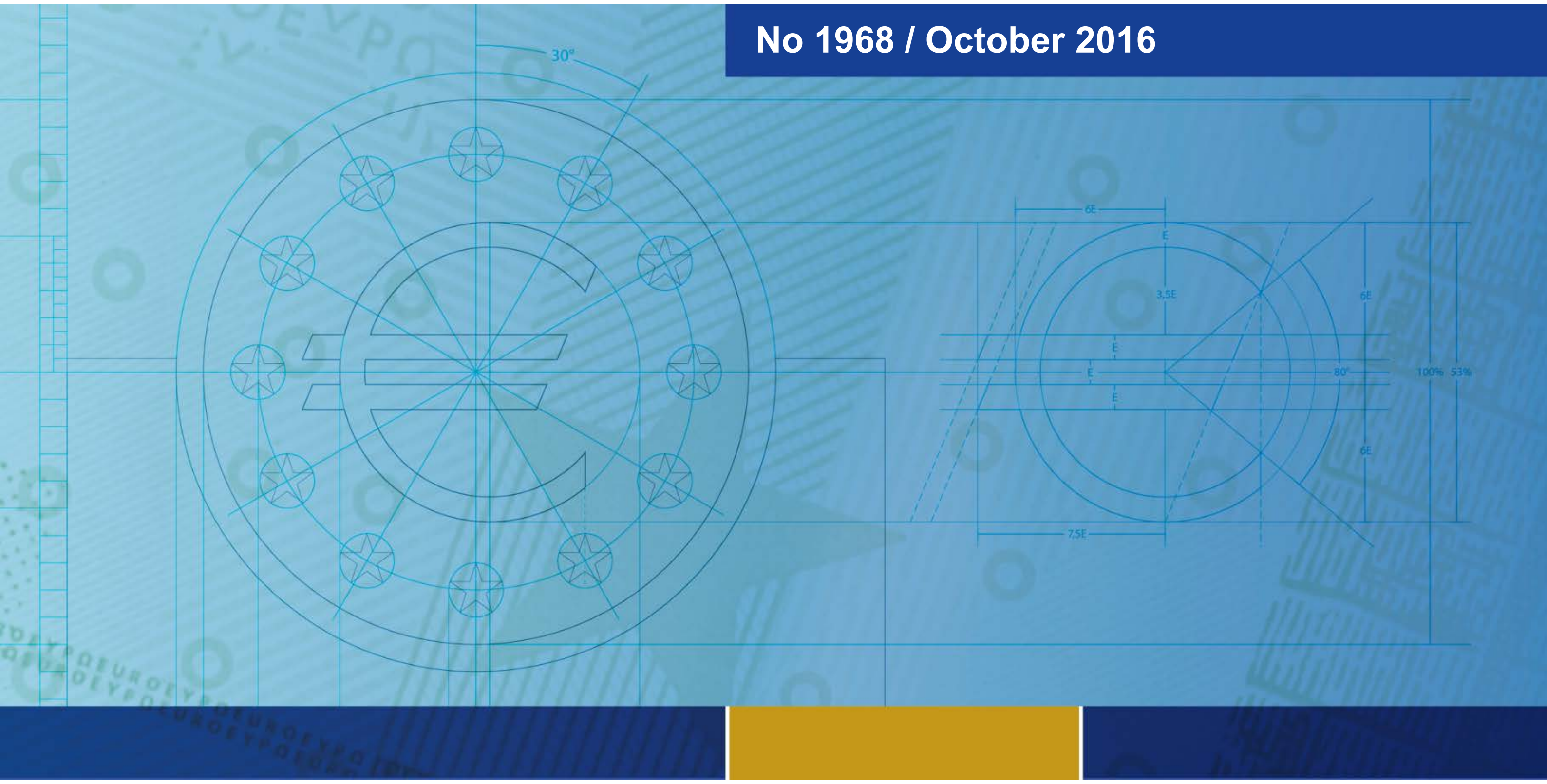
EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

Andrea Falconio

Carry trades and monetary conditions



No 1968 / October 2016

Abstract

This paper investigates the relation between monetary conditions and the excess returns arising from an investment strategy that consists of borrowing low-interest rate currencies and investing in currencies with high interest rates, so-called "carry trade". The results indicate that carry trade average excess return, Sharpe ratio and 5% quantile differ substantially across expansive and restrictive conventional monetary policy before the onset of the recent financial crisis. By contrast, the considered parameters are not affected by unconventional monetary policy during the financial crisis.

Keywords: carry trade, volatility, monetary conditions

JEL classification: F31, G15, E52

Non-technical summary

One of the cornerstones of international finance is the uncovered interest rate parity condition, which predicts that exchange rate changes will eliminate any profit arising from the differential in interest rates across countries. Nevertheless, many studies show that the opposite holds true empirically: high interest rate currencies tend to appreciate rather than depreciate against low interest rate currencies. This leads investors to engage in the so-called "carry trade", which is an investment strategy consisting of borrowing low-interest rate currencies and investing in currencies with high interest rates.

The most persuasive explanation for carry trade profitability is based on a risk argument: currencies with high interest rates are riskier than low interest rate currencies and so deliver higher expected returns. Empirical research has had serious problems in identifying which risk factors drive the considered returns. However, recent studies have shown that foreign exchange (FX) volatility risk and exposure to countries' external imbalances are keys to understanding rewards from carry trade.

