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Dodging the Steamroller: Fundamentals versus the Carry Trade

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Dodging the Steamroller: Fundamentals versus the Carry Trade

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Abstract

Although, according to uncovered interest rate parity, exchange rates should move so as to prevent the carry trade being systematically profitable, there is a vast empirical literature demonstrating the opposite. High interest currencies more often tend to appreciate rather than depreciate, as noted by Fama (1983). In this paper, we treat volatility as the critical state variable and show that positive returns to the carry trade are overwhelmingly generated in the low-volatility "normal" state, whereas the high-volatility state is associated with lower returns or with losses as currencies revert to the long run level approximated by their mean real exchange rate – in other words, purchasing-power parity (PPP) tends to reassert itself, at least to some extent, during periods of turbulence. We confirm these results by comparing the returns from three possible monthly trading strategies: the carry trade, a strategy which is long the undervalued and short the overvalued currencies (the "fundamental" strategy) and a mixed strategy which involves switching from carry trade to fundamentals whenever volatility is in the top quartile. The mixed strategy generates positive returns greater than for either of the pure strategies.

JEL Classification: F3, G12, G15

Keywords: carry trade, trading strategies, currency portfolios

1 Introduction

We know from International Finance 101 that, under risk-neutrality and rational expectations, uncovered interest rate parity should apply at all times subject only to the cost of arbitrage trading. In other words, exchange rates and interest rates should move so as to prevent the carry trade being systematically profitable. However, it has long been clear to practitioners and academics alike that the reality is very different. Even in the long run, it is in fact possible to earn excess returns by borrowing in low interest rate currencies and lending in high interest rate currencies, as is demonstrated by a vast empirical literature. In other words, the appreciation of low interest rate currencies and depreciation of high interest rate currencies is insufficient to offset the interest rate differential. On the contrary, as for example Cumby and Obstfeld (1981) and the well-know paper by Fama (1984) showed, exchange rates are more often seen to move in the opposite direction from the one predicted by interest rate parity i.e. high interest currencies tend to appreciate rather than depreciate, and vice versa.

A number of possible explanations of this anomaly have been suggested in the published literature. Froot and Frankel (1989) pointed to deviations from rational expectations. Fama (1984) himself suggested that the cause may be a time-varying risk premium, setting off a hunt for plausible factors. In recent years, the search has focus on volatility, either in currency markets (e.g. Menkhoff et al (2012)) or in the broader financial environment (Christiansen et al (2011)). A closely related literature looks to crash risk Brunnermeier, Nagel et al (2008) and Peso problems (Farhi and Gabaix (2008)) for an explanation along the lines summarised by the expression "picking up pennies ahead of the steamroller"[1].

In this paper, we extend the argument in Menkhoff et al (2012), who showed that monthly carry trade returns were driven by two factors, one which was common to all currency markets (the “dollar factor”) and one which reflected currency-specific risk, as measured by innovations in the monthly volatility computed from daily data. We demonstrate, first, that volatility is more helpfully viewed as a state variable. To this extent, we follow Christiansen et al (2011), but whereas they focus on stock and bond market volatility as the relevant state variables, we find that the simple Menkhoff et al (2012) measure of currency market volatility is sufficient for the purpose at hand. Secondly, we show that positive returns to the carry trade are overwhelmingly generated in the low-volatility “normal” state, whereas the high-volatility state is associated with lower returns or with losses. Thirdly, we show that losses in the high-volatility state are explained by the tendency of currencies to revert to their long run level, as measured by their mean real exchange rate – in other words, purchasing-power parity (PPP) tends to reassert itself, at least to some extent, during periods of turbulence. Finally, we confirm these results by comparing the returns from three possible monthly trading strategies. The first, the traditional carry trade strategy, involves selling short a portfolio of the lowest interest rate currencies and using the proceeds to take a long position in the high interest rate currencies (as in Menkhoff et al (2012)). The second relies on fundamentals, selling short a portfolio of each month's most overvalued currencies (on the basis of long run purchasing power parity), and using the proceeds to take a long position in the most undervalued. The third strategy is mixed, switching between carry trade and fundamental strategies, depending on the previous month's standard deviation of

[1] It has not been possible to identify the original source of this expression which gives this paper its title.

return. Consistent with the results in the rest of the paper, we find that the mixed strategy[2] yields a higher return than either a pure carry-trade or a fundamental-based strategy. Moreover, our conclusions are robust with respect to the 2007-8 financial crisis and are supported by out-of-sample tests.

Our conclusions are also consistent with the large literature on nonlinear exchange rate models. The majority of papers published this century find that exchange rates follow a random walk in the neighbourhood of their equilibrium level (modelled in most cases by relative prices), but adjust in the direction of equilibrium more rapidly the further they are from it (see Taylor, Peel and Sarno (2001)).

In summary, this paper contributes to the literature on three well-known anomalies: the excess returns to the carry trade, the exchange rate disconnect puzzle (Meese and Rogoff (1983), Bacchetta and van Wincoop (2006)) and the slow convergence to PPP (Rogoff (1996)), showing that all three originate in the difference between the behaviour of currency markets in high- and low-volatility states.

In the next section, we provide a brief overview of the recent literature on the carry trade. We then go on in Section 2 to describe our dataset and give definitions of the key variables. Before considering the carry trade explicitly, we first revisit the well-known Fama regression (Section 3), decomposed into high- and low-volatility states, and use the results to motivate the comparison between carry trade and fundamental-based strategies in Section 4. We then go on to examine the returns to a mixed strategy in Section 5. We test the robustness of the results by extending them out of sample and then present some brief conclusions in the final two sections.

[2] or, as Nozaki (2010) calls it, the "hybrid" strategy.

2 Recent Literature

The recent research on the carry trade puzzle has been inspired in a number of respects by research in equity markets. In some cases, this has simply meant applying methodologies (e.g. portfolio-based studies). In other cases, it has involved postulating an explicit link between the two.[3]. In the attempt to resolve the carry trade paradox, many researchers have looked at the same variables believed to play an important part in equity markets, for example liquidity (Acharya and Pedersen (2005)) and liquidity spirals (Plantin and Shin (2008)), yield curve factors (Campbell and Clarida (1987), Backus, Foresi and Telmer (2001), Clarida, Davis and Pedersen (2 and market microstructure (Burnside et al (2007)).

This paper relates to a number of different branches of the published literature. Our research methodology starts by briefly revisiting the Fama (1984) equation, but mainly involves a trading strategy approach, employing a dataset of as many as 29 currencies, which allows us to examine the returns on zero-cost portfolios rather than simply on individual currencies. In this respect, our approach follows Menkhoff et al (2012), who show that, given the pattern of exchange rate volatility over time, the apparent excess return on carry trade portfolios can be regarded as the reward for bearing relatively high risk. We take their results a step further by going on to examine the role played by the key fundamental, the real exchange rate, in generating the returns. However, take the approach no further than looking at the PPP deviation i.e the gap between the real exchange rate and its sample mean value. Any serious attempt to incorprorate a real exchange rate model, as in Nozaki (2010) or Jorda and Taylor (2012), has the drawback that the research which follows inevitably

[3] Or see Koijen et al (2013) who start from a completely general multisector concept of carry as the return on any asset when its price is unchanged.

becomes a joint test of a hypothesis about the carry trade and the real exchange rate model.

