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The Carry Trade

Theory, Strategy & Risk Management

Michael R. Rosenberg

Abstract

Positive carry is both an important source and predictor of total returns across all asset classes. FX carry trades, which are the focus of this report, can therefore be viewed as a subset of a broader array of carry-trade related strategies that can be undertaken across all asset classes. Part I of this report starts out by discussing how a typical carry-trade cycle evolves over time—from an initial widening in interest-rate spreads, to a gradual buildup in net speculative positions in favor of high-yield currencies, and finally to the eventual forced unwinding of those positions when liquidity conditions tighten and risk appetite declines.

Part II discusses the theoretical foundations of the carry trade. According to theory, the excess returns on FX carry trades should be zero if the uncovered interest rate parity (UIP) condition held. According to the UIP condition, high-yield currencies might offer an initial yield advantage over their low yielding counterparts, but over time that yield advantage will tend to be offset by an expected depreciation of the high-yield currencies versus the low-yield currencies. The UIP condition has been one of the most widely tested propositions in the field of international finance. In Part III we review the empirical evidence on UIP to determine the extent to which investors could have profited from deviations from UIP.

Carry trades have generated attractive positive excess returns over long periods of time, but there have also been episodes where large losses on carry-trade positions were incurred when market conditions have turned turbulent. Because carry trades are subject to sudden downside moves, the excess returns that carry trades have earned are considered to be compensation to investors who are willing to bear that risk. Part IV discusses the risk factors that have been found to be an important driver of carry-trade returns.

There are many ways to pursue carry-trade strategies in the FX market—in terms of selecting the currencies that should be included in a long/short carry-trade portfolio and how they should be ranked, deciding how long and short positions should be weighted, and how volatility, correlation and skewness considerations should be incorporated into the carry-trade decision making process. Part V discusses these various approaches to carry-trade construction. Part VI reviews the many different forms of overlay models, crash protection indicators, and risk-management systems that can be integrated into an otherwise passively managed carry-trade portfolio to help minimize the downside risks associated with FX carry trades. Part VII concludes by tying all of these pieces together, and considers the pros and cons of adopting a judgmental versus a quantitative approach to carry-trade strategy and risk management.

About the Author

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Michael Rosenberg is a consultant for Bloomberg, where he is responsible for designing a wide range of new FX functionality (FXIP, FXCT, FXFB, and FXFC) and global macro/economic analytics (ECFC, ECOW, FED, TAYL) and the Bloomberg Financial Conditions Indices (BFCIUS, BFCIEU, and BFCIAXJ). He also authors a variety of research reports for Bloomberg, including FX Market Insights (FXMI) and Financial Conditions Watch (FCW).

Mr. Rosenberg has a long history of managing award-winning research teams on Wall Street. He was Managing Director and Global Head of FX Research at Deutsche Bank from 1999 to 2004, and Managing Director and Head of International Fixed Income Research at Merrill Lynch from 1984 to 1999. Mr. Rosenberg also managed Prudential Insurance Company's global bond portfolio over the 1982–1984 period, and was a Senior FX/Money Market Analyst at Citibank from 1977 to 1982. More recently, Mr. Rosenberg has worked for two macro hedge funds: as a senior strategist for Harbert Management Corporation's Global Macro Hedge Fund, and as a principal in Global Trading Systems' quant fund.

Mr. Rosenberg's FX research team at Deutsche Bank was voted #1 in the world in Institutional Investor magazine's 2001 All-Global Research Team and in Euromoney magazine's 2003 Annual FX poll. Mr. Rosenberg's team was also ranked #1 in the pan-European Extel Surveys for FX Strategy in 2002-04 as well as in Global Investor, FXMM, and FX Week magazines' annual rankings of FX research analysts. As a global fixed-income strategist at Merrill Lynch, Mr. Rosenberg was ranked #1 in Global Investor magazine's annual ranking of international fixed-income research analysts in both 1996 and 1997.

Mr. Rosenberg has written numerous articles on international bond management and the foreign-exchange market for various academic journals and handbooks, and has taught MBA courses in International Financial Markets at Adelphi University and Baruch College. Mr. Rosenberg has authored two books in the field of exchange-rate forecasting: *Currency Forecasting: A Guide to Fundamental and Technical Models of Exchange Rate Determination* (Irwin/McGraw-Hill, 1996) and *Exchange Rate Determination* (McGraw-Hill, 2003). Mr. Rosenberg recently co-authored the 2012 Level-2 CFA "Reading on Currency Forecasting".