Against this background, my paper investigates the relation between monetary conditions and carry trade returns. To this end, an empirical analysis is carried out at the monthly frequency considering Federal Reserve (Fed) monetary policy as a proxy for changes in monetary conditions and using 37 daily spot and one month forward exchange rates per US dollar covering the period from November 1983 to June 2015. Currencies are sorted into six portfolios according to their forward discounts (or, equivalently, their relative interest rate differential versus U.S. money market interest rates): the zero cost strategy that goes long in portfolio 6 and short in portfolio 1 results in a carry trade portfolio. Carry trade portfolio returns are measured at time t based on monetary conditions at time $t-1$. In this way, average returns, Sharpe ratios and 5% quantiles are computed across different monetary conditions.

My main result is that carry trade portfolio average return, Sharpe ratio and 5% quantile differ substantially across expansive and restrictive conventional monetary policy before the onset of the recent financial crisis. Specifically, I find that expansive periods are characterised by significantly higher average returns and Sharpe ratios and lower downside risk. Concerning this, I argue that expansive conventional monetary policy is able to improve market expectations across countries and in this way lower FX volatility risk. This generates a currency appreciation for net debtor nations and an increase in carry trade profits.

Second, I present evidence suggesting that the considered parameters are similar across aggressive and stabilising unconventional monetary policy during the recent financial crisis. So, the Federal Reserve could not affect market expectations during this time.

For investors, this evidence suggests that rewards from carry trade vary with changes in monetary conditions only during "normal" times. For researchers, this evidence suggests that recognising the relevance of monetary policy is crucial to understanding the pricing implications of FX volatility risk for carry trade.

1 Introduction

One of the cornerstones of international finance is uncovered interest parity (UIP), which predicts that exchange rate changes will eliminate any profit arising from the differential in interest rates across countries. Nevertheless, many studies provide empirical evidence against UIP[1]: in particular, they show that high interest rate currencies tend to appreciate rather than depreciate against low interest rate currencies (forward premium puzzle). As a consequence, one of the most popular currency speculation strategy is carry trade, which consists of borrowing low-interest rate currencies and investing in currencies with high interest rates (Burnside (2012)).

The most persuasive explanation for the forward premium puzzle is the intertemporal variation in currency risk premia. Nevertheless, empirical research finds it difficult to identify which risk factors drive the considered premia. As showed by Burnside *et al.* (2011), conventional factor models, i.e. those traditionally used to explain stock returns like the Capital Asset Pricing Model (CAPM), the Fama and French three factor model, the quadratic CAPM, the CAPM-volatility model and the Consumption CAPM, cannot explain currency risk premia. By contrast, less traditional factor models, which adopt empirical risk factors specifically designed to price the cross section of currency returns, are quite successful.

Adopting a cross-sectional asset pricing framework, Menkhoff *et al.* (2012) show that global FX volatility innovations can explain time-varying currency risk premia. Using a similar methodology, Della Corte *et al.* (2016) shed light on the macroeconomic forces driving currency premia. In particular, they show that exposure to countries' external imbalances (global imbalance risk factor)

---

[1] See Engel (2014) for a review of the empirical literature on UIP.

is key to understanding carry trade returns. In addition, they provide evidence that net-debtor nations experience a currency depreciation when FX volatility risk is high, unlike net-creditor countries. So, investors require a risk premium for holding net debtor countries' currencies because these currencies perform poorly during bad times[2].

This work contributes to the considered literature by empirically analyzing whether the temporal variation in currency risk premia is systematically linked to changes in monetary conditions and investigating whether currency risk premia predictability provides information that is economically valuable. Focusing on monetary conditions, this paper tries to propose an underlying factor that drives the temporal variation in the price of volatility. In particular, I argue that monetary expansions improve expectations of market participants across countries, which in turn lowers FX volatility risk. This positively affects the global imbalance risk factor and carry trade returns because high (low) interest rate currencies positively (negatively) load on the considered factor.

Consistent with recent literature examining the risk-return profile of carry trades (e.g. Lustig *et al.* (2011), Menkhoff *et al.* (2012), Della Corte *et al.* (2016)), currencies are allocated to six portfolios according to their forward discount at the end of each period: the zero cost strategy that goes long in portfolio 6 and short in portfolio 1 results in a carry trade portfolio. Then, following the methodology used by Jensen and Moorman (2010) to analyze the relation between the price of security liquidity and monetary policy, carry trade portfolio returns in each period t are measured based on monetary conditions in period $t-1$. Finally, carry trade portfolio average return, Sharpe

---

[2] Other important contributions suggesting explanations for the forward premium puzzle include Lustig and Verdelhan (2007), Lustig *et al.* (2011), Mancini *et al.* (2013), Ahmed and Valente (2015), Brunnermeier *et al.* (2009) and Christiansen *et al.* (2011).

ratio and 5% quantile are computed across different monetary conditions.

My main result is that carry trade portfolio average return, Sharpe ratio and 5% quantile differ substantially across expansive and restrictive conventional monetary policy before the onset of the recent financial crisis. Specifically, I find that expansive periods are characterised by significantly higher average returns and Sharpe ratios and lower downside risk. Second, I present evidence suggesting that the considered parameters are similar across aggressive and stabilising unconventional monetary policy during the recent financial crisis.

The remaining of this work proceeds as follows. Next section presents the data and describes monetary policy indicators used in the analysis. Section 3 explains the empirical framework. Section 4 provides a discussion of my findings, while robustness checks are presented in section 5. Section 6 concludes the paper.

2 Data and variables

2.1 Data

The dataset consists of daily spot and one month forward exchange rates per US dollar covering the period from November 1983 to June 2015. These data are available on Datastream. Following the relevant literature since Fama (1984), logarithms of spot and forward rates will be considered: they will be denoted as s and f respectively.

