists but is accentuated in this period, with the forward premium inversely predicting the future spot returns.

5.3.2 Pre Euro-Data analysis

Table 12. PLM Regression for Pre EURO period (1975-1998)

1Month *USD JPY AUD NZD DEM GBP* **�� ��** + - +* -* **��** 0,03 0,01 -0,27 -0,23 -0,29 0,02 -0,12 -0,12 3 3 0 1 ***3Month*** *USD*

JPY AUD NZD DEM GBP **�� ��** + - +* -* **��** 0,03 0,17 -0,50 -0,49 -0,38 -0,18 -0,23 -0,23 2 4 0 3 ***6Month*** *USD JPY AUD NZD*

DEM GBP **�� ��** + - +* -* **��** 0,04 1,02 -0,81 -0,50 -0,53 -0,57 -0,22 -0,50 2 4 0 0 ***12Month*** *USD JPY AUD NZD DEM GBP*

�� �� + - +* -* **��** 0,11 0,45 -0,45 -0,24 -0,07 -0,23 -0,07 -0,07 2 4 0 1 Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

The last table represents panel data regression results for the pre-Euro period, examining the relationship between the forward premium and spot returns. For 1 month maturity the coefficients are relatively low, with several countries showing negative values, such as Australia at -0.27 and Germany at -0.29. This suggests a weak and potentially negative short-term predictive power of the forward premium. For 3-month maturity negative coefficients are more pronounced, particularly for Australia and New Zealand, which show -0.50 and -0.49 respectively, indicating a stronger negative relationship over a 3-month period. For 6 months the coefficients for Japan turn significantly positive at 1.02, suggesting a strong positive relationship between the forward premium and spot returns. However, this is not consistent across all countries, with Australia showing -0.81. Finally, for 12 months the coefficients are mixed, with Japan at 0.45 showing a moderately positive

relationship, and Australia at -0.45 indicating a negative one. This maturity does not provide a consistent predictive direction for the forward premium. The mean and median values are negative for most lags, which aligns with the generally negative coefficients, suggesting an overall negative predictive power of the forward premium during this period.

5.4 Transaction Cost Regressions

5.4.1 Post-Euro Transaction Cost Analysis

Table 13. TC full period post-Euro (1999 - 2023)

�� ���� ̃ + - +* -* USA Base Currency

beta_top1% 1,145 0,472 22 13 4 1 *beta_top5%* 0,065 -0,114 16 19 2 4 *beta_top10%* 0,301 0,438 22 13 2 2 *beta_top20%*

-0,191 -0,126 15 20 2 3 *beta_top40%* -0,155 -0,144 17 18 0 4 *beta_rest60%* -0,333 -0,848 13 22 0 2 Japan Base Currency

beta_top1% 0,473 0,148 19 16 6 2 *beta_top5%* 0,650 0,008 18 17 3 2 *beta_top10%* -0,448 -0,023 17 18 3 2 *beta_top20%*

0,360 0,085 18 17 5 1 *beta_top40%* -1,358 -1,126 8 27 0 2 *beta_rest60%* -1,861 -2,122 11 24 0 2 Australia Base Currency

beta_top1% 1,524 1,963 20 15 10 5 *beta_top5%* -1,226 -1,222 16 19 1 8

beta_top10% 0,256 0,098 18 17 2 1 *beta_top20%* -0,105 0,284 22 13 2 3 *beta_top40%* 0,044 0,390 18 17 1 2 *beta_rest60%*

0,087 0,229 18 17 2 0 New Zealand Base Currency

beta_top1% 0,786 0,150 18 17 5 6 *beta_top5%* -1,838 -1,939 10 25 3 5 *beta_top10%* 0,157 0,862 21 14 3 4 *beta_top20%*

-0,186 -0,012 17 18 3 0 *beta_top40%* -0,445 -0,210 15 20 1 3 *beta_rest60%* -0,696 -0,023 16 19 1 2 Euro Base Currency

beta_top1% 1,170 0,758 22 13 4 3 *beta_top5%* -0,333 -0,227 17 18 2 3 *beta_top10%* -0,151 0,279 19 16 2 4 *beta_top20%*