Mr. Rosenberg holds a B.S. in accounting from the University at Albany, an M.A. in economics from Queens College, and a Ph.D. in economics from Penn State University. Mr. Rosenberg was the recipient of Penn State University's 2010 Alumni Fellow Award, the highest award given by the Penn State Alumni Association for outstanding professional accomplishments

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Part I — Introduction

Carry trades have become a major area of interest for market participants and policymakers alike. From the perspective of FX market participants, diversified carry-trade portfolios have been shown to generate attractive risk-adjusted returns over long periods of time. As a result, many global fund managers today devote at least a portion of their portfolios to carry-trade-related strategies.

The number of academic journal articles that examine the risk/return attributes of FX carry trades has soared in the past decade and many investment banks, recognizing the growing interest, have created tradable indices based on G-10 and emerging market (EM) carry trades to make it easier for their clients to participate in such trading strategies. Ten years ago, a simple search on Bloomberg looking for securities and tradable indices with the term “carry” attached to them would have found very few. Today, you would find 2073 securities.

From the perspective of policymakers, there is a clear concern that carry-trade activities might be playing a major role in generating exchange-rate misalignments and financial bubbles around the world. As carry-trade activities have become a more important part of the FX landscape, there exists a risk that a global search for yield could drive high-yield currencies deep into overvalued territory, which could have serious negative consequences for economic activity in such markets. In that environment, monetary authorities in high-yield markets might feel compelled to resort to capital controls to stem the inflow of foreign capital into their markets to prevent an undesired appreciation of their currencies or a rise in domestic asset prices in general.

The term “currency wars,” which has been used quite frequently in recent policy-related discussions, is a manifestation of policymaker concern about the role that carry trades are now playing in the global financial markets.

Another policy-related danger of carry-trade activities is that in a low-interest-rate world, a global search for yield could encourage investors to take on large highly leveraged exposures in higher yielding risky securities. If speculative positions lean too heavily in one direction, one runs the risk that a forced unwinding of carry-trade positions could precipitate a serious currency or financial crisis. The carry-trade unwind of 2008 illustrates the risks that these trades could have on exchange rates. During that period, we saw high-yield currencies such as the Australian and New Zealand dollars—as well as many high-yielding EM currencies—lose considerable ground, even though none of those high-yielding markets were at the epicenter of the 2007-09 Global Financial Crisis.

The Importance of Positive Carry

Positive carry is both an important source and predictor of returns across all assets, not just foreign exchange. The total return on any asset can be broken down into two parts: (1) the positive carry (if any) that the asset earns, and (2) the percentage change in the asset’s price. In the case of equities, their total return consists of the dividend yield (the equity market’s notion of positive carry) plus the percentage change in the price of equities. For bonds, the total return on a medium-to-longer-dated maturity bond consists of the term-premium on the bond (plus the roll-down from riding the yield curve), which represents a bond’s positive carry, plus the change in the bond’s price. For foreign exchange, the total return on a long high-yield/short low-yield currency position consists of the positive carry on the long/short currency position (the average yield spread between the high and low-yield currency positions) plus the rate of change in the high-yield currency’s value versus the low-yield currency.

Carry has been found to be both an important source and a predictor of total returns across all major asset classes. For example, in the case of equities, dividends have made up roughly 40%-45% of total equity market returns over the 1926-2013 period. In the case of fixed income, the return on medium-to-longer-dated Treasuries over the 1952-2009 period (a 57-year time span where the starting and ending period yield levels were broadly the same) outperformed shorter-dated Treasuries by an amount roughly equal to the term-premium that the medium-to-longer-dated Treasuries offered (see Figure I-1).

Figure I-1

Performance of U.S. Fixed-Income Carry Trades
(1952-2009)

Maturity	Excess Return	Standard Deviation of Return	Sharpe Ratio	Skew
3-Year	1.60	4.30	0.36	0.66
5-Year	2.30	5.30	0.43	0.04
7-Year	2.60	6.50	0.39	0.07
10-Year	2.70	8.30	0.33	0.16

Source: Norges Bank Investment Management (2011)

A recent study entitled “Carry” by Koijen, Moskowitz, Pedersen, and Vrugt (2012) found that positive carry tended to predict future returns across all asset classes. That is, securities that offered the highest positive carry in each asset class tended to generate the highest total return over time in that asset class. Koijen et al. found that carry trades in each of the major asset classes—equities, bonds, currencies and commodities—where investors undertook long positions in the higher yielding instruments funded with short positions in the lower yielding instruments in the respective asset classes, generated relatively high Sharpe ratios averaging between 0.5 and 0.9, which were higher than the reported Sharpe ratio of 0.4 for a long-run buy-and-hold investment in the S&P 500 index.

