The Carry Trade in Industrialized and Emerging Markets*

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Abstract

I revisit the evidence on the profits associated with currency carry trades, explore its relationship to the uncovered interest parity (UIP) puzzle and the behavior of risk premia. I confirm earlier findings that carry trades are profitable, and that UIP fails for a group of industrialized-country currencies. Emerging market carry trades are also profitable, despite there being less "statistical" evidence against UIP. Because most emerging market currencies have persistently high interest rates, time variation in the risk premia of these currencies plays a smaller role in the average profits to emerging market carry trades. I find that those risk factors that seem able to summarize or explain the returns to carry trades in industrialized economies do not explain the returns to investing in emerging market currencies. Additionally, I find that BIS bank capital is relatively insensitive to the interest differentials that make carry trades attractive to investors.

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The profitability of currency carry trades, in and of itself, is "economic" evidence against the uncovered interest parity (UIP) condition. There is a wide variety of "statistical" evidence against UIP. Yet the relationship between these two types of evidence, and their implications for time variation in risk premia is not fully understood. Furthermore, most of the literature has focused on the currencies of industrialized economies. The failure of UIP in emerging market currencies, and its implications for the risk premia of these currencies, has received considerably less attention. In this paper I reconsider UIP, the carry trade, and the behavior of risk premia and draw comparisons between currencies in industrialized economies and those in emerging markets.

Why should policy makers care about these questions? One reason is that some economists argue that central bank policy decisions play an important role in influencing capital flows. For example, Moutot and Vitale (2009), informally, and Plantin and Shin (2011), more formally, describe scenarios in which low interest rates in the world's larger economies cause capital to flow to smaller, higher interest rate economies. This capital tends to be inflationary, and leads inflation-targeting central banks in the small economies to raise interest rates, and this sets of a destabilizing spiral of further capital flows. A key aspect of these stories is that investors are chasing higher yields in the small economies believe that the yield spread reflects a positive expected return (or positive risk premium). This, in turn, requires that UIP does not hold. So, to assess whether there is a genuine policy problem, a better understanding of UIP and its implications for carry trades is important.

To summarize my findings, I confirm results, from many previous papers, that there are widespread "economic" and "statistical failures" of UIP for industrialized country currencies. I find that these failures appear to be linked, and that both reflect important time series variation in risk premia.[1] On the other hand, for emerging market currencies I find stronger "economic" than "statistical" evidence against UIP. Additionally, because most emerging market currencies are persistently higher interest rate currencies, I find less compelling evidence that the average returns to carry trading in emerging markets are the result of time series variation in risk premia.

The UIP condition states that the interest rate differential between riskless assets denominated in two currencies is equal to the rate at which the higher interest rate currency

[1] In this paper, I use the term "risk premium" loosely. I *define* the risk premium as the conditional mean of the payoff to an investor's currency position, while ignoring possible transactions costs, and abstracting from any informational biases or frictions.

is conditionally (and unconditionally) expected to depreciate against the lower interest rate currency. UIP has been widely tested in the literature, using regressions of changes in spot rates on interest differentials, or, equivalently, forward premia. It has been widely rejected. This has led to the phrase "UIP puzzle" or "forward premium puzzle".

Several authors, e.g. Bilson (1981), Fama (1984), Bekaert and Hodrick (1992), Backus, Gregory, and Telmer (1993), and Engel (1996), have also studied the conditional expected payoff to bilateral exchange rate investments for groups of bilateral exchange rates. Here a numeraire currency is chosen and the payoffs to long positions in the other currencies, financed by borrowing in the numeraire currency, are studied. In some cases, such as the tests performed by Fama (1984), there is one to one mapping between these tests and tests of UIP. In other cases, the tests involve projecting payoffs onto a wider variety of lagged variables. But once again, generally speaking, the literature has rejected the hypothesis that foreign currency investments have conditionally mean zero payoffs.

An additional fact about currency investments is that carry trades in currencies are profitable. This has been documented, in a variety of ways, by Burnside et al. (2006), Lustig and Verdelhan (2007), Villanueva (2007), Burnside, Eichenbaum, and Rebelo (2011), Burnside et al. (2011), Lustig, Roussanov, and Verdelhan (2011), Burnside (2012), Menkhoff et al. (2012), Rafferty (2012), etc. In these carry trades, an investor specifically borrows a low interest rate currency in order to lend in a high interest rate currency. If investors were risk neutral—or even if UIP for some reason held despite risk aversion—the expected payoff on such trades would be zero, both conditionally and unconditionally, because these trades have a zero price.

In Section 1, I revisit the statistical evidence against UIP. I do this using data for 18 industrialized economy currencies for samples of varying length in the period 1976 to 2013. I also study 25 emerging market currencies. The data for most of these currencies is available over a shorter time span. The literature has frequently emphasized negative slope coefficients in regressions of exchange rate changes on forward premia as a key component of the UIP puzzle. I find this characterization to be valid for the industrialized currencies, but only for a small subset of the emerging market currencies. Additionally, I find much less statistical evidence against UIP from "UIP regressions."

In Section 2 I revisit the economic evidence provided by the profits to the carry trade. One of the advantages of economic evidence is that it can be aggregated across currencies by forming portfolios. As in previous work, I find that there are significant profits to carry trade investments formed using industrialized currencies. I also find significant profits associated with portfolios of carry trades involving emerging market currencies.

In Section 3, like Hassan and Mano (2013), I explore the links between the statistical and economic evidence against UIP and the behavior of the risk premium. I find compelling evidence that the returns to the carry trade, at least for industrialized economies, are mainly due to the way in which this trade exploits time varying currency risk premia. I come to this conclusion by comparing the returns to standard carry trades and carry trades that hold static positions in each currency. Because most emerging market currencies are persistently "high interest rate", my method is not able to conclusively discern whether time varying premia are important for emerging market currencies. In a sense, the distinction between time variation and constant idiosyncratic risk premia is not important when forming carry trade portfolios in emerging market currencies.

In Section 4 I consider risk-based explanations of the returns to the carry trade. Measures of risk that have proven useful in the study of equity returns are insufficiently correlated with the returns to the carry trade to explain the fact that carry trades are profitable. Borrowing the methodology of Lustig, Roussanov, and Verdelhan (2011), for a panel of industrialized economies I show that a pair of risk factors, DOL and HML, usefully summarize most of the cross-sectional and time series variation in the returns to investing in these currencies.[2] I show, however, that these risk factors do not summarize the behavior of emerging market currencies. In particular, I show that these factors leave much more time series variation in the emerging market currencies unexplained. Additionally I show that there is insufficient cross-sectional variation in the exposure of emerging market currencies to HML to explain the cross-sectional variation in the returns to investing in emerging market currencies.

In Section 5 I come back to the policy issue I highlighted above, and consider the role of interest rate spreads in determining capital flows. My discussion is limited to the correlation between interest rate differentials and the net positions taken by BIS reporting banks against foreign counterparties. The limited information I have from these data suggests that the quantitative association between bank capital flows and interest rate differentials is both small in the cross-section as well as in the time series dimension.

[2]These risk factors are derived directly from currency returns, so there is a sense in which they reduce the dimensionality of the puzzle that carry trades are profitable on a currency by currency basis.

1 Uncovered Interest Parity and the Risk Premium

I start with a basic definition that is used throughout this paper. Ignoring transactions costs, the payoff to borrowing one U.S. dollar (USD) at time t in order to take a long position in a foreign currency is:

$$x_{t+1}^L = (1+i_t^*)\frac{S_{t+1}}{S_t} - (1+i_t), \tag{1}$$

where i_t is the rate of interest on riskless USD-denominated securities, i_t^* is the interest rate on riskless foreign denominated securities, S_t is the spot exchange rate expressed as USD per foreign currency unit (FCU).[3] Covered interest rate parity (CIP) implies that:

$$\frac{1+i_t}{1+i_t^*} = \frac{F_t}{S_t}, \tag{2}$$

where F_t is the one period forward exchange rate expressed as USD per FCU. When CIP holds, we can equivalently rewrite equation (1) as

$$x_{t+1}^L = \left(\frac{S_{t+1}-F_t}{F_t}\right)(1+i_t), \tag{3}$$

I make frequent use of this definition throughout the paper.

If we assume that there is a stochastic discount factor (SDF), M_t, that prices foreign currency investments, then the payoff, x_t^L, must satisfy:

$$E_t\left(M_{t+1}x_{t+1}^L\right) = 0. \tag{4}$$

This follows from the fact that there is no up-front cost to the investment (it's price is zero).

I define the *risk premium* associated with the long position in foreign currency to be $p_t = E_t(x_{t+1}^L)$, which, using equation (4), we can write as

$$p_t = -\frac{\operatorname{cov}_t\left(M_{t+1}, x_{t+1}^L\right)}{E_t\left(M_{t+1}\right)}. \tag{5}$$

The variable p_t is referred to as the conditional risk premium and corresponds to the conditional expectation of the payoff.

When investors are risk neutral the SDF is constant over time ($M_t = M$ for all t), in which case $p_t = 0$ for all t. In this case equation (4) reduces to $E_t(x_{t+1}^L) = 0$, or, using equation (1):

$$\frac{E_t S_{t+1}}{S_t} = \frac{1+i_t}{1+i_t^*}. \tag{6}$$

[3] With this definition, x^L has a natural interpretation as the excess return to investing in foreign one-month treasury securities. Of course, if an investor has one dollar the first term $(1+i_t^*)\,S_{t+1}/S_t$ is the gross return to investing that dollar in foreign short-term securities. So x^L can be interpreted as an excess return over the US risk free rate.