0,781 0,766 20 15 4 0 *beta_top40%* -0,185 -0,387 15 20 2 4 *beta_rest60%* -0,557 -0,613 13 22 1 2 UK Base Currency

beta_top1% 1,967 1,198 21 14 4 0 *beta_top5%* -0,046 -0,466 15 20 3 4 *beta_top10%* -0,786 -0,667 14 21 1 4 *beta_top20%*

0,276 0,147 21 14 4 3 *beta_top40%* -0,628 -0,414 15 20 0 6 *beta_rest60%* -1,480 -0,386 14 21 1 5 Note: +/- is

positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

We see that for weak currencies like the New Zealand and Australian dollars, the betas for the top 1% tier indicate a strong predictive power of top-tier forward premiums on spot exchange rate returns. This supports the hypothesis that higher transaction costs, which are implied by larger forward premiums at deeper discount tiers, lead to larger betas.

For strong currencies like the US dollar, Japanese yen, Euro, and UK pound, the predictive power of top-tier forward premiums also appears to be significant in the top 1% tier, with betas exceeding 1. This is consistent with the notion that higher transaction costs are associated with significant deviations in exchange rate returns.

For example, Australian base currency where the beta for the top 1% tier is 1.524. This suggests that when the forward premium is within the most extreme 1%, the beta indicates a strong predictive power of the forward premium on the exchange rate return. Another example is the Euro base currency with a top 1% beta of 1.170, again indicating a strong prediction power in the most extreme tier.

High betas, particularly those greater than 1, indicate good prediction of spot exchange rate returns by forward premiums. This could be indicative of carry trade activities where investors capitalize on the differences in interest rates across currencies. Strong currencies often attract carry trades due to their stability and potential for appreciation.

The varying impact of these costs across tiers can be seen where betas decrease as we move from the top 1% to 60%, suggesting a decreasing impact of forward premiums on exchange rate returns as we move down the discount tiers.

In general, we see that higher transaction costs lead to larger betas, supported by the strong currencies exhibiting betas greater than 1 in the top tiers (H1). Also, the impact of the forward premium's magnitude on exchange rate returns, is evidenced by the decrease in beta values across the discount tiers, suggesting that increasing transaction cost implications lead to a reduced impact of forward premiums (H2).

Table 14. TC First sub-period post-Euro (1999 - 2010)

	��	��̃	+	-	+*	-*
USA Base Currency						
beta_top1%	0,655	0,001	36	34	6	4
beta_top5%	0,127	0,003	38	32	6	3
beta_top10%	0,161	-0,001	33	37	3	4
beta_top20%	-0,358	0,001	35	35	4	4
beta_top40%	0,114	0,003	40	30	2	4
beta_rest60%	0,312	0,001	38	32	3	3
Japan Base Currency						
beta_top1%	-0,143	-0,004	30	39	6	7
beta_top5%	0,022	0,001	38	31	8	6
beta_top10%	0,765	0,002	42	27	4	8
beta_top20%	-1,691	-0,001	30	39	3	7
beta_top40%	0,866	-0,006	29	40	1	6
beta_rest60%	0,046	- 0,005	29	40	1	7
Australia Base Currency						
beta_top1%	1,153	0,001	36	33	9	7
beta_top5%	0,075	-0,000	34	35	5	5
beta_top10%	-1,301	-0,000	34	35	2	4
beta_top20%	0,322	-0,000	34	35	4	1
beta_top40%	-0,839	-0,004	26	43	2	4
beta_rest60%	-0,423	-0,002	25	44	6	2
New Zealand Base Currency						
beta_top1%	-0,510	-0,005	29	40	7	10
beta_top5%	-0,502	0,001	36	33	1	6
beta_top10%	-0,520	0,001	39	30	2	1
beta_top20%	0,246	0,001	37	32	3	1
beta_top40%	-0,512	-0,000	34	35	2	4
beta_rest60%	0,110	-0,001	30	39	6	2
Euro Base Currency						
beta_top1%	1,105	0,000	35	34	7	9
beta_top5%	-0,786	-0,001	33	36	6	6
beta_top10%	0,155	0,002	38	31	10	1
beta_top20%	0,231	-0,001	33	36	1	5
beta_top40%	1,034	0,001	38	31	6	2
beta_rest60%	1,626	0,006	41	28	8	1
UK Base Currency						
beta_top1%	1,147	0,001	36	33	5	5
beta_top5%	- 1,038	- 0,003	30	39	4	4
beta_top10%	0,340	0,001	36	33	5	4
beta_top20%	0,159	0,003	39	30	2	3
beta_top40%	-0,516	-0,000	34	35	1	3
beta_rest60%	-0,138	0,001	36	33	5	3

Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

During the 1999-2010 period, beta values across currencies showed varied predictive power of forward premiums, compared to the full period data.

USA Base Currency displayed a moderately positive beta in the top 1%, indicating some predictive power, though less pronounced than in the full period.

This suggests relative stability or a less volatile response to forward premiums in the foreign exchange market.

Japan Base Currency presented mixed results, with a significant positive beta in the top 10% and a substantial negative beta in the top 20%. These contrasting values might reflect specific economic or policy impacts on the yen, possibly deviating from longer-term trends.

Australia Base Currency had a strong positive beta in the top 1%, indicating a good predictive relationship, consistent with the full period's findings. However, the negative beta in the top 10% tier suggests a shift in the influence of forward premiums on exchange rate returns.

Euro Base Currency showed a very strong positive beta in the rest 60% tier, contrasting with the full period's generally lower betas. This could indicate a changing market response to transaction costs later in the sub-period.

UK Base Currency exhibited strong positive betas in both top and bottom tiers, implying consistent predictive power, aligning with the full period's trend. Overall, the first sub-period's beta values provide insights into the market's response to forward premiums, revealing both alignment and divergence in their predictive power on spot exchange rate returns. These variations could be due to factors like market sentiment, economic policies, and global financial events. *Table*

15. TC Second sub-period post-Euro (2011- 2023)

			+	-	+*	-*
USA Base Currency						
beta_top1%	-0,782	0,431	19	15	3	4
beta_top5%	-0,898	-0,251	16	18	2	1
beta_top10%	0,302	-0,129	17	17	1	3
beta_top20%	0,580	0,573	19	15	1	2
beta_top40%	-0,587	-0,483	11	23	2	2
beta_rest60%	-0,861	-0,533	15	19	1	1
Japan Base Currency						
beta_top1%	-4,479	-2,884	11	23	2	2
beta_top5%	4,472	2,705	23	11	9	2
beta_top10%	-1,321	-0,648	15	19	5	2
beta_top20%	0,356	-0,657	15	19	2	2
beta_top40%	-2,720	-2,043	12	22	1	3
beta_rest60%	-2,598	-3,086	12	22	0	5
Australia Base Currency,						
beta_top1%	-2,624	-1,556	16	18	2	6
beta_top5%	1,524	2,734	27	7	2	0
beta_top10%	1,424	1,640	20	14	2	2
beta_top20%	-0,334	0,756	20	14	2	3
beta_top40%	-0,975	-1,112	13	21	0	0
beta_rest60%	-1,957	-0,599	14	20	0	4
New Zealand Base Currency						
beta_top1%	-1,050	0,102	18	16	1	5
beta_top5%	-0,502	0,130	17	17	2	3
beta_top10%	-0,532	-0,672	16	18	6	6
beta_top20%	-1,125	0,478	21	13	0	6
beta_top40%	0,096	0,154	18	16	0	0
beta_rest60%	-2,544	-1,571	7	27	0	2
Euro Base Currency						
beta_top1%	-0,979	-0,480	16	18	1	1
beta_top5%	1,405	-0,221	16	18	3	2
beta_top10%	-1,041	0,518	18	16	5	2
beta_top20%	0,870	0,678	20	14	2	1
beta_top40%	-0,798	-1,121	10	24	1	1
beta_rest60%	0,824	-0,405	16	18	0	0
UK Base Currency						
beta_top1%	-2,088	-1,007	14	20	1	4
beta_top5%	0,153	-0,220	17	17	5	0
beta_top10%	2,001	2,329	22	12	1	3
beta_top20%	3,188	1,146	21	13	4	2
beta_top40%	-4,549	-0,067	16	18	1	6
beta_rest60%	-2,697	-0,121	16	18	3	3

Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

For the second sub-period (2011-2023), beta values across currencies showed significant variation, reflecting different market dynamics from the initial period. USA Base Currency displayed a mix of positive and negative betas. Notably, the top 1% had a negative beta (-0.782), marking a shift to more negative betas in higher tiers, possibly indicating changing market conditions or responses to transaction costs.

Japan Base Currency exhibited an extreme negative beta at the top 1% (- 4.479), a stark contrast to the less extreme, mixed values of the previous period. This suggests substantial shifts in market dynamics or currency valuation policies.

Australia Base Currency's betas were mixed, with a notable negative beta in the top 1% (-2.624), differing from the earlier period's positive beta. This change might reflect shifts in economic factors affecting the currency market.

New Zealand Base Currency showed a pattern of negative betas in the top tiers, deviating from the earlier positive values, indicating altered market risk perceptions or valuation drivers.

Euro Base Currency demonstrated high variability with mixed positive and negative betas, indicating inconsistent predictive power of forward premiums. UK Base Currency had a highly positive beta in the top tiers, suggesting a stronger predictive relationship compared to the first sub-period. Overall, these variations in beta values imply evolving relationships between forward premiums and spot exchange rate returns, potentially influenced by changes in economic policies, global financial markets, or investor risk perceptions.

5.4.2 Pre-Euro Transaction Cost Analysis

Table 16. TC pre-Euro (1975- 1998)

�� ���� ̃ + - +* -* USA Base Currency

beta_top1% -0,035 0,235 7 6 2 3

beta_top5% -0,501 -0,472 6 6 0 2 *beta_top10%* -0,532 -0,206 5 8 0 1 *beta_top20%* -0,253 0,155 7 6 0 1 *beta_top40%* 1,172 1,313 10 3 2 0 *beta_rest60%* 0,666 1,166 7 6 0 0 Japan Base Currency

beta_top1% -0,562 -0,144 6 7 0 2 *beta_top5%* 0,018 0,670 7 5 0 1 *beta_top10%* -0,263 -0,423 6 7 1 0 *beta_top20%* -1,279 -1,486 1 12 0 3 *beta_top40%* 2,421 2,160 11 2 5 0 *beta_rest60%* 2,832 1,638 10 3 3 0 Australia Base Currency

beta_top1% 0,118 0,977 9 4 1 0 *beta_top5%* 1,364 0,617 9 3 1 0 *beta_top10%* -0,021 0,276 8 5 0 1 *beta_top20%* -0,241 -0,759 5 8 0 1 *beta_top40%* -1,155 -0,762 4 9 0 1 *beta_rest60%* -1,112 0,266 9 4 0 1 New Zealand Base Currency

beta_top1% -2,642 -4,232 4 9 0 9 *beta_top5%* 1,328 1,551 10 2 1 0 *beta_top10%* -0,324 -0,478 5 8 0 1 *beta_top20%* 0,831 0,795 8 5 0 0 *beta_top40%* -1,330 -0,581 3 10 0 2 *beta_rest60%* -0,850 -0,390 5 8 0 1 Germany Base Currency

beta_top1% -0,543 -0,217 6 7 0 3 *beta_top5%* 0,328 0,283 7 5 1 1 *beta_top10%* -0,403 -0,401 5 8 1 1 *beta_top20%* -0,344 0,108 7 6 1 0 *beta_top40%* 0,209 -0,171 4 9 1 0 *beta_rest60%* 0,443 0,068 8 5 1 0 UK Base Currency

beta_top1% -0,531 -0,321 6 7 0 3 *beta_top5%* 0,286 0,343 7 5 0 0 *beta_top10%* 0,513 0,303 8 5 1 0 *beta_top20%* -1,149 -0,976 5 8 0 3 *beta_top40%* 0,965 0,428 10 3 2 0 *beta_rest60%* 1,088 1,278 9 4 2 0 Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

During this period, individual European currencies would have been influenced by national economic policies, which is reflected in the beta values. For example, the USA Base Currency showed a high beta in the top 40% tier, suggesting significant predictive power for that segment of forward premiums. However, the relatively balanced count of positive and negative betas indicates a market that was neither overly optimistic nor pessimistic.