What is particularly interesting about Koijen et al.’s results is that the returns on carry trades in the four asset classes have not been highly correlated with one another. Hence, the authors find that a diversified carry-trade strategy across all four of the asset classes would have generated a very impressive Sharpe ratio of 1.4.

The FX Carry Trade — A Brief Overview

FX carry trades, which are the focus of this report, can be viewed as a subset of a broader array of carry-trade related strategies that can be undertaken across all asset classes. As we will demonstrate, positive carry is both an important source and predictor of currency returns. Figure I-2 shows that over the 1971-2005 period, high-yield currencies outperformed their low-yielding counterparts both in absolute and risk-adjusted terms. The table comes from a recent study by Lustig and Verdelhan (2006) who first ranked all major G-10 and EM currencies by their yield level—from lowest to highest yielding currency. Lustig and Verdelhan then created six equally weighted currency baskets, placing the lowest yielding currencies into Basket 1, then placing the medium-to-higher yielding currencies into Baskets 2-5, and finally placing the highest yielding currencies into Basket 6. As shown in Figure I-2, the lowest yielding currencies (Basket 1) generated the lowest average return in U.S. dollar-terms over the 1971-2005 period, while the highest yielding currencies (Basket 6) generated the highest average return in U.S.$ terms over the same period.

Figure I-2

Positive Carry as a Predictor of Currency Excess Returns
FXC Carry Trade Performance of Low, Medium, and High-Yield Currency Baskets
(1971-2005)

	Currency Baskets						
	Low Yield		Medium Yield			High Yield	
	1	**2**	**3**	**4**	**5**	**6**	**Long 6/Short 1**
Average Annual Return (%)	-1.06	1.44	1.07	2.47	2.42	3.29	4.35
Standard Deviation (%)	9.84	9.88	9.78	8.81	8.97	8.86	6.77
Sharpe Ratio	-0.11	0.15	0.11	0.28	0.27	0.37	0.64

Source: Lustig and Verdelhan, “Evaluating the Carry Trade as a Trading and Investment Strategy” (2006).

Lustig and Verdelhan then constructed a diversified carry-trade portfolio from their data set by simulating a strategy that takes a long position in Basket 6 (the high-yielders) and a short position in Basket 1 (the low-yielders). As shown in Figure I-2, the simulated carry-trade strategy would have generated a positive excess return of 4.35% per annum over the 1971-2005 period.

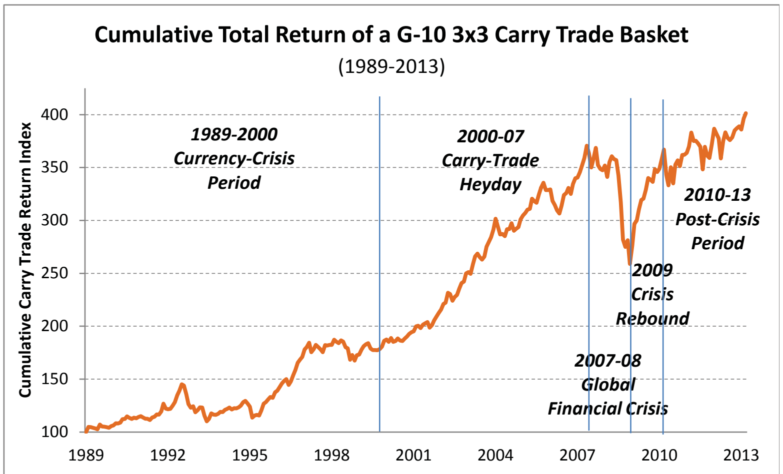
Because the strategy is fully funded—the long position in Basket 6 is funded by a short position in Basket 1—the reported return of 4.35% per annum should be viewed as an "excess return", i.e., the reported return that is in excess of whatever the prevailing risk free rate was during the test period. The reported Sharpe ratio of 0.64 on the long Basket 6/short Basket 1 simulated carry trade portfolio is significantly higher than what could have been generated by a buy-and hold long position in U.S. equities (0.4).

Macro Drivers of Carry Trade Returns

An FX carry trade entails taking on a long position in a high-yield currency (or a group of high-yielders) and a short position in a low-yield currency (or a group of low-yielders). By taking on such a long/short currency position, the carry-trade investor is betting that the yield advantage earned by being long the high-yielders and short the low-yielders will not be completely offset by a depreciation of the high-yield currencies versus the low-yield currencies.