Hence, if the foreign interest rate is higher than the US interest rate the foreign currency is expected to depreciate against the USD by the amount of the interest differential. This is the UIP condition. Equivalently, equations (2) and (3) imply that the forward rate is an unbiased predictor of the future spot rate:

$$E_t(S_{t+1}) = F_t. \tag{7}$$

Another interesting special case is when the spot exchange rate is a martingale; i.e. $E_t(S_{t+1}) = S_t$. In this case, using equation (1), we see that the risk premium is equal to the interest differential:

$$p_t = E_t(x^L_{t+1}) = i^*_t - i_t. \tag{8}$$

Equivalently, using equation (3), we see that the risk premium is proportional to the forward discount of the foreign currency:

$$p_t = E_t(x^L_{t+1}) = \left(\frac{S_t - F_t}{F_t}\right)(1 + i_t). \tag{9}$$

The UIP condition, (6), is often tested using regressions that involve logarithmic approximations:

$$\Delta \ln S_{t+1} = a + b(i_t - i^*_t) + \varepsilon_{t+1}, \tag{10}$$

or

$$\Delta \ln S_{t+1} = a + b \ln(F_t/S_t) + \varepsilon_{t+1}. \tag{11}$$

When UIP holds, up to the log approximation, $\text{plim}\, \hat{a} = 0$ and $\text{plim}\, \hat{b} = 1$.[4] If, instead, the logarithm of the spot exchange rate is a martingale $\text{plim}\, \hat{a} = \text{plim}\, \hat{b} = 0$. Rather than using this type of regression, I directly test the UIP condition by running the regression

$$x^L_{t+1} = \alpha + \beta\phi_t + \varepsilon_{t+1}, \tag{12}$$

where

$$\phi_t = \left(\frac{F_t - S_t}{F_t}\right)(1 + i_t) \tag{13}$$

is proportional to the forward premium of the foreign currency. If UIP holds $\text{plim}\, \hat{\alpha} = \text{plim}\, \hat{\beta} = 0$, because x^L is conditionally (and unconditionally) mean zero. When $E_t(S_{t+1}) =$

[4] An exact test could, instead, be based on the regression

$$\frac{S_{t+1} - S_t}{S_t} = a + b\left(\frac{i_t - i^*_t}{1 + i^*_t}\right) + \epsilon_{t+1}.$$

Under the null hypothesis that UIP holds, $\text{plim}\, \hat{a} = 0$ and $\text{plim}\, \hat{b} = 1$.

S_t, instead, we have $\text{plim}\,\hat{\alpha} = 0$ and $\text{plim}\,\hat{\beta} = -1$. Additionally, in any finite sample we have $\hat{\alpha} \approx \hat{a}$, and $\hat{\beta} \approx \hat{b} - 1$.[5]

Estimates of equation (12) are shown in Table 1, using monthly data on spot and one-month forward rates. The data are sampled on the last business day of each month. The sample size used in these regressions varies by currency, depending on available data. For euro-legacy currencies the sample usually begins in 1976 and ends in 1998 [see Table 1A]. I combine data for the Deutschmark (DEM) with data for the euro (EUR) and treat it as one currency. These data, and data for several other advanced economy currencies, run from 1976 to mid-2013, although the sample for Australia and New Zealand begins in the mid 1980s [see Table 1B]. Data for emerging market currencies is generally available over a shorter sample, mainly beginning after 1996 and ending in 2013 [see Table 1C]. For this reason, cross country comparisons of parameter estimates are non-trivial. I begin by simply reporting estimates over available samples and making broad qualitative comparisons. Figure 1 also summarizes the estimates of $\hat{\alpha}$ and $\hat{\beta}$ in a scatter plot. Estimates for a "G18" of industrialized economies appear as solid blue circles. Estimates for 26 emerging market (E26) currencies appear as open circles. When the joint null hypothesis that $\alpha = \beta = 0$ is rejected at the 5% level or less, the circle is surrounded by a red box.

The estimates for the G18 and E26 currencies appear to have somewhat different characteristics. First, most of the point estimates for the G18 lie away from the origin, with sharply negative values of $\hat{\beta}$ in 12 of the 18 cases. In contrast, most of the estimates for the E26 currencies lie below but not far from the origin. Second, out of the G18 currencies, there are ten for which the null hypothesis of UIP is rejected. Of the remaining eight countries, six are euro-legacy currencies. On the other hand, for the E26 currencies, there are only eight currencies for which the null hypothesis is rejected.

There are at least two caveats to the tempting conclusion that emerging market currencies are different. First, consider a different null hypothesis that $\alpha = 0$ and $\beta = -1$. This hypothesis is rejected for only three of the G18 currencies and seven of the E26 currencies. Thus, it is difficult to reject that exchange rates are a martingale for most of the currencies in both samples. Second, the sample periods are quite different for the two sets of countries. To address this I consider the sample period from 1997 to 2013 for both sets of currencies. For all practical purposes this eliminates the euro-legacy currencies from consideration leaving a

[5] To see this, notice that $z^L_{t+1} \approx \Delta \ln S_{t+1} - \ln(F_t/S_t)$ and $\phi_t \approx \ln(F_t/S_t)$. If these equalities were exact we would have $\hat{\alpha} = \hat{a}$ and $\hat{\beta} = \hat{b} - 1$.

G10 group. The G10 currencies are available for the full 1997–2013 sample period, while an E26 group of emerging country currencies is available for various subsets of this period. In this case I find that the null hypothesis $\alpha = 0$, $\beta = -1$ is rejected at the 5% level for eight of the G10 currencies, but only eight of the E26 currencies.

Sometimes, the fact that $\hat{\beta}$ is less than -1—or, equivalently, that $\hat{b} < 0$ when the regression is based on equation (10)—for several currencies is interpreted as evidence that high interest rate currencies tend to appreciate relative to low interest rate currencies. However, as Hassan and Mano (2013) point out, this interpretation is not directly warranted. Using equation (12) we have

$$\Delta \ln S_{t+1} - E(\Delta \ln S_{t+1}) \approx -(\beta + 1)[i_t^* - i_t - E(i_t^* - i_t)] + \varepsilon_{t+1}. \tag{14}$$

The fact that $\beta < -1$, by itself, only implies that when a country's interest differential is above its mean value it's currency will tend to appreciate more (or depreciate less) than it does on average. Indeed, if we use equation (10) to infer general tendencies we have

$$E(\Delta \ln S_{t+1}) \approx \alpha - (\beta + 1)E(i_t^* - i_t) \approx \alpha + (\beta + 1)E[\ln(F_t/S_t)]. \tag{15}$$

Clearly, $\beta < -1$ is not sufficient for currencies that are high interest rate, on average (have a negative average forward premium), to appreciate on average. This also depends on the value of α. Figure 2 shows that, in fact, currencies that, on average, have high interest rates relative to the USD also, on average, depreciate against the USD. This is true for 12 of the G18 currencies and 17 of the E26 currencies. Figure 2 also, however, shows that most currencies did not depreciate or appreciate as much, on average, as UIP would predict in our sample period. For 36 of the 37 currencies on the left side of the origin, $E(\Delta \ln S_{t+1})$ lies above the 45 degree line, while for three of the seven currencies on the right side of the origin, $E(\Delta \ln S_{t+1})$ lies below the 45 degree line.

Typically, estimates of β are unstable when they are estimated on rolling subsamples of the data. In Figure 3 I illustrate this by showing the median estimates of β obtained using five-year rolling windows. The values of median$(\hat{\beta})_{\mathrm{G18}}$ and median$(\hat{\beta})_{\mathrm{E26}}$ are plotted as time series, with the date on the horizontal axis being the end of the rolling window used in estimation. Estimates for the G18 currencies are highly volatile and, not surprisingly, persistent through time, since the windows overlap. There is much less variation in median$(\hat{\beta})_{\mathrm{E26}}$ than in median$(\hat{\beta})_{\mathrm{G18}}$. Up to 2000, they appear to covary negatively, with the sign of the correlation changing thereafter.

2 Carry Trade

2.1 Benchmark Carry Trade Strategies

As in Burnside et al. (2011), Burnside, Eichenbaum, and Rebelo (2011), and Burnside (2012) I define the payoff to a USD carry trade in currency j as:

$$x_{jt+1}^{C} = \text{sign}(i_{jt}^{*} - i_t)\left[(1 + i_{jt}^{*})\frac{S_{jt+1}}{S_{jt}} - (1 + i_t)\right] = \text{sign}(i_{jt}^{*} - i_t)x_{jt+1}^{L}. \tag{16}$$

Under CIP this is equivalent to defining

$$x_{jt+1}^{C} = \text{sign}(S_{jt} - F_{jt})x_{jt+1}^{L}. \tag{17}$$

I measure payoffs to the carry trade using equation (17), and implement the strategy currency by currency at the one month horizon. Statistics for these individual carry trades are provided in the Appendix. To summarize them, nine out of G18 currencies have statistically significant positive average returns. Six of the E26 currencies have statistically significant positive average returns.

I also consider portfolios of carry trades. In particular, I define the payoff to an equally weighted carry (EWC) portfolio of all the individual currency carry trades as

$$x_t^{\text{EWC}} = \frac{1}{N_t}\sum_{j=1}^{N_t} x_{jt+1}^{C}, \tag{18}$$

where N_t is the number of currencies available in the sample at time t.

Table 2 provides summary information about the profitability of the EWC portfolio, depending on the set of currencies it includes, and depending on the sample period. Over the full sample (1976M1-2013M6) a portfolio based only on the G18 currencies earns an annualized average excess return of 4.5% with a standard deviation of 5.2%, and a Sharpe ratio of 0.87. If all currencies are used to defined the equally-weighted portfolio the average return is slightly lower (4.4%) but the standard deviation is lower still (4.8%), so the Sharpe ratio is higher (0.92). In each case the average return and the Sharpe ratio are statistically significant at low levels of significance. It's useful to compare the performance of these portfolios to the US stock market, which earned an average return of 6.9% in this period, with a standard deviation of 15.6% and a Sharpe ratio of 0.45 (see Table 3).

It is impossible to define an emerging market portfolio over the full sample because the number of available emerging market currencies is zero until 1983 and is very small until the mid 1990s. Instead, for comparisons, I compute returns from the end of 1996 to 2013. Over this period the average returns to the G18 portfolio (3.7%) are similar to those of the E26 portfolio (3.8%), though the latter portfolio has more volatile returns, and has a smaller Sharpe ratio that is not quite significant at the 5% level. As it turns out, the portfolio that includes all currencies performs best of all. Its returns are higher (4.0%) because emerging currencies get more weight towards the end of the sample, when their performance improves. The Sharpe ratio for the combined portfolio is 0.80 and is statistically significant. Over the same period, as Table 3 indicates, the US stock market had an average excess return of 5.7%, a standard deviation of 16.6% and a Sharpe ratio of 0.34. Neither the average return nor the Sharpe ratio is statistically significant over this period.