Our simple approach indirectly casts light on the nature of the puzzle famously cited by Rogoff (1996) that the half-life of PPP-deviations appears to be anything from 3 to 5 years. More generally, exchange rates seem for much of the time to fluctuate completely independently of the variables which are believed to be fundamental to their determination (the exchange rate disconnect puzzle).[4] The results reported in this paper add to the growing body of evidence that, whatever may be the ultimate cause of these anomalies, exchange rate behaviour is far less perverse when volatility is high. Anomalous results may be the norm, but they are largely a low-volatility phenomenon. Clearly, this is another perspective on the nonlinear convergence literature (Peel and Venetis (2005), Taylor, Peel and Sarno (2001)), the empirical results of which are sometimes assumed to be the result of incomplete arbitrage in the goods markets (Dumas (1992)).

Insofar as the rewards for bearing excess volatility can be interpreted as a crash premium (Brunnermeier, Nagel et al (2008)), we also relate indirectly to the large literature on rare events and in particular the research which follows this line in trying to resolve the equity risk premium puzzle (e.g. Barro (2006)).[5]

[4] A number of explanations have been offered for this paradox, most recently by Bacchetta and van Wincoop (2006)

[5] Note that since we assume that our chosen volatility measure is the truth, rather than an underestimate, it follows that we have nothing to say about the Peso problem, at least in its original interpretation as an anomaly explained by the need to price events so rare they are either totally absent from the dataset or at least occur with a far lower frequency than in the true unobservable distribution. One way to address that issue is by using options, as in Burnside et al (2008). Of course, we do not rule out a Peso effect as a possible alternative or additional explanation of the carry trade return.

3 Data

Our raw dataset consists of end-month exchange rates for the 29-OECD countries over a maximum period from November 1983 to September 2011, collected in all cases from DataStream.[6].

3.1 Carry Trade Returns

In place of the interest rate differential, we compute excess returns from the carry trade using the forward premium, on the assumption that covered interest rate parity holds at all times. Our spot and 1-month forward exchange rates against the US dollar are closing mid-rates or bid and ask rates in the case of tests explicitly allowing for transaction costs. Hence, we define the (excess) return to the carry trade, rx_{t+1}^k for any currency k (other than the US dollar) as follows:

$$
\begin{aligned}
rx_{t+1}^k &= \left(i^k - i_t\right) - \left(s_{t+1}^k - s_t^k\right) \qquad (1) \\
&= \left(f_t^k - s_t^k\right) - \left(s_{t+1}^k - s_t^k\right) \\
&= f_t^k - s_{t+1}^k
\end{aligned}
$$

where i_t and i_t^j are one-month risk-free interest rates on the two currencies, and s_t^k and f_t^k are logs of the spot and forward exchange rates in terms of units of currency k per dollar. Descriptive statistics are given in Table 1. Mean returns are insignificant, but with considerable variation. Apart from the extreme case of Iceland, where returns ranged from a minimum of -2.8% to a maximum of +2%, major currencies yielded returns ranging from

[6] including the Deutschemark (DEM) until 1998, subsequently the Euro. The list of countries in the sample and data periods can be found along with descriptive statistics in Table 1.

about -1.5% to +1.5%.

Our main results are presented with and without allowance for transaction costs, which involved deducting bid-ask spreads from returns whenever a currency enters and/or exits a portfolio according to the rule followed in Menkhoff et al (2012) (see Appendix). We then proceed to rank the returns by one of the two criteria considered in the paper, and use the ranking to form five equally-weighted portfolios ordered from lowest to highest quintile.

3.2 Exchange Rate Volatility

Following Menkhoff et al (2012), we define the volatility for each month t, σ_t^{FX} in terms of the mean absolute return across all of the currencies for each of the days in the month:

$$\sigma_t^{FX} = \frac{1}{T_t} \sum_{\tau \in T_t} \left[\sum_{k \in K_\tau} \frac{|\Delta s_\tau^k|}{K_\tau} \right] \tag{2}$$

where K_τ is the number of currencies for which data are available on day τ and there are T_t days in month t. This definition is consistent with the time-aggregation results in, for example, Andersen et al (2001), but insofar as replacing the squared returns by absolute returns reduces the impact of extreme values, our definition could be regarded as more conservative in terms of the tests in this paper. In any case, σ_t^{FX} defined in this way tracks periods of tension in financial markets quite closely.[7]

As can be seen from Figure 1, the resulting volatility series peaks during the 2008 crisis, but does not otherwise track recessions very closely.[8]

[7] Note that we use a multi-currency measure of volatility, as an indicator of the state of the foreign exchange market in general, unrelated to any particular nondollar currency. In fact, in computing volatility, we included another 19 currencies (i.e. a total of 48) for which we could find exchange rates but no consumer price indexes comparable to those for the core 29 countries.

[8] Compare Figure 1 in Menkhoff et al (2012)). Although our dataset is a little different (and two years

3.3 Prices

This paper is not focussed on the determination of nominal exchange rates. In particular, we do not follow Nozaki (2010) in attempting to model long run equilibrium exchange rates explicitly. Instead, we make the simplest possible assumption that at some point market forces rectify deviations in real exchange rates, defined here for currency k as:

$$q_t^k = s_t^k + \left(p_t - p_t^k\right) \tag{3}$$

where s_t^k is the price of a dollar and $\left(p_t - p_t^k\right)$ is the log of the ratio of the US to the foreign consumer price index.[9]

4 The Fama Equation Revisited

We start by revisiting the standard test of uncovered interest rate parity test taken from the seminal paper by Fama (1984). Based on the second line of (1) above under the assumption that the excess return has an expected value of zero, the test reduces to the following OLS regression:

$$\Delta s_{t+1}^k = \alpha + \beta\left(f^k - s_t^k\right) + u_{t+1} \tag{4}$$

Fama (1984)

showed that in this equation, we are almost invariably able to reject the hypothesis that $\alpha = 0$ and $\beta = 1$, as implied by rational expectations and risk-neutrality, and instead find

longer), the patterns are very similar .

[9] The vast literature on Purchasing Power Parity includes experiments with a range of other price indices, notably indices of producer prices of one kind or another. There is no clear indication that any one index is superior, and in any case it is impossible to find comparable alternatives to consumer prices for all the countries in our dataset.

that in most cases $\beta = 0$ or even $\beta < 0$ are more plausible conclusions, implying that high (low) interest-rate currencies tend to appreciate (depreciate). In other words, currency movements on average appear to point in the opposite direction from what is predicted by the standard textbook model of international interest-rate parity with rational expectations. In the intervening years, the paradox has been confirmed, with similar results being found for a wide range of currencies and data periods. In fact, according to Burnside at al (2006) the average of the estimates of β across all published papers was -0.85.

In Panel (a) of Table 2, the same broad pattern can be seen for eight of the currencies in our dataset.[10] Point estimates of the slope coefficient are negative for six out of eight currencies, though significantly less than zero only for GBP. In most cases, the point estimates are more than two standard deviations away from +1.0. Only for Norway is there any sign of the force of interest rate parity asserting itself.

The other two panels of the table start our explanation of the apparent anomaly. We hypothesize that at any given moment the currency markets are in one of two states, depending on whether volatility is high or low in the month in question. Specifically, we classify each month, t, either as high volatility if $\sigma_{t-1}^{FX} > 0.0048$ where σ_{t-1}^{FX} is defined in (2) and 0.0048 is the 25th percentile in our dataset, or low volatility otherwise.[11]. Then rerunning the equation on the upper- and lower-three-quartile datasets separately gives dramatically

[10] To save space, we show results only for the eight currencies covered in Clarida, Davis and Pedersen (2009). For the full dataset of 29 currencies, the conclusions are broadly similar (results available from authors).