Speculative bets in favor of high-yield currencies at the expense of low-yield currencies have turned out to be profitable ones. Figure I-3 plots the long-run cumulative return that could have been earned on a simulated diversified G-10 carry-trade strategy in which equally weighted long positions in the three highest yielding G-10 currencies and equally weighted short positions in the three lowest yielding G-10 currencies were held over the 1989-2013 period. This simple strategy would have generated an average annual excess return of 5.9% over this 24-year period, with an annualized volatility of return of 9.3%, and an estimated Sharpe ratio of more than 0.6.

Figure I-3



Source: *Bloomberg* FXFB <GO>

Figure 1-4

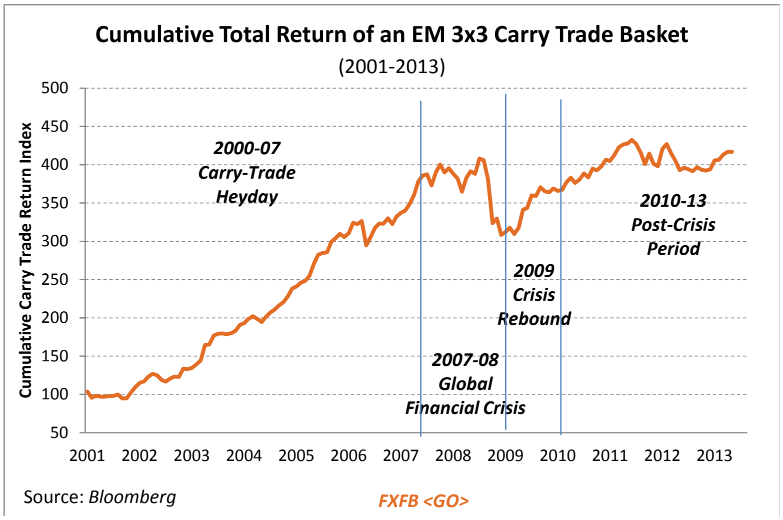


Figure I-4 illustrates the risk/return attributes of a similarly constructed portfolio for the EM currencies. The time span examined here is much shorter than the one used for G-10 currencies, largely due to data limitations, but the 2002-2013 period is also probably better representative of global investor interest in EM carry trades. Diversified EM carry trades have only come into vogue in the past decade. Prior to that, many EM countries had experienced periodic crises involving currency crashes, debt defaults, and inflation spikes, which evidently discouraged investors in developed markets from actively pursuing carry-related strategies in EM currencies.

On top of that, liquidity conditions in many EM currencies were generally not deep enough to attract sizable amounts of overseas capital. In several cases, capital-flow restrictions and regulatory structures probably limited the involvement of international investors in EM carry trades as well. With that said, the simulated returns on a simple 3 X 3 diversified EM carry-trade strategy over the 2002-13 period would have generated an impressive annual return of 12.4% per annum, with an annualized standard deviation of return of 10.6% and an estimated Sharpe ratio of 1.2.

One of the interesting things that stands out in Figures I-3 and I-4 is the tendency of carry trades to post long successful runs where positive returns were earned for consecutive years at a time, but then suffer through brief episodes where very large losses are incurred. In the case of G-10 carry trades, the most notable setbacks were in 1992, with the collapse of the ERM carry trade; in 1998, with the infamous unwinding of the yen carry trade; in 2006, as signs of overstretched markets first became apparent; and then in 2008-09, with large declines registered by many high-yielding currencies during the Global Financial Crisis. EM currencies suffered similar fates in the past decade.

This pattern of long successful runs followed by sudden currency crashes can be attributed in part to several factors. Brunnermeier, Nagel, and Pedersen (2009) trace the evolution of a typical carry-trade cycle from the gradual buildup of speculative positions in long high-yield/short low-yield carry-trade strategies to the forced unwinding of those positions when the volatility regime shifts and liquidity conditions tighten.

According to Brunnermeir et al., in a typical carry-trade cycle, an initial widening in high-yield/low-yield interest rate spreads tends to attract capital into the high-yield market, but the pace of capital inflow tends to be modest at first. There appears to be a great deal of inertia in capital inflows in the early stages of a carry-trade cycle for several reasons. First, most global fund managers need to see evidence of a sustained period of positive excess returns to make them confident to add risky high-yield currencies to their portfolios. Wider spreads alone will not attract large waves of capital inflows unless investors are confident that exchange rates will not move to offset the yield advantage that high-yield currencies offer. To gain that confidence, investors often rely on successful back-tests of risky strategies before they are ready to commit meaningful amounts of capital to the trade. As evidence accumulates that the uptrend in carry-trade returns appears sustainable, only then will more capital be committed to the trade. This wait-and-see approach gives rise to a gradual adjustment in portfolio allocations, which in turn gives rise to a gradual pace of capital inflow and trend-persistence in positive excess returns earned on FX carry trades.

