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CURRENCY CARRY TRADE, CRASH RISK AND THE ROLE OF SPECULATORS: EVIDENCE FROM PANEL DATA MODELS

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Abstract

This work project studies the dynamics of carry trade within a sample of developed currency markets. Using univariate and multivariate analysis, I studied the links between interest rates and foreign currency investments. The results obtained are consistent with the hypothesis that there are positive links between interest rate differentials, currency returns and traders' long positions, and a negative link between interest rates and the conditional skewness. In addition, I also analysed if carry traders act as stabilizers or destabilizers of foreign exchange rates. The results cannot consistently support the hypothesis of under reaction and stabilization advanced by Brunnermeier, Nagel and Pedersen (2008).

Keywords: *Carry Trade, Crash Risk, UIP, Interest Rate Differential*

1. Introduction

Investment strategies consisting of borrowing funds from low interest rate currencies, and investing them in currencies yielding higher interest rates are known as carry trade strategies. Besides the interest rate differential, the profitability of such type of strategies is also driven by exchange rate appreciations of the investment currencies. The latter source of profit contradicts the Uncovered Interest Parity (UIP) hypothesis, which states that in order for a risk-neutral investor to be indifferent between holding two different currencies, the currency which earns the higher interest rate is expected to depreciate by as much as the interest rate differential. Under such hypothesis, the expected returns of carry trade should be zero, being the interest rate differentials totally offset by exchange rate unfavorable movements.

Research related to the UIP has documented that, empirically, the parity has been consistently holding in reverse, providing carry trade statistically significant returns. Within foreign exchange markets, forward premium pointing in the wrong direction for the *ex post* movement in the spot exchange rate is known as the "forward premium puzzle", a puzzle widely and robustly tested across different time frames and currencies and which makes the carry trade profitable on average. The present work provides two evidences corroborating such anomaly. First, considering the overall period covered by this work (1999-2016), the majority of the currencies studied had an evolution of its exchange rates which went against UIP predictions, with exchange rates against the US dollar monthly appreciating on average for most of the currencies with positive interest rate differentials and monthly depreciating on average for most of the currencies with negative interest rate differentials. Second, also between 1999 and 2016, simple portfolios built under carry trade strategies broadly accumulated positive returns as illustrated by the upward trends presented below in Figure 1. According to the results of this dissertation, portfolios investing in currencies with the highest interest rate differentials to the dollar and shorting currencies with the lowest ones were characterized by averaging monthly positive returns considering the entire time spectrum (1999-2016).

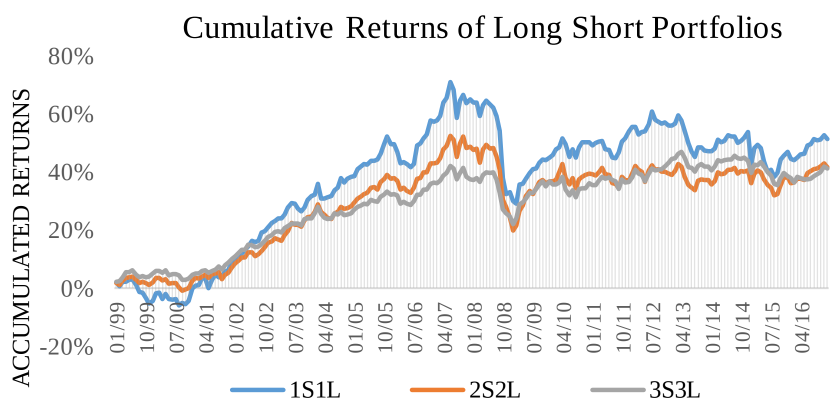

Figure 1 Accumulated of short-long portfolios taking long (short) positions in higher (lower) yielding currencies.
Note: kSkL. k=1, 2, 3 indicates the number of currencies in each leg of the portfolio (S- Short leg and L- Long Leg).

Further analyzing Figure 1, it is possible to detect a significant and sudden drawdown of the performance of such portfolios in the second half of 2008, which threw the accumulated returns back to 2003 levels. Such stylized fact is illustrative of the possibility of currency crashes. The sharp losses experienced by the three portfolios is explained by the dynamics of each individual foreign currency exchange rate. Comparing the exchange rate movements of currencies with positive and negative interest rate differentials in the following months starting in the second semester of 2008, one can detect significant differences. The hypothesis under study is that currencies with higher interest rate differentials provide systematic returns but bear the risk of experiencing extreme loses at any time, i.e. risk of crash. In foreign exchange rate markets the frequently used image is that high yielding currencies go “up by the stairs and down by the elevator”. In effect, over this time span, higher yielding currencies’ exchange rates against the US dollar, namely the ones from Australia and New Zealand, depreciated almost 40% when compared to the level at the beginning of the second semester of 2008, while exchange rates from low yielding currencies, namely the Swiss franc and the Japanese yen revealed a different trend, having respectively just slightly depreciated by less than 15% and actually appreciated more than 15%[1]. Confronting the literature on the topic, different approaches as well as possibilities have arisen in order to provide explanations for such pattern present in exchange rate movements. Brunnermeier et al. (2008) link currencies yielding higher interest rates to higher crash risk, as measured by more negative exchange rate movements’ realized skewness.

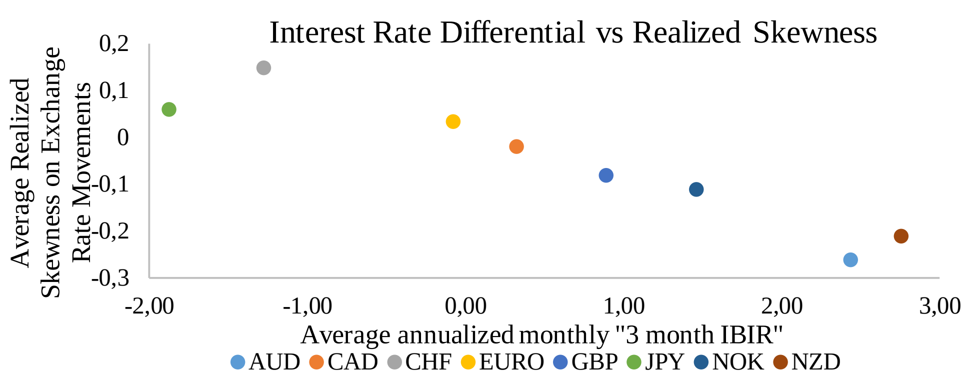

Figure 2 Correlation between interest rate differential and realized skewness. The horizontal axis measures the average interest rate differential while vertical axis the average realized skewness from daily data within (overlapping) quarterly time periods.

[1] The different evolution of these currencies over that period is illustrated in Figure A.1 of the Appendix.

Figure 3 indicates that for the period between 1999 and 2016 that relationship persisted. With effect, currencies are distributed around a line with a negative slope, with an R^2 of 88.77%, suggesting a positive link between crash risk and interest rate differentials.

Regarding the negative skewness, it may be possible that this is endogenously created. Small carry trade losses may be enough to lead traders to unwind their positions, further depreciating the exchange rates of investment currencies. This implies an important role for carry traders in the exchange rate changes and Brunnermeier et al. (2008) suggest that this role is actually stabilizing during normal times. They argue that the profitability of carry trade results from a slow response of capital flows to interest rate shocks, being profitable for speculators to invest in a currency for the period in which it has not yet reached the exchange rate from which the UIP predicts it should start depreciating. Accordingly, if more carry trade took place, the exchange rate would reach its fundamental value quicker, with markets with liquidity frictions spreaders of adverse events prone to the existence of crashes responsible for detracting the exchange rates of high yielding currencies, which were not even as high as they fundamentally should as traders had initially underreacted.

The documented profitability of investing in high yielding currencies, the crash risk evidence and the hypothesis of carry trade activity itself influencing how exchange rates distance themselves from their fundamental value motivated this work project.