The strong performance of the EWC portfolio over the full sample period is also illustrated in Figure 4. Here I plot the cumulative returns to reinvesting all funds in a bank account in the EWC portfolio starting with \$1 in January 1976. By the end of June 2013, a carry trade investor would have had roughly \$32 in the account. An investor in the US stock market, on the other hand, would have had roughly \$54. However, the investor in the stock market clearly faces the risk of persistently negative returns.

Figure 5 compares the cumulative performance of the different carry trade strategies over the 1996-2013 sample. Once again, we see that the carry trade offers similar cumulative returns as the stock market, without the same degree of volatility. An investor in the "All Currency" portfolio who starts with \$1 in Dec 1996, ends up with \$2.87 at the end of June 2013. An investor in the US stock market, in contrast, ends up with \$3.09. The investor in stocks, however, twice sees his cumulative returns reduced to less than those of an investor in US treasuries. There is, of course, a period from mid 1997 into early 1998 where an investor in the emerging market currencies suffers considerable losses, with the cumulative return falling to \$0.83. This reflects losses from holding long positions in Asian currencies through the currency crisis of that period.

2.2 Alternative Carry Trade Strategies

High-Minus-Low (HML) I construct one alternative strategy as follows. At each point in time, I sort the currencies in my sample into five bins according to their forward discount against the USD. The USD is also included in the sort with a forward discount of zero. The bins, labeled C1, C2, C3, C4 and C5 start from the currencies with the smallest forward discounts (lowest interest rates), and work up to the currencies with the largest forward discounts (highest interest rates). I then calculate the return to an equally weighted long position in the constituent currencies of each bin.[6] This is equivalent to calculating the average value of $(S_{t+1} - F_t)(1 + i_t)/F_t$ for the currencies within the bin. The high-minus-low (HML) carry trade portfolio that I study involves investing 1 USD in C5 and -1 USD in C1. This strategy, compared to the EWC strategy, is dollar neutral, in the sense that the USD interest rate plays no special role in determining whether each of the other currencies appears as a long or short position, or not at all. Here the investor borrows funds in a group of low interest rate currencies to fund a position in high interest rate currencies. I form two versions of the HML strategy. One includes only the G18 currencies. One includes all the currencies in my sample.

Deutsche Bank-mimicking (DBM) I construct another alternative strategy to mimic the Deutsche Bank G10 Currency Future Harvest (DBCFH) index. The DBCFH index, which dates back to 1993, currently takes positions in up to six currencies from a list of ten. It is formed by taking equally-weighted long (short) positions in the three currencies with the highest (lowest) interest rates. Its currency composition is rebalanced quarterly. To mimic this index, I form an index using the same procedure as for HML, but where the portfolio takes a long position in the top three deciles and takes a short position in the bottom three deciles in my interest rate sort. I rebalance the portfolio monthly, and refer to it as the DBM portfolio. I form two versions of the DBM strategy. One includes only the G18 currencies. One includes all the currencies in my sample.

Performance of the Alternative Strategies As Table 4 indicates, over the full sample, the HML carry trade strategy based on the G18 currencies had an average annual excess return of 6.7%, with a standard deviation of 9.3% and a Sharpe ratio of 0.72. The DBM strategy, which is a more diversified close cousin of the HML strategy had a lower average return (5.8%), but was considerable less volatile (SD= 7.5%) and so had a slightly higher Sharpe ratio (0.78). When the emerging market currencies are included in these portfolios their performance is considerably stronger with average returns rising to 9.0% and 7.1%, respectively, and Sharpe ratios in excess of 1. These results should be treated with caution because both portfolios put heavy weight on relatively high interest rate emerging market

[6] This is, essentially, the same procedure used by Lustig, Roussanov, and Verdelhan (2011) and **?**.

currencies which may or may not be sufficiently liquid to absorb large speculative positions, and which may have had capital controls in place during the period I study.

2.3 Higher Moments of Currency Returns

Brunnermeier, Nagel, and Pedersen (2008) note the saying among traders that "exchange rates go up by the stairs and down by the elevator." This refers to the skewness of payoffs to currency bets. Indeed, as can be seen in Tables 2 and 4, most of the currency portfolios formed here have negatively skewed payoffs. Additionally these payoffs display excess kurtosis, with noticeable central peakedness. However, this evidence must be put in context compared to similar statistics for stock returns. As can be seen in Table 3, US stock returns are as skewed or more skewed than currency returns. They are also considerably more volatile. The worst monthly payoffs to stocks are also considerably more negative than those for currency returns. For example, over the full 1976–2013 sample, the worst payoff to any of the currency portfolios is -11%, for the HML-G18 portfolio in October 2008. The same portfolio lost more than 5% of its value in 17 out of 449 months in the sample. In contrast, the worst month for US stocks was an excess return of -23% (October 1987), there were five months with returns less than -11%, and 43 months with returns less than -5%. Given this evidence, it is hard to argue that the observed skewness of currency returns, in and of itself, would deter investors from holding the portfolios discussed in this paper.

3 UIP, Carry Trade, and Currency Returns

As mentioned in Section 1, if the UIP condition held, the conditional expectation to a long position in foreign currency would always be zero. That is, $E_t x^L_{jt+1} = 0$ for all j, t. In Section 1 we documented the statistical failure of UIP for ten of the G18 currencies and eight of the E26 currencies based on standard "UIP (or forward premium) regressions". Additionally, we saw that the null hypothesis of a random walk was rejected for only three of the G18 currencies and eight of the E26 currencies. In a sense, Section 2 also documents the failure of UIP. Why? Recall that all the strategies discussed in Section 2 involve forming portfolios of positions in foreign currency. These portfolios are formed based on information available to the investor at time t, and their payoffs are all linear combinations, across j, of the currency-level payoffs x^L_{jt+1}. Hence, each of these portfolios as well as the individual currency carry trades should have an expected payoff of zero under UIP. What we found, however, is that for several currencies, average carry trade returns were significantly positive in our sample. Secondly, we found that several portfolios of carry trades were highly profitable in our sample. Since this should not be the case under UIP, our evidence in Section 2 constitutes a strong rejection of UIP.

In this sense, the failure of UIP and the returns to the carry trade are clearly intimately related. However, it isn't entirely clear what aspect of the failure of UIP is linked to the returns to the carry trade. Are carry trades profitable because risk premia are constant or close to constant? Or is time variation in risk premia responsible for these returns?

To shed light on these questions consider, once more, the the definition of the risk premium associated with a long position in currency j: $p_{jt} = E_t x^L_{jt+1}$. This means we can write

$$x^L_{jt+1} = p_{jt} + \epsilon_{jt+1}$$

with $E_t \epsilon_{jt+1} = 0$. Now let

$$p_{jt} = p_j + p_t + v_{jt},$$

where p_j is some constant, p_t is a time varying component with mean zero, and v_{jt} is a currency-and-time varying component with mean zero. Therefore $E(x^L_{jt+1}) = p_j$. I now try to assess to what extent the profits to the carry trade reflect constant risk premia that vary across currencies (i.e. the p_j term), common risk premia that vary over time (i.e. the p_t term), or idiosyncratically time-varying risk premia (i.e. the v_{jt} term).

To assess the nature of risk premia I consider currency strategies of the following kind. An investor takes a long position in a foreign currency if an observable variable, z_{jt}, lies in some set, otherwise he takes a short position. In particular, I consider strategies that can be defined as follows

$$x_{jt+1} = \begin{cases} x^L_{jt+1} & \text{if } z_{jt} > 0 \\ -x^L_{jt+1} & \text{if } z_{jt} \leq 0. \end{cases}$$

What is the expected payoff to this strategy? It is

$$E(x_{jt+1}) = -\Pr(z_{jt} \leq 0) E(x^L_{jt+1} | z_{jt} \leq 0) + \Pr(z_{jt} > 0) E(x^L_{jt+1} | z_{jt} > 0).$$

Because z_{jt} is in the time t information set

$$E(x_{jt+1}) = -\Pr(z_{it} \leq 0) E(p_{jt} | z_{jt} \leq 0) + \Pr(z_{jt} > 0) E(p_{jt} | z_{jt} > 0). \tag{19}$$

Because

$$E(p_{jt}) = \Pr(z_{jt} \leq 0)E(p_{jt}|z_{jt} \leq 0) + \Pr(z_{jt} > 0)E(p_{jt}|z_{jt} > 0)$$

we can solve for

$$\Pr(z_{jt} \leq 0)E(p_{jt}|z_{it} \leq 0) = E(p_{jt}) - \Pr(z_{jt} > 0)E(p_{jt}|z_{jt} > 0).$$

Using this expression in equation (19), we get

$$E(x_{jt+1}) = 2\Pr(z_{jt} > 0)E(p_{jt}|z_{jt} > 0) - E(p_{jt}). \tag{20}$$

If the risk premium is time invariant, so that $p_{jt} = p_j$ for all t then $E(p_{jt}|z_{jt} > 0) = E(p_{jt}) = p_j$. Then the expected payoff of any strategy of the type described above is

$$E(x_{jt+1}) = [2\Pr(z_{jt} > 0) - 1]\, p_j. \tag{21}$$

A Static Carry Trade Strategy Suppose $z_{jt} = z_j = E(S_{jt} - F_{jt})$, the mean of the forward discount for currency j. This means the investor goes long currency j *always* if, *on average*, it is at a forward discount. In this case, since z_{jt} is time invariant, the probability in the expression for profits is 1 if $E(S_{jt} - F_{jt}) > 0$ and 0 if $E(S_{jt} - F_{jt}) \leq 0$ and expected profits are just

$$E(x_j^{\text{STATIC}}) = \text{sign}[E(S_{jt} - F_{jt})]p_j.$$

This strategy is profitable if a country's mean forward discount, $E(S_{jt} - F_{jt})$, has the same sign as its constant risk premium p_j. In other words, if a country has a high interest rate and a positive risk premium, then the strategy is profitable.