The sample contains the following countries: Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand and the United Kingdom. The euro series starts in January 1999. Euro area countries are excluded after this date.

Following Lustig *et al.* (2011), the following observations are not taken into account due to large failures of covered interest parity: South Africa from the end of July 1985 to the end of August 1985, Malaysia from the end of August 1998 to the end of June 2005 and Indonesia from the end of December 2000 to the end of May 2007.

2.2 Monetary policy measures

To proxy for changes in monetary conditions, Federal Reserve (Fed) monetary policy is considered. In particular, shifts in its policy are identified by changes in the federal funds rate and the Fed total assets: the former captures conventional monetary policy, while the latter is an indicator of Fed unconventional monetary policy.

The dummy variable *Conventional* is used to identify changes in conventional monetary policy over the period November 1983 to December 2007 (namely, prior to the onset of the recent financial crisis). When the federal funds rate decreases from month $t-1$ to month t, *Conventional* is labelled “expansive” for month t, while if the previous change in the federal funds rate was an increase, *Conventional* is considered “restrictive”. When there are no changes in the federal funds rate, *Conventional* does not change its prior label.

The dummy variable *Unconventional* is considered for the period January 2008 to June 2015. It is labelled “aggressive” for a given month t whenever the Fed total assets increase from month $t-1$ to month t by more than 20000 millions of dollars. By contrast, it is “stabilising” for a given month t if the previous change in the Fed total assets was smaller than 20000 millions of dollars. This threshold is chosen in order to have a balanced number of "aggressive" and "stabilising" unconventional monetary policy periods.

3 Empirical framework

In order to investigate whether the temporal variation in currency risk premia is systematically linked to changes in monetary conditions, currency portfolios are considered[3]. In particular, currencies are allocated to six portfolios according to their forward discounts $f_t - s_t$ observed at the end of each month t. If the covered interest parity holds empirically at the frequency analyzed, then the forward discount is equal to the interest rate differential versus US interest rate: therefore, sorting on forward discount is equivalent to sorting on interest rate differentials. Concerning this, Akram *et al.* (2008) show that covered interest parity holds at daily and lower frequency.

Currencies are ranked from low to high interest rates (or forward discounts): therefore, currencies with the lowest interest rates or smallest forward discounts are contained in portfolio 1, while currencies with the highest interest rates or largest forward discounts are contained in portfolio 6. The zero cost strategy that goes long in portfolio 6 and short in portfolio 1 (the high-minus-low strategy H/L) is labelled carry trade portfolio.

Monthly excess returns for buying a foreign currency k in the forward exchange market and selling it in the spot market after one month are:

$$rx_{t+1}^{k} \approx f_t^k - s_{t+1}^k \tag{1}$$

---

[3] I am considering currency portfolio data available at the following website: https://sites.google.com/site/lustighanno/data. These portfolios are built following Lustig *et al.* (2011).

where s^k_{t+1} and f^k_t are respectively the logarithm of daily spot and one month forward exchange rates at the end of month $t+1$ and t. Gross returns for portfolio j are computed as the equally weighted average of excess returns for the constituent currencies. Net excess returns are derived using the bid-ask quotes for spot and forward contracts. In addition, it is assumed that investors go short in portfolio 1 and long in all the other foreign currencies.

Carry trade portfolio returns are measured for every month t based on monetary conditions in month $t-1$. In this way, carry trade portfolio average return, Sharpe ratio and 5% quantile can be computed across different monetary conditions.

To formally test the relation between carry trade portfolio average return and monetary policy shifts, the classical regression model is used:

$$rx_t^{H/L} = \omega + x_{t-1}\beta + \epsilon_t \tag{2}$$

where x_{t-1} is a 1×2 vector containing rx_{t-1} and a dummy variable ($Conventional_{t-1}$ or $Unconventional_{t-1}$) that measures monetary conditions, β is a 2×1 coefficient vector, ω is the intercept and ϵ_t is the error term. $Conventional_{t-1}$ ($Unconventional_{t-1}$) is equal to one in month $t-1$ when monetary policy is expansive (aggressive) and it is zero when monetary policy is restrictive (stabilising).

Carry trade portfolio quantiles across expansive and restrictive monetary periods are formally compared using the Koenker and Bassett (1978) quantile regression framework:

$$rx_t^{H/L} = \omega_\theta + x_{t-1}\beta_\theta + \epsilon_{t,\theta} \tag{3}$$

where θ is a given confidence level, β_θ is a 2×1 coefficient vector, ω_θ is the intercept and $\epsilon_{t,\theta}$ is an error term such that its θth conditional quantile $q_t(\epsilon_{t,\theta}/x_{t-1}) = 0$.

The relation between carry trade portfolio Sharpe ratio and monetary policy shifts is tested using the symmetric studentized bootstrap confidence interval proposed by Ledoit and Wolf (2008). In their paper Ledoit and Wolf (2008) assume that data are strictly stationary time series and define the difference between Sharpe ratios of two investment strategies x and y as:

$$\begin{aligned} \Delta &= Sh_x - Sh_y \\ &= \frac{\mu_x}{\sigma_x} - \frac{\mu_y}{\sigma_y} \end{aligned} \tag{4}$$

where μ_x and σ_x are respectively the mean and the standard deviation of investment strategy x excess returns (over a given benchmark) and μ_y and σ_y are the mean and the standard deviation of investment strategy y excess returns. They propose to test the null hypothesis $H_0 : \Delta = 0$ by constructing a two-sided bootstrap confidence interval for Δ: if zero is not contained in this interval, then the null hypothesis is rejected at the chosen significance level.

