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# Risk in carry trades: a look at target currencies in Asia and the Pacific[1]

*We analyse carry trades involving the Australian dollar, Indonesian rupiah, Indian rupee, New Zealand dollar and Philippine peso as target currencies. We find evidence supporting the view that downside risk is an important feature of such strategies and propose ways of measuring this risk.*

*JEL classification: F310, G150, G180, N250*.

Carry trades are often viewed as a highly speculative investment strategy, to be tried only by the most sophisticated investor. Empirically, however, these trades have been shown to perform well quite consistently for protracted periods and have thus become a fairly common strategy. Confirming this observation is the fact that market participants have created tradable indices as well as various forms of structured FX instruments referencing carry trade strategies.

Based on a sample of target currencies in Asia and the Pacific, we find that carry trades have had extraordinarily high returns but also a risk of large losses. This finding suggests that carry trade returns may, at least in part, reflect compensation for very large downside risks. On balance, our analysis of carry trades involving target currencies in Asia and the Pacific does indeed show that the perceived risks of carry trading would be captured well by focusing on downside risk. Using value-at-risk (VaR) and expected shortfall as measures of downside risk, we find a positive relationship between risks and returns for carry trades.

This special feature is organised as follows. In the first section we briefly review the literature on uncovered interest parity (UIP), a condition that would make carry trades unprofitable. The second section presents alternative measures of risk for carry trades, focusing on five target currencies in Asia and

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the Pacific. The third section presents preliminary evidence on the links between risk and return for carry trades. The final section concludes.

## Carry trades versus uncovered interest parity

Carry trade strategies work when uncovered interest parity does not

The carry trade strategy involves borrowing in a currency with low interest rates (called the funding currency) and investing in one with high interest rates (the target currency). If the target currency does not depreciate vis-à-vis the funding currency during the life of the investment, then the investor earns at least the interest differential. This strategy does not work if uncovered interest parity (UIP) holds. The UIP condition states that higher-yielding currencies will tend to depreciate against lower-yielding ones at a rate equal to the interest differential so that expected returns are equalised in a given currency. Under UIP, any interest differential is offset by currency movements.

The forward premium puzzle

In a large body of empirical literature, however, UIP has been shown to fail almost universally at time horizons shorter than five years.[2] Indeed, in many cases the relationship is precisely the opposite of what is predicted by UIP: currencies with high interest rates tend to appreciate while those with low interest rates depreciate.[3] Remolona and Schrijvers (2003) show that UIP fails especially when investors hold instruments with maturities that are longer than the investment horizon. This failure of UIP is so well established that the phenomenon is called the "forward premium puzzle". In a world of risk, UIP is almost certainly false. The condition states that expected returns would be equal regardless of risk. Risks clearly vary across currencies, however, and different risks should command different expected returns.

The failure of UIP has been no secret to participants in currency markets. Indeed, the most popular investment strategy in these markets has been the carry trade, which is essentially a bet against UIP. The strategy has become so commonplace that the market has created tradable benchmarks for them and has introduced structured FX instruments referencing these benchmarks (see Box next page).[4]

A significant interest rate differential is necessary

Carry trades tend to be pursued only when the interest differential is wide enough to compensate for the foreign exchange risk being taken.[5] Hence, they have so far tended not to involve most major currencies as targets; instead, they have involved such target currencies as the Australian dollar (AUD),

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2 See, for example, the surveys of the literature by Engel (1996) and Flood and Rose (2002). Chinn and Meredith (2004) suggest that UIP does hold at horizons longer than five years.

3 Carry trades are an important feature of financial globalisation. See Gudmundsson (2007) for the implicatons of such globalisation on the monetary transmission mechanism.

4 See Galati et al (2007) for a discussion of the difficulties involved in estimating the size of global carry trade activity.

5 Galati and Heath (2007) provide evidence that foreign exchange trade volumes are positively correlated with higher domestic interest rates. Hattori and Shin (2007) find evidence that volumes of carry trades involving the yen are high when interest differentials against the yen are high.

## Carry trades as a standard trading strategy

Carry trades have in recent years become so commonplace that the market has created tradable benchmarks for them and has introduced structured FX instruments referencing these indices.