The Japan Base Currency displayed extreme positive betas in the top 40% and rest 60% tiers, highlighting a strong response to the top-tier forward premiums, which could be due to Japan's distinct economic position during this period.

The Australia Base Currency showed positive betas in the top 1% and 5% tiers, suggesting that forward premiums were somewhat effective in predicting exchange rate movements in the higher discount tiers.

Comparing the pre-Euro data with the full period data of post-Euro, it's apparent that the introduction of the Euro brought a convergence in the behavior of what were previously individual European currencies. This would be especially evident when examining currencies like the German Base Currency, which showed moderate betas across most tiers during the pre-Euro period but may have experienced a shift post-Euro introduction.

5.5 Seemingly Unrelated Regression (SURe)

Table 107. SURe summary for 3-month Interbank rate from 1999 to 2023

Base	��	��̃	+	-	+*	-*
USA	0,274695	-0,07775	11	14	3	1
Japan	0,177721	0,014095	13	12	3	4
Australia	0,258559	0,07424	15	10	3	1
New Zealand	-0,00595	-0,14903	10	15	3	5
EURO	0,335178	0,002428	13	12	4	0
UK	0,049314	-0,16734	8	17	3	3

Note: +/- is positive/negative count and +*/-* is significance of (+/-) count at 0.1 SL

From the results of the Seemingly Unrelated model, the summary statistics of which is given within the table above we can see that most of the coefficients are within a range of -1 and 1, which proves the mean and median results. However,

there are only a few significant coefficients (33 out of 150) with a mixed amount of positive and negative coefficients, which leaves the thought that our test lacks power. Diving into the countries, Mexico exhibits a relatively high mean beta value (1.51). However, it has the highest significant coefficients (5) amount at 10% significance level which suggests the strong positive relationship between Spot Return and Forward Premium.

Hong Kong and Denmark have mean beta values (-0.16 and -0.38 respectively) that are within a range of -1 and 1, but still show a number of significant beta coefficients (4 and 3 respectively) across base countries, which indicates slightly inverse relationships between the Forward Premium and the Spot Return.

Switzerland's mean beta value is 0.01, with 4 significant beta coefficients and the same number of significant intercepts. This suggests that both the baseline level of the Spot Return and the impact of the Forward Premium are significant and slightly stronger than proportionality.

Singapore, South Africa, and Sweden have mean beta values 0.05, 3.58, and 0.61 respectively, with a few significant beta coefficients, indicating a more proportional impact of Forward Premium on the Spot Return.

Thailand' mean beta coefficient is nearly close to 1 (0.93), but with only 1 significant coefficient whereas Australia, Canada, New Zealand, and several other countries show mean beta values that fall within the ideal range, but with no significant beta coefficients, implying that the Forward Premium's effects are not statistically significant.

Japan, Norway, and Thailand have mean beta values that are negative but within the ideal range (-0.29 and -0.22 respectively) with Japan showing one significant beta coefficient each, and Norway showing none. This suggests a proportional but inverse relationship between the Forward Premium and the Spot Return for these countries.

Nevertheless, the R-squared values for almost every SURe coefficient is less than 1%, where some of them are even negative, which indicates that the following model does not fit well into such regression.