A second factor contributing to slow-moving capital into high-yielding markets is that currency fund managers need access to funding from bank counterparties to help finance their carry-trade activities. Such funding might not be as forthcoming in the early stages of a carry-trade cycle, when investment-manager capital might still be modest and counterparty confidence and capital might be in short supply. Investment managers need to develop a successful track record to attract capital and that takes time. Hence, these institutional factors could slow the pace of investor participation in FX carry trades.

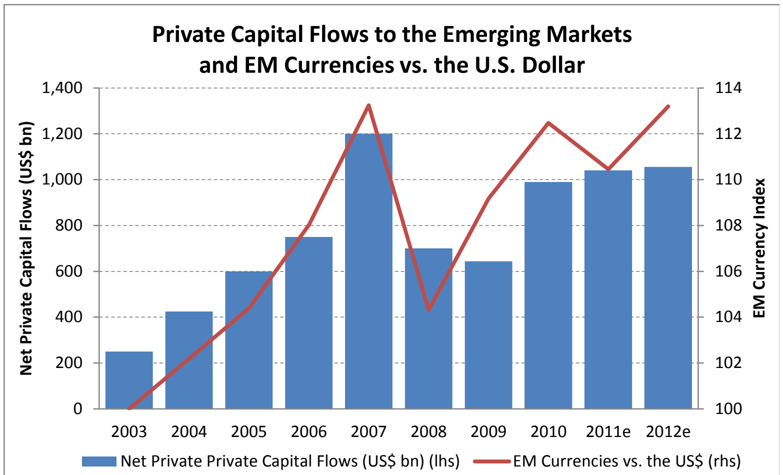
Third, trend persistence in carry-trade excess returns can be reinforced by the actions of central-bank policymakers. From a purely macro perspective, cycles in interest rates and interest rate spreads tend to proceed gradually, which in turn, generate trend persistence in cumulative positive carry and trend increases in high-yield currency values. The gradual trend-like behavior of short-term interest rates follows from the pursuit of gradualism in the conduct of monetary policy by most central banks. Monetary policymakers in most nations tend to adjust their official lending rates gradually rather than rapidly over time—in part because of the uncertainty that policymakers face in general and in part because the authorities do not want to seriously disrupt their domestic financial markets.

Because the monetary authorities in both high and low-yield countries tend to gradually adjust their domestic policy rates over time, a high-yield country will most likely see its short-term interest rates rise gradually relative to the level of short-term interest rates in the low-yield country. These slowly evolving policy courses will therefore give rise to trend-persistence in positive carry enjoyed by the high-yield market, and in the process encourage trend-persistence in the positive excess returns earned by FX carry trades.

Fourth, trend-persistence in carry-trade excess returns can be facilitated by the FX intervention stances of central banks in both target and funding markets. Consider the case of the Japanese yen and Swiss franc. Both the Bank of Japan (BoJ) and Swiss National Bank (SNB) have at times intervened strongly to limit the strength of their currencies. Both central banks have also kept their policy rates at very low levels to limit the upside moves in their currencies. Since both the yen and Swiss franc have tended to be funding currencies in FX carry trades, limiting the upside potential of both currencies reduces some of the downside risks in carry-trade strategies. Indeed, reducing the downside risk creates a sort of one-way street that encourages investors to become more actively involved in yen and Swiss franc-funded carry trades. Investors, however, are unlikely to jump into such trades the moment the BoJ and SNB intervene. They will need to see evidence that the intervention stance is working first and that takes time, which in turn, helps to generate trend-persistence in both yen and Swiss franc borrowing, and thus trend-persistence in carry-trade excess returns.

In the case of EM currencies, the intervention stance of EM monetary authorities has contributed to the trend-persistence in EM carry trades. As shown in Figure I-5, capital flows to EM nations have climbed in the past decade—with a brief decline in 2008-09 during the Global Financial Crisis—and the value of EM currencies as a group has tended to rise and fall in sympathy with changes in those capital flows. There probably would have been considerably greater upward pressure on those currencies if not for the concerted intervention efforts by EM central banks to limit EM currency gains, particularly in the case of Asian authorities.