Several tradable carry trade index families have been launched over the last year. All of them include one or more Asian currencies (see table below). These indices combine a long position in one or more high-yielding currencies with a short position in one or more low-yielding currencies. In terms of currencies referenced, the indices fall into two categories. One category references only 10 major currencies, namely the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), pound sterling (GBP), Japanese yen (JPY), Norwegian krone (NOK), New Zealand dollar (NZD), Swedish krona (SEK) and US dollar (USD). The other group references combinations of these and selected regional currencies. Thus, even the indices based on a smaller set of currencies include Asia-Pacific currencies, namely the AUD, JPY and NZD. Indices with a broader base of currencies typically include all the Asia-Pacific currencies except the CNY and HKD.

A distinction can be made between indices where the choice of funding and investment currencies is done according to simple rules and those relying on more sophisticated allocation methods. The simple rule approach, which is used by the Deutsche Bank, puts equal weight on the three lowest-yielding and the three highest-yielding currencies every month. The more sophisticated approach, which is used for the CSFB and Barclays indices, deploys some form of mean-variance optimisation when choosing the index weights, which implies lower aggregate weights on highly correlated currencies

### Characteristics of selected carry traded indices

| Index family | Originator | Inception | Structure | Asian currencies referenced |
|---|---|---|---|---|
| CSFB Rolling optimised carry trade indices | Credit Suisse First Boston | April 2007 | Reallocation every month across 10 major + EM currencies | AUD, JPY, NZD, SGD |
| GEMS Asia Index | Barclays Capital | March 2007 | Five currencies one month forward vs EUR or USD | IDR, NDR, KRW, PHP THB |
| DB Harvest | Deutsche Bank | March 2007 | Reallocation every month across 10 major and 11 EM currencies | AUD, JPY, KRW, NZD, SGD, THB, TWD |
| Intelligent Carry Trade Index | Barclays Capital | March 2007 | Reallocation every month across 10 major currencies | AUD, JPY, NZD |

Sources: Citigroup; Credit Suisse First Boston; Deutsche Bank; Barclays Capital.

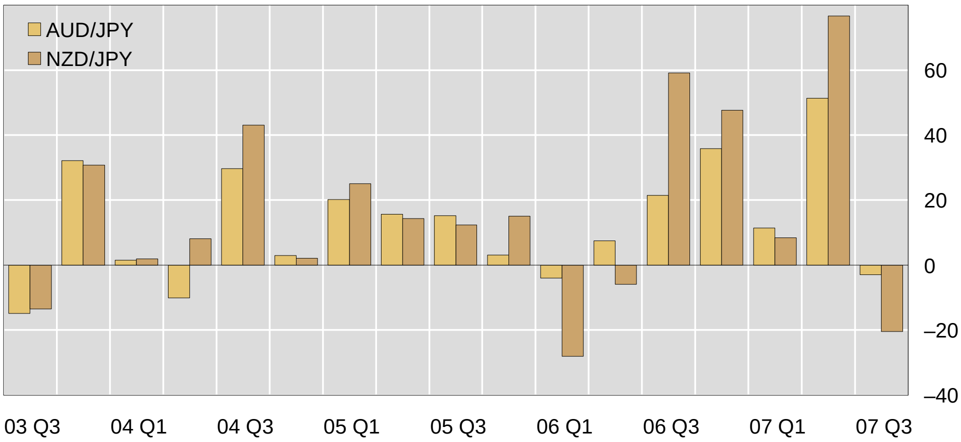
Recently structured FX instruments based on carry trades have also been introduced in the form of collateralised foreign exchange obligations (CFXOs). The first deals were completed in spring 2007. A CFXO is a collateralised debt obligation based on the cash flow from underlying carry trades (Merrill Lynch (2007)). Investors are paid in order of priority, starting with senior investors and ending with equity holders.

An additional indication that carry trades are becoming a standard asset type in the global financial market is the fact that major international rating agencies have issued or are in the process of issuing methodology documents as well as guidelines on how they rate CFXOs and similar instruments. So far only Fitch Ratings has published guidelines and descriptions of the methodology used in their ratings (Fitch (2007)), while S&P and Moody's will probably do so going forward. Similar to carry trade indices, CFXOs typically reference either only 10 major currencies or combinations of these and other typically regional currencies.