They proxy for the distribution function of the studentized statistic using the bootstrap in the following way:

$$\psi\left(\frac{|\hat{\Delta} - \Delta|}{s(\hat{\Delta})}\right) \approx \psi\left(\frac{|\hat{\Delta}^* - \hat{\Delta}|}{s(\hat{\Delta}^*)}\right) \tag{5}$$

where Δ is the true difference between the Sharpe ratios, $\hat{\Delta}$ is the estimated difference computed from the original sample, $s(\hat{\Delta})$ is the standard error for $\hat{\Delta}$, $\hat{\Delta}^*$ is the estimated difference computed from bootstrap data, $s(\hat{\Delta}^*)$ is the standard error for $\hat{\Delta}^*$ and $\psi()$ is the distribution function. So, the bootstrap

$1-\alpha$ confidence interval for Δ is:

$$CI = \hat{\Delta} \pm z^*_{1-\alpha} s(\hat{\Delta}) \tag{6}$$

where $z^*_{1-\alpha}$ is the $1-\alpha$ quantile of $\psi\left(\frac{|\hat{\Delta}^*-\hat{\Delta}|}{s(\hat{\Delta}^*)}\right)$.

Bootstrap data are generated by resampling block of pairs from the observed pairs with replacement and each block has a fixed size $b \geq 1$. Ledoit and Wolf (2008) propose a calibration method in order to choose b.

The choice of using this inference method is due to the fact that other Sharpe ratio tests assume that data are normally distributed and do not exhibit persistence. Since it is well known that financial returns are not normally distributed and are characterized by volatility clustering, these other tests are not valid. By contrast, the inference method proposed by Ledoit and Wolf (2008) assumes only that excess returns are strictly stationary time series.

4 Results

4.1 Currency portfolio returns

For comparison with prior research, descriptive statistics for the six currency portfolios and the carry trade portfolio are presented in tables 1 and 2 without regard to monetary conditions. Table 1 considers the sample period November 1983 to December 2007, while table 2 contains results for the period January 2008 to June 2015 (namely, after the outbreak of the recent financial crisis). Panel A provides results for gross excess returns in US dollars, while panel B reports results for excess returns net of transaction costs.

In table 1 unadjusted and adjusted annualized average returns and Sharpe ratios increase when moving from portfolio 1 to portfolio 6 and the H/L portfolio. When transaction costs are considered, the average return on the carry trade portfolio decreases from 967 basis points to 562 basis points, while the Sharpe ratio decreases from 1.08 to 0.63. It is also interesting to note that the skeweness (SK) shows a decreasing trend when moving from portfolio 1 to portfolio 6 and the H/L portfolio. No clear pattern emerges for the standard deviation, the kurtosis (KR) and the 5% quantile[4].

In table 2 the carry trade portfolio is characterised by negative net average excess returns. Furthermore, it is interesting to note that the 5% quantile shows a decreasing trend when moving from portfolio 2 to portfolio 6.

4.2 Monetary conditions and carry trade portfolio returns

Table 3 reports annualized means, Sharpe ratios and 5% quantiles for excess returns of the carry trade portfolio across expansive and restrictive monetary periods, as measured by shifts in the Fed conventional monetary policy. Panel A provides results for gross excess returns, while panel B reports results for excess returns net of transaction costs. Figures are reported in percentage points and refer to the sample period November 1983 to December 2007.

Average excess returns seem to be related to conventional monetary policy: specifically, gross and net returns are equal respectively to 13.07% and 9.07% after expansive monetary periods, while they are equal to 6.73% and 2.63% after a restrictive policy. This is confirmed by a p-value equal to 0.04 for the coefficient of the dummy variable $Coventional_{t-1}$ in equation (2), estimated

---

[4] For portfolio 1, no 5% quantile is reported because the investor is short in these currencies.

for excess returns without and with transaction costs adjustments. Newey and West (1987) standard error is considered to perform the relevant tests.

From both panels in table 3 it also emerges that the Sharpe ratio for the H/L portfolio differs substantially across expansive and restrictive conventional monetary policy. This is formally tested using the symmetric studentized bootstrap confidence interval proposed by Ledoit and Wolf (2008). When considering gross excess returns, the p-value of the test is about 0.02 and so the null $H_0 : \Delta = 0$ is rejected at 5% significance level. When considering net excess returns, the null is also rejected since the p-value of the test is about 0.04.

Table 3 shows also that the 5% quantile for gross and net excess returns of the H/L strategy seems to be linked to conventional monetary policy. In order to find statistical support for this hypothesis, equation (3) is estimated and the coefficient covariance matrix is calculated via XY-pair bootstrap[5]. When considering excess returns without transaction costs adjustments, the coefficient relating to $Conventional_{t-1}$ is significant at 10% confidence level. However, removing rx_{t-1} from the independent variables, the same coefficient becomes significant at 5% significance level[6]. The same happens for net excess returns.

Table 4 reports annualized means, Sharpe ratios and 5% quantiles for excess returns of the carry trade portfolio across expansive and restrictive unconventional monetary policy. Panel A provides results for gross excess returns, while panel B reports results for excess returns net of transaction costs. Figures are reported in percentage points and refer to the sample period January 2008 to June 2015.

Surprisingly, from table 4 it emerges that means and Sharpe ratios for excess

---

[5] See Koenker (2005) for a discussion on covariance matrix estimation in quantile regression.

[6] The coefficient relating to rx_{t-1} is not significant in any of the considered regressions.

returns without and with transaction costs adjustments are higher after a less expansive unconventional monetary policy. However, testing these hypotheses using equation (2) and the symmetric studentized bootstrap confidence interval by Ledoit and Wolf (2008), I find that carry trade average returns and Sharpe ratios are not statistically different across monetary conditions during the recent financial crisis.