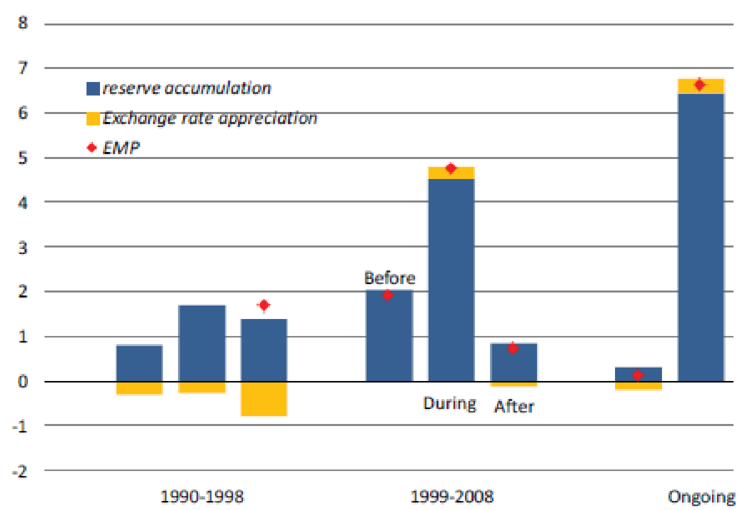
Figure I-5



Source: *Suttle et al. (2011); Bloomberg* USTWOITP INDEX<GO>

As shown in Figure I-6, exchange-market pressure tends to show up either in outright exchange-rate appreciation or through central-bank reserve accumulation, which is designed to resist the upward pressure on currency values. The IMF constructs Exchange Market Pressure (EMP) indices to capture the total pressure being exerted on EM currencies by weighting both the monthly movement in currency values and the monthly change in FX reserves held by EM central banks. According to the IMF's EMP indices, more than 90% of the upward pressure on Asian currency values has been resisted through outright intervention by Asian monetary authorities. Such intervention tends to stretch out the trend appreciation of the Asian currencies versus the U.S. dollar, which in turn, tends to generate trend persistence in Asian currency carry-trade returns.

Figure I-6



Source: Mahmood Pradhan, Ravi Balakrishnan, Reza Baqir, Geoffrey Heenan, Sylwia Nowak, Ceyda Oner, and Sanjaya Panth, "Policy Responses to Capital Flows in Emerging Markets", IMF Staff Discussion Note, SDN/11/10, April 21, 2011, page 11.

Carry Trades through History

Brunnermeier et al. make the case that slow-moving capital into FX carry trades creates a timeline in which a steady widening in interest-rate differentials contributes to a gradual buildup of net speculative positions. That buildup then places carry-trade investors in a vulnerable position in which a sudden shock might force investors to unwind those speculative positions, thereby precipitating a crash in carry-trade returns. While it is often the case that capital tends to move slowly into FX carry trades, the exit from FX carry trade positions tends to be rapid.

There have been a number of classic episodes of long, persistent runs of positive excess returns earned on FX carry trades that are followed by sharp sudden setbacks. Accominotti and Chambers (2013) document that large gains were generated in carry-trade related strategies in the 1920s, which were then followed by a decade-long period of negative returns after the global equity markets crashed and the world economies entered into the Great Depression in the 1930s. The U.S. dollar's run-up in the first half of the 1980s was carry-trade-related as U.S. short-term interest rates rose to levels well above those in most other tradable markets in the G-10. The dollar then gave back those gains in the second half of the decade when U.S. interest rates receded.

The heyday of the yen carry trade in the second half of the 1990s is another example of a long, persistent run in the performance of FX carry trades. Low Japanese short-term interest rates encouraged investors to short the yen in favor of the dollar and other high-yield currencies between the spring of 1995 and the fall of 1998. The short-yen trade generated significant profits for carry-trade investors for much of that 3 1/2 year period, before the sudden and dramatic unwinding of the yen carry trade in the fall of 1998.

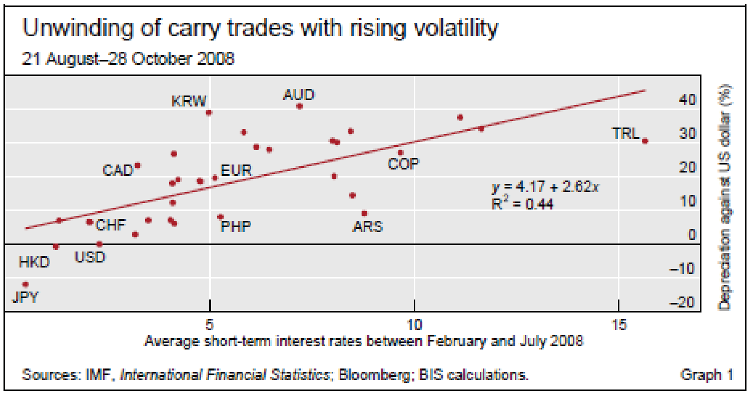
The 2002-07 period witnessed large reported gains on both G-10 and EM carry trades. A confluence of highly favorable factors operated to create an extremely hospitable environment for risky assets in general and global FX carry trades in particular. These favorable factors included a dramatic easing in U.S. policy rates that drove U.S. real short-term interest rates into negative territory and pushed the U.S. Fed Funds rate significantly below Taylor Rule prescribed policy-rate settings. The Fed's easy monetary-policy stance helped foster an environment of highly accommodative financial conditions—as evidenced by the dramatic declines in risk spreads—and in significant declines in equity-market volatility readings. The low level of U.S. policy rates encouraged investors to "search for yield", which lead them to become more highly involved in risky assets and strategies that offered the opportunity to earn higher returns. As the returns on risky assets and strategies rose, investors became more emboldened to take on more highly leveraged bets in such strategies to eke out ever higher returns.