Icelandic króna (ISK), New Zealand dollar (NZD), South African rand (ZAR), Swedish krona (SEK), Turkish lira (YTL) and occasionally the pound sterling (GBP). In periods where interest differentials have been sufficiently wide, carry trades have also involved target currencies under managed float

**Carry trades: ex post returns**

Annualised average daily return, in per cent[1]




[1] Calculated as the sum of interest rate differentials and the percentage change in the target currency's bilateral exchange rate against the Japanese yen.

Sources: Bloomberg; BIS calculations. Graph 1

regimes, such as the Brazilian real (BRL), Czech koruna (CZK), Hungarian forint (HUF), Indian rupee (INR), Indonesian rupiah (IDR) and Philippine peso (PHP).

Carry trade investors face downside risk

The focus in this special feature is on the nature of the risk in carry trades. For a preliminary illustration of this risk, Graph 1 shows the performance of recent carry trades involving the Australian dollar and New Zealand dollar as target currencies and the Japanese yen as the funding currency. In the graph, realised returns have tended to be positive and have often been quite high but there have been occasional periods of negative returns. This pattern of returns suggests that the risk faced by investors in carry trades is downside risk, in which there is a small probability of a large loss. We analyse this risk more formally below.

## Measuring the risk in carry trades

Consider 10 currency pairs in Asia and the Pacific

To explore the nature of the risk faced by investors in carry trades, we consider the return distributions for combinations of five currencies in Asia and the Pacific that are known to have been target currencies and two currencies that have been funding currencies, resulting in 10 currency pairs. The target currencies are the Australian dollar, Indonesian rupiah, Indian rupee, New Zealand dollar and Philippine peso, and the two funding currencies are the Swiss franc and Japanese yen. We look at the period from end-December 2000 to end-September 2007, a period when the relevant interest differentials were fairly wide. Carry trades for these currency pairs have been so common that Bloomberg makes daily returns for them available on page FXCT. These daily returns are calculated using three-month eurodeposit rates for the funding as well as the target currencies. We use these daily returns from Bloomberg for the period to construct return distributions. We then measure the extent to which the returns are more peaked or more flat relative to a normal distribution (kurtosis). A distribution with high kurtosis has a distinct peak near the mean, declines rather rapidly and has heavy tails. More importantly, we also measure the extent to which returns lack symmetry or exhibit skewness. The return distribution is negatively skewed if it has a long tail in the negative direction.

*Return distributions*

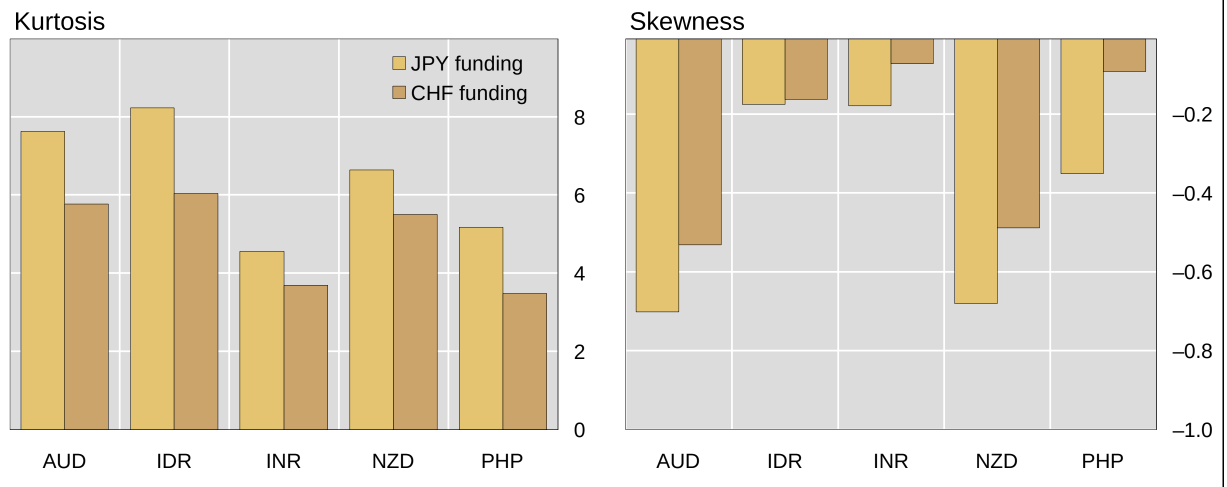
In terms of mean returns, our sample of carry trade strategies has tended to outperform the major stock markets for the period under consideration. The annualised average daily return on the Australian dollar/yen carry trade, for example, was 12.5% per year during the period 2001 to September 2007, compared to 3.6% for the S&P 500 Index. Carry trades involving the Japanese yen as the funding currency show stronger average returns than trades involving the Swiss franc as the funding currency. This difference in performance arises in part because the interest differentials involving the yen have been wider than those involving the Swiss franc.