Table 4 shows also that carry trade portfolio 5% quantile could be related to unconventional monetary policy. Employing the quantile regression framework to formally test this hypothesis, it emerges that 5% quantile of the H/L strategy is not systematically linked to monetary conditions during the sample period January 2008 to June 2015.

4.3 Terminal wealth in different monetary conditions

To provide further information about the relation between carry trade average excess returns and monetary conditions, figures 1 and 2 show the monthly growth of one dollar invested in the the carry trade portfolio under different policies. The former considers conventional monetary policy and the sample period November 1983 to December 2007, while the latter considers unconventional monetary policy and refers to the recent financial crisis.

Figure 1 illustrates the striking difference in the growth of gross and net H/L portfolio value in expansive monetary conditions (black line) versus restrictive monetary conditions (red line). In particular, the black dotted line shows that compounded net excess returns for the carry trade portfolio grow substantially during expansive periods, while the red dotted line indicates nearly zero growth during restrictive periods.

Figure 2 shows how compounded gross and net excess returns of the H/L portfolio are similar across monetary conditions during the recent financial crisis. Furthermore, it confirms the poor performance of the carry trade strategy during the considered period.

5 Robustness

To shed more light on the role of monetary conditions for currency risk premia, carry trade portfolio excess returns are regressed on a constant, FX volatility risk and the dummy variable $Conventional_{t-1}$ or $Unconventional_{t-1}$.

Following Menkhoff *et al.* (2012), global FX volatility in month t is proxied as:

$$\sigma_t^{FX} = \frac{1}{T_t} \sum_{\tau \in T_t} \left[\sum_{k \in K_\tau} \frac{|r_\tau^k|}{K_\tau} \right] \tag{7}$$

where $|r_\tau^k| = |\Delta s_\tau|$ is the absolute log return for currency k on day τ, K_τ is the number of available currencies on day τ and T_t is the number of trading days in month t. Innovations in global FX volatility ($\Delta\sigma_t^{FX}$) are computed using the residuals from an estimated AR(1) model for σ_t^{FX}.

Table 5 shows that both $Conventional_{t-1}$ and $\Delta\sigma_t^{FX}$ are statistically significant variables before the onset of the recent financial crisis. The impact of expansive monetary policy on monthly excess returns without and with transaction costs adjustments is about 0.5%. The monthly effect of a positive one standard deviation shock to FX volatility risk[7] on gross and net H/L returns is -0.66%. The considered variables are statistically and economically significant also in the 5% quantile regression model.

From table 6 it emerges that FX volatility innovations have a significant impact on currency risk premia even after the outbreak of the recent financial crisis.

---

[7] The monthly standard deviation of $\Delta\sigma_t^{FX}$ is equal to 0.09%

Nevertheless, unconventional monetary policy does not seem to be related to the H/L portfolio average return and 5% quantile.

These results show that before the financial crisis Fed expansive monetary policy was able to improve expectations of market participants across countries and in this way to lower FX volatility risk. By contrast, the Federal Reserve could not affect the considered expectations during the crisis.

For investors, this evidence suggests that rewards from carry trade vary with changes in monetary conditions during "normal" times. For researchers, this evidence suggests that recognising the relevance of monetary policy is crucial to understanding the pricing implications of FX volatility risk for carry trade.

6 Conclusion

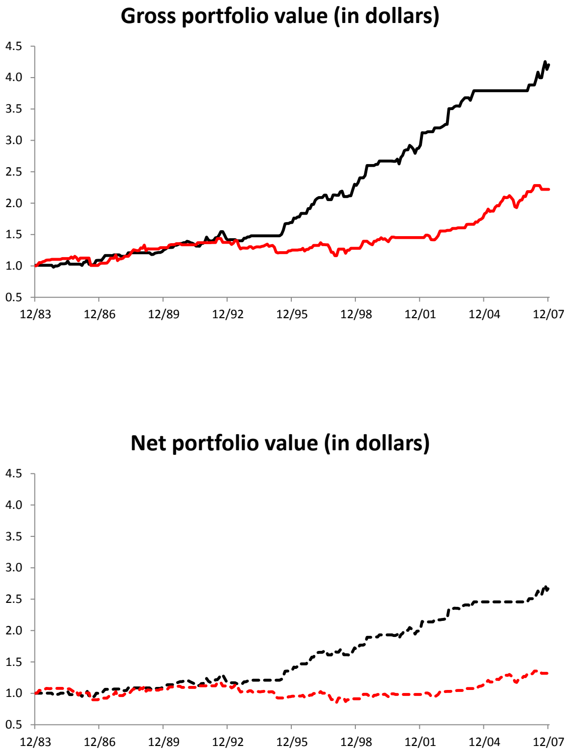
The empirical failure of uncovered interest parity is one of the enduring puzzles in international finance: many studies show the existence of the forward premium puzzle, namely, the trend for high interest rate currencies to appreciate rather than to depreciate against low interest rate currencies. This leads investors to engage in the so-called "carry trade", which is an investment strategy consisting of borrowing low-interest rate currencies and investing in currencies with high interest rates. The major avenue of research to explain this puzzle and the resulting carry trade profitability is the consideration of time-varying currency risk premia (Menkhoff *et al.* (2012)).