FX market conditions in the world currency markets were also especially attractive, heading into the early 2000s. Many of the G-10 currencies had been pushed dramatically lower and were undervalued on purchasing power parity grounds after the U.S. dollar's run-up in the second half of the 1990s when the U.S. tech boom helped drive both U.S. equities and the dollar sharply higher. And many of the EM currencies had fallen sharply in the second half of the 1990s, following the Asian financial crisis of 1997-98 and a number of large one-off devaluations in some prominent EM currencies in the 2-3 years that followed. As a result of these depressed trading levels when the new millennium began, there was great upside potential in many of the G-10 and EM currencies once the global financial environment turned more favorable.

Figure I-7

The Impact of Increased Market Volatility on Low-Yield and High Yield Currencies

Depreciation of Currrencies against the U.S. Dollar from August-October 2008



Source: Robert N McCauley, Patrick McGuire, "Dollar Appreciation in 2008: Safe Haven, Carry Trades, Dollar Shortage and Overhedging", BIS Quarterly Review, December 2009, 7 December 2009, page 88.

The dramatic unwinding of the global FX carry trade during the 2008-09 Global Financial Crisis followed the script of previous major carry-trade unwinds. Financial conditions started to deteriorate in 2007 and then collapsed when the global financial markets melted down in the fall of 2008. With liquidity conditions turning less favorable, highly leveraged investors found that their access to funding liquidity had dried up, which forced them to unwind their carry-trade positions in favor of safe-haven currencies such as the U.S. dollar. Figure I-7, which comes from a BIS study, reveals that countries with the highest short-term interest rates saw their currencies depreciate the most versus the U.S. dollar in 2008. Thus, the currencies that rode the carry-trade boom in 2002-07, fell the hardest in 2008.

Despite the quick recovery of many high-yield currencies in 2009 and the trend decline in FX and equity-market volatility readings over the 2010-12 period, there was very little follow-through in terms of high-yield currency gains. Several factors contributed to the muted performance of FX carry trades during the post-crisis period.

First, many investors pulled back from all risky assets and strategies, including FX carry trades. Second, the level of positive carry earned on FX carry trades declined significantly, with many central banks having cut their policy rates to historically low levels. Third, there was an increased frequency of volatility spikes—particularly in 2010-12—relative to the number of spikes that occurred in the pre-crisis era.

As we look beyond the immediate post-crisis period, signs are beginning to emerge that the environment for FX carry trades is turning more favorable. Risky assets in general have posted strong returns since mid-2012 as evidenced by the strong performance of the world equity markets. FX carry trades have generated strong returns as well, both in the G-10 and EM spheres.

Nevertheless, it remains to be seen whether these gains will persist going forward. FX carry trades will have to overcome a number of hurdles—including the overvaluation of several key high-yield currencies, the broad-based decline in positive carry offered by the high-yield currencies, and the recent broad-based gains made by the U.S. dollar—in order for G-10 and EM carry trades to continue their recent strong run.

Part II — Theory

It has been said that the FX carry trade is a trading strategy that is unprofitable in theory, but profitable in practice (see Cavallo (2006). According to theory, the excess returns on FX carry trades should be zero. This is one of the principal theoretical findings from one of the stalwart equilibrium conditions in the field of international finance—the uncovered interest rate parity (UIP) condition. The UIP condition maintains that the returns on high and low-yield currencies should match each other over time. If the returns on high and low-yield currencies matched each other, it would not be possible to generate positive excess returns on strategies that were long high-yield currencies and short low-yield currencies.

According to the UIP condition, the initial yield advantage that a high-yield currency offers over its low-yielding counterpart will be expected to be offset by a depreciation of the high-yield currency versus the low-yield currency. If the offset is complete, the all-in returns (the initial yield spread plus the change in the exchange rate) on the high and low-yield currencies should be broadly the same. Thus, according to theory, if the returns on high and low-yield currencies are expected to be the same, then FX carry trades, which are long high-yield currencies and short low-yield currencies would not be undertaken by international investors.