5.6 Overlapping Samples

5.6.1 Post Euro analysis

Table 18. OS Full Period Post EURO from 1999 to 2023

USA Base GBP EUR AUD JPY NZD �� ��̃ + - +* -* +** -** β -0,371 0,892 0,826 -0,390 0,536 0,031 -0,032 21 14 9 12 5 6 *Japan Base*

GBP EUR AUD NZD USD �� ��̃ + - +* -* +** -** β -1,013 -0,500 -1,728 -1,532 -0,380 -0,738 -0,543 10 25 6 18 4 10 *Australia Base*

GBP EUR JPY NZD USD ���� ̃ + - +* -* +** -** β 0,280 0,387 -2,301 -1,534 0,444 -0,044 -0,034 17 18 5 18 4 10

New Zealand Base
GBP EUR AUD JPY USD ���� ̃ + - +* -* +** -**

β -0,671 -3,307 -1,598 -1,957 0,282 -0,628 -0,680 8 27 5 18 4 10 *EURO Base GBP AUD JPY NZD USD* ���� ̃ + - +* -* +** -** *B*

-0,352 0,327 -0,841 -3,144 0,668 0,654 0,438 25 10 18 5 10 2

UK Base EUR AUD JPY NZD USD ���� ̃ + - +* -* +** -** β -0,295 0,341 -1,227 -0,453 -0,624 -0,166 -0,311 13 22 5 13 5 4

Note: +* and -* indicate positive and negative significant coefficients for the first overlapping regression, +** and -** are for adjusted regression with covariance matrix. Significance Level is 0.1

The beta coefficients adjusted for overlapping biases provide a more reliable measure of the forward premium's predictive power. For example, the beta for the USA base against the UK is -0.371, indicating a weak and potentially inverse relationship. In contrast, for the New Zealand base against the USA, the beta is 0.282, suggesting a positive but less than proportional predictive power.

Negative beta values indicate an inverse relationship between forward premiums and future spot rates. This could be indicative of a scenario where investors might be expecting a depreciation in the currency value but instead, the currency appreciates. For instance, a beta of -1.013 for Japan base against the UK signifies a strong inverse relationship, contradicting the typical expectation that a higher forward premium predicts depreciation.

Some of beta’s coefficients are statistically significant and positive, implying that the forward rate is a good predictor of future spot rates in the direction of appreciation. For example, Japan and Australian bases have 14 significant betas out of 33 countries. Thus, these countries had more statistically significant results among other bases.

Furthermore, the results for weak currencies like New Zealand and Australia against various bases show mixed predictions. Negative betas, like -3.307 for New Zealand base against the UK, could imply that carry trade strategies might not be as straightforward, as expected interest rate differentials do not align with the currency movements.

For carry trades, where investors borrow in currencies with low-interest rates and invest in currencies with high-interest rates, the results suggest that this strategy might not always yield predictable returns, as indicated by the mixed betas and significance levels. For instance, despite Australia's higher interest rates historically, the beta of -1.728 against Japan suggests that the expected depreciation from carry trades might not be as pronounced as the interest rate differential would suggest.

Table 19. OS First sub-period from 1999 to 2010

USA Base GBP EUR AUD JPY NZD �� ��̃ + - +* -* +** -** β -1,136 1,809 0,799 1,459 0,537 0,207 0,099 18 17 13 13 9 6 *Japan Base*

GBP EUR AUD NZD USD �� ��̃ + - +* -* +** -** β -0,874 0,878 -10,801 -3,874 1,420 -0,691 0,245 18 17 14 13 11 9 *Australia Base*

GBP EUR JPY NZD USD �� ��̃ + - +* -* +** -** β 1,580 0,874 -12,464 -0,953 0,098 -2,099 -0,611 11 24 5 21 4 15

New Zealand Base *GBP EUR AUD JPY USD* �� ��̃ + - +* -* +** -**

β 0,067 -4,011 -1,051 -4,388 0,285 -1,490 -1,206 9 26 5 21 4 15 *EURO Base GBP AUD JPY NZD USD* �� �� ̃ + - +* -* +** -** β 1,484

0,598 0,239 -3,943 1,577 1,854 1,484 28 7 20 5 9 3 *UK Base EUR AUD JPY NZD USD* �� �� ̃ + - +* -* +** -**

β 1,683 1,705 -1,086 0,143 -1,527 -0,108 0,010 18 17 11 13 6 8

Note: +* and -* indicate positive and negative significant coefficients for the first overlapping regression, +** and -** are for adjusted regression with covariance matrix. Significance Level is 0.1