This paper is aimed at investigating whether the temporal variation in currency risk premia is systematically linked to changes in monetary conditions and whether currency risk premia predictability provides information that is economically valuable. To this end, an empirical analysis is carried out at the monthly frequency considering Federal Reserve monetary policy as a proxy for changes in monetary conditions and using daily spot and one month forward exchange rates per US dollar. Currencies are sorted into six portfolios according to their forward discounts and carry trade portfolio returns are measured at time t based on monetary conditions at time $t-1$: in this way, average returns, Sharpe ratios and 5% quantiles are computed across different monetary conditions.

Firstly, the analysis shows that carry trade portfolio average return, Sharpe ratio and 5% quantile differ substantially across expansive and restrictive conventional monetary policy before the onset of the recent financial crisis. In particular, I find that expansive periods are characterised by significantly higher average returns and Sharpe ratios and lower risk. Second, I find that the considered parameters are similar across aggressive and stabilising unconventional monetary policy during the recent financial crisis.

For investors, this evidence suggests that rewards from carry trade vary with changes in monetary conditions during "normal" times. For researchers, this evidence suggests that recognising the relevance of monetary policy is crucial to understanding the pricing implications of FX volatility risk for carry trade.

Figure 1: Growth of the H/L portfolio across monetary conditions (Conventional)

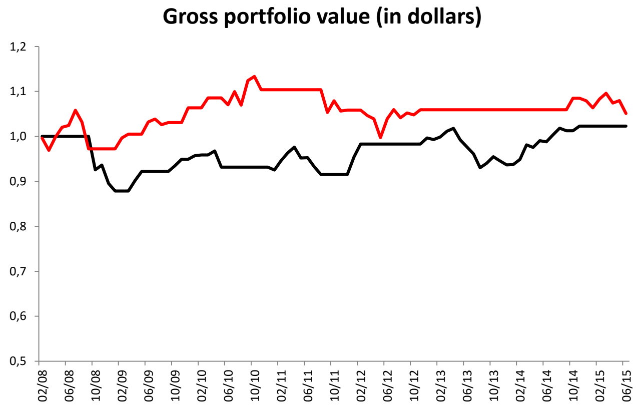


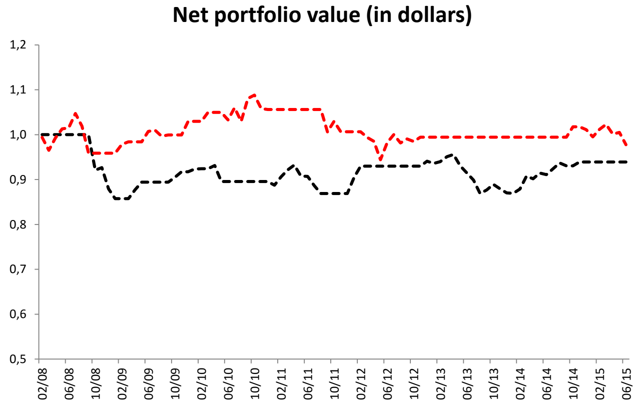
Gross portfolio value (in dollars)

Net portfolio value (in dollars)

Note: This figure shows the monthly growth of one dollar invested in the carry trade portfolio in different monetary conditions over the sample period November 1983 to December 2007. The black line shows the dollar growth for investing in the considered portfolio after expansive conventional monetary policy and not investing after restrictive states. The red line shows the dollar growth for investing in the carry trade portfolio after restrictive periods and not investing after expansive states. Solid lines refer to cost unadjusted excess returns, while dotted lines refer to net excess returns.

Figure 2: Growth of the H/L portfolio across monetary conditions (Unconventional)


Gross portfolio value (in dollars)


Net portfolio value (in dollars)

Note: This figure shows the monthly growth of one dollar invested in the carry trade portfolio in different monetary conditions over the sample period January 2008 to June 2015. The black line shows the dollar growth for investing in the considered portfolio after aggressive unconventional monetary policy and not investing after less expansive states. The red line shows the dollar growth for investing in the carry trade portfolio after stabilising periods and not investing after aggressive states. Solid lines refer to cost unadjusted excess returns, while dotted lines refer to net excess returns.

Table 1: Descriptive Statistics (pre-crisis period)

The table reports annualized mean, standard deviation, Sharpe ratio and 5% quantile for excess returns of currency portfolios sorted monthly according to their forward discounts. For portfolio 1, the table reports *minus* the actual average excess return and no 5% quantile because the investor is short in these currencies. Means, standard deviations and quantiles are reported in percentage points. Portfolio 1 contains currencies with the lowest forward discount, while portfolio 6 contains currencies with the highest forward discount. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1. Annualized means are computed multiplying monthly means by 12, while annualized standard deviations and quantiles are computed multiplying monthly standard deviations and quantiles by $\sqrt{12}$. The Sharpe ratio is the ratio of annualized mean to the annualized standard deviation. The table also reports skewness (SK) and kurtosis (KR) of currency portfolios. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is November 1983 to December 2007.

Panel A: Gross Excess Returns							
Portfolio	1	2	3	4	5	6	H/L
Mean	-2.00	0.13	1.59	4.30	3.99	7.67	9.67
St. Dev.	8.08	7.39	7.48	7.39	8.00	9.30	8.96
Sharpe Ratio	-0.25	0.02	0.21	0.58	0.50	0.82	1.08
5% Quantile	-	-11.74	-12.27	-10.19	-11.39	-13.63	-13.59
SK	0.25	0.16	0.13	0.10	-0.47	0.07	-0.64
KR	4.08	4.25	4.10	6.08	5.37	3.87	4.65
Panel B: Net Excess Returns							
Mean	-0.86	-0.85	0.34	2.97	2.44	4.76	5.62
St. Dev.	8.10	7.38	7.44	7.33	7.99	9.21	8.95
Sharpe Ratio	-0.11	-0.12	0.05	0.41	0.31	0.52	0.63
5% Quantile	-	-12.03	-12.64	-10.45	-11.87	-14.24	-14.71
SK	0.27	0.15	0.09	0.06	-0.53	-0.01	-0.68
KR	4.13	4.26	4.13	6.04	5.59	3.76	4.56