Briefly, covering a different period, this dissertation, in line with existing literature, was developed to study carry trade returns, crash risk and the possibility that speculators, pursuing carry trade strategies or unwinding their positions, may affect the movements of exchange rates. In sum, its results document the profitability of carry trades; link wider interest rate differentials to aggravated exchange rate changes' conditional skewness; suggest that speculators tend to pursue interest rate differentials; and establish a positive relationship between speculative positions in a currency and its level of risk, connecting carry trade activity with future negative skewness. Additionally, results do not suggest that speculators under react to a widening of interest rate differentials, not proving a stabilizing role of carry trade activity as Brunnermeier et al. (2008). This dissertation also stresses the possibility that since the 2008 crisis, interest rate differentials do not systematically predict positive carry returns for the currencies under study as it did previously.

This work is organized as follows : Section 2 compiles a brief description of relevant works in finance and economics concerning UIP violations, carry trade, and exchange rate responses to interest rates; Section 3 details the data collected, the variables used and the treatment given to them; Section 4 describes the methodology and techniques used to reach the present work's results, introducing the main regressions and the mechanics of the different models and equations; Section 5 presents and discusses the empirical results obtained, being subdivided into summary statistics, simple regressions, models of risk prediction and multivariate models; and finally Section 6 delivers a final conclusion of the work.

2. Literature Review

Innumerous papers and articles published over the last decades cover directly or indirectly the thematic of UIP and carry trade. Resorting to a top down approach, this section offers a structured view of the whole problematic, introducing works recognizing UIP violations, providing different theories on what is behind it and underlying which are farther or closer to the present work. Moreover, a perspective on works encompassing multivariate analysis of shocks to interest rates affecting the nominal exchange rates is also offered.

UIP implies that under rational expectations, interest rate differentials are an unbiased estimate of the upcoming exchange rate changes. To test unbiasedness and as a consequence the verification of UIP, typically, the following regression is considered, where Δs is the exchange rate (dollar price of one unit of foreign currency) change between two periods, while i_t and i^*_t are, respectively, the domestic and the foreign interest rates:

$$\Delta s_{t+k} = \alpha + \beta(i_t - i_t^*) + \epsilon_{t+k} \qquad (1)$$

Under the null hypothesis of unbiasedness and UIP, H_0: $\beta=1$, meaning that if a foreign currency is yielding lower interest rates than the dollar ($i_t > i^*_t$), the exchange rate of such foreign currency should appreciate by the same amount as the interest rate differential. Froot and Thaler (1990) in an article overviewing the anomalies within foreign exchange markets calculated the average coefficient β across 75 different publications to be -0.88, which not only offers strong support against the null hypothesis, but also provides evidence that interest rate differentials also are predictors of movements of exchange rates in the same direction. Lewis (1995), Engel (1996), or more recently Burnside, Eichenbaum and Rebelo (2009) and Breedon, Rime and Vitale (2016) also found β to be significantly smaller than one and frequently negative.

This pattern is what makes carry trade profitable on average, and many economists, taking *Equation. 1* as a starting point, devoted themselves to further investigate that profitability. Norges Bank (2014) compares the results of a multitude of studies regarding carry trade returns. The table below provides a relevant summary of such comparison and it is followed by a review of each of the publications.

Table 1 Overview of Carry Trade Positive Returns Documentation – Adapted from Norges Bank (2014)

Authors	Publication	Period	Interest	Currencies	Return	Volatility
Brunnermeier et al.	NBER 2008	1986–2006	3-month	9	7,2%	9.0%
Burnside et al.	RFS 2011	1976–2009	1-month	21	4.8%	5.3%
Christiansen et al.	JFQA 2011	1995–2008	1-day	10	4.6%	
Lustig et al.	RFS 2011	1983–2009	1-month	35	8.5%	9.0%
Barroso and Santa-Clara	JFQA 2013	1996–2011	1-month	27	21.4%	24.3%
Jurek	JFE 2013	1990–2012	1-month	10	4.5%	9.5%
Norges Bank	DN 2014	1983–2013	1-month	10	5.5%	9.1%

While documenting abnormal returns, different researchers explore different hypotheses and methodologies. Lustig, Roussanov and Verdelhan (2011) argue that cross-sectional variation in excess returns of currency portfolios sorted by their interest rate differential against the US dollar is explained by the higher loading of higher interest rates on consumption growth risk, claiming that the single factor HML_{FX} offers the explanation to the cross-sectional variation in currency excess returns. Barroso and Santa-Clara (2011) alert that HML_{FX} is itself a currency strategy, so, according to them, exploiting connections to more fundamental risk sources persists as a relevant research topic in the currency market. Their work concluded that carry, among other variables, was relevant for the optimization of returns. According to them, the profitability of their parametric portfolio strategy considering carry, momentum, and reversal could not be explained by the generally discussed risk factors, including crash risk since the excess kurtosis and left-skewness of diversified portfolios were substantially reduced. The authors end up running an OLS regression of the returns of the optimal strategy on hedge fund assets under management and the coefficient they obtain, although not significant, indicates that the level of hedge fund capital predicts negatively the returns of the optimal strategy. This can be interpreted as evidence of a market inefficiency and that the returns of their diversified currency strategy are an anomaly that is gradually being corrected by the activity of hedge funds. Barroso and Santa-Clara (2011) do not favor any risk factor, but other authors suggest otherwise. Christiansen, Ranaldo and Söderlind (2011) study the hypothesis of time-varying risk. Developing a multi-factor and regime-dependent model, based on a logistic smooth transition regression methodology, they find that in turbulent times carry trade significantly increases its systematic risk and the exposure to stocks. In terms of individual currencies, the typical investment currencies in their sample increases that type of exposure during periods of foreign exchange market turmoil, while the inverse happens in typical funding currencies. According to them, the regime-dependence of systematic risk associated to carry trade is relevantly determined by foreign exchange market volatility, funding and, less significantly, by the volatility of equity markets and the measures of risk aversion. Burnside, Eichenbaum, Kleshchelski and Rebelo (2011), on the other hand argue that the payoffs of carry trade reflect a peso problem, that is, the returns on some currencies may be influenced by a small probability of a major crash that may not have yet occurred. Their work consists in the development of a portfolio hedged against these peso events using options and implementing such a method, they found that the payoff of the hedged portfolio is substantially smaller, providing evidence that the average payoff to the unhedged carry trade reflects a peso problem. Burnside et al. (2011) covers the relationship of carry trade returns with rare events, even if they are yet to happen, and claim that peso state, term used to refer to abnormal times, more relevantly, reflects the higher values of the stochastic discount factor and not necessarily very large negative payoffs to the unhedged carry trade. Nevertheless this work is closer to those which find links between the excess returns of the carry trade and extreme tail risks, measurable by the negative skewness in the changes of exchange rate. Jurek (2013) and especially Brunnermeier, Nagel and Pedersen (2008) are works with that focus. Jurek (2013) uses a different hedging strategy, supported in out-of-the-money options, to find excess returns to crash-hedged currency carry trades still significantly positive, classifying peso problems as an unlikely cause for carry trade high profitability. Even though, the comparison between hedged and unhedged portfolios leads the author to indicate that crash risk premia accounts for close to one-third of the total excess return earned by currency carry trades over the period he analyzed. Considering skewness, Jurek (2013) agrees on the strong cross-sectional evidence linking mean interest rate differentials and skewness mean levels, but alerts that the time-series relationship is weaker. Brunnermeier, Nagel and Pedersen (2008) is the work most similar to the present one. It bases its analysis on skewness as a measure for crash risk, and it documents that exchange rate movements between high-interest-rate and low-interest-rate currencies are negatively skewed, arguing that it is connected to unwinds of carry trade positions, triggered by negative shocks to funding liquidity and risk appetite. Among their findings are also that higher interest rate differentials are associated with large speculative positions and that these large positions increase crash risk. Additionally, their empirical findings, through a VAR analysis suggest that there is an under reaction to increments in interest rates since exchange rates fail to immediate reach their implied new level, from which the UIP predicts it should start declining. Under their view carry trade might be profitable because capital is slow moving and it takes time for exchange rates to reach their fundamental value. Broadly, their findings are consistent with their hypothesis that currencies' sudden depreciations frequently arise from endogenous unwinding of carry trade activity in the presence of liquidity frictions, as carry trade faces the risk that small changes in investors' risk aversion might lead to unwinding of positions, which could result in currency crashes. Anzuini and Fornari (2011) used Brunnermeier, Nagel and Pedersen (2008) as their starting point to develop a macroeconomic analysis of the structural shocks. First, their work adapts the VAR model developed by Brunnermeier Nagel and Pedersen (2008), finding coinciding results, and second, it employs a larger VAR exploiting four structural shocks (monetary policy, supply, demand and confidence), and resorting to sign restrictions in order to identify them. The results of such model provide evidence that demand shocks are a significant determinants of carry trade activity, and a key factor behind the response of returns to interest rate shocks.