Carry trade returns are negatively skewed

It is also evident that carry trade returns are not normally distributed. Graph 2 shows that return distributions for all the carry trades in our sample have positive kurtosis and thus heavier tails than a normal distribution. More importantly, the returns tend to be negatively skewed, reflecting a higher frequency of large negative returns.[6] The negative skew reflects the presence of occasional large negative returns in the range of 2% to 4%. This skew is what we call downside risk. The graph shows that, for the period under consideration, the negative skew is most pronounced for carry trades involving the Australian and New Zealand dollars as target currencies. The negative skew is less pronounced for the target currencies under managed float regimes, namely the Indonesian rupiah, Indian rupee and Philippine peso. It does not seem to matter very much whether the funding currency is the Swiss franc or the yen: the resulting distributions tend to be similar for the two

**Skewness and kurtosis for daily returns**

January 2001 to September 2007




Sources: Bloomberg; BIS calculations. Graph 2

[6] Using a Jarque-Bera test, the null hypothesis of normality is rejected with significance well below the 1% level in all cases.

currencies.[7]

*Risk measures*

Three measures of risk

Given the distributions of returns for carry trades, what would be the appropriate measure of risk? Here we consider three possible measures: (1) volatility; (2) value-at-risk (VaR); and (3) expected shortfall.[8] Volatility of returns is the most common measure of risk in financial markets and would be most appropriate for normally distributed returns, or at least symmetric return distributions.[9] VaR may be defined as the capital needed to cover a certain level of losses from a financial instrument over a given holding period and for a given confidence level.[10] It is a standard measure of risk in credit markets, where return distributions feature small probabilities of large losses. Expected shortfall is the potential expected loss in situations where losses exceed a given VaR.[11] Both VaR and expected shortfall are measures that focus on downside risk. However, unlike the VaR measure, expected shortfall is considered to be a coherent measure of risk, that is, it always captures benefits from diversification (Artzner et al (1997), Artzner (1999)). For this article, VaR and expected shortfall are estimated using an extreme value theory approach.[12] We use the 99% confidence level for both measures.

Carry trades appear much less risky based on volatility …

… but less so based on downside risk measures

For purposes of comparing risks, we use the major equity markets as a reference point. Using volatility as the measure of risk, carry trades appear much less risky than major equity markets. In Table 1, daily return volatilities for carry trades in the period 2001 to 2007 are in the 0.6–0.8% range, which is well below that for major equity markets, where volatilities are in the 1–1.4% range. While the VaR and expected shortfall measures for carry trades are also below those of equity markets, the difference with the equity measures is less in relative terms. For instance, the ratio of the average of risk estimated for the 10 currency pairs and the average for the three stock markets reported in

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7 The return profiles of carry trade returns are consistent with the Plantin and Shin (2007) theoretical analysis of carry trades. Their model predicts that UIP will fail and that high-yielding currencies will have periods of gradual appreciation followed by abrupt reversals.

8 Other downside risk measures one could consider are implied volatilities for deep-out-of-the-money call options and risk reversals. While these measures have the advantage of being forward-looking, they also contain risk premia and are therefore potentially misleading measures of risk.

9 The return distributions for the equity markets in Table 1 all have positive kurtosis and are sligthly negatively skewed.