[11] Dividing the sample into top quartile and bottom three quartiles follows Clarida, Davis and Pedersen (2009). An earlier version of the paper compared top and bottom quartiles, with results that were even more striking than those reported here.

different results (see Table 3). In the low-volatility regime (Panel (c)), all the estimated slope coefficients are negative, without exception. Moreover, we can we reject the hypothesis that $\beta = +1.0$ for every currency except CAD. By contrast, in Panel (b) we see that for the high-volatility regime, the estimates are markedly higher. In fact, the unit coefficient is rejected only for NZD. It is worth noting that the divergence between the results in the two regimes is most marked for the three most heavily-traded currencies. The point estimate for the DEM is -1.5 in the low-volatility state, but nearly 4.0 in the high-volatility state, and similar figures are -0.64 compared with 0.13 for JPY and -2.58 compared with -0.06 for GBP. To reinforce this point, Table 3 shows the effect of introducing volatility dummies. In the low-volatility regime, we reject the unit slope coefficient decisively in 7 out of 8 cases, whereas we accept it in 7 out of 8 cases when volatility is high.

These results point to the conclusion that the Fama equation anomaly is for the most part a low-volatility phenomenon. The textbook relationship between interest rates and subsequent exchange rate movements is a reasonable characterization of market behaviour during the relatively short periods when the currency markets are at their most turbulent. In the longer periods of calm between these episodes, however, the carry trade generates the paradoxical excess returns observed for so long both by researchers and practitioners.

In the next section, we shall test the implications of these results for trading strategies aimed at exploiting this pattern of returns. To point the way forward, however, we show in Table 4 the relationship between the nominal exchange rate change at $t+1$ and the real exchange rate deviation, $\left(q_t^k - \overline{q}\right)$ in the previous month, by testing a simple linear adjustment model:

$$s_{t+1}^k - s_t^k = \gamma^k + \delta^k \left(q_t^k - \overline{q^k}\right) + u_{t+1}^k \qquad (5)$$

for high- and low-volatility regimes separately. The coefficient δ^k, which ought to be negative, measures any tendency for nominal exchange rates to regress linearly in the direction of the long run mean real exchange rate. The results can be compared with the large literature exploring nonlinearities in this relationship (Taylor, Peel and Sarno (2001), **?**). Table 4 illustrates clearly that adjustment to real exchange rate disequilibrium is mostly restricted to high-volatility regimes. When volatility is low, there is little or no discernible reversion to the long run real exchange rate. The point estimate of delta is only negative in half the cases and is never significantly less than zero, whereas when volatility is high, it is always negative and several times greater in absolute terms for all 8 currencies.

5 Trading Strategies: Carry Trade versus the Fundamentals

Motivated by the results in the previous section, we now proceed to consider their implications for trading strategies based respectively on the carry trade and fundamentals i.e. the real exchange rate deviation. This involves forming portfolios of each type along the lines set out below, that is to say forming portfolios at t based, for each currency, either on its prospective carry trade return or on whether it is over- or undervalued relative to its long-run level adjusted appropriately for consumer-price level movements. The portfolios are rebalanced each month.

Notice that, although analysis of portfolios is a well-established research methodology in equity markets, it is a relatively recent innovation in currencies, dating back only to the work of (Lustig and Verdelhan (2007)). The attraction of this particular approach is twofold. First, it provides a direct test of the returns to different trading strategies, and thereby gives an insight into the pricing of risk in the markets in question. Second, by aggregating and averaging out currency-specific factors, it provides a sharper test of the hypothesis in question than could be achieved by focussing on a number of currencies individually.[12]

5.1 Excess Returns to the Two Strategies

In Table 5, Panel A lists the return on each of seven portfolios, without allowing for the bid-ask spread (top half) and allowing for it in the bottom half. In the column labelled 1 (5), we give the descriptive statistics for the return on an equally-weighted portfolio of the five currencies with the lowest (highest) carry-trade returns, based on the forward premium or discount in the preceding month. The column labelled DOL_{CT} gives the return on a portfolio that is short the dollar and long all the other currencies, while HML_{CT} denotes the return to a global carry-trade strategy that involves going long portfolio 5 and short portfolio 1 (i.e. borrowing the currencies in the lowest-interest quintile and lending those in the highest quintile).

Whether we ignore transaction costs (top half of Panel A) or include them (bottom half), it can be seen that the net return is positive for all portfolios except the lowest-interest quintile, and more importantly, the mean return is monotonically increasing as we go from portfolio 1 to 5. In other words, the higher the interest rate, the greater the return, which is

[12] Of course, it can only be implemented where we have a sufficient number of different currencies,as we have here. However, that in turn means incorporating results for relatively illiquid minor currencies.

precisely the well-known carry trade anomaly familiar from the Fama equation, reappearing in portfolio returns.

Notice that, although there is no clear pattern in the standard deviations, the Sharp ratio increases as we move from portfolio 1 to 5, and it is a maximum for HML_{CT}, the "supercarry" portfolio, all of which suggests that the excess returns may simply be a reward for bearing risk in the form of exchange rate volatility, as claimed by Menkhoff et al (2012) among others.

Panel B gives equivalent statistics for portfolios ranked by the real exchange rate fundamental i.e. from the most positive real exchange rate deviation (most overvalued currencies) in portfolio 1 to the least positive or most negative (most undervalued) in portfolio 5. The results mirror those for the carry trade. In fact, before allowing for transaction costs, the return from being long the most undervalued and short the most overvalued currencies is 0.1% higher than from the global carry trade portfolio (6.58% against 6.49%), with a slightly lower standard deviation. The big difference is in the skewness, which is a lot lower for the fundamental strategy. Allowing for the bid-ask spread makes very little difference to these conclusions, as is clear from the bottom half of the table.

Note that if negative skewness reflects crash risk, as (Brunnermeier, Nagel et al (2008)) suggest, these results imply that a fundamentals-based strategy comprehensively dominates carry trading, generating the same return for no increase in standard deviation ("everyday volatility") and a substantial reduction in jump risk.

5.2 The Role of Volatility

The results in the previous section are puzzling, but we believe the explanation can be found in the relationship between returns to the two strategies and volatility. We start our investigation with the barcharts in Figure 2, which plot log excess returns against current-period (Panel A) and last-period (Panel B) volatility quartiles, before and after incorporating dealing costs. The pattern is the same in all four graphs. In each case, whether we analyse returns in terms of current or lagged standard deviation, with or without the bid-ask spread, the carry trade dominates the fundamental strategy when volatility is in the bottom three quartiles. By contrast, when volatility is in its top 25%, the carry trade return is low or negative, while the fundamental-based portfolio position yields a very substantial excess return.

The barcharts suggest a portfolio strategy based on switching between carry trades and fundamentals in order to exploit these return patterns, with volatility providing the critical signal. What we call a "mixed strategy" involves forming a portfolio at time t based on carry trade returns at $t-1$ whenever volatility is in its bottom three quartiles, and changing to one based on the size of $(q_{t-1} - \overline{q})$ whenever volatility is currently (or was in the preceding month) in the top quartile.[13] The results of implementing this mixed strategy during our sample period are given in Tables 6A and 6B for current and lagged volatility respectively. Overall, they are completely consistent with the results in earlier sections of this paper.

[13] We show results using both current and the preceding month's volatility, because our monthly volatility is computed using daily absolute returns. By day s of month, t, traders have a proportion $s/22$ of the data needed to compute the current month's volatility. Results based on the previous month's volatility are therefore conservative - perhaps too conservative - estimates of the return to this strategy.

In both Tables 6A and 6B, the portfolios are ranked as before, in the sense that #1 includes the currencies that are shorted in the mixed strategy i.e. the most overvalued currencies when volatility is high, the lowest interest rate currencies the rest of the time. Conversely, the column labelled 5 gives the returns for the long portfolios (high interest rate currencies when volatility is low, undervalued when it is high). Again, the returns are monotonically increasing, but noticeably greater than with either of the pure, unmixed strategies. In fact, even in the conservative lagged-volatility setting, the return from shorting portfolio 1 so as to go long portfolio 5 is 8.5% gross and 7.6% net of transaction costs. Moreover, although the switching strategy is associated with slightly more volatility, the increase is more than compensated by higher mean return, so that the Sharpe ratio is greater than for pure carry trade or pure fundamental trading.