Researchers seem to agree that the UIP does not hold empirically. However, the causes behind the profitability of carry trade, either a response to traditional risk factors, or anomalies, or crash risks are still a matter of debate. The present dissertation is among the works that concentrate on crash risk and carry trade speculative activity. Its purpose is to connect currency returns to higher crash probability as well as to provide understanding of how speculators affect the distance between the actual and fundamental exchange rates.

3. Data and Definitions

The current work uses the same type of data as in Brunnermeier, Nagel and Pedersen (2008) but for a different time period. For the time span between 1999 and 2016 and concerning USA (USD) and eight major developed markets: Australia (AUD), Canada (CAD), Switzerland (CHF), Euro area (EUR), Great Britain (GBP), Japan (JPY), Norway (NOK), and New Zealand (NZD), the daily nominal exchange rates were extracted from the Pacific Exchange Rate Service of the University of British Columbia's Sauder School of Business and the monthly 3-month interbank interest rates were collected from FRED (Federal Reserve Economic Data).

Throughout the present work, nominal exchange rates s_t (units of dollar per foreign currency) are in logarithms and the interest rates, obtained in annualized terms, when working as input to compute currency returns are properly monthly adjusted.

This work considers the USD as the domestic currency and denotes the dollar return of an investment in the foreign currency financed by borrowing in the domestic currency as:

$$z_{t+1} = (i_t^* - i_t) + \Delta s_{t+1} \tag{2}$$

where z_{t+1} is the return of the investment after a certain month, i^*_t and i_t are respectively the foreign and the domestic interest rates available at the beginning of that month and Δs_{t+1} is the change verified in the nominal exchange rate over the month under analysis. As underlined in *Equation. 2* the returns for each investment currency derive from its interest rate differential and its exchange rate appreciation.

It is important to state that there are other possibilities for carry traders than taking positions relatively to the USD. If one speculator was merely looking to exploit, at a certain point in time, the positive interest rate differential between the high yielding NZD and the low yielding JPY, he could just take proper positions relatively to those currencies. The present work is not limited to analyze pairs in which one of the currencies is the USD, it is also able to capture the profitability of previous strategies. If regressions predict the appreciation relative to USD of currencies yielding more than USD and also the depreciation relative to USD of currencies yielding less than USD, then such regressions forecast high yielding currencies to appreciate relatively to low yielding ones. Using the previous example, regressions would foresee the NZD to appreciate against JPY. Although indirectly, the data setup presented in this work allows for the comparisons between all the involved currencies and provides informative regressions.

Other relevant data features concern skewness. Skewness measures the asymmetry of the probability distribution of a real-valued random variable about its mean. When it is negative, there is an indication that the left tail of the distribution is fatter or longer than the right one. Applying it to the topic of this work, a more negative realized skewness is indicative of higher crash risk. This is a characteristic for certain currencies' exchange rate movements. In most of the observations they accumulate relatively small appreciations, concentrating the mass distribution on the right side, but intercalate, at some points in time, such successive appreciations with relatively large sudden depreciations, forming a prominent left tail. Throughout the work $Skewness_t$ denotes the measure of skewness of daily exchange rate changes within the quarter ending at time t.

Concerning carry trade, the present work uses, as proxy to its activity, the futures position of non-commercial traders in the foreign currency collected upon data of Commodity Futures Trading Commission available on Quandl. As in Brunnermeier et al. (2008), $Futures_t$ is the net (long minus short) futures position of non-commercial traders in the foreign currency, expressed as a fraction of total open interest of non-commercial traders. For this work, such data was collected for six of the eight currencies (AUD, CAD, CHF, EUR, GBP and JPY). Both the imperfect division between commercial and non-commercial traders, and the inability of the variable to capture the liquidity in the currency market present in in the over-the-counter forward market represent downsides of using such an indicator, however, this is most likely the best publicly available data to show the direction of the currency trade of speculators.

Along the dissertation, data is organized in a panel assembling monthly observations of currencies' individual characteristics for the 1999-2016 period. Every time an observation of any variable with respect to any currency was missing, the option relied on filling the blank space with a value equal to the previous observation, which is the same as to assume that the variable remained unchanged. Relatively to the data collected on futures positions, since such data is available on a weekly basis, it was chosen to consider the last observation available from each month as the one existing at the end of it. Besides, models and regressions using the variable *Futures* exclude from the panel all observations relative to countries whose futures data could not be collected.

Table A.1 in the appendix contains the introduced variables' synthesized description.

4. Methodology

The empirical analysis conducted in this work project starts by providing some general statistics, on both individual currencies and portfolios. In terms of method, it is relevant to explain how the portfolios were built. At the beginning of each month, the currencies with the highest interest rates are selected to go long on, while the currencies with the lowest are selected for taking a short position. Three portfolios were constructed, using respectively the top and bottom one, two or three yielding currencies and each monthly return was derived from the weighted return of each individual carry trade involving the dollar and one foreign currency. The weights attributed to each carry trade are $1/m_l$ in the case of long positions and $1/m_s$ in the case of the short ones. All portfolios are designed to be dollar neutral and equal weighted. m_l (number of long carry trades) and m_s (number of short carry trades) are equal and range between one and three. The following formula provides the return for each of the portfolios at the end of each month:

$$R_t^p = \sum_{l=1}^{m_l} w_{t-1}^l * z_t^l - \sum_{s=1}^{m_s} w_{t-1}^s * z_t^s. \quad (3)$$

Following the general statistics, in order to understand which variables are being influenced by interest rates, three sets of regressions using country fixed effects are performed. The generic formulation of these univariate regressions is as shown below, where x_t can represent z_t, $Futures_t$ or $Skewness_t$.

$$x_{i,t+\tau} = \alpha_i + \beta\left(i_{i.t}^{*} - i_{i,t}\right) + \varepsilon_{i.t} \qquad (4)$$

Fixed effects regressions, where α_i is taken to be a country-specific constant term, allow us to control for such specific effects, directing the regressions to produce results not induced by the differences in terms of interest rates and currency risk that are due to structural disparities across countries. The fixed effects methodology is also applied to regressions of higher complexity, aiming to perceive if any of the studied variables is a significant predictor of crash risk. Regressions including or not the variable of currency returns (z_t) were both modeled and below it is possible to confront the most extensive formulation of such regressions. The chosen specifications involve a 3-month ahead prediction in order to assure that the overlapping variable *Skewness* observed at time t does not share any common component with the value that is being predicted, since otherwise it would be strongly correlated by construction.

$$Skewness_{i,t+3} = \alpha_i + \beta_1\left(i_{i,t}^{*} - i_{i,t}\right) + \beta_2 Futures_{i,t} + \beta_3 z_{i,t} + \beta_4\, Skewness_{i,t} + \varepsilon_{i,t} \qquad (5)$$