10 For a random variable X with continous distribution function F models losses over a given time horizon. $VaR_p$ is then the p-th quantile of the distribution F: $VaR_p = F^{-1}(1-p)$ where $F^{-1}$ is the inverse of the distribution function F.

11 We use $ES_{0.01}$,which is the expected loss given the loss exceeds the 1% VaR and is given by $ES_{0.01} = E(X \mid X > VaR_{0.01})$.

12 When estimating VaR and expected shortfall we follow the peak-over-threshhold method from Gilli and Këllezi (2006) and estimate a Generalized Pareto Distribution for the left tail of the distribution.

| Risk measures and returns for daily carry trade returns<br>January 2001 to September 2007; in per cent | | | | | |
|---|---|---|---|---|---|
| Currency pairs (long/short) | Mean return | | Volatility | 1% VaR | 1% expected shortfall |
| | Daily | Annualised | | | |
| AUD/JPY | 0.047 | 12.493 | 0.722 | 2.082 | 2.822 |
| IDR/JPY[1] | 0.040 | 10.404 | 0.803 | 2.453 | 3.195 |
| INR/JPY | 0.033 | 8.626 | 0.593 | 1.499 | 1.908 |
| NZD/JPY | 0.056 | 14.937 | 0.807 | 2.354 | 3.191 |
| PHP/JPY[2] | 0.034 | 8.897 | 0.624 | 1.555 | 2.199 |
| AUD/CHF | 0.024 | 6.077 | 0.638 | 1.836 | 2.397 |
| IDR/CHF[1] | 0.016 | 4.133 | 0.850 | 2.542 | 3.438 |
| INR/CHF | 0.010 | 2.403 | 0.666 | 1.630 | 1.963 |
| NZD/CHF | 0.032 | 8.381 | 0.722 | 2.070 | 2.697 |
| PHP/CHF[2] | 0.011 | 2.685 | 0.680 | 1.656 | 1.965 |
| *Memo:* | | | | | |
| *AUD/JPY (since 1996)* | *0.029* | *7.572* | *0.805* | *2.282* | *3.005* |
| *NZD/JPY (since 1996)* | *0.033* | *8.544* | *0.845* | *2.412* | *3.090* |
| *S&P 500* | *0.014* | *3.614* | *1.063* | *2.802* | *3.494* |
| *Nikkei 225* | *0.021* | *5.469* | *1.374* | *3.507* | *4.178* |
| *FTSE 100* | *0.009* | *2.176* | *1.126* | *3.160* | *4.201* |

[1] From August 2001. [2] From February 2001.

Sources: Bloomberg; JPMorgan; UBS; BIS calculations using Matlab code from Gilli and Këllezi (2006). Table 1

Table 1 is 0.60 when risk is measured by volatility, 0.62 when measured by VaR, and 0.65 when measured by expected shortfall.

These results are of interest because some researchers have found carry trades to offer unusually attractive risk-return trade-offs when using volatility as their measure of risk. Burnside et al (2007), for example, show that carry trades have much higher Sharpe ratios – which use volatility as a measure of risk - than equity markets. But the results may vary if we use other measures of risk. We next turn briefly to this issue.[13]