As it turns out, for most currencies, the static carry trade is profitable as illustrated by Figure 6. The solid blue dots in the figure are G18 currencies, the open dots are E26 currencies. The average forward discount for most (37 of 44) currencies is positive, and for all but one of these currencies the average payoff to being long, i.e. the risk premium, is also positive. For the seven currencies with a negative average forward discount only three have negative risk premia.[7] Summary statistics for an equally weighted portfolio of all the static strategies are found in Table 5. Over the full sample the mean annualized payoff to the static G18 carry trade is 1.8%, with a Sharpe ratio of 0.44. For all currencies, it is 2.3%,

[7] It is important to keep in mind that we can really only execute the static carry trade ex-post using an estimates of $E(S_{jt} - F_{jt})$ for each currency. This is arguably not a problem since the exercise here is not to study the static carry trade as am investment strategy, per se. Rather, it is to use the hypothetical payoffs to static trade to help discern the nature of the risk premium.

with a Sharpe ratio of 0.52. All of these statistics are significant at the 5% level. Over the 1996–2013 sample we see some contrast between results for the G18 and E26 currencies. For the G18 currencies, the average payoff is just 1.0% in this period, while for E26 currencies it is 4.2% and statistically significant.

Standard Carry Trade Now suppose $z_{jt} = S_{jt} - F_{jt}$, the forward discount for currency j at time t. The investor goes long currency j if it is *currently* at a forward discount. This is standard carry trade described in section (2.1).

What are the expected profits associated with this strategy? Since we are currently assuming that the true risk premium is constant we simply use equation (21) which becomes

$$E(x_j^{\text{STD.}}) = [2\Pr(S_{jt} - F_{jt} > 0) - 1]\, p_j.$$

Notice that if currency j is sometimes at a forward discount and sometimes at a forward premium the probability in this expression lies strictly between 0 and 1. In this case, if $\text{sign}[E(S_{jt} - F_{jt})] = \text{sign}(p_j)$ we have

$$E(x_j^{\text{STD.}}) < E(x_j^{\text{STATIC}}).$$

In other words, if the static carry trade is profitable, and risk premia are constant, the standard carry trade should be less profitable than the static carry trade.

Looking currency-by-currency Figure 7 plots the sample mean of $x_j^{\text{STD.}}$ against the sample mean of x_j^{STATIC}. If risk premia are constant the null hypothesis is that the points in this figure should lie below the 45 degree line. As it turns out, there is a stark contrast between the results for the G18 currencies and those for the E26 currencies. For most of the G18 currencies the null hypothesis seems to be incorrect as most of the points lie above the 45 degree line. A standard carry trade strategy is more profitable than a static one. On the other hand, for the E26 currencies most of the points like below the 45 degree line or on the 45 degree line. The points on the 45 degree line correspond to currencies that were always at a forward discount in sample. Consequently, the static and standard carry trade are equivalent and our test has no power to distinguish between time varying and constant risk premia.

The overall picture left by Figure 7 is that the comparison between static and standard carry trade allows us to reject the notion that risk premia are constant for the G18 currencies, but not for the E26 currencies. Indeed, if we formally test the null hypothesis that $E(x_j^{\text{STD.}}) <$

$E(x_j^{\mathrm{STATIC}})$ for each of the G18 currencies, it is rejected at the 5% level for six of them, and at the 10% level for a further six. It is only rejected for four of the E26 currencies.

If we look at portfolio returns, the results are even sharper, as indicated by a comparison of Tables 2 and 4. Over the full sample, and over the 1996–2013 sample, there is a 2.7% gap between the returns to the standard EWC-G18 strategy, and an equally-weighted portfolio of static strategies. The difference is statistically significant at less than the 1% level over the full sample, and at the 5% level over the shorter sample. The results also suggest that the constant components of the risk premia account for no more than 40% of the overall returns to the carry trade. Over the 1996–2013 sample, in contrast, the returns to the standard EWC-E26 strategy are actually lower, though not significantly so, than those of an equally-weighted portfolio of static strategies. While our test does not rule out the possibility that currency risk premia are time varying in emerging markets, this time variation may not be that important in determining the *average* profits to carry trades in these currencies.

Returning to the UIP regressions, as specified in equation (12), notice that we can rewrite the the equation as

$$p_j + p_t + v_{jt} + \epsilon_{jt+1} = \alpha_j + \beta_j \phi_{jt} + \varepsilon_{jt+1}. \tag{22}$$

Clearly, the mean of the risk premium does not affect the slope coefficient in this regression. The slope coefficient reflects the covariance between the time varying components and the forward premium of currency j:

$$\beta_j = \frac{\mathrm{cov}(p_t, \phi_{jt}) + \mathrm{cov}(v_{jt}, \phi_{jt})}{\mathrm{var}(\phi_{jt})}. \tag{23}$$

Unfortunately, UIP regressions do not make it straightforward to determine the separate roles of p_t and v_{jt}.

If risk premia were purely constant, clearly the typical UIP regression would result in a constant $\alpha_j = p_j$ and $\beta_j = 0$. Going back to the evidence in Table 1, this is not what we find from typical UIP regressions, most especially for the G18 currencies. For 12 of these currencies we can reject $\beta_j = 0$ at less than the 5% level, and for two more we can do so at the 10% level. For the E26 currencies, β is significantly different from 0 in seven cases, and borderline so in four more. So the strongest evidence against the constant risk premium is for the G18 currencies.

4 Risk Exposure of Carry Trades

A number of explanations of the returns to the carry trade have been explored in the literature. Perhaps the most obvious explanation is that carry trades are risky, and that UIP fails in empirical tests because investors are risk averse. In this case the UIP condition, (6), does not hold, and is replaced by its risk-adjusted equivalent, equation (4).

While the literature has sought risk-based explanations for the returns to the carry trade, these have only met with a modest degree of empirical success. According to standard asset pricing theory, zero price investments, such as the carry trade, should have risk-adjusted conditional means equal to zero. That is, $E_t(M_{t+1}x_{t+1}) = 0$, where x_{t+1} is the payoff to the investment and M_{t+1} is some measure of risk. Using the law of iterated expectations it follows that

$$E(Mx) = 0. \tag{24}$$

Much of empirical finance is devoted to models in which the measure of risk, M, is specified to be linear in one or more risk factors. For example, suppose we let

$$M_t = \xi\left[1 - (f_t - \mu)' b\right], \tag{25}$$

where ξ is a scalar, f_t is a $k \times 1$ vector of risk factors, $\mu = E(f_t)$, and b is a $k \times 1$ vector of parameters. Given the normalization $\xi = 1$, equation (24) implies that

$$E(x) = \operatorname{cov}(x, f)\, b \tag{26}$$

or

$$E(z) = \underbrace{\operatorname{cov}(x, f)\, \Sigma_f^{-1}}_{\beta}\underbrace{\Sigma_f b}_{\lambda}, \tag{27}$$

where Σ_f is the covariance matrix of f_t. Equation (27) is the beta representation of the model. Equation 26 tells us that if risk explains the returns to the carry trade then there should be some risk factors, f, that are correlated with those returns. As Burnside et al. (2011), Burnside, Eichenbaum, and Rebelo (2011) and Burnside (2012) point out, however, standard measures of risk, such as stock returns, stock market volatility, consumption growth, and many more, are approximately uncorrelated with, or insufficiently correlated with, the returns to carry trade strategies such as the EWC, HML, and DBM strategies discussed above.[8]

[8]By "uncorrelated" and "insufficiently correlated" I mean the following. Given estimates of the risk

Another approach is to construct "risk factors" from currency returns themselves. For example, Lustig, Roussanov, and Verdelhan (2011) construct portfolios of currency similar to the portfolios C1, C2, C3, C4 and C5 that I constructed above. They use the payoff to an equally-weighted long position in all foreign currencies (vis-a-vis the USD), denoted DOL, and the payoffs to the HML strategy as risk factors to explain the cross-section of returns to the C1–C5 portfolios. It turns out that the five portfolios have very similar exposures to DOL, but very different different exposures to HML. This can be seen in Table 6 which shows estimates of β for the two-factor DOL-HML model. The betas with respect to DOL are all close to 1, while the betas with respect to HML rise from a low value of -0.52 for the C1 portfolio to a high value of 0.48 for the C5 portfolio. Additionally, the R^2 statistics in Table 6 indicates that DOL and HML can explain a great deal of the time variation in the returns to C1 through C5. Estimates of the SDF [equation (26)] and beta [equation (27)] representations for this model are found in Table 7. To evaluate the estimated model there are at least three standard metrics. First, the b and λ coefficients associated with the HML factor are statistically significant. Second, as indicated by the R^2-statistic the model-predicted expected returns, $\hat{\beta}\hat{\lambda}$, explain 84% of the cross-sectional variation of the average returns in the data ($\bar{z}$). Finally, because the model has less parameters than moment restrictions the J-statistic indicates that the model is marginally rejected at the 5% level. This is mainly due to the large pricing error associated with the C2 portfolio.

The DOL-HML model leaves unexplained by the HML strategy, itself, is profitable, but it suggests that we can understand most of the behavior of the five G18 portfolios through a further understanding of DOL and HML.