Additionally, in an effort to provide a more dynamic model than that in *Equation 4*, like in Brunnermeier, Nagel, Pederson (2008), the present work presents a Panel VAR model with the ordering i_t^{*}-i_t, z_t, $Skewness_t$, and $Futures_t$. In specific, a VAR(4) specification is used, i.e.,

$$x_{i,t} = \Gamma_0 + \Gamma_1 x_{i,t-1} + \Gamma_2 x_{i,t-2} + \Gamma_3 x_{i,t-3} + \Gamma_4 x_{i,t-4} + f_i + e_t \qquad (6)$$

where $x_{i,t}$ is a four variable vector [(i^{*}-i), z, *Skewness, Futures*)]. The VAR analysis, in the present work, is based on orthogonalized impulse response functions and focuses only on interest rate shocks. The impulse-response functions obtained describe the reaction of all variables present in the model to the innovations of interest rates differentials, while holding all other shocks equal to zero. In order to get such information, it is necessary to isolate shocks for each of the variables, so that for example, the effects of innovations to *(i^*-i)* in the variable *z* do not incorporate the effects of other variables. Due to the unlikeliness that the actual variance–covariance matrix of the errors is set to be diagonal, the isolation of interest rate shocks to the different variables requires a decomposition of the residuals, using a Choleski decomposition that ensures that they become orthogonal. In this work, the VAR ordering of the variables used is *(i^*-i), z, Skewness,* and *Futures*. The identifying assumption is that variables appearing first in the ordering affect the succeeding variables contemporaneously, while the variables that come afterwards influence the preceding variables only with a lag. Since the analysis focuses on shocks to interest rate differentials, the relevant assumption considered within the variance–covariance matrix is that those shocks originate contemporaneous changes in the other variables while shocks to *z, Skewness* and *Futures* do not affect the VAR innovation of the interest rate differential. As explained in Love and Zicchino (2006) when applying the VAR procedure to panel data, it is necessary to impose the restriction that the underlying structure is the same for each cross-sectional unit (each individual currency). Introducing fixed effects (f_i) in the model overcomes the possibility that such restriction is not verified. In practice, this procedure allows for "individual heterogeneity" and the chosen methodology underlying it is the Helmert transformation as expressed in Abrigo and Love (2016) which specifies that the panel fixed-effects are detached by the removal only of the forward mean, i.e. the mean of all the future observations available for each currency-year combination. All estimations are done by generalized method of moments (GMM) and the confidence bands for the impulse response functions portrayed are estimated using a Gaussian approximation based on Monte Carlo draws from the estimated panel VAR models, as also illustrated in Abrigo and Love (2016). As for the order selection, the present work followed the moment and model selection criteria proposed by Andrews and Lu (2001), which pretends to be analogous to the maximum likelihood-based model selection criteria proposed by Akaike (AIC).[2]

5. Results

5.1 Summary Statistics

The starting point for the presentation of results are the summary statistics for each currency.

Table 2 presents the mean of each variable for each of the currencies considering the period between 1999 and 2016, from which cross-sectional features can be highlighted.

Table 2 – Monthly Means over the period 1999-2016

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD
Δs	0,07	0,06	0,14	-0,05	-0,14	-0,02	-0,06	0,12
z	0,27	0,09	0,03	-0,06	-0,06	-0,18	0,06	0,35
(i^*-i)	2,41	0,32	-1,30	-0,10	0,89	-1,90	1,47	2,73
Skewness	-0,26	-0,02	0,15	0,03	-0,08	0,04	-0,11	-0,22
Futures	0,17	0,04	-0,07	0,01	-0,02	-0,07	-	-

The analysis of this Table 2 suggests a positive link between average interest rate differentials and average returns. Both AUD and NZD dollar averaged the highest interest rate differentials and currency returns, while Japan averaged the lowest values in both variables. Except for the Swiss franc, all currencies with negative interest rate differentials averaged negative returns, while with the exception of the British pound (GBP) every currency averaging positive interest rate differentials, averaged positive returns. Cross sectional evidence suggests UIP violations and indicates that currency carry trade is a profitable strategy on average. First it suggests that the inverse sign of the interest rate differential might be a predictor of the sign of returns, and second that the larger the differential the higher might be the expected return of a currency.

Concerning how the interest rate differentials correlate with the remaining variables, Table 2 provides evidence that higher interest rate differentials face on average a higher risk of crash, and

[2]The criteria consists in selecting the pair of vectors (p, q) that minimizes $(k^2p, k^2q) - 2k^2(|q| - |p|)$, where J is the Hansen J statistic.

that on average, speculators pursue carry trade activities. The first conclusion, follows the interpretation of Figure 2. The higher yielding currencies AUD and NZD have the most negative skewness, while the lower yielding currencies JPY and CHF delivered the most positive values. The second conclusion arises from observing the positive correlation between the variables *Futures* and $(i^{*}-i)$. Excepting the GBP the futures' positions align perfectly and positively with $(i^{*}-i)$.

Shifting the analysis from an individual currency perspective to a portfolio one allows us to explore further evidences. Table 3 presents some performance measurements among the long-short portfolios built as described in the previous section.

Table 3 – Monthly and Quarterly Measures of Portfolio Performance 1999-20016

	Monthly			**Quarterly**		
	1L1S	**2L2S**	**3L3S**	**1L1S**	**2L2S**	**3L3S**
Average Return (%)	0,42	0,34	0,33	1,19	0,95	0,92
Standard Deviation	3,67	2,96	2,27	6,71	5,45	4,25
Skewness	-1,30	-0,85	-0,63	-1,24	-1,48	-1,41
Kurtosis	6,09	2,86	1,37	3,73	5,10	4,02
Annualized Sharpe Ratio	0,39	0,40	0,51	0,35	0,35	0,43

Table 3 exposes relevant facts. The average returns of the carry trade portfolios built for this work tend to decrease as more currencies are added to it, and the standard deviation also tends to decrease. The effects from diversifying portfolios are common for both quarterly and monthly windows and get translated into higher annualized Sharpe Ratios, leading us to conclude that adding currencies to a portfolio may be beneficial in terms of variance and return payoff. As for skewness, it is relevant to underline that carry trade strategies, at least, as constructed here, deliver negatively skewed returns, differing in some conclusions if quarterly or monthly data is considered. Quarterly data portfolios support the idea of Brunnermeier, Nagel and Pedersen (2008) that there is no evidence that skewness and excess kurtosis can be diversified away, while on the other hand, monthly data portfolios suggest that adding currencies may actually enhance the reduction of excess kurtosis and left-skewness of diversified portfolios. Overall the portfolio analysis confirms that carry trade is averagely profitable and faces crash risk, with significant realized skewness in the returns of different portfolios. The notable left tails of the portfolios' returns in Figure 3 are illustrative of such characteristics.

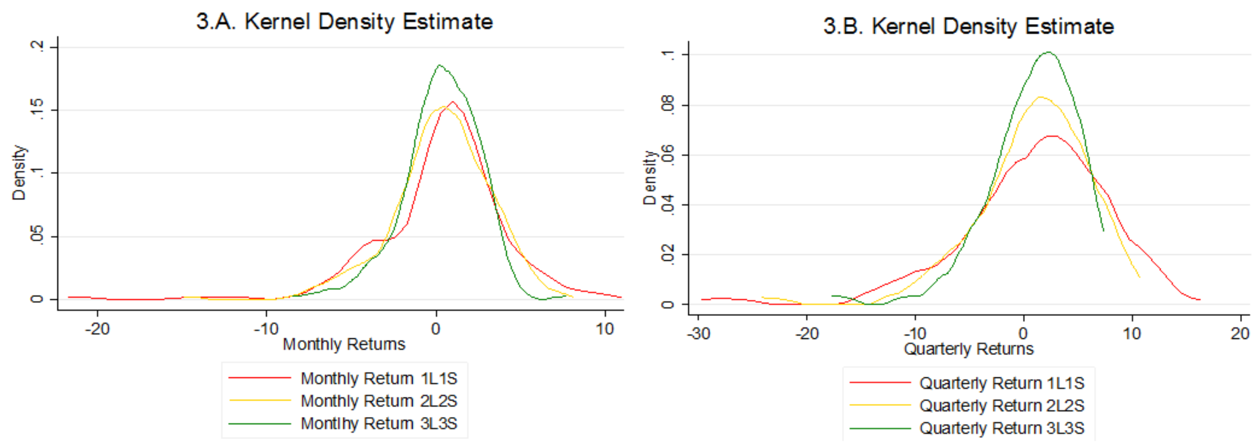

Figure 3 Kernel Distribution of Carry Trade Portfolio Returns: 3.A. displays monthly returns; 3.B. displays quarterly

5.2 Evidence from Simple Regressions

In section 4, *Equation 4* provided a generic regression with the interest rate differential as independent variable. Choosing different dependent variables, one at each time, informs how the current interest rate differentials predict the behavior of future carry trade returns, skewness or speculative positions. Table 4 shows the estimated coefficients β for multiple months ahead.