6 Robustness Tests

In order to ensure that the results reported in the previous section were not simply a statistical artefact of our data period (November 1983 to September 2011), we examine the performance of the three trading strategies over a holdout period, October 2011 to March 2013 (Table 7). The problem here is that, over this post-sample period, volatility was only in the upper quartile (above 0.0048) during the final three months of 2011, so the mixed strategy involves holding the carry portfolio for 15 out of 18 months. In the event, the relatively low return on the fundamental portfolio during the three months it was chosen dragged down the net return on the mixed strategy to 9.8% , compared to 11.75% on the carry trade alone.

Table 8, which covers the period December 2007 to March 2013, may provide a better demonstration of the impact of volatility. Starting the dataset at this point, which the NBER estimated as the turning point of the cycle, means we cover the global banking crisis which culminated in the bankruptcy of Lehman Brothers in September 2008, while continuing till March 2013 allows us to go 18 months beyond our sample dataset.

The results are a spectacular vindication of the mixed strategy because although the fundamental portfolio generates only zero gross (-0.17% net) during the period, compared to 3.1% gross (2.8% net) from the carry trade, the mixed strategy still gave the best outcome, with 6.25% gross and 5.5% net. The explanation is to be found in the dark days at the end of 2008, when carry trades lost heavily as the "flight to quality" meant that investors deserted the high-interest currencies (especially GBP and NZD) in favour of the traditional funding currencies (JPY and CHF), with the result that in relative (though not absolute terms) fundamental-based portfolios yielded high returns.

As final vindication, consider the results of breaking our sample period before the 2008 financial crisis. As Table 9 shows, over this subsample, both carry trade and fundamental strategies gave negative returns of -0.5% gross (-0.8% net) and -0.4% (-0.6% net) respectively, yet the mixed strategy yielded positive returns of 5% (4.1% net), which demonstrates the power of switching based on the volatility signal.

7 Conclusions

In this paper, we have provided evidence both from time-series regressions and from detailed analysis of appropriate trading strategies that the well-known puzzle of excess returns from the carry trade is essentially a low-volatility phenomenon. When currency markets are turbulent, the carry trade is far less profitable and indeed often generates substantial losses. Instead, exchange rates are overwhelmingly driven by fundamentals. As such, our work casts light on other anomaly, the exchange rate disconnect, and in particular the slow rate of convergence to PPP. In fact, it can be seen in the context of a long-established pattern in which a number of basic parity relationships between markets fit best when the processes invoved exhibit trends, as can be seen for example in the case of the closed economy Fisher equation (Mishkin (1992)).

It is difficult to know how to interpret these results. On the one hand, we have confirmed the conclusions reached by Menkhoff et al (2012) and others, that at first blush the excess return to the carry trade appears to be a reward for bearing the risks associated with losses during brief episodes of volatility in the currency markets. On the other hand, we show that, even using the most unsophisticated methods based on a crude indicator of real exchange rate equilibrium and the simplest possible measure of monthly volatility, it is quite possible to enjoy the supposed risk premium without bearing the risk. In fact, in terms of cumulative returns, the fundamental-based strategy on its own is as successful as the pure carry trade, and the mixed strategy dominates both over the data period as a whole (Figure 3). Moreover, it seems that our results cannot be explained simply by crash risk (Brunnermeier, Nagel et al (2008)), given that, unlike carry trade returns, the returns to the fundamentalist and mixed strategies are not negatively skewed.

The empirical results given in this paper clearly relate to the literature on the nonlinear disequilibrium behaviour of exchange rates. In other work, we are exploring that relationship in more depth in order to see whether the data generating process implied by smooth-transition autoregression (STAR) models is consistent with the trading results reported here.

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8 Appendix: Transaction Costs Adjustments

Bid-ask spreads are deducted from returns whenever a currency enters and/or exits a portfolio, assuming the investor has to establish a new position in each individual currency in the first month and has to close all positions in the final month. Returns for portfolio 1 are adjusted for transaction costs in short positions whereas portfolios 2 to 5 are adjusted for transaction costs in long positions. Net excess returns are calculated by pricing end-month positions at the bid or ask if they are liquidated or at the mid-rate if they are left unchanged into the succeeding month. In summary, we evaluate net retruns as in the following table:

	Net return long position	Net
Currency enters portfolio at start of t, exits end of t	$rx^l_{t+1}= f^b_t - s^a_{t+1}$	r
Currency enters portfolio at start of t, remains past end of t	$rx^l_{t+1}= f^b_t - s_{t+1}$	r
Currency exits portfolio at end of t, but was already in portfolio in $t-1$	$rx^l_{t+1}= f_t - s^a_{t+1}$	r

where rx^l_{t+1}, rx^s_{t+1} are the net returns to long and short positions respectively, f_t, f^b_t, f^a_t are logs of midmarket, bid and ask forward exchange rates respectively, and $s_{t+1}, s^b_{t+1}, s^a_{t+1}$ are the same for spot rates.

Table 1 Carry Trade Descriptive Statistics

Annualized (%) return on borrowing U.S. dollar, lending other currencies.

	AUS	GERMANY	BELGIUM	CHILE	CANADA	CZECH	DENMARK
Mean	3.88	2.02	-7.49	2.99	1.74	4.14	5.98
S.D	12.04	11.71	9.53	13.29	7.16	13.22	11.46
Maximum	109.62	95.45	61.61	84.72	107.72	116.73	96.44
Minimum	-205.20	-131.40	-75.08	-232.21	-151.48	-146.82	-130.36
Skewness	-0.85	-0.20	-0.15	-1.82	-0.54	-0.27	-0.25
Kurtosis	5.76	3.10	2.49	9.82	8.47	3.21	3.29
Observations	321	182	25	90	321	177	169
Start Month	1985M01	1983M12	1997M01	2004M04	1985M01	1997M01	1985M01
End Month	2011M09	1999M01	1999M01	2011M09	2011M09	2011M09	2011M09
Jarque-Bera	140.63	1.29	0.37	224.33	415.82	2.50	2.32
Probability	0.00	0.52	0.83	0.00	0.00	0.29	0.31

Name	FRANCE	GREECE	HUNGARY	ICELAND	IRELAND	ITALY	JAPAN	
Mean	3.87	-0.03	5.78	0.34	1.01	3.59	1.15	
S.D	11.26	11.27	14.44	17.85	7.76	11.30	11.49	
Maximum	95.83	74.10	136.22	200.01	64.35	95.47	186.63	
Minimum	-127.69	-116.76	-230.07	-277.09	-65.28	-163.30	-128.59	
Skewness	-0.23	-0.85	-1.24	-1.30	-0.42	-0.58	0.34	
Kurtosis	3.27	4.50	7.19	8.41	3.03	4.52	4.44	
Observations	182	25	167	90	63	178	334	
Start Month	1983M12	1997M01	1997M11	2004M04	1993M11	1984M04	1983M12	2
End Month	1999M01	1999M01	2011M09	2011M09	1999M01	1999M01	2011M09	2
Jarque-Bera	2.24	5.39	164.53	134.99	1.87	27.07	35.23	
Probability	0.33	0.07	0.00	0.00	0.39	0.00	0.00	