An obvious question, then, is whether the factors that seem to explain the returns to portfolios of developed country currencies also explain the returns to investing in emerging market currencies. With this question in mind, I first form an equally-weighted portfolio of long-positions in the E26 currencies, which I refer to as EMDOL. I also form five portfolios on the basis of each period's forward discount versus the US dollar, which I refer to as EM1, EM2, EM3, EM4 and EM5. When I regress the returns to these portfolios on the DOL and HML factors, I find that DOL is significant but the coefficients are much smaller than is typically the case for the G18 currencies (see Table 8). I find, consistent with the G18

premia (λ) associated with the risk factors, the betas (β) of the carry trade portfolios with respect to the factors are either statistical zeros or they are statistically significant but too small to explain the expected returns.

currencies, that the coefficients on HML are small for the lower interest rate portfolios and larger for the high interest rate portfolios. But I also find the R^2-statistics in these time series regressions to be much smaller than for the G18 currencies. There seems to be significant time series variation in the values of the E26 currencies that is not captured by the DOL and HML factors. I also use the estimated values of λ obtained using the G18 currencies (found in Table 7) to check whether the DOL-HML model correctly prices the five emerging market currency portfolios and EMDOL. It does not. To see this, consider Figure 8 which plots actual expected returns, $\bar{z}$ (vertical axis), against model predicted expected returns, $\hat{\beta}\hat{\lambda}$ (horizontal axis). Figure 8 illustrates two issues. First, the highest interest rate portfolio, EM5, is clearly a different animal. The average return in the data is very high compared to any of the other portfolios, but its exposure to HML is similar to that of the other portfolios. Second, because the EM portfolios all have similar exposures to HML the model explains very little of the cross-sectional variation in their returns.

One interesting possibility is that an investor might be tempted to borrow the low interest rate EM currencies in order to go long the high interest rate EM currencies. For now I will leave aside the EM5 portfolio since it frequently contains currencies with very high interest rates. Instead I consider the return to being long the EM4 portfolio and short the EM1 portfolio. This EMHML portfolio earned a 4.9% annual return in sample, with a standard deviation of 6.9%, and an annualized Sharpe ratio of 0.71. This portfolio has a DOL beta equal to 0.19 and an HML beta equal to 0.14, so from the perspective of the DOL-HML model it should only have an expected return of 1.4% per year. One reason this strategy is so profitable and has such a high Sharpe ratio is that the exchange rates in the EM1 and EM4 portfolios are highly correlated in the time series (they have a correlation of 0.71). Consequently, an investor who goes long one portfolio and short the other hedges considerable common comovement against the dollar.[9]

5 Bank Capital Flows and Interest Differentials

As I mentioned in the introduction, one view of policy making in small open economies is that the central bank's decisions play an important role in determining capital flows because of a variety of market frictions. Moutot and Vitale (2009) imagine a scenario in which investors

[9] I am grateful to my discussant, Rodrigo Valdés for suggesting that I examine a "within EM" trading strategy like this one.

in a large economy with low interest rates are attracted to a higher prevailing interest rate in a small open economy. This leads to a sort of feedback loop in which the resulting capital flows gradually appreciate the exchange rate, create inflationary pressure, thus causing the central bank in the recipient country to raise rates, thus causing more inflows, etc. Plantin and Shin (2011) provide a more formal model that captures the same idea. In their model, sluggish exchange rate dynamics resulting from infrequent portfolio rebalancing, combined with an inflation targeting central bank, lead to similar feedback loop. The model predicts that bubbly equilibria can emerge in which the exchange rate appreciates for a while and then reverts sharply towards its fundamental value. The policy angle provided by their analysis is that the stronger the central bank's response to inflationary pressure, the more likely are realized paths with occasional sharp depreciations of the recipient economy's currency.

To briefly evaluate these ideas, I consider the correlation between interest rate differentials and the net positions taken by BIS reporting banks against foreign counterparties. For each country in my sample, I measure these net positions on a quarterly basis and express their annual averages as a proportion of GDP. I examine data from 1990 to 2012, although the sample depends on the availability of forward discounts for the recipient countries. Similarly, I measure the average forward discount (or interest differential) of each of the countries in my sample. I then regress the BIS bank net positions on the forward discounts to obtain some notion as to the sensitivity of capital flows to the spreads. When I include no other regressors, the results suggest that when the interest rate spread rises by 1 percentage point, the position of BIS banks rises by 0.79 percent of GDP against the recipient country. This strikes me as a relatively small value. When I include country fixed effects in the analysis the estimate shrinks to 0.26 percent of GDP. When I also include time dummies in the analysis the estimate shrinks to 0.08 percent of GDP and is statistically insignificant.

I do not think these results are conclusive, but they at least cast doubt on the hypothesis that widening interest rate spreads attract massive capital inflows. It could, for example, be the case that the BIS data do not reflect the type of "hot money" capital inflows that are most relevant to the policy question. Additionally, in my sample period there were significant changes in international financial markets. Capital flows to emerging markets have increased significantly in the past decade and the relevance of carry trade to these markets has probably increased with them.

6 Conclusion

In this paper, I revisited the evidence regarding the UIP puzzle and carry trade profitability, with an emphasis on a comparison between a group of industrialized-country and emerging market currencies. I found that there is less regression-based evidence against UIP in emerging markets but carry trades in these currencies are nonetheless profitable.

The returns to investing in industrialized economies' currencies are well summarized in the cross-section and time dimension by two risk factors, DOL and HML. However, these risk factors are much less successful in explaining the returns to emerging market currencies both in the time dimension and cross-section. Additional factors seem to be at work.

Interest rate spreads attract carry trade investors. Policy makers are often concerned that the resulting capital flows could be destabilizing. I briefly consider how sensitive capital flows are to interest rate differentials by looking at their association with the net investment positions of BIS banks. Although I find a statistically significant association the effect is quantitatively small.

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TABLE 1

Uncovered Interest Parity Regressions

A) Euro-Legacy Currencies

	$\alpha \times 100$	β	R^2	$(\beta = 0)$	$(\beta = -1)$	(UIP)	(RW)
ATS	0.318	-2.02	0.028	0.015	0.217	0.036	0.228
	(0.211)	(0.83)					
BEF	0.062	-1.46	0.014	0.034	0.502	0.065	0.696
	(0.213)	(0.69)					
FRF	0.012	-0.76	0.006	0.333	0.757	0.490	0.944
	(0.231)	(0.78)					
IEP	0.034	-0.49	0.003	0.617	0.604	0.733	0.837
	(0.279)	(0.98)					
ITL	-0.116	-0.76	0.012	0.083	0.591	0.099	0.415
	(0.276)	(0.44)					
NLG	0.339	-2.55	0.044	0.001	0.044	0.004	0.090
	(0.215)	(0.77)					
PTE	-0.153	-0.47	0.021	0.099	0.065	0.143	0.003
	(0.286)	(0.29)					
ESP	0.238	-0.13	0.001	0.787	0.076	0.266	0.133
	(0.300)	(0.49)					

TABLE 1

Uncovered Interest Parity Regressions

B) Other Industrialized Economies

	$\alpha \times 100$	β	R^2	$(\beta = 0)$	$(\beta = -1)$	(UIP)	(RW)
AUD	-0.161	-1.94	0.018	0.005	0.169	0.004	0.362
	(0.252)	(0.69)					
CAD	-0.048	-1.77	0.018	0.003	0.202	0.003	0.398
	(0.111)	(0.60)					
DKK	-0.030	-1.72	0.031	0.000	0.120	0.001	0.283
	(0.158)	(0.46)					
EUR/DEM	0.174	-1.98	0.014	0.016	0.231	0.053	0.407
	(0.191)	(0.82)					
JPY	0.696	-2.76	0.035	0.000	0.018	0.001	0.010
	(0.230)	(0.74)					
NOK	-0.052	-1.42	0.019	0.023	0.502	0.037	0.795
	(0.173)	(0.62)					
NZD	-0.170	-2.04	0.046	0.000	0.046	0.000	0.104
	(0.244)	(0.52)					
SEK	0.103	-0.07	0.000	0.913	0.137	0.749	0.330
	(0.168)	(0.63)					
CHF	0.593	-2.25	0.030	0.003	0.100	0.010	0.039
	(0.233)	(0.76)					
GBP	-0.269	-2.57	0.036	0.000	0.033	0.002	0.088
	(0.165)	(0.74)					

TABLE 1

Uncovered Interest Parity Regressions

C) Emerging Market Currencies

	$\alpha \times 100$	β	R^2	$(\beta = 0)$	$(\beta = -1)$	(UIP)	(RW)
ARS	-0.295	-0.91	0.626	0.000	0.342	0.000	0.013
	(0.173)	(0.10)					
BRL	-0.239	-1.84	0.030	0.038	0.343	0.001	0.333
	(0.811)	(0.88)					
CLP	0.166	-0.27	0.001	0.635	0.190	0.542	0.418
	(0.289)	(0.56)					
COP	0.373	0.01	0.000	0.988	0.007	0.334	0.020
	(0.323)	(0.37)					
HRK	-0.085	-2.14	0.031	0.033	0.257	0.077	0.507
	(0.331)	(1.00)					
CZK	0.300	-0.42	0.002	0.464	0.316	0.321	0.396
	(0.268)	(0.58)					
EGP	0.108	-0.77	0.329	0.000	0.014	0.000	0.048
	(0.100)	(0.09)					
HUF	-0.180	-1.34	0.008	0.113	0.685	0.009	0.905
	(0.637)	(0.85)					
ISK	-0.148	-0.58	0.001	0.822	0.870	0.925	0.696
	(1.336)	(2.57)					
IDR	-1.092	-2.06	0.053	0.096	0.392	0.225	0.211
	(0.678)	(1.24)					
INR	-0.165	-0.80	0.014	0.104	0.680	0.239	0.263
	(0.200)	(0.49)					
ILS	0.196	-0.33	0.001	0.756	0.523	0.441	0.746
	(0.266)	(1.05)					
KRW	0.338	0.59	0.012	0.351	0.012	0.374	0.029
	(0.293)	(0.63)					