Table 4 – Estimated coefficients for univariate regressions

	$z_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Skewness_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Futures_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$	
	β	**S.E**	**β**	**S.E**	**β**	**S.E**
t+1	0,1706***	0,0516	-0,0760***	0,0095	0,0371***	0,0053
t+2	0,1146***	0,0517	-0,0742***	0,0095	0,0328***	0,0053
t+3	0,0784	0,0518	-0,0690***	0,0095	0,0285***	0,0053
t+4	0,0979	0,0518	-0,0614***	0,0095	0,0248***	0,0053
t+5	0,1049***	0,0518	-0,0554***	0,0096	0,0221***	0,0053
t+6	0,0804	0,0518	-0,0523***	0,0096	0,0197***	0,0054
t+8	0,0792	0,0519	-0,0464***	0,0096	0,0151***	0,0054
t+10	0,1461***	0,0518	-0,0371***	0,0096	0,0115***	0,0054
t+12	0,1508***	0,0518	-0,0334***	0,0096	0,0104	0,0054
t+16	0,1179***	0,0519	-0,0359***	0,0095	0,0073	0,0054

	$z_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Skewness_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Futures_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$	
	β	**S.E**	**β**	**S.E**	**β**	**S.E**
t+20	0,0530	0,0519	-0,0345***	0,0096	-0,0004	0,0054
t+24	-0,0613	0,0518	-0,0334***	0,0096	-0,0118***	0,0055
Note: Panel regressions using fixed effects for the period 1999-2016						

The interpretation of these three univariate regressions is not equally straightforward. The evolution presented in the first column is the most challenging to characterize. The regression tested first suggests that higher interest rates positively predict future returns to an investment in a foreign currency financed by borrowing in USD, being the estimated coefficient positive for several months. This is in accordance with the previous evidence provided by this work that UIP does not hold for the period covered by the sample. Nevertheless, a deeper look into the results reveals that the returns predicted by the interest rate differentials do not follow a regular trend until they are no longer positive as in Brunnermeier, Nagel and Pedersen (2008), where the interest rate differentials would predict positive but decaying returns. Since the distinction of the present work lies in its period covered, it is possible that in recent years either interest rates differentials began failing to predict returns so systematically or the convergence towards lower interest rates among the developed markets[3] has affected possible carry trade attractiveness.[4]

As for skewness, the third column provides evidence that higher interest rate differentials predict higher crash risk going forward. At the end of each of the following months, each foreign currency interest rate percentage point above the one yielded by the USD affects negatively its conditional skewness, being also suggested by the regressions that the impact slowly contracts as one extends the time horizon. Combining this reflection with the evidence linking interest rate differentials and future currency returns, it is plausible to conjecture that higher interest rate differentials are

[3]In the Appendix, it is possible to see the convergence of interest rates and their descending trend since 2008 in Figure A.2.
[4] In the Appendix, it is possible to confront summary statistics (Tables A.2 and A.3) and regression estimates like in Table 4 (Tables A.4 and A.5) showing how the relationship between interest rate differentials and currency returns among developed currency markets has changed after the 2008 financial crisis.

followed by particularly high returns on the one hand but also by particularly negative skewness on the other. Times where it seems attractive to invest in order to predictably collect significant returns, are times where the risk of the foreign currency suddenly depreciates is also significantly high. Using a greatly known expression, investors may use the signal present in the interest rate differential to go up by the stairs, facing however, the risk that at any point in time, they can come down by the elevator. Interestingly, the fifth column suggests that speculators used that sign, being the speculative positions as measured by the variable *Futures* positively linked to the interest rate differentials mainly over the following twelve months. From Table 4, one may perceive that futures traders, in a clear bet against the verification of the UIP, took long positions on highly yielding currencies, speculating on its appreciation. Just like when using *Skewness* as dependent variable, the coefficients using *Futures* slowly decay towards zero.

Overall this sets of regressions exposed the positive link between interest rate differentials, futures speculative positions and foreign currency returns and the negative relationship between the *(i*-i)* and skewness. To illustrate the later phenomenon of higher crash risk in high yielding currencies, Figure 4, shows the distribution of the monthly and quarterly returns, with the observations from the sample split into three groups according to the respective *(i*-i)*, as explained by the labels.

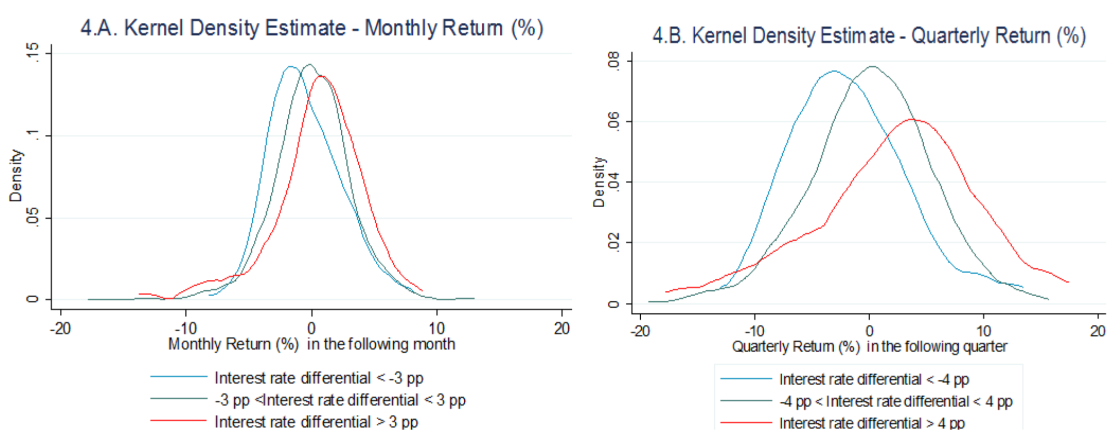

Figure 4. Kernel Distribution of Individual Currency Returns: 4.A. displays monthly returns; 4.B. displays quarterly returns.

From Figure 4 it is clear that the returns distribution depends on the interest rate differential existent at the beginning of the respective month or quarter. Observations associated to higher interest rate differentials appear to have higher mean returns but also more examples of strong negative outcomes. Inversely, the returns observations connected to lower interest rate differentials are mostly concentrated in lower values, but count with some extremely positive values as well. Both on monthly and quarterly returns, as the interest rate differentials associated to the group increases, the distribution becomes more left skewed.

5.3 Predicting Crash Risk

The previous section treated interest rate differentials as the only determinant of the other variables' dynamics. Table 5 presents the estimation results from the regression introduced by *Equation 5* as well as from a simpler configuration, in which the variable z_t is not included.

Table 5 – Predicting Crash Risk

	Skewness$_{t+3}$		**Skewness$_{t+3}$**	
	Coefficient	S.E	Coefficient	S.E
i_t^*-i_t	-0,0606***	0,0124	-0,0581***	0,0123
z_t	-	-	-0,0202***	0,0061
Futures$_t$	-0,4347***	0,0629	-0,3476***	0,0679
Skewness$_t$	0,0544**	0,0287	0,0726**	0,0291
	R^2 = 0,1067		R^2 = 0,1149	
Note: Panel regressions using fixed effects for the period 1999-2016				

The first and second column of coefficient estimates provide further evidence that i_t^*-i_t predicts negative skewness, and in addition it suggests that skewness is persistent, with its present value positively correlated with its past ones. Furthermore, futures positions are negatively linked to future skewness in both regressions, being that relation, curiously, of a smaller magnitude when the variable z_t is included as is possible to verify in the second column of coefficient estimates. This drive-out effect happens due to the correlation between the two variables. Past currency returns predict negative skewness, the same as futures positions do, not excluding the interpretation that currency gains may lead speculators to increase their positions and to face larger future crash risk as a consequence. The idea is that positive returns are accompanied by higher speculative positions, in an increase of the carry trade activity, which would also increase crash risk, as the negative impact in the foreign currencies exchange rates entailed by a hypothetical unwinding of such positions is amplified. Like in Brunnermeier, Nagel and Pedersen (2008), this suggests that some of the exchange rates movements' skewness may be endogenously formed by carry trade activity itself when possible losses trigger previous mechanisms, being all reflected on realized negative conditional skewness.