Name	NORWAY	NZ	AUSTRIA	POLAND	PORTUGAL	SWEDEN	SWITZ
Mean	3.92	6.36	-7.48	5.36	-6.72	2.71	1.23
S.D.	10.94	12.44	9.57	15.70	9.12	11.57	12.12
Maximum	88.30	149.63	62.40	116.33	60.68	105.90	151.18
Minimum	-153.65	-160.97	-75.72	-187.55	-66.15	-186.17	-141.97
Skewness	-0.56	-0.35	-0.15	-0.95	-0.09	-0.47	0.02
Kurtosis	4.43	5.17	2.50	4.74	2.42	4.31	3.42
Observations	321	321	25	115	25	321	334
Start Month	1985M01	1985M01	1997M01	2002M03	1997M01	1985M01	1983M12
End Month	2011M09	2011M09	1999M01	2011M09	1999M01	2011M09	2011M09
Jarque-Bera	44.14	69.69	0.35	31.69	0.39	34.96	2.44
Probability	0.00	0.00	0.84	0.00	0.82	0.00	0.29

TABLE 2 The Fama Regression In High and Low Volatility Regimes Nov 1983 to Sep 2011

Columns headed "Full Sample" include all observations, $Volatility_H$ includes only those in the top quartile with respec
covers the remaining observations in the bottom three quartiles for volatility.

$$s_{t+1} - s_t = \alpha + \beta(f_t - s_t) + u_{t+1}$$

Name	Panel (a) Full Sample			Panel (b) $Volatility_H$			P
	$\hat{\alpha}$	$\hat{\beta}$	T	$\hat{\alpha}$	$\hat{\beta}$	T	$\hat{\alpha}$
AUD	0.001	-0.581	321	0.010	-0.108	78	0
	(0.003)	(0.769)		(0.009)	(1.912)		(0
CAD	0.000	-0.842	321	0.007*	-2.931	78	-0.
	(0.001)	(0.756)		(0.004)	(1.970)		(0
CHF	-0.004	-0.705	334	-0.001	2.299	85	-0.0
	(0.002)	(0.820)		(0.006)	(1.817)		(0
DEM	-0.002	0.564	182	0.002	3.989**	54	-0
	(0.003)	(0.894)		(0.006)	(1.860)		(0
GBP	0.003	-1.740**	334	0.003	-0.058	85	0
	(0.002)	(0.864)		(0.007)	(2.278)		(0
JPY	-0.005*	-0.529	334	-0.011*	0.129	85	-0
	(0.002)	(0.681)		(0.005)	(1.511)		(0
NOK	-0.003	1.002*	321	-0.002	2.447**	78	-0
	(0.002)	(0.543)		(0.005)	(1.021)		(0
NZD	0.002	-0.951*	321	0.011	-1.485	78	-0
	(0.003)	(0.496)		(0.007)	(0.942)		(0

Standard deviations are reported in the brackets, and *** 1% significant ** 5% significant * 10% significant

Table 3 The Fama Regression With High and Low Volatility Dummies Nov 1983 to Sep 2011

D^H is a dummy variable taking the value 1 when volatility is in its top quartile, zero when volatility is in the three low
given as p-values for Wald tests for each state. LM test p-values are tests for residual autocorrelation. Standard deviat
3/2/1 stars for 1%/5%/10% significance

$$s_{t+1} - s_t = \alpha + \beta_1 D^L (f_t - s_t) + \beta_3 D^H (f_t - s_t) + u_{t+1}$$

	$\hat{\alpha}$	$\widehat{\beta_1}$	$\widehat{\beta_3}$	H0: $\beta_1 = 1$	H0: $\beta_3 = 1$	R^2	LM te
AUD	0.003	-1.885**	0.334	[0.002]***	[0.482]	0.017	[0.458
	(0.003)	(0.916)	(0.947)				
CAD	-0.001	-0.403	1.710	[0.102]	[0.601]	0.006	[0.905
	(0.001)	(0.857)	(1.356)				
CHF	-0.005**	-2.775***	0.757	[0.000]***	[0.861]	0.030	[0.994
	(0.002)	(0.906)	(1.384)				
DEM	-0.003	-2.155*	1.961	[0.005]***	[0.491]	0.032	[0.699
	(0.003)	(1.113)	(1.391)				
GBP	0.003	-2.606***	0.394	[0.000]***	[0.630]	0.024	[0.315
	0.002	(0.975)	(1.255)				
JPY	-0.010***	-3.593***	-0.266	[0.000]***	[0.178]	0.061	[0.443
	(0.002)	(0.785)	(0.937)				
NOK	0.001	-1.836**	0.030	[0.000]***	[0.154]	0.018	[0.404
	(0.002)	(0.767)	(0.679)				
NZD	0.003	-1.571**	-0.294	[0.000]***	[0.024]**	0.016	[0.768
	(0.003)	(0.702)	(0.597)				

Table 4: Real Exchange Rate Process

Columns headed “Full Sample” include all observations, $Volatility_H$ includes only those in the top quartile with respec
the remaining observations in the bottom three quartiles for volatility.

$$s_{t+1} - s_t = \gamma + \delta(q_t - \bar{q}) + u_{t+1}$$

Name	Panel (a) Full Sample			Panel (b) $Volatility_H$			P
	$\hat{\gamma}$	$\hat{\delta}$	T	$\hat{\gamma}$	$\hat{\delta}$	T	$\hat{\gamma}$
AUD	-0.001	-0.011	321	0.009	-0.033	78	-0.004*
	(0.002)	(0.011)		(0.006)	(0.032)		(0.002
CAD	-0.001	-0.010	321	0.003	-0.033	78	-0.002*
	(0.001)	(0.009)		(0.003)	(0.026)		(0.001
CHF	-0.003	-0.022*	334	-0.004	-0.044*	85	-0.00
	(0.002)	(0.012)		(0.005)	(0.024)		(0.002
DEM	-0.002	-0.028**	128	0.002	-0.056*	54	-0.00
	(0.002)	(0.014)		(0.007)	(0.029)		(0.003
GBP	-0.000	-0.036***	334	0.008*	-0.116***	85	-0.00
	(0.002)	(0.015)		(0.005)	(0.000)		(0.002
JPY	-0.003*	-0.023**	334	-0.010***	-0.030	85	-0.00
	(0.002)	(0.011)		(0.004)	(0.023)		(0.002
NOK	-0.001	-0.035***	321	0.006	-0.109***	78	-0.003
	(0.002)	(0.013)		(0.005)	(0.030)		(0.002
NZD	-0.001	-0.019*	321	0.003	-0.030	78	-0.00
	(0.002)	(0.010)		(0.005)	(0.027)		(0.002

Standard deviations are reported in the brackets, and *** 1% significant ** 5% significant * 10% significant

Table 5 Carry Trade and Fundamental Portfolios: Descriptive Statistics

The table reports mean returns (annualized), standard deviations (annualized) and skewness of currency portfolios. Sh left hand panel (Panel A), the portfolios are sorted monthly on time t-1 forward discounts. Portfolio 1 contains the 20% c discounts whereas Portfolio 5 contains currencies with highest forward discounts. In the right hand side panel (Panel E time t-1 real exchange rate deviation. Portfolio 1 contains the 20% of all currencies with the most positive real excha most overvalued) whereas portfolio 5 contains currencies with the most negative real exchange rate deviation (curr returns are log excess returns in USD. DOL denotes the average return of the five currency portfolios and HML deno portfolio 5 and short in Portfolio 1. Log returns are reported both without adjustment for the bid-ask spread (without b time period is from November 1983 to September 2011.