TABLE 1

Uncovered Interest Parity Regressions

C) Emerging Market Currencies

	$\alpha \times 100$	β	R^2	$\beta = 0$	$(\beta = -1)$	(UIP)	(RW)
MXN	-0.156	-0.83	0.038	0.011	0.589	0.003	0.318
	(0.312)	(0.32)					
MAD	0.325	-0.01	0.000	0.994	0.265	0.378	0.428
	(0.278)	(0.89)					
MYR	-0.217	-0.69	0.012	0.437	0.729	0.285	0.420
	(0.167)	(0.89)					
MYR	0.234	-0.43	0.001	0.712	0.626	0.421	0.429
	(0.189)	(1.17)					
PHP	0.449	0.71	0.008	0.512	0.114	0.255	0.260
	(0.361)	(1.08)					
PLN	0.416	-0.18	0.001	0.621	0.029	0.039	0.030
	(0.424)	(0.37)					
RON	-0.103	-1.29	0.017	0.268	0.801	0.236	0.966
	(0.630)	(1.17)					
RUB	0.598	0.64	0.029	0.266	0.004	0.132	0.013
	(0.298)	(0.58)					
SGD	0.215	-1.41	0.013	0.070	0.600	0.192	0.141
	(0.139)	(0.78)					
THB	0.142	-0.16	0.001	0.806	0.201	0.653	0.286
	(0.159)	(0.66)					
TRY	-1.161	-2.03	0.115	0.001	0.100	0.000	0.237
	(0.711)	(0.63)					
TWD	-0.070	-0.48	0.007	0.200	0.159	0.184	0.368
	(0.128)	(0.37)					
ZAR	-0.104	-0.41	0.014	0.000	0.000	0.000	0.000
	(0.244)	(0.06)					

TABLE 2

Excess Returns to Equally-Weighted Carry Trade Portfolios

1976M1–2013M6	Mean	SD	SR	Skew	Kurt
G18 currencies	0.045	0.052	0.87	-0.55	3.84
	(0.009)	(0.004)	(0.19)	(0.35)	(1.37)
All currencies	0.044	0.048	0.92	-0.65	4.16
	(0.009)	(0.004)	(0.21)	(0.33)	(1.13)
1996M12–2013M6	**Mean**	**SD**	**SR**	**Skew**	**Kurt**
G18 currencies	0.037	0.054	0.68	-0.22	0.88
	(0.013)	(0.004)	(0.26)	(0.19)	(0.35)
E26 currencies	0.038	0.067	0.57	-0.34	3.26
	(0.018)	(0.008)	(0.31)	(0.34)	(1.07)
All currencies	0.040	0.050	0.80	-0.62	2.28
	(0.013)	(0.005)	(0.31)	(0.27)	(0.78)

TABLE 3

Excess Returns of the Value-Weighted U.S. Stock Market

	Mean	SD	SR	Skew	Kurt
1976M1–2013M6	0.069	0.155	0.45	-0.73	2.28
	(0.026)	(0.009)	(0.18)	(0.27)	(1.16)
1996M12–2013M6	0.056	0.165	0.34	-0.65	0.76
	(0.045)	(0.013)	(0.29)	(0.20)	(0.58)

TABLE 4

Excess Returns to Alternative Carry Trade Portfolios, 1976M1–2013M6

HML Carry	Mean	SD	SR	Skew	Kurt
G18 currencies	0.067	0.093	0.72	-0.31	2.63
	(0.016)	(0.006)	(0.19)	(0.31)	(0.92)
All currencies	0.090	0.083	1.08	-0.38	1.32
	(0.014)	(0.004)	(0.19)	(0.17)	(0.38)
DBM Carry	Mean	SD	SR	Skew	Kurt
G18 currencies	0.058	0.075	0.78	-0.54	2.51
	(0.013)	(0.005)	(0.20)	(0.27)	(0.75)
All currencies	0.071	0.067	1.06	-0.37	1.99
	(0.011)	(0.005)	(0.20)	(0.20)	(0.51)

TABLE 5

Excess Returns to Static Carry Trade Portfolios

1976M1–2013M6	Mean	SD	SR	Skew	Kurt
G18 currencies	0.018	0.041	0.44	-0.61	4.62
	(0.008)	(0.003)	(0.21)	(0.53)	(2.57)
All currencies	0.023	0.045	0.52	-0.75	4.76
	(0.009)	(0.004)	(0.21)	(0.47)	(1.84)
1996M12–2013M6	**Mean**	**SD**	**SR**	**Skew**	**Kurt**
G18 currencies	0.010	0.028	0.35	-0.30	0.79
	(0.007)	(0.002)	(0.24)	(0.29)	(0.88)
E26 currencies	0.042	0.070	0.59	-0.63	2.68
	(0.019)	(0.008)	(0.31)	(0.30)	(0.80)
All currencies	0.032	0.044	0.73	-0.98	3.53
	(0.012)	(0.005)	(0.33)	(0.40)	(1.32)

TABLE 6

Factor Betas of the Sorted G18 Currency Portfolios

Portfolio	Mean Return	DOL	HML	R^2
C1	-0.9%	0.98*	-0.52*	0.94
	(1.8)	(0.02)	(0.02)	
C2	-0.9%	0.86*	-0.09*	0.79
	(1.6)	(0.03)	(0.03)	
C3	2.1%	0.90*	0.03	0.87
	(1.7)	(0.02)	(0.02)	
C4	3.1%	0.94*	0.08*	0.86
	(1.6)	(0.02)	(0.02)	
C5	5.8%	0.98*	0.48*	0.94
	(2.0)	(0.02)	(0.02)	

February 1976 to June 2013. The table reports estimates of the equation $z_t = a + f_t'\beta + \epsilon_{t+1}$, where z_t is the monthly excess return of each of the portfolios indicated and f_t is a 2×1 vector of the indicated risk factors. The DOL factor is the average excess return to an equally weighted portfolio of long positions in all the available G18 currencies. The HML carry portfolio is the excess return to being long portfolio C5 and short portfolio C1. Heteroskedasticity consistent standard errors are in parentheses. Slope coefficients that are statistically significant at the 5 percent level are indicated by an asterisk (*).

TABLE 7

GMM Estimates of Linear Factor Models for the Sorted G18 Currency Portfolios

	b	λ	R^2	J	Pricing Errors (α)				
		(%)			C1	C2	C3	C4	C5
DOL	1.77	0.17	0.84	7.97	0.8%	-2.0*	0.1	0.6	0.4
	(1.95)	(0.13)		(0.047)	(0.4)	(0.7)	(0.6)	(0.6)	(0.5)
HML	8.10*	0.59*							
	(2.06)	(0.13)							

February 1976 to June 2013. Test assets are the sorted currency portfolios C1–C5. The DOL factor is the average excess return to an equally weighted portfolio of long positions in all the available G18 currencies. The HML carry portfolio is the excess return to being long portfolio C5 and short portfolio C1. The table reports first stage GMM estimates of the SDF parameter, b, and the factor risk premia, λ, reported in monthly percent. The R^2 is a measure of fit between the mean excess returns and the predicted mean returns. Test statistics, J, for the overidentifying restrictions are also reported. The annualized pricing errors of the S1–S5 portfolios (α) are reported (in percent). Heteroskedasticity consistent standard errors are in parentheses, except for the J statistics, for which the p-value is in parentheses. An asterisk (*) indicates statistical significance at the 5 percent level.

TABLE 8

Factor Betas of Emerging Market Currency Portfolios

Portfolio	Mean Return	DOL	HML	R^2
EMDOL	3.8%	0.63*	0.13*	0.58
	(2.2)	(0.05)	(0.04)	
EM1	-0.9%	0.50*	0.03	0.60
	(1.5)	(0.04)	(0.03)	
EM2	1.5%	0.56*	0.07	0.41
	(2.2)	(0.05)	(0.04)	
EM3	-0.3%	0.71*	0.12*	0.43
	(2.6)	(0.06)	(0.05)	
EM4	4.0%	0.69*	0.17*	0.49
	(2.5)	(0.07)	(0.04)	
EM5	14.4%	0.53*	0.25*	0.25
	(3.2)	(0.09)	(0.09)	

January 1997 to June 2013. The table reports estimates of the equation $z_t = a + f_t'\beta + \epsilon_{t+1}$, where z_t is the monthly excess return of each of the portfolios indicated and f_t is a 2×1 vector of the indicated risk factors. The DOL factor is the average excess return to an equally weighted portfolio of long positions in all the available G18 currencies. The HML carry portfolio is the excess return to being long portfolio C5 and short portfolio C1. Heteroskedasticity consistent standard errors are in parentheses. Slope coefficients that are statistically significant at the 5 percent level are indicated by an asterisk (*).