5.4 VAR analysis

Section 5.2 offered a univariate analysis of how other variables' behavior is affected by interest rate differentials. This section offers a multivariate analysis, using vector autoregressive models as detailed in section 4. This analysis rests on the impulse response functions and delivers evidence on the relationships between interest rate differentials, foreign currencies exchange rates, future positions and skewness over multiple periods. It may as well contribute to understand the role of carry traders in the dynamics of exchange rates, whether it is stabilizing or destabilizing. The impulse response functions to an interest rate shock estimated from the VAR(4) are reported in Figure 5.

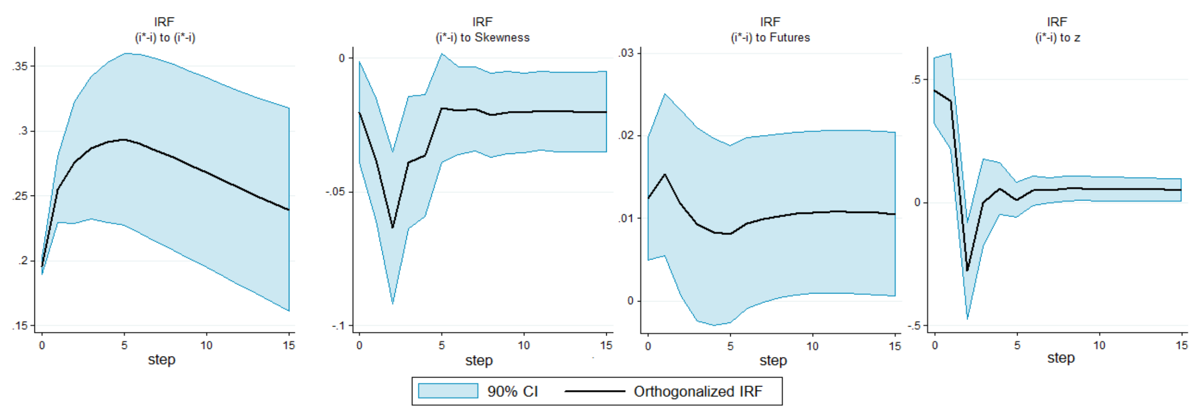

Figure 5 – Impulse response functions from VAR(4) for shock to interest rate differential with 90 percent confidence bands.

The third graph shows with statistical significance that interest rate differential shocks lead to an increase in the long positions for the corresponding currency in the short run, which is consistent with the idea that as currency premia widens, speculators initiate carry trades. In the long-run this effect may be permanent, but there is not enough statistical evidence to reject the hypothesis that the long positions slowly revert to initial levels as the confidence bands point out.

The second graph indicates that following an interest rate differential shock, conditional skewness gets more negative before slowly adjusting back to a value closer to its mean. The suggestion provided in 5.3 that as currency gains and speculative positions increase, negative skewness accentuates is compatible with the impulse response functions reported in Figure 5.

The first graph shows that following the shock, interest rate differentials keep increasing for several month before starting a reversion back to their mean.

The results of this analysis[5] are broadly in line with those from the univariate regressions. The predicted effects from changes in interest rate differentials for futures and skewness are the same in both configurations. As for currency returns, the VAR(4) also predicts a sort of irregular behavior as it is illustrated by fourth graph of Figure 5 and by Figure 6.

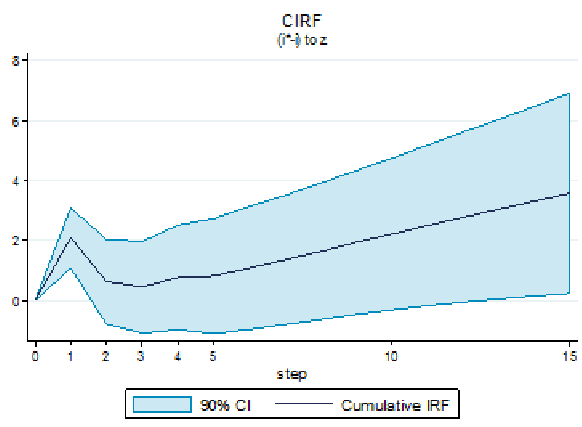

Figure 6 – Cumulative impulse response function from VAR(4) for shock to interest rate differential with 90%confidence bands.

[5] The essential analysis is based on the impulse response functions. To access de estimates of the VAR(4), please confront Table A.6 from the Appendix

Figure 5 shows that following the interest rate differential shock, returns immediately increase, but within a month they have a less significant drawdown before stabilizing near their mean.

From the impulse response in terms of cumulative returns reported in Figure 6, one detects that results differ from the ones predicted in Brunnermeier, Nagel and Pedersen (2008), in which cumulative returns initially underreacted, with currency returns almost not immediately reacting to the shock. Under reaction, which leaded the authors to advance with the possibility that slow capital flows were making carry trade profitable on average. According to them, liquidity frictions would prevent an immediate response by investors and an immediate appreciation to of the exchange rate, which would only appreciate slowly, making carry trade profitable throughout this period. Under this scenario crashes would also be connected to liquidity frictions, as small shocks in risk aversion could lead to a domino effect of shortages of available liquidity, unwinding of carry trades and significant depreciations on investment currencies. Their hypothesis also implied that more carry trade would contribute to enforce quickly the implied appreciation of the exchange rates following a positive shock to interest rate differentials, being possible that currency crashes interrupted a process that was conducting currencies to their fundamental value. The present work does not provide further evidence favoring that theory since the estimated impulse response to an interest rate differentials shock suggests a quick reaction from carry traders and carry trade returns, not indicating that, after a widening of the interest rate differentials, more carry trade activity would drive exchange rates to their fundamental value rather than pushing them away.

The multivariate analysis linked positively the widening of interest rate differentials, to immediate currency carry trade gains, increased carry trade activity and reinforced crash risk, which as described in 5.3 suggests some of the exchange rates movements' skewness can be endogenously generated by carry trade activity itself. Also in line with findings of previous sections, the VAR(4) predicts a zigzagging behavior of returns. Finally, and not favoring Brunnermeier, Nagel and

Pedersen (2008), the model did not capture evidence of slow moving capital nor of under reaction of both traders and carry trade returns. As explained in 5.2 the different period covered might also explain the weaker link between interest rate differentials and carry trade returns than what is found in the literature, as well the lack of evidence suggesting an under reaction of carry traders and carry trade returns to the widening of interest rate differential.

6. Conclusion

This work succeeded in establishing links between interest rate differentials and other variables. For the currencies considered and for the period between 1999 and 2016, multiple analyses proved the positive link between interest rate differentials and currency returns. It also proved the positive link between interest rate differentials, suggesting that speculators are pursuing carry trade activities. The study of conditional skewness allowed to confirm that high yielding currencies exchange rates reveal a more negative realized skewness. In addition, it evidenced that positive returns, long speculative positions and past negative skewness all predict increased crash risk. Globally, the results are consistent with the possibility of endogenously created skewness as negative skewness accentuates in times of currency gains and increase of speculative long positions. As for the stabilizing role of carry trade, the multivariate analysis does not provide evidence that carry traders react sluggishly to interest rate shocks, and does not predict significant returns going forward. The influence of the post-financial crisis period appeared to have effect on currency carry trade dynamics, possibly motivating future research exploiting if there is dissipation of carry trade profitability among the sample currencies or if other conditionings relating to the studied currency markets have limited the trade attractiveness.