The beta coefficients from 1999 to 2010 show some different results. The beta for the US base against UK is more negative in the first sub-period (-1.136), showing a stronger inverse relationship than in the entire period. Also, the beta of Japan's base against Australia is significantly negative (-10.801), indicating a strong inverse relationship, possibly influenced by Japan's economic policies and deflation. The beta of New Zealand Base vs. Japan is significantly negative (-4.388), indicating a persistent inverse relationship throughout the period. However, the beta of Euro based on the USA (1.577) suggests better predictive power in the first sub-period, being closer to 1.

If we Compare with the full period (1999-2023), the first sub-period shows less predictive accuracy with fewer betas close to 1. Stronger inverse relationships in the first sub-period, especially for Japan vs. UK and Australia vs. Japan, likely due to market conditions like the financial crisis. Similar numbers of significant positive and negative betas in both periods, but differences in new significance counts suggest changing market dynamics and the impact of additional data over the full period.

Table 20. OS Second sub-period from 2011 to 2023

USA Base	*GBP*	*EUR*	*AUD*	*JPY*	*NZD*	��	��̃	+	-	+*	-*	+**	-**
β	-1,258	-1,325	-0,274	-1,256	-0,993	-0,326	-0,404	11	23	5	14	5	3

Japan Base	*GBP*	*EUR*	*AUD*	*NZD*	*USD*	��	��̃	+	-	+*	-*	+**	-**
β	1,931	1,083	-1,955	-1,672	-1,249	-0,782	-0,999	13	21	10	17	7	11

Australia Base	*GBP*	*EUR*	*JPY*	*NZD*	*USD*	��	��̃	+	-	+*	-*	+**	-**
β	-0,122	-0,980	-2,061	-2,353	-0,318	-0,151	-0,359	10	24	4	17	3	11

New Zealand Base	*GBP*	*EUR*	*AUD*	*JPY*	*USD*	��	��̃	+	-	+*	-*	+**	-**
β	-1,573	-4,364	-2,337	-1,730	-1,083	-1,003	-1,052	10	24	4	17	3	11

EURO Base	*GBP*	*AUD*	*JPY*	*NZD*	*USD*	��	��̃	+	-	+*	-*	+**	-**
β	-3,608	-0,851	0,793	-4,019	-1,421	-0,284	0,288	20	14	11	11	8	6

UK Base	*EUR*	*AUD*	*JPY*	*NZD*	*USD*	��	��̃	+	-	+*	-*	+**	-**
β	-3,629	-10,456	1,815	-1,148	-1,175	0,023	0,272	20	14	13	6	10	4

Note: +* and -* indicate positive and negative significant coefficients for the first overlapping regression, +** and -** are for adjusted regression with covariance matrix. Significance Level is 0.1

Again, we see some changes in betas for the second sub-period from 2011 to 2023. Betas on US bases against major currencies like the UK and Japan are less negative than before, indicating a slight improvement in predictive power but still an inverse relationship. A significant positive beta of Japan base (1.931) against the UK contrasts with previous negative values, suggesting a shift in market dynamics. The beta on Australia Base against the UK is near zero, showing no predictive power, while against Japan it remains negative but less so than before. Also, the beta on New Zealand Base against Japan is less negative than in the earlier period, indicating a change in the relationship between forward premiums and future spot rates. Moreover, the beta on Euro base against the USA is negative and lower than before, hinting at increased unpredictability or other influential factors. If we compare results with the full period (1999-2023) betas generally indicate weaker predictive power with many negative values suggesting inverse relationships. Negative betas continue but with changed magnitudes, reflecting evolving market perceptions and economic forces. There is a noticeable shift in significance for several currency pairs, possibly due to economic adjustments post crisis, monetary policy changes, or shifts in global trade dynamics. Overall, the second sub-period shows evolved relationships between forward premiums and future spot rates, with many pairs exhibiting weaker or inverse predictive power.