FIGURE 1

Regression Tests of Uncovered Interest Parity

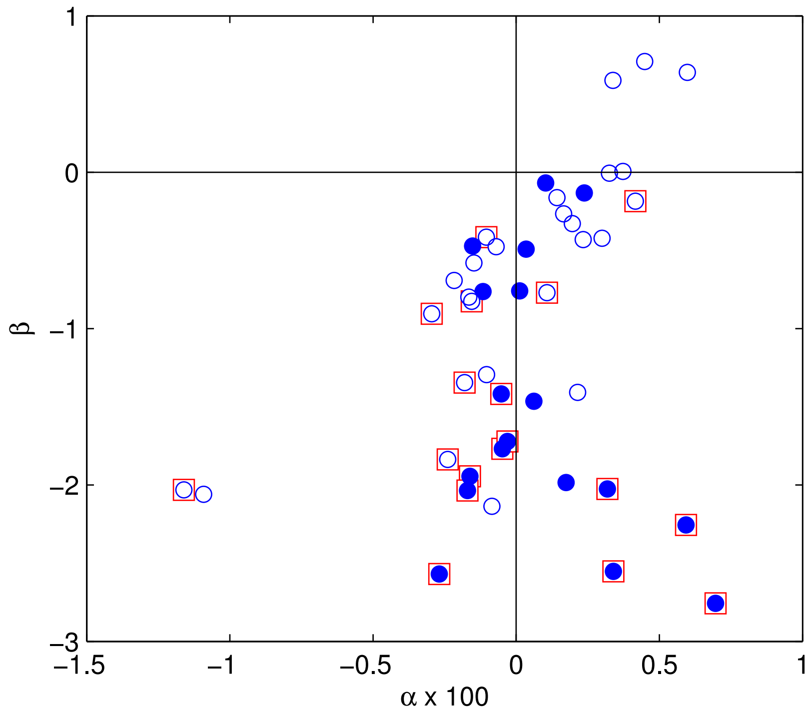


FIGURE 2

Average Rates of Appreciation and Forward Premia

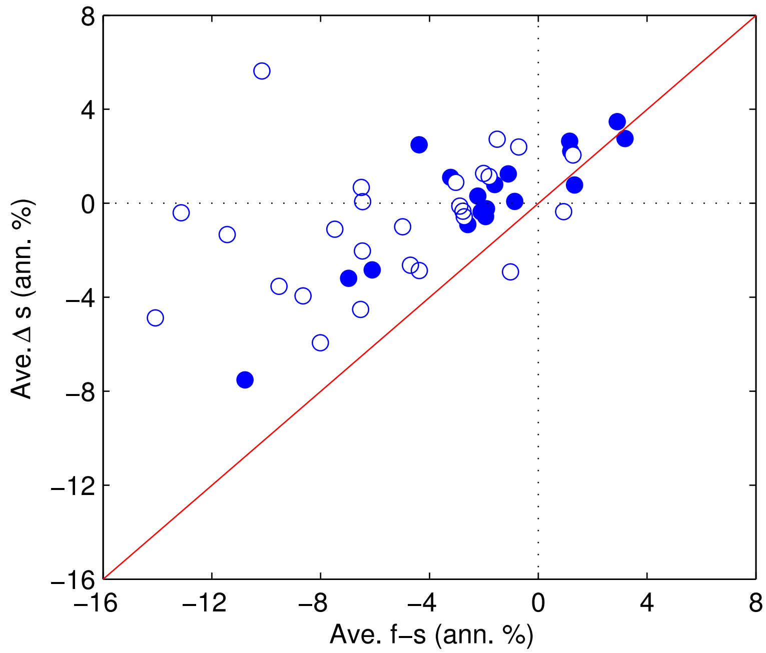


FIGURE 3

Median Rolling Betas from UIP Regressions

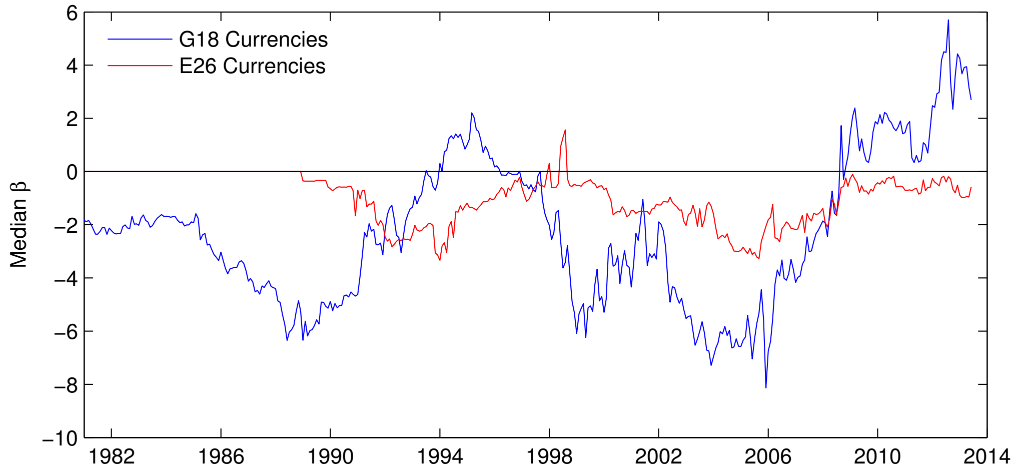


FIGURE 4

Cumulative Returns to Investment Strategies

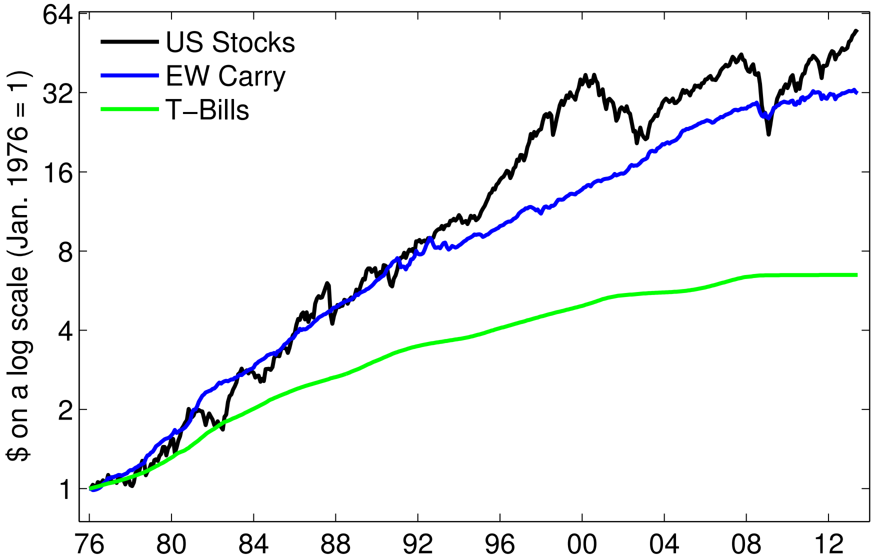


FIGURE 5

Cumulative Returns to Investment Strategies

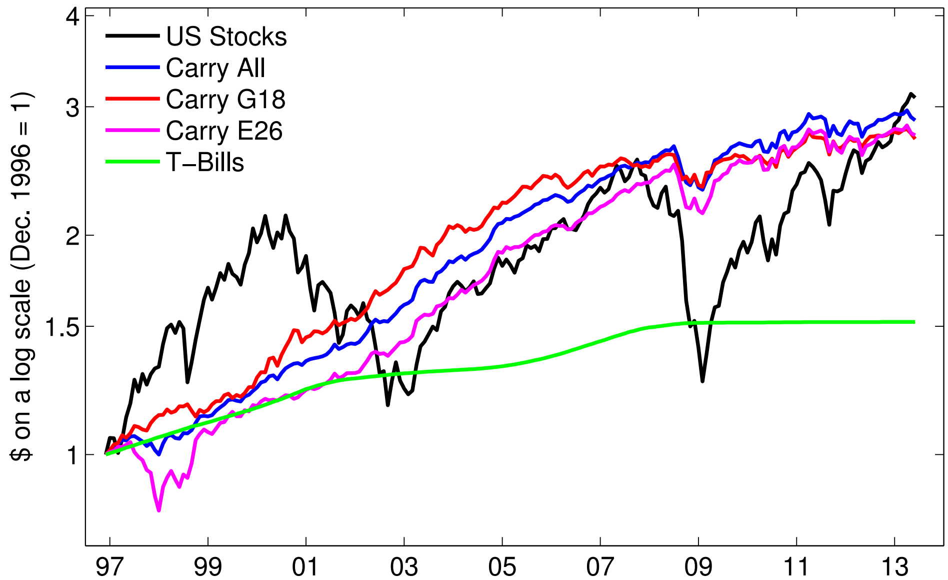


FIGURE 6

Mean Forward Discounts and Payoffs to Static Carry Trade

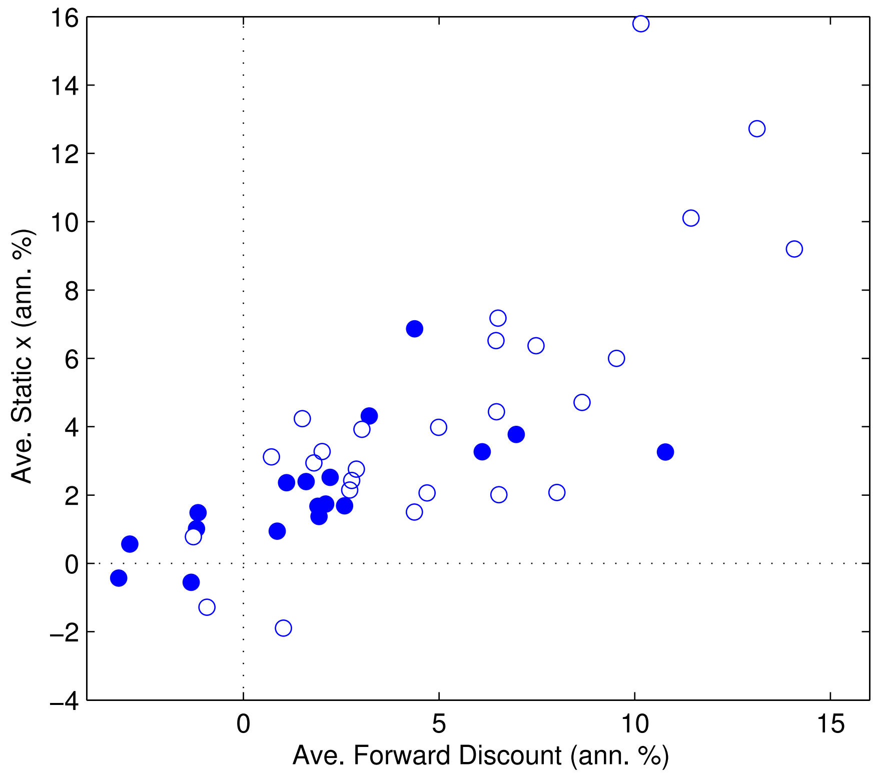


FIGURE 7

Static and Standard Carry Trade Payoffs

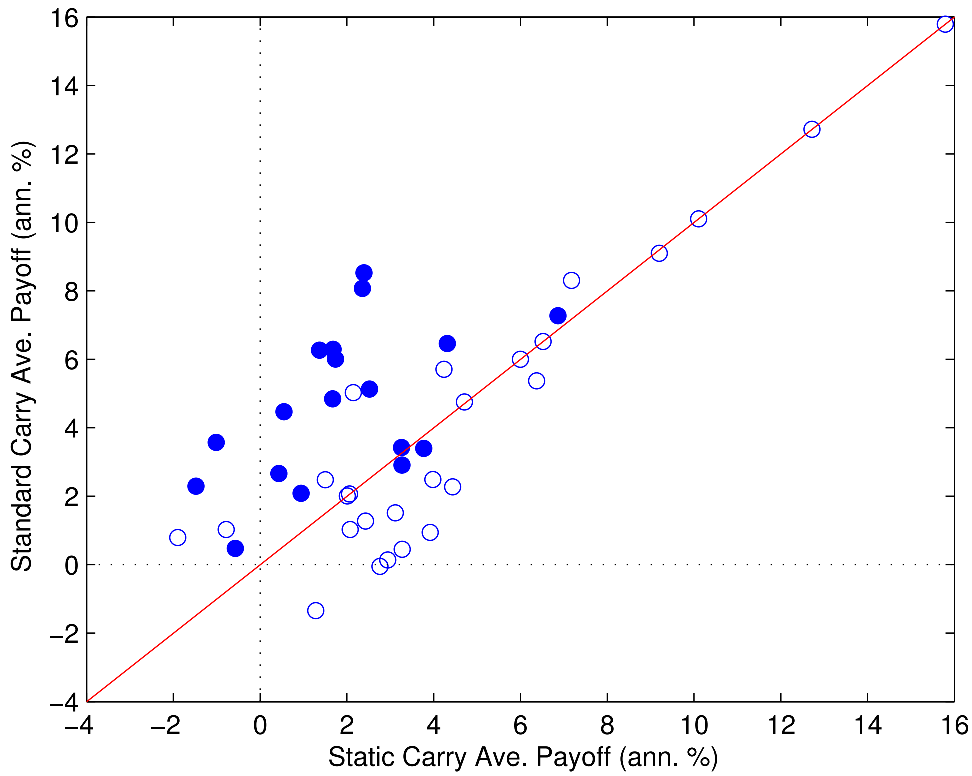
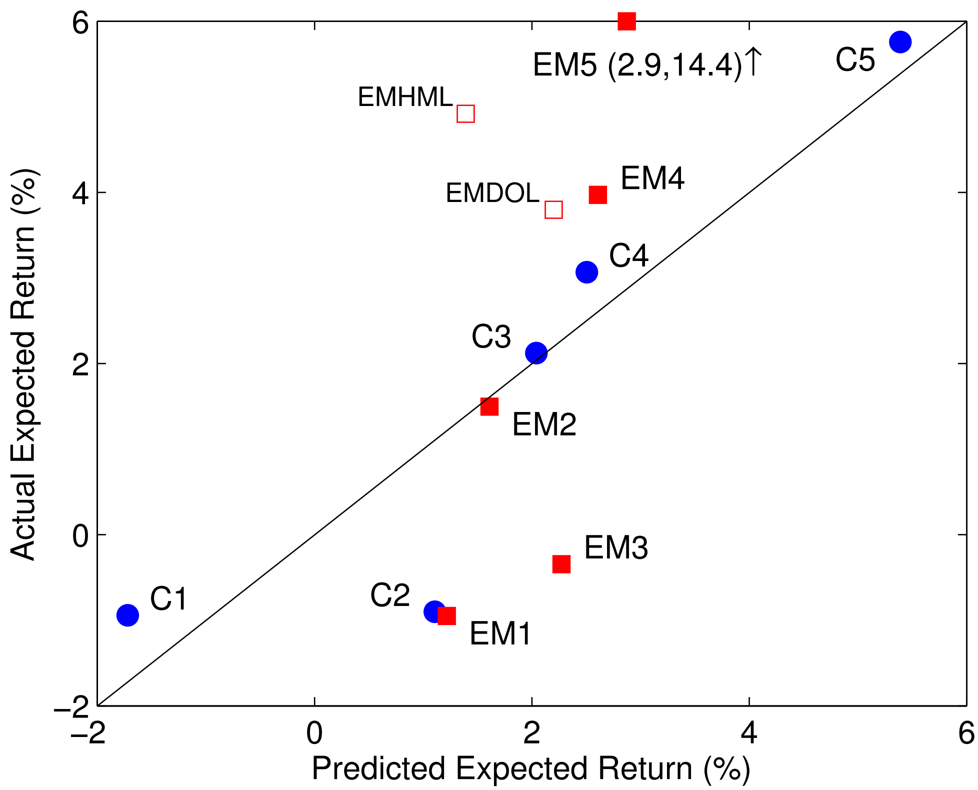


FIGURE 8

Actual and Model-Predicted Expected Returns for the DOL-HML Model



Appendix

I use data from Reuters/WMR and Barclays (available from Datastream) for spot and forward exchange rates. There are eight euro-legacy currencies: ATS, BEF, FFR, ITL, NLG, PTE, ESP (available Jan 1976–Dec 1998) and IEP (Apr 1979–Dec 1998). I treat the DEM and EUR as one currency (available Jan 1976–Jun 2013). I define the rest of the G18 currencies as CAD, DKK, NOK, SEK, CHF and GBP (Jan 1976–Jun 2013), JPY (Jun 1978–Jun 2013) and AUD and NZD (Dec 1984–Jun 2013).

The E26 currencies, with start dates indicated, are ZAR (Jan 1984), SGD (Dec 1984), MYR (Dec 1984–Aug 1998), IDR, THB (Feb 1995), PLN (May 1995), MXN (Sep 1995), CZK (Jun 1996), TWD (Oct 1996), PHP (Dec 1996), INR, KRW (Mar 1997), COP, HUF (Oct 1997), CLP (Jan 1998), ILS (Aug 2000), ARS, BRL, TRY (Jan 2003), HRK, EGP, ISK, MAD, RON, RUB (Mar 2004), and MYR (Jul 2005). All end dates are Jun 2013 except as indicated for MYR. I treat the second sample for MYR as a separate currency.

For all currencies most data prior to Dec 1996 is taken from Reuters/WMR GBP quotes on Datastream, although data for some currencies (AUD, NZD, SGD, MYR, ZAR), is taken from Barclays USD quotes on Datastream. Data after Dec 1996 is mainly taken from Reuters/WMR USD quotes on Datastream. Additionally, some data from J.P. Morgan is used to fill in data for some emerging market currencies both before and after Dec 1996. I use the risk free rate from Kenneth French's database as a measure of the U.S. interest rate.