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Appendix

This section is not essential for the comprehension and appreciation of the final work.

1. Tables

Table A.1 Variables description

Variable	Expression	Interpretation
i_t^*-i_t	(Interest rate differential)*100	Annualized interest rate differential existing between foreign and domestic currency. It should be read as percentage points.
Δs_t	[log(nominal exchange rate)$_t$ - log(nominal exchange rate)$_{t-1}$] * 100	The percentage change verified in the exchange rate between the period *t-1* and *t*
z_t	$z_{(t)}=(i_{t-1}^*-i_{t-1})+\Delta s_{(t)}$	Currency monthly/ quarterly return
Skewness$_t$		Skewness of the daily changes in the nominal exchange rate within the 3 month period ending at period *t*
Futures$_t$	(Noncommercial Long $_t$ - Noncommercial Short $_t$) / Open Interest $_t$	Net futures position of non-commercial traders expressed as a fraction of total open interest of non-commercial traders at period t.

Table A.2 – Monthly Means over the period 1999-2007

	AUD	**CAD**	**CHF**	**EUR**	**GBP**	**JPY**	**NOK**	**NZD**
Δs	0,32	0,40	0,17	0,19	0,17	0,00	0,30	0,34
z	0,47	0,41	-0,01	0,15	0,26	-0,29	0,39	0,55
(i^*-i)	1,74	0,03	-2,17	-0,55	1,15	-3,51	1,11	2,61
Skewness	-0,36	0,01	0,15	0,05	-0,02	0,24	-0,08	-0,30
Futures	0,20	0,07	-0,12	0,14	0,08	-0,09	-	-

Comment: There is a link between *z* and (i^*-i). Excepting the EUR, all positive (negative) interest rate differentials are linked to positive (negative) currency returns. The highest yielding currencies averaged the highest currency returns (AUD and NZD) and the lowest yielding currencies the lowest currency returns (CHF and JPY)

Table A.3 – Monthly Means over the period 2011-2016

	AUD	**CAD**	**CHF**	**EUR**	**GBP**	**JPY**	**NOK**	**NZD**
Δs	-0,48	-0,42	-0,12	-0,33	-0,33	-0,51	-0,54	-0,16
z	-0,25	-0,35	-0,16	-0,33	-0,30	-0,51	-0,42	0,06
(i^*-i)	2,76	0,76	-0,51	0,06	0,34	-0,08	1,53	2,56
Skewness	-0,12	-0,06	0,14	-0,05	-0,19	-0,25	-0,21	-0,14
Futures	0,05	-0,04	-0,04	-0,18	-0,06	-0,16	-	-

Comment: The link from A.4 fades away. All currencies with negative interest rate differentials averaged negative currency returns, but positive interest rate differentials lost the link to positive currency returns. The highest yielding currency (AUD) averaged merely the third highest currency return, the third highest yielding (NOK) averaged the second last return and the lowest yielding averaged the second highest return.

Table A.4 – Estimated coefficients for univariate regressions

	$z_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Skewness_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Futures_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$	
	β	S.E	β	S.E	β	S.E
t+1	0,3394***	0,0561	-0,0704***	0,0099	0,0565***	0,0068
t+2	0,3278***	0,0562	-0,0705***	0,0098	0,0543***	0,0069
t+3	0,3289***	0,0561	-0,0686***	0,0097	0,0524***	0,0068
t+4	0,3371***	0,0565	-0,0644***	0,0098	0,0504***	0,0068
t+5	0,3324***	0,0565	-0,0615***	0,0098	0,0486***	0,0068
t+6	0,3177***	0,0564	-0,0586***	0,0099	0,0468***	0,0068
t+8	0,2787***	0,0565	-0,0532***	0,0098	0,0421***	0,0067
t+10	0,2362***	0,0587	-0,0445***	0,0099	0,0373***	0,0068
t+12	0,1916***	0,0641	-0,0374***	0,0100	0,0348***	0,0068
t+16	0,1405***	0,0678	-0,0342***	0,0095	0,0240***	0,0069
t+20	0,0840	0,0693	-0,0271***	0,0099	0,0186***	0,0068
t+24	0,0110	0,0686	-0,0217***	0,0097	0,0096***	0,0069

Note: Panel regressions using fixed effects for the period 1999-2007
C**ommen**t: Until 2007 positive interest rate differentials predicted higher returns with more significance. Also before 2008, each unit of interest rate differential at time *t* predicted currency returns positively and in a decaying way.

Table A.5 – Estimated coefficients for univariate regressions

	$z_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Skewness_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$		$Futures_{(t+\tau)}=\alpha+\beta(i_t^*-i_t)+\varepsilon_t$	
	β	S.E	β	S.E	β	S.E
t+1	0,0919	0,2090	-0,1796***	0,0520	0,1416***	0,0248
t+2	0,0579	0,2107	-0,1768***	0,0539	0,1105***	0,0245
t+3	0,0955	0,2118	-0,1535***	0,0558	0,0980***	0,0241
t+4	0,0538	0,2126	-0,1247	0,0558	0,0909***	0,0238
t+5	-0,0407	0,2104	-0,1207	0,0562	0,0826***	0,0233
t+6	0,1169	0,2111	-0,1095	0,0565	0,0756***	0,0229
t+8	-0,1320	0,2110	-0,1021	0,0562	0,0626***	0,0226
t+10	0,0940	0,2025	-0,0794	0,0550	0,0226***	0,0225
t+12	0,1576	0,1974	-0,0148	0,0514	0,0067***	0,0227
t+16	0,1667	0,1971	-0,0402	0,0505	0,0204***	0,0220
t+20	0,3525	0,1921	-0,0567	0,0501	0,0374***	0,0212
t+24	0,3921***	0,1960	-0,1541***	0,0499	0,0378***	0,0202

Note: Panel regressions using fixed effects for the period 2011-2016
Comment: Since 2011, positive interest rate differentials do not predict positively returns consistently and in a decaying form as until 2008. Each increment in interest rate differentials at time *t* predicts returns in an irregular way and with less statistical significance.

2. Figures

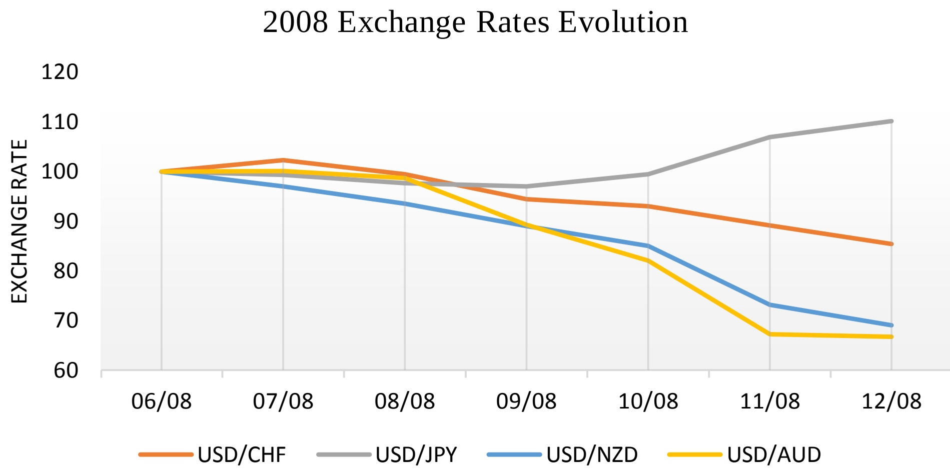

Figure A.1 Exchange rates evolution in second semester of 2008. The vertical axis measures the exchange rate at a certain period as a percentage of the base period (June of 2008). CHF and JPY were at the date lower yielding currencies than NZD and AUD.