Table 2: Descriptive Statistics (crisis period)

The table reports annualized mean, standard deviation, Sharpe ratio and 5% quantile for excess returns of currency portfolios sorted monthly according to their forward discounts. For portfolio 1, the table reports *minus* the actual average excess return and no 5% quantile because the investor is short in these currencies. Means, standard deviations and quantiles are reported in percentage points. Portfolio 1 contains currencies with the lowest forward discount, while portfolio 6 contains currencies with the highest forward discount. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1. Annualized means are computed multiplying monthly means by 12, while annualized standard deviations and quantiles are computed multiplying monthly standard deviations and quantiles by $\sqrt{12}$. The Sharpe ratio is the ratio of annualized mean to the annualized standard deviation. The table also reports skewness (SK) and kurtosis (KR) of currency portfolios. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is January 2008 to June 2015.

Panel A: Gross Excess Returns							
Portfolio	1	2	3	4	5	6	H/L
Mean	-1.12	-2.12	0.27	-1.53	2.48	0.01	1.13
St. Dev.	7.07	6.21	7.17	8.72	10.05	10.98	7.97
Sharpe Ratio	-0.16	-0.34	0.04	-0.18	0.25	0.00	0.14
5% Quantile	-	-9.42	-13.84	-16.89	-18.69	-19.61	-13.47
SK	0.47	-0.44	-0.11	-0.41	-0.32	-0.91	-0.57
KR	5.70	5.53	4.00	3.36	3.73	4.95	3.43
Panel B: Net Excess Returns							
Mean	-0.20	-2.72	-0.71	-2.87	1.22	-1.21	-1.01
St. Dev.	7.10	6.22	7.17	8.69	10.05	11.01	8.02
Sharpe Ratio	-0.03	-0.44	-0.10	-0.33	0.12	-0.11	-0.13
5% Quantile	-	-9.70	-14.19	-17.18	-19.04	-19.95	-13.92
SK	0.59	-0.46	-0.13	-0.40	-0.32	-0.95	-0.62
KR	6.01	5.58	4.02	3.36	3.72	5.06	3.61

Table 3: H/L performance across monetary conditions (Conventional)
The table shows annualized mean, Sharpe ratio and 5% quantile for excess returns of the H/L portfolio across different monetary conditions. Returns are measured in month t based on changes in conventional monetary policy at time $t-1$. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1: portfolio 6 contains currencies with the highest forward discount, while portfolio 1 contains currencies with the lowest forward discount. Means and quantiles are reported in percentage points. Annualized means are computed multiplying monthly means by 12, while annualized standard deviations and quantiles are computed multiplying monthly standard deviations and quantiles by $\sqrt{12}$. The Sharpe ratio is the ratio of annualized mean to the annualized standard deviation. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is November 1983 to December 2007.

Panel A: Gross Excess Returns				
Conventional	Expansive	Restrictive	P-value	All
Mean	13.07	6.73	0.04	9.67
Sharpe Ratio	1.59	0.71	0.02	1.08
5% Quantile	-10.43	-16.27	0.09	-13.59
Panel B: Net Excess Returns				
Mean	9.07	2.63	0.04	5.62
Sharpe Ratio	1.10	0.28	0.04	0.63
5% Quantile	-11.59	-17.57	0.06	-14.71

Table 4: H/L performance across monetary conditions (Unconventional)
The table shows annualized mean, Sharpe ratio and 5% quantile for excess returns of the H/L portfolio across different monetary conditions. Returns are measured in month t based on changes in unconventional monetary policy at time $t-1$. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1: portfolio 6 contains currencies with the highest forward discount, while portfolio 1 contains currencies with the lowest forward discount. Means and quantiles are reported in percentage points. Annualized means are computed multiplying monthly means by 12, while annualized standard deviations and quantiles are computed multiplying monthly standard deviations and quantiles by $\sqrt{12}$. The Sharpe ratio is the ratio of annualized mean to the annualized standard deviation. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is January 2008 to June 2015.

Panel A: Gross Excess Returns				
Unconventional	Aggressive	Stabilising	P-value	All
Mean	0.90	1.71	0.83	1.12
Sharpe Ratio	0.12	0.20	0.91	0.14
5% Quantile	-12.54	-13.27	0.99	-13.47
Panel B: Net Excess Returns				
Mean	-1.37	-0.28	0.78	-1.01
Sharpe Ratio	-0.17	-0.03	0.84	-0.13
5% Quantile	-12.96	-13.75	0.95	-13.92

Table 5: FX volatility risk and monetary conditions significance (Conventional) The table presents the robustness check results. H/L portfolio excess returns are regressed on a constant (ω), FX volatility innovations ($\Delta\sigma_t^{FX}$) and the dummy variable $Conventional_{t-1}$. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1: portfolio 6 contains currencies with the highest forward discount, while portfolio 1 contains currencies with the lowest forward discount. P-values of coefficient estimates are reported in parentheses. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is November 1983 to December 2007.