The UIP condition has been one of the most widely tested propositions in the field of international finance. The overwhelming finding from hundreds of empirical studies is that changes in the value of high-yield currencies have *not* completely offset the yield advantage that high-yield currencies have offered relative to their low-yielding counterparts. That is, when we take into account both the initial yield advantage and the actual change in exchange rates, the evidence suggests that high-yield currencies have actually outperformed their low-yielding counterparts over time.

Investors could have profited from this difference in total-return outcomes by actively pursuing long high-yield/short low-yield FX carry trade strategies. But while such strategies have been found to be profitable over time, they have by no means been riskless. In the world financial markets, nothing goes up in a straight line forever. Indeed, from time to time, investors have suffered large losses on their carry-trade positions when high-yield currencies have suffered major setbacks. How one manages those downside risks is important both from a long-run, stay-in-business standpoint, and to insure that one has sufficient financial resources and confidence to re-enter carry-trade positions when the going gets good again.

Understanding the ins and outs of the UIP condition—how it is supposed to operate in theory, and how it stands up to empirical verification—is critical for understanding how and why FX carry trades have been able to generate positive excess returns over time, and why such trading positions can run into trouble when volatility, valuation, and positioning readings become stretched. In this section, we discuss the theory behind the UIP condition. In Part III we review the empirical evidence on UIP to determine the extent to which investors can profit from deviations from UIP.

The UIP condition is actually one of several international parity conditions that describes how, under certain ideal conditions, expected inflation differentials, interest-rate differentials, forward exchange rates, and current and expected future spot exchange rates should all be linked internationally. Knowing how these international parity conditions are linked both theoretically and empirically will help one better understand the opportunities and risks associated with FX carry trades.

There are actually six key international parity conditions that describe how relative interest rates, expected inflation rates and spot and forward exchange rates relate to one another on a purely theoretical level. These include (1) the UIP condition, (2) the ex-ante purchasing power parity condition, (3) the covered interest rate parity condition, (4) real interest-rate parity, (5) a parity condition that links nominal interest-rate differentials and expected differences in national inflation rates and (6) the forward-rate unbiasedness hypothesis, which asserts that if the UIP and the covered interest-rate parity conditions both hold, then the forward exchange rate should be a reliable and unbiased predictor of the future spot exchange rate. We discuss each of these parity conditions more fully below, both on an individual basis and how they interact with one another.

Covered Interest Rate Parity

An investment in a long high-yield/short low-yield carry-trade strategy is a risky undertaking because the rate of return on the strategy can be highly variable, and at the same time, those returns can be exposed to large downside moves during periods of financial and economic stress. If an investor wanted to hedge the associated FX risk in a carry-trade position by selling the high-yield currency forward in the forward exchange market, one might wonder if it would be possible to construct a position that protects the investor's downside, and at the same time provide the opportunity for upside gains.

According to the theory of covered interest rate parity (CIP), the answer to that posed question would be no. Eliminating the FX exposure through a forward-rate hedge would completely eliminate the possibility that an investor could earn any positive excess return on the fully hedged carry-trade strategy.

The CIP condition contends that arbitrage will eliminate all excess profits on fully hedged long high-yield/short low-yield carry trade positions. By eliminating the FX risk in the forward exchange market, a fully hedged high-yield currency investment would have the same risk characteristics as a low-yield currency investment. With similar risk characteristics, their returns should then be the same. Hence, a carry-trade position that is long a fully hedged high-yield currency and short a low-yield currency should be expected to earn a zero profit.

Mathematically, the CIP condition can be expressed in the following manner. The continuously compounded rate of return on a low-yield money-market instrument in time period *t* (i^L_t) should yield the same exact continuously compounded rate of return on a fully hedged high-yield money-market instrument over the same time period ($i^H_t + [f_t - s_t]$):

$$i^L_t = i^H_t + (f_t - s_t) \tag{1}$$

where s_t and f_t are the respective spot and forward exchange rates expressed in logs, and $(f_t - s_t)$ represents the continuously compounded percent forward discount that the high-yield currency's forward exchange rate trades relative to the spot exchange rate. Arbitrage will insure that the percent forward discount will trade at a level that just equalizes the returns on the low-yield and fully hedged high-yield money-market instruments.

Mathematically, Equation 1 can be re-written to show that the percent forward discount on a high-yield currency must equal the yield spread between the low and high-yield markets when CIP holds:

$$(i^L_t - i^H_t) = (f_t - s_t) \tag{2}$$

Equation 2 can be recast as a covered interest arbitrage condition by subtracting the right side of the equation from the left side, as shown in Equation (3):