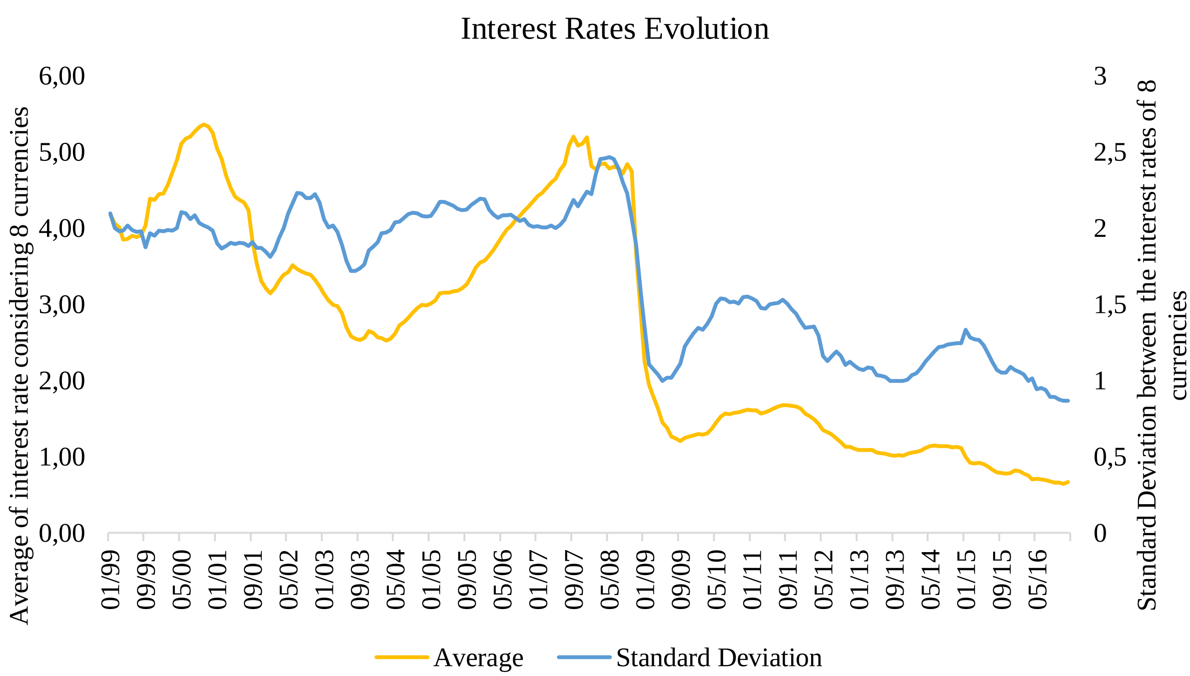

Figure A.2 Evolution of the average (left vertical axis) interest rates considering the ones inherent to AUD, CAD, CHF, EUR, GBP, JPY, NOK, NZD and USD as well as the respective standard deviation (right vertical axis). Interest rates are evolving to lower and closer values.

3. VAR(4)

Table A.6 - VAR(4) estimates

(i-i)*	Coef.	Std. Error	z	P>z	95% Conf. Interval	
(i-i)*						
L1.	1,285	0,072	17,740	0,000	1,143	1,427
L2.	-0,279	0,084	-3,330	0,001	-0,444	-0,115
L3.	0,044	0,094	0,460	0,643	-0,140	0,227
L4.	-0,066	0,050	-1,310	0,189	-0,165	0,033
z						
L1.	0,006	0,006	0,950	0,344	-0,006	0,017
L2.	-0,003	0,004	-0,760	0,445	-0,010	0,004
L3.	-0,005	0,003	-1,960	0,050	-0,011	0,000
L4.	0,004	0,003	1,570	0,117	-0,001	0,010
Skewness						
L1.	0,005	0,017	0,280	0,780	-0,029	0,038
L2.	0,004	0,018	0,250	0,802	-0,031	0,040
L3.	-0,018	0,014	-1,280	0,202	-0,045	0,010
L4.	0,001	0,013	0,080	0,938	-0,024	0,026
Futures						
L1.	0,082	0,062	1,330	0,185	-0,039	0,204
L2.	0,018	0,056	0,330	0,743	-0,091	0,127
L3.	-0,011	0,044	-0,260	0,799	-0,098	0,076
L4.	-0,028	0,036	-0,770	0,441	-0,098	0,043
z	Coef.	Std. Error	z	P>z	[95% Conf. Interval]	
(i-i)*						
L1.	2,092	0,586	3,570	0,000	0,943	3,241
L2.	-4,127	0,942	-4,380	0,000	-5,974	-2,280
L3.	2,254	0,972	2,320	0,020	0,349	4,158
L4.	-0,032	0,617	-0,050	0,959	-1,240	1,177
z						
L1.	-0,016	0,040	-0,400	0,691	-0,093	0,062
L2.	-0,025	0,044	-0,570	0,571	-0,111	0,061
L3.	0,074	0,039	1,910	0,056	-0,002	0,151
L4.	-0,001	0,034	-0,030	0,974	-0,069	0,066
Skewness						
L1.	-0,065	0,231	-0,280	0,779	-0,518	0,388
L2.	0,337	0,240	1,400	0,161	-0,134	0,807
L3.	-0,068	0,223	-0,300	0,760	-0,504	0,368
L4.	-0,117	0,190	-0,620	0,538	-0,490	0,256
Futures						
L1.	0,776	0,545	1,420	0,155	-0,293	1,845
L2.	0,508	0,625	0,810	0,416	-0,716	1,732
L3.	-0,272	0,654	-0,420	0,678	-1,553	1,010
L4.	-0,627	0,528	-1,190	0,235	-1,662	0,408

Skewness	Coef.	Std. Error	z	P>z	[95% Conf. Interval]	
(i-i)*						
L1.	-0,097	0,059	-1,650	0,099	-0,212	0,018
L2.	-0,031	0,095	-0,330	0,744	-0,217	0,155
L3.	0,228	0,111	2,060	0,039	0,011	0,445
L4.	-0,114	0,061	-1,860	0,063	-0,235	0,006
z						
L1.	-0,007	0,005	-1,280	0,201	-0,018	0,004
L2.	0,001	0,006	0,150	0,877	-0,010	0,012
L3.	-0,022	0,005	-4,160	0,000	-0,033	-0,012
L4.	-0,004	0,005	-0,900	0,367	-0,014	0,005
Skewness						
L1.	0,742	0,047	15,670	0,000	0,649	0,835
L2.	0,013	0,046	0,280	0,779	-0,077	0,102
L3.	-0,285	0,051	-5,620	0,000	-0,385	-0,186
L4.	0,192	0,043	4,500	0,000	0,109	0,276
Futures						
L1.	-0,052	0,082	-0,630	0,527	-0,213	0,109
L2.	-0,082	0,091	-0,910	0,363	-0,260	0,095
L3.	0,196	0,090	2,180	0,029	0,020	0,372
L4.	-0,238	0,074	-3,220	0,001	-0,382	-0,093

Futures	Coef.	Std. Error	z	P>z	[95% Conf. Interval]	
(i-i)*						
L1.	0,006	0,026	0,230	0,815	-0,045	0,058
L2.	-0,029	0,043	-0,660	0,508	-0,113	0,056
L3.	0,058	0,041	1,440	0,151	-0,021	0,138
L4.	-0,027	0,023	-1,140	0,253	-0,073	0,019
z						
L1.	0,015	0,002	7,400	0,000	0,011	0,019
L2.	0,000	0,002	0,110	0,912	-0,003	0,004
L3.	0,001	0,002	0,380	0,705	-0,003	0,004
L4.	-0,003	0,002	-1,730	0,083	-0,006	0,000
Skewness						
L1.	0,007	0,012	0,580	0,565	-0,016	0,030
L2.	0,020	0,013	1,560	0,120	-0,005	0,046
L3.	0,003	0,012	0,210	0,832	-0,022	0,027
L4.	-0,001	0,011	-0,070	0,941	-0,022	0,021
Futures						
L1.	0,602	0,042	14,350	0,000	0,520	0,684
L2.	0,077	0,045	1,710	0,087	-0,011	0,166
L3.	0,016	0,042	0,380	0,706	-0,067	0,099
L4.	0,070	0,035	1,970	0,049	0,000	0,139