Panel A: Gross Excess Returns		
	Mean regression	5% quantile regression
ω	0.006	-0.041
	(0.004)	(0.000)
$\beta_{Conventional_{t-1}}$	0.005	0.017
	(0.056)	(0.044)
$\beta_{\Delta\sigma_t^{FX}}$	-7.348	-12.314
	(0.000)	(0.015)
Panel B: Net Excess Returns		
	Mean regression	5% quantile regression
ω	0.002	-0.046
	(0.232)	(0.000)
$\beta_{Conventional_{t-1}}$	0.005	0.015
	(0.052)	(0.058)
$\beta_{\Delta\sigma_t^{FX}}$	-7.727	-12.702
	(0.000)	(0.008)

Table 6: FX volatility risk and monetary conditions significance (Unconventional)

The table presents the robustness check results. H/L portfolio excess returns are regressed on a constant (ω), FX volatility innovations ($\Delta\sigma_t^{FX}$) and the dummy variable $Unconventional_{t-1}$. H/L denotes the zero cost strategy that goes long in portfolio 6 and short in portfolio 1: portfolio 6 contains currencies with the highest forward discount, while portfolio 1 contains currencies with the lowest forward discount. P-values of coefficient estimates are reported in parentheses. Panel A and panel B consider excess returns in US dollars without and with transaction costs adjustments respectively. The sample period is January 2008 to June 2015.

Panel A: Gross Excess Returns		
	Mean regression	5% quantile regression
ω	0.001	-0.033
	(0.748)	(0.000)
$\beta_{Unconventional_{t-1}}$	0.0002	0.002
	(0.956)	(0.749)
$\beta_{\Delta\sigma_t^{FX}}$	-9.810	-10.294
	(0.000)	(0.000)

Panel B: Net Excess Returns		
	Mean regression	5% quantile regression
ω	-0.0008	-0.034
	(0.785)	(0.000)
$\beta_{Unconventional_{t-1}}$	0.00001	0.002
	(0.997)	(0.780)
$\beta_{\Delta\sigma_t^{FX}}$	-9.998	-10.302
	(0.000)	(0.000)

References

Ahmed S. and Valente G. (2015), “Understanding the Price of Volatility Risk in Carry Trades”, *Journal of Banking and Finance* 57, pp. 118–129.

Akram F.Q., Rime D. and Sarno L. (2008), “Arbitrage in the Foreign Exchange Market: Turning on the Microscope”, *Journal of International Economics* 76, pp. 237–253.

Brunnermeier M.K., Nagel S. and Pedersen L.H. (2009), “Carry Trades and Currency Crashes”, in D. Acemoglu, K. Rogoff and M. Woodford (eds.), “NBER Macroeconomics Annual 2008”, University of Chicago Press, pp. 313–347.

Burnside C. (2012), “Carry Trades and Risk”, in J. James, I.W. Marsh and L. Sarno (eds.), “Handbook of Exchange Rates”, Hoboken: John Wiley and Sons.

Burnside C., Eichenbaum M. and Rebelo S. (2011), “Carry Trade and Momentum in Currency Markets”, *Annual Review of Financial Economics* 3, pp. 511–536.

Christiansen C., Ranaldo A. and Soderlind P. (2011), “The Time-Varying Systematic Risk of Carry Trade Strategies”, *Journal of Financial and Quantitative Analysis* 46, pp. 1107–1125.

Della Corte P., Riddiough S.J. and Sarno L. (2016), “Currency Premia and Global Imbalances”, *Review of Financial Studies* 29, pp. 2161–2193.

Engel C. (2014), “Exchange Rates and Interest Parity”, in G. Gopinath,

E. Helpman and K. Rogoff (eds.), "Handbook of International Economics", Elsevier.

Fama E.F. (1984), "Forward and Spot Exchange rates", *Journal of Monetary Economics* 14, pp. 319–338.

Jensen G.R. and Moorman T. (2010), "Inter-temporal Variation in the Illiquidity Premium", *Journal of Financial Economics* 98, pp. 338–358.

Koenker R. (2005), *Quantile Regression*, Cambridge University Press.

Koenker R. and Bassett G. (1978), "Regression Quantiles", *Econometrica* 46, pp. 33–50.

Ledoit O. and Wolf M. (2008), "Robust Performance Hypothesis Testing with the Sharpe Ratio", *Journal of Empirical Finance* 15, pp. 850–859.

Lustig H., Roussanov N. and Verdelhan A. (2011), "Common Risk Factors in Currency Markets", *Review of Financial Studies* 24, pp. 3731–3777.

Lustig H. and Verdelhan A. (2007), "The Cross Section of Foreign Currency Risk Premia and Consumption Growth Risk", *American Economic Review* 97, pp. 89–117.

Mancini L., Ranaldo A. and Wrampelmeyer J. (2013), "Liquidity in the Foreign Exchange Market: Measurement, Commonality and Risk Premiums", *Journal of Finance* 68, pp. 1805–1841.

Menkhoff L., Sarno L., Schmeling M. and Schrimpf A. (2012), "Carry Trades and Global Foreign Exchange Volatility", *Journal of Finance* 67, pp. 681–718.

Newey W.K. and West K.D. (1987), “A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix”, *Econometrica* 55, pp. 703–708.

Acknowledgements

I would like to thank Marco Cucculelli, Simone Manganelli, Hiroyuki Nakata, Giorgio Valente, as well as seminar participants at Università Politecnica delle Marche. Responsibility for any remaining errors lies with the author alone. The views expressed in this paper are mine and do not necessarily reflect those of the European Central Bank.

Andrea Falconio

European Central Bank, Frankfurt am Main, Germany; email: andrea.falconio@ecb.int

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

ISSN 1725-2806 (pdf)
ISBN 978-92-899-2216-6 (pdf)
DOI 10.2866/069514 (pdf)
EU catalogue No QB-AR-16-085-EN-N (pdf)