APPENDIX TABLE 1

Average Payoffs to Individual Currency Carry Trades

A) euro-Legacy Currencies				B) Other Industrialized Currencies			
	Mean	SD	SR		Mean	SD	SR
ATS	0.023	0.117	0.20	AUD	0.065	0.121	0.54
	(0.027)	(0.006)	(0.23)		(0.024)	(0.009)	(0.21)
BEF	0.081	0.115	0.70	CAD	0.021	0.067	0.31
	(0.024)	(0.006)	(0.21)		(0.011)	(0.005)	(0.17)
FRF	0.060	0.110	0.55	DKK	0.085	0.109	0.78
	(0.024)	(0.005)	(0.22)		(0.019)	(0.005)	(0.18)
IEP	0.063	0.111	0.57	EUR/DEM	0.045	0.138	0.32
	(0.028)	(0.006)	(0.25)		(0.024)	(0.023)	(0.15)
ITL	0.029	0.108	0.27	JPY	0.027	0.119	0.22
	(0.025)	(0.007)	(0.23)		(0.021)	(0.006)	(0.18)
NLG	0.036	0.117	0.31	NOK	0.051	0.106	0.48
	(0.027)	(0.006)	(0.23)		(0.018)	(0.005)	(0.17)
PTE	0.034	0.112	0.31	NZD	0.073	0.126	0.58
	(0.026)	(0.006)	(0.24)		(0.026)	(0.010)	(0.21)
ESP	0.034	0.112	0.30	SEK	0.063	0.109	0.57
	(0.029)	(0.007)	(0.26)		(0.017)	(0.006)	(0.17)
				CHF	0.005	0.124	0.04
					(0.022)	(0.006)	(0.17)
				GBP	0.048	0.105	0.46
					(0.017)	(0.006)	(0.16)

APPENDIX TABLE 1

Average Payoffs to Individual Currency Carry Trades

C) Emerging Market Currencies

	Mean	SD	SR		Mean	SD	SR
ARS	0.091	0.089	1.02	MXN	0.060	0.104	0.58
	(0.026)	(0.029)	(0.21)		(0.025)	(0.010)	(0.28)
BRL	0.158	0.152	1.04	MAD	0.009	0.090	0.10
	(0.055)	(0.017)	(0.41)		(0.029)	(0.010)	(0.32)
CLP	-0.001	0.115	0.00	MYR	0.008	0.085	0.09
	(0.028)	(0.013)	(0.24)		(0.026)	(0.020)	(0.31)
COP	0.023	0.119	0.19	MYR	0.015	0.067	0.23
	(0.033)	(0.011)	(0.28)		(0.020)	(0.008)	(0.29)
HRK	0.005	0.111	0.04	PHP	0.021	0.089	0.23
	(0.037)	(0.011)	(0.33)		(0.024)	(0.013)	(0.29)
CZK	0.057	0.129	0.44	PLN	0.054	0.136	0.40
	(0.029)	(0.008)	(0.22)		(0.028)	(0.012)	(0.21)
EGP	0.101	0.041	2.49	RON	0.083	0.140	0.59
	(0.019)	(0.006)	(0.50)		(0.049)	(0.013)	(0.37)
HUF	0.065	0.144	0.45	RUB	0.025	0.105	0.24
	(0.037)	(0.015)	(0.28)		(0.034)	(0.016)	(0.33)
ISK	0.020	0.162	0.12	SGD	0.010	0.056	0.18
	(0.059)	(0.034)	(0.38)		(0.009)	(0.005)	(0.15)
IDR	0.048	0.283	0.17	THB	0.050	0.113	0.45
	(0.066)	(0.070)	(0.25)		(0.029)	(0.027)	(0.31)
INR	0.025	0.071	0.35	TRY	0.127	0.150	0.85
	(0.017)	(0.008)	(0.25)		(0.052)	(0.016)	(0.36)
ILS	0.001	0.087	0.02	TWD	-0.013	0.057	-0.23
	(0.024)	(0.008)	(0.27)		(0.014)	(0.006)	(0.23)
KRW	0.013	0.151	0.08	ZAR	0.010	0.155	0.07
	(0.034)	(0.028)	(0.23)		(0.030)	(0.011)	(0.19)