	Panel A: The Carry Trade Strategy							Panel B: Th		
	Portfolio sorted by the size of forward discount							Portfolio sorted by the		
	Log return (without b-a)							Log		
Portfolio	1	2	3	4	5	DOL_{CT}	HML_{CT}	1	2	3
Mean(%)	-0.69	2.53	3.74	3.17	5.97	2.58	6.49	-0.41	2.18	2.31
Std. Dev.	9.62	9.98	9.48	10.56	10.01	9.09	8.41	10.25	10.02	9.98
Skewness	0.02	-0.31	-0.34	-0.99	-0.69	-0.38	-0.93	-0.74	-0.44	-0.33
SR	-0.07	0.25	0.39	0.3	0.6	0.28	0.77	-0.04	0.22	0.23

	Log return (with b-a)							Log re		
Portfolio	1	2	3	4	5	DOL_{CT}	HML_{CT}	1	2	3
Mean(%)	-0.48	2.27	3.48	2.92	5.38	2.71	5.86	-0.24	1.74	2.36
Std. Dev.	9.62	9.97	9.44	10.42	9.98	8.89	8.73	10.24	10.03	9.85
Skewness	0.03	-0.32	-0.35	-0.78	-0.68	-0.46	-0.92	-0.74	-0.44	-0.31
SR	-0.05	0.23	0.37	0.28	0.54	0.31	0.67	-0.02	0.17	0.24

Table 6A Returns to the mixed strategy (with current month volatility)

15 OECD Countries

Log return (without b-a)							
Portfolio	1	2	3	4	5	DOL_{mix}	HML_{mix}
Mean(%)	-2.78	1.88	3.94	4.44	7.36	2.97	10.14
Std. Dev.	10.37	10.12	9.71	10.3	9.39	8.95	9.03
Skewness	-0.64	-0.39	-0.45	-0.52	-0.09	-0.47	-0.19
SR	-0.27	0.19	0.41	0.43	0.78	0.33	1.12

Log return (with b-a)							
Portfolio	1	2	3	4	5	DOL_{mix}	HML_{mix}
Mean(%)	-2.45	1.48	3.61	4.16	6.5	2.66	8.95
Std. Dev.	10.33	10.12	9.6	10.04	9.51	8.84	9.19
Skewness	-0.64	-0.41	-0.42	-0.28	-0.4	-0.42	-0.32
SR	-0.24	0.15	0.38	0.41	0.68	0.3	0.97

Table 6B Returns to the mixed strategy (with previous month volatility)

15 OECD Countries

Log return (without b-a)							
Portfolio	1	2	3	4	5	$\mathrm{DOL}_{\mathrm{mix}}$	$\mathrm{HML}_{\mathrm{mix}}$
Mean(%)	-1.87	2.36	3.54	3.54	7.08	2.93	8.95
Std. Dev.	9.97	10.13	9.57	10.21	9.83	8.93	8.79
Skewness	-0.46	-0.37	-0.39	-0.72	-0.32	-0.5	-0.29
SR	-0.19	0.23	0.37	0.35	0.72	0.33	1.02

Log return (with b-a)							
Portfolio	1	2	3	4	5	$\mathrm{DOL}_{\mathrm{mix}}$	$\mathrm{HML}_{\mathrm{mix}}$
Mean(%)	-1.52	1.86	3.2	3.11	6.36	2.6	7.88
Std. Dev.	9.97	10.14	9.5	10.05	9.86	8.86	8.9
Skewness	-0.45	-0.37	-0.42	-0.56	-0.45	-0.46	-0.42
SR	-0.15	0.18	0.34	0.31	0.65	0.29	0.88

Table 7 Out-of-sample Returns: 2011M10 to 2013M3

Panel A. The Mixed Strategy with $\mathbf{volatility}_{t-1}$=0.00479

	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL}_{\mathrm{mix}}$	$\mathrm{HML}_{\mathrm{mix}}$	1	2	3	4
Mean(%)	-3.80	-3.77	1.76	7.86	6.47	1.70	10.27	-3.61	-3.99	1.40	7.
Std. Dev.	8.16	8.37	9.88	10.79	11.47	9.16	7.51	8.18	8.37	9.88	10.
Skewness	0.30	-0.91	-0.86	-0.01	-0.77	-0.68	-0.13	0.30	-0.90	-0.86	-0.
SR	-0.47	-0.45	0.18	0.73	0.56	0.19	1.37	-0.44	-0.48	0.14	0.

Panel B. The Carry trade Strategy

	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL}_{\mathrm{CT}}$	$\mathrm{HML}_{\mathrm{CT}}$	1	2	3	4
Mean(%)	-5.78	-1.92	4.01	6.63	6.29	1.85	12.07	-5.64	-2.08	3.66	6.
Std. Dev.	6.73	8.34	10.66	10.64	11.95	9.20	7.77	6.73	8.35	10.67	10.
Skewness	-0.40	-0.85	-0.55	-0.07	-0.67	-0.65	-0.26	-0.41	-0.84	-0.55	-0.
SR	-0.86	-0.23	0.38	0.62	0.53	0.20	1.55	-0.84	-0.25	0.34	0.

Panel C. The Fundamental Strategy

	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL}_{\mathrm{FM}}$	$\mathrm{HML}_{\mathrm{FM}}$	1	2	3	4
Mean(%)	1.85	-1.74	-0.49	4.55	3.46	1.53	1.61	1.88	-1.88	-0.71	4.
Std. Dev.	10.66	9.62	9.57	8.11	9.87	9.05	4.10	10.66	9.63	9.56	8.
Skewness	-0.64	-0.90	-0.48	0.13	-0.15	-0.68	-0.23	-0.64	-0.90	-0.49	0.
SR	0.17	-0.18	-0.05	0.56	0.35	0.17	0.39	0.18	-0.20	-0.07	0.5

Table 8 Returns for Subsample + Holdout Period 2007M12 to 2013M03

Panel A. The Mixed Strategy with $\mathbf{volatility}_{t-1}$=0.00458											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{mix}}$	$\mathrm{HML_{mix}}$	1	2	3	4
Mean(%)	-3.60	-3.54	3.00	2.76	2.65	0.39	6.25	-3.27	-3.95	2.36	2.
Std. Dev.	13.13	13.24	12.83	12.86	12.59	12.01	9.34	13.13	13.24	12.82	12.
Skewness	-0.91	-0.92	-0.68	-0.85	-0.53	-0.81	0.79	-0.92	-0.92	-0.68	-1.
SR	-0.27	-0.27	0.23	0.21	0.21	0.03	0.67	-0.25	-0.30	0.18	0.

Panel B. The Carry trade Strategy											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{CT}}$	$\mathrm{HML_{CT}}$	1	2	3	4
Mean(%)	-1.36	-1.48	2.01	0.60	1.74	0.30	3.10	-1.24	-1.73	1.52	0.
Std. Dev.	9.83	11.26	13.52	15.61	14.16	12.12	9.61	9.83	11.26	13.54	15.
Skewness	-0.07	-0.68	-0.52	-1.18	-1.13	-0.79	-1.03	-0.07	-0.68	-0.52	-1.
SR	-0.14	-0.13	0.15	0.04	0.12	0.02	0.32	-0.13	-0.15	0.11	0.

Panel C. The Fundamental Strategy											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{FM}}$	$\mathrm{HML_{FM}}$	1	2	3	4
Mean(%)	0.99	-4.05	-0.29	3.24	0.99	0.18	0.00	1.01	-4.27	-0.64	2.8
Std. Dev.	15.26	13.60	12.64	10.95	11.41	11.93	9.63	15.25	13.61	12.65	10.
Skewness	-0.84	-0.92	-0.58	-1.41	-0.58	-0.81	0.91	-0.84	-0.92	-0.58	-1.
SR	0.07	-0.30	-0.02	0.30	0.09	0.01	0.00	0.07	-0.31	-0.05	0.