5.6.2 Pre Euro analysis

Table 21. OS Pre EURO from 1975 to 1998

USA Base DEM GBP AUD JPY NZD �� ��̃ + - +* -* +** -** β 0,397 1,178 2,795 0,308 1,465 0,587 0,397 11 2 8 1 5 1 *Japan Base*

DEM USD GBP AUD NZD �� ��̃ + - +* -* +** -** β 1,624 2,786 4,983 0,370 0,313 0,735 0,313 9 4 6 3 5 3 *Australia Base DEM USD*

GBP JPY NZD �� ��̃ + - +* -* +** -** β -0,902 0,223 0,424 0,264 1,096 -0,300 -0,225 5 8 2 4 2 0 *New Zealand Base DEM USD GBP*

JPY AUD �� ��̃ + - +* -* +** -** β -0,339 1,414 -0,080 0,179 1,003 -0,061 -0,165 3 10 2 4 2 0 *Germany Base USD GBP JPY AUD NZD*

�� ��̃ + - +* -* +** -** β 0,378 0,419 1,612 -0,849 -0,244 -0,151 -0,244 3 10 3 8 1 5

UK Base DEM USA JPY AUD NZD �� ��̃ + - +* -* +** -** β 0,406 1,136 5,089 0,400 -0,012 0,640 0,272 11 2 7 1 3 1

Note: +* and -* indicate positive and negative significant coefficients for the first overlapping regression, +** and -** are for adjusted regression with covariance matrix. Significance Level is 0.1

The Pre-Euro Period shows that the beta for the USA against New Zealand and the UK are positive, with the USA/UK pair showing a high beta (1.178), indicating a strong predictive power of forward rates during this period. For Japan, it shows a mixed response, with a high positive beta against the UK (4.983) but small against Australia (0.370), suggesting different levels of predictiveness of forward rates against these currencies.

Australia Base beta against the USA is slightly positive (0.23), indicating some predictive power, while the negative beta against Germany (-0.902) suggests an inverse relationship. Moreover, the beta on New Zealand Base coefficients is negative across all listed comparisons, implying that forward rates were not good predictors of future spot rates for New Zealand during this period.

Germany has a positive beta against the USA (0.378) and negative against Australia (-0.849), indicating varying predictive power of forward rates. Also, the UK shows positive betas against both the USA and Germany, suggesting that forward rates had some predictive power for the UK during the pre-Euro era.

If we compare with Post-Euro Period Results (1999 to 2023), beta coefficients tend to be more positive, especially for the USA/Germany and Japan/UK pairs, compared to the post-Euro period where betas are generally lower or negative.

The prevalence of negative betas in the pre-Euro period for certain pairs, such as New Zealand against all bases, seems to decrease in the post-Euro period, implying a change in the relationship between forward premiums and future spot rates.

The number of instances where the beta coefficients are significant appears to be fewer in the pre-Euro period compared to the post-Euro period. This could be due to increased market integration and the establishment of the Euro, which may have introduced new dynamics to the currency markets.

The transition to the Euro era seems to have brought about changes in the relationships between forward premiums and spot rates, with betas generally decreasing in magnitude.

6. Discussion

7. Recommendations

8. Conclusion

9. References

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10. Appendices

Appendix 1.

Table 11. List of the Countries

Base Currencies Other

Pre-Euro UK, USA, Germany, Japan, New Zealand, Australia

Post-Euro UK, USA, EURO, Japan, New Zealand, Australia

Belgium, France, Netherland, Ireland, Portugal, Spain, Greece, Italy

Canada, Japan, India, China, Hong Kong, Indonesia, Israel, Kuwait, Malaysia, South Korea, Pakistan, Philippines, Russia, Saudi Arabia, Singapore, Turkey, Taiwan, Czech Republic, Denmark, Netherlands, Iceland, Ireland, France, Germany, Greece, Kazakhstan, Italy, Norway, Poland, Portugal, Sweden, Switzerland, Spain,

Belgium, Mexico, Peru, South Africa, Slovakia, Chile, Thailand