## Risk and return in carry trades

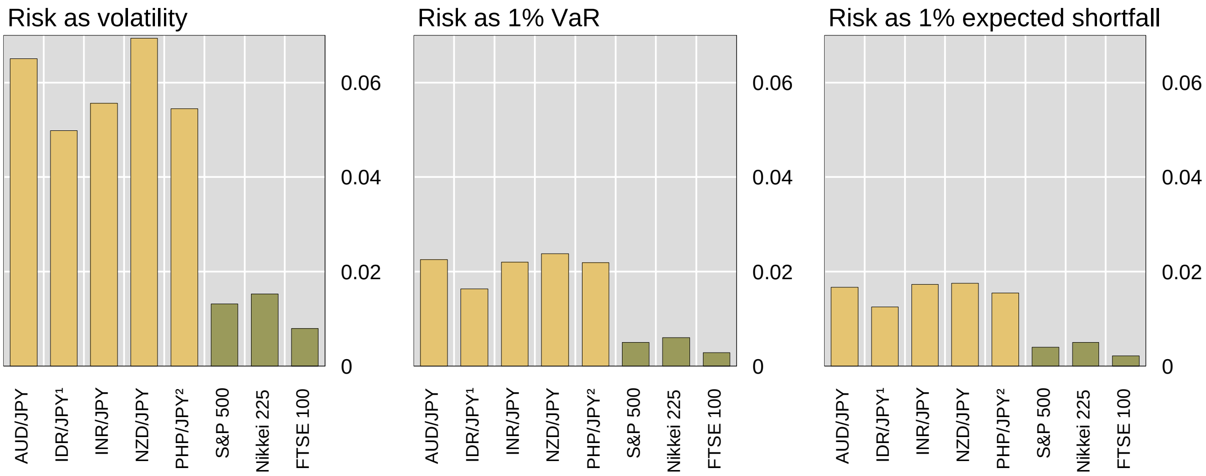
In the following analysis, we are limited to comparing risk and return for a sample of only 10 carry trades. Hence, the conclusions we will draw will necessarily be tentative and suggestive.

Given the appropriate risk measure, ie assuming that the risk measure is what is used by market participants, expected returns would reflect risk. The higher the risk, the higher the expected return. One way to look at this relationship is to consider the ratio of expected returns to risk. The most common is the Sharpe ratio, which is the ratio of expected return to

[13] Our estimates of return and risk may be subject to a “peso problem”, ie they may reflect a perceived small probability of a large discrete change in the exchange rate, and thus be upwardly biased (Krasker (1980)).

**Risk-return trade-offs: volatility versus downside risk**

Average return divided by risk measure for carry trades and equity markets, January 2001 to September 2007




[1] From August 2001. [2] From February 2001.

Sources: Bloomberg; JPMorgan; BIS calculations. Graph 3

volatility.[14] The left-hand panel of Graph 3 compares the Sharpe ratios for carry trades and equity markets calculated over the 2001–07 period. In this case, the trade-offs between risk and return for carry trades have been far more attractive than for equity markets. This is consistent with the results of Burnside et al (2007), who consider these findings to be a puzzle. Moreover, the ratios vary substantially from one carry trade to another.

Carry trade returns reflect downside risk

Once we turn to measures that focus on downside risk, however, the pattern of risk-return trade-offs looks different. In the case of both VaR and expected shortfall, the absolute differences between carry trade and equity market strategies, in terms of compensation received per unit of risk, have narrowed considerably (although they remain quite large). More importantly, we now find that the differences between carry trades are smaller. This implies that the compensation received per unit of downside risk is similar across carry trade strategies. While this does not show either VaR or expected shortfall to be the better measure of downside risk, the relative uniformity of risk-return ratios across currency pairs for either risk measure suggests that returns for carry trade strategies may be closely aligned to downside risks.[15]

## Conclusions

We look at the risk profile of 10 carry trade strategies involving the Australian dollar, Indonesian rupiah, Indian rupee, New Zealand dollar and Philippine peso as target currencies and the Swiss franc and Japanese yen as funding

[14] Strictly speaking, the Sharpe ratio is the ratio of expected *excess* return to volatility. For our purposes, however, the distinction between return and excess return is immaterial.

[15] The standard deviations for the return risk ratios of the 10 currency pairs are respectively: 2% for the return to volatility ratio, 0.7% for the return to VaR ratio and 0.5% for the return to expected shortfall ratio.

currencies. In recent years these strategies have yielded average returns that have seemed extraordinarily high relative to their risk in terms of volatilities. However, their return distributions show both fat tails and significant negative skewness. This suggests that to capture the perceived risks of carry trade strategies, appropriate measures of risk for these strategies would be those that focus on downside risk.

We consider two common measures of downside risk, VaR and expected shortfall. We find that both measures lead to broadly similar risk-return trade-offs across carry trade strategies. This suggests that expected carry trade returns do in fact reflect downside risk. We also find that the difference between risk-return trade-offs for carry trade strategies and those trade-offs for equity markets remain wide regardless of the risk measure used. This suggests that carry trades and equity markets belong to different asset classes, for which risks are priced differently.

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