Table 9 Subsample Returns 2007M12 to 2011M11

Panel A. The Mixed Strategy with $\mathbf{volatility_{t-1}}$=0.00458											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{mix}}$	$\mathrm{HML_{mix}}$	1	2	3	4
Mean(%)	-3.90	-3.28	2.95	2.66	1.05	-0.10	4.95	-3.55	-3.73	2.23	2.
Std. Dev.	14.76	14.84	13.69	13.59	13.15	13.06	10.13	14.75	14.84	13.69	13.
Skewness	-0.90	-0.86	-0.69	-1.26	-0.42	-0.78	0.95	-0.91	-0.86	-0.68	-1.
SR	-0.26	-0.22	0.22	0.20	0.08	-0.01	0.49	-0.24	-0.25	0.16	0.

Panel B. The Carry trade Strategy											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{CT}}$	$\mathrm{HML_{CT}}$	1	2	3	4
Mean(%)	0.41	-1.31	1.22	-1.81	-0.08	-0.32	-0.49	0.52	-1.59	0.66	-2.
Std. Dev.	10.85	12.33	14.61	17.26	15.04	13.20	10.15	10.85	12.31	14.63	17.
Skewness	-0.12	-0.62	-0.46	-1.14	-1.14	-0.75	-1.06	-0.12	-0.63	-0.47	-1.
SR	0.04	-0.11	0.08	-0.11	-0.01	-0.02	-0.05	0.05	-0.13	0.05	-0.

Panel C. The Fundamental Strategy											
	Log return (without transaction cost)							Log return (with			
Portfolio	1	2	3	4	5	$\mathrm{DOL_{FM}}$	$\mathrm{HML_{FM}}$	1	2	3	4
Mean(%)	0.65	-5.49	0.92	1.78	0.24	-0.38	-0.41	0.66	-5.71	0.58	1.
Std. Dev.	16.85	14.87	13.52	12.06	12.35	12.97	11.22	16.85	14.88	13.53	12.
Skewness	-0.79	-0.84	-0.57	-1.42	-0.54	-0.77	0.83	-0.79	-0.84	-0.57	-1.
SR	0.04	-0.37	0.07	0.15	0.02	-0.03	-0.04	0.04	-0.38	0.04	0.

Figure 1 FX Volatility

Shaded Bars are NBER recessions

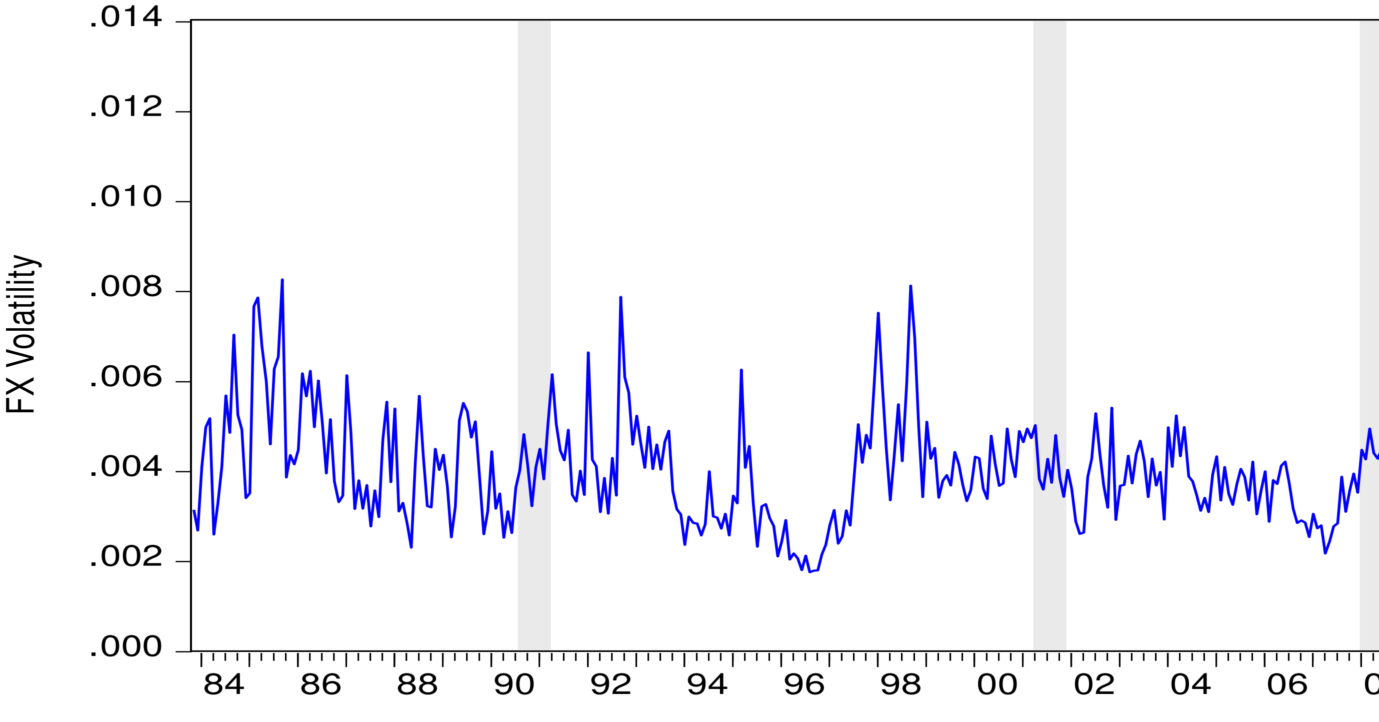
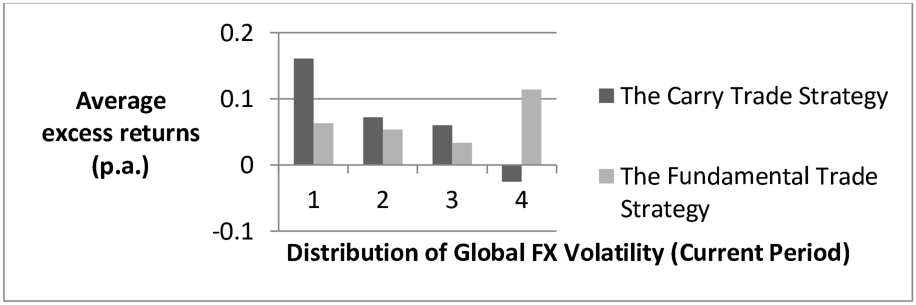


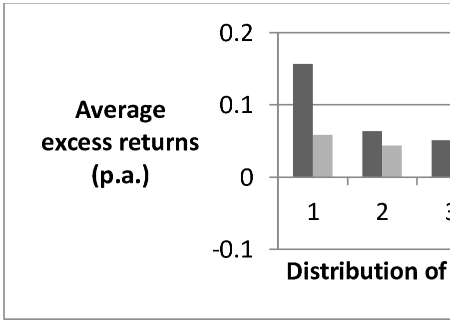
Figure 2 Excess Returns and FX Volatility

Panel A: Log excess return and volatility of current perio

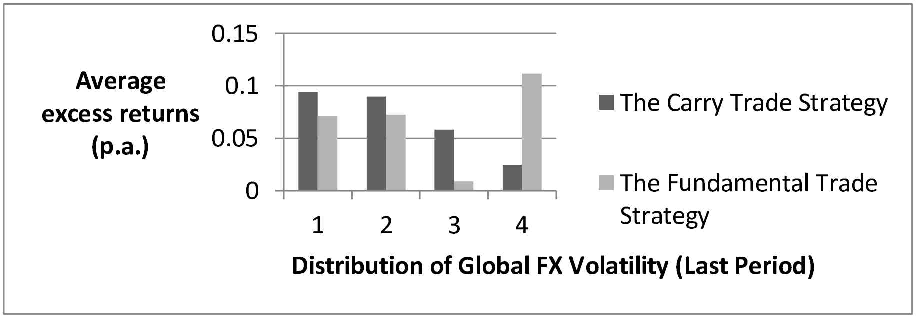
Log Excess Returns without b-a



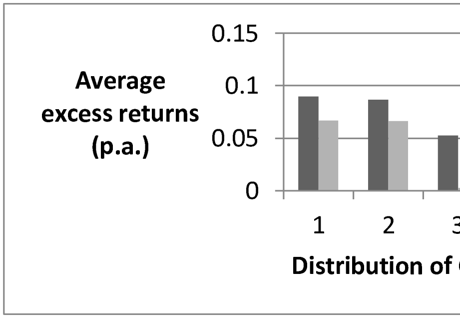
Log Excess Re



Panel B. Log excess return and volatility of last period



Log Excess Returns without b-a

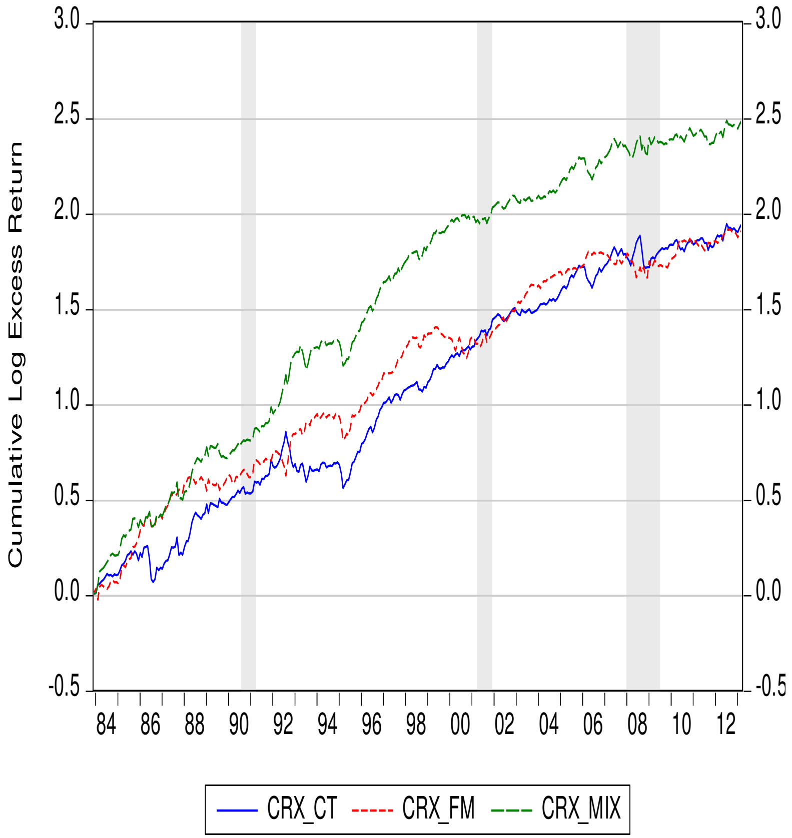


Log Excess Ret

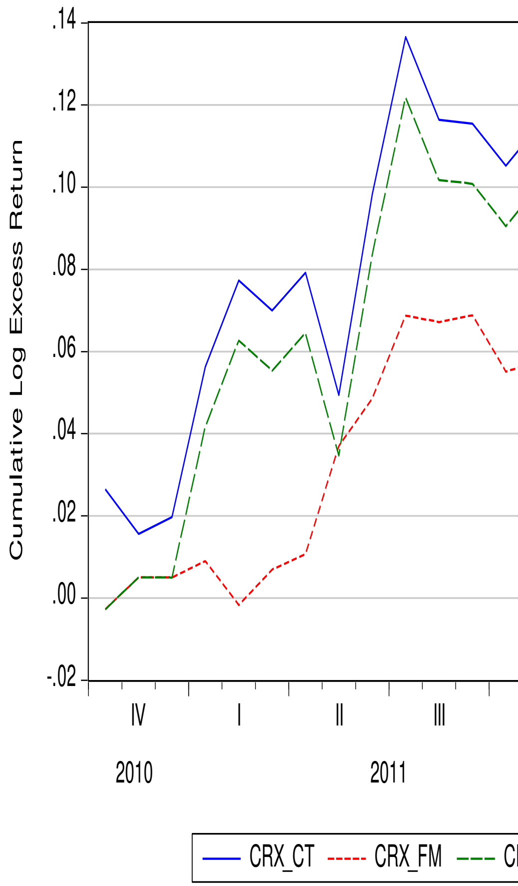
Figure 3 Cumulative Log Excess Returns for 3 Strategies

CRX_CT/FM/MIX = cumulative log excess return from carry trade/fundamental strategy/mixed st

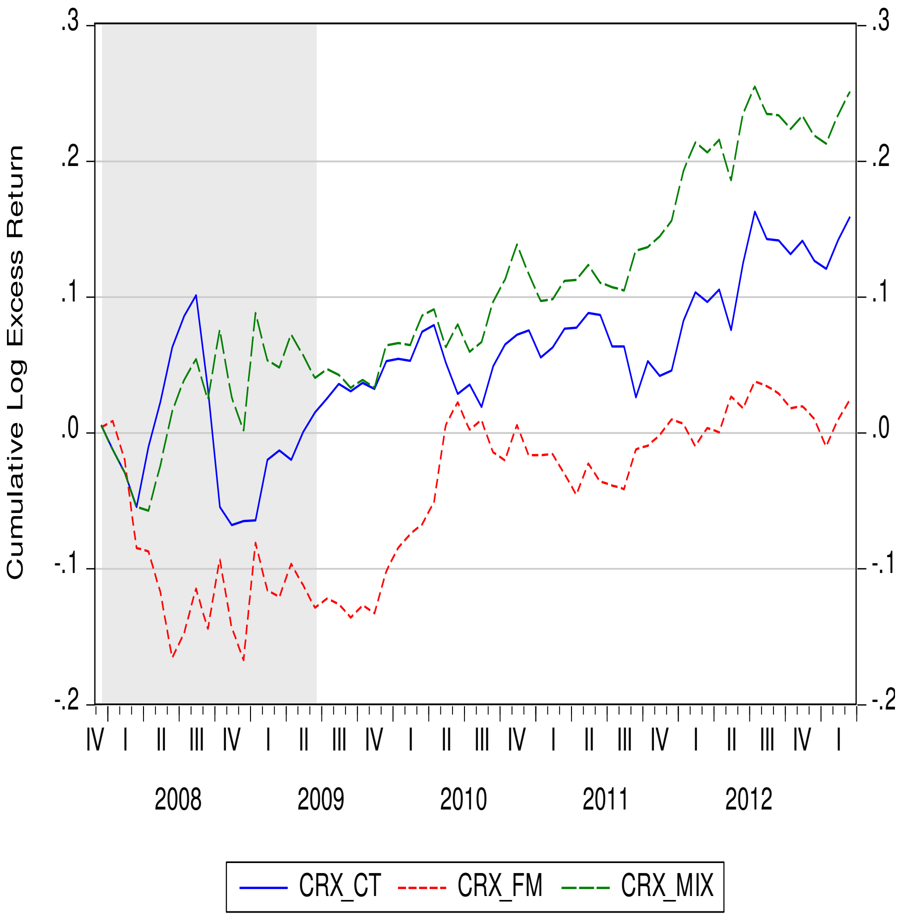
Panel a: 1983M12 to 2013M03



Panel b: 2010M10 to 2013M



Panel c: 2007M12 to 2013M03



Panel d: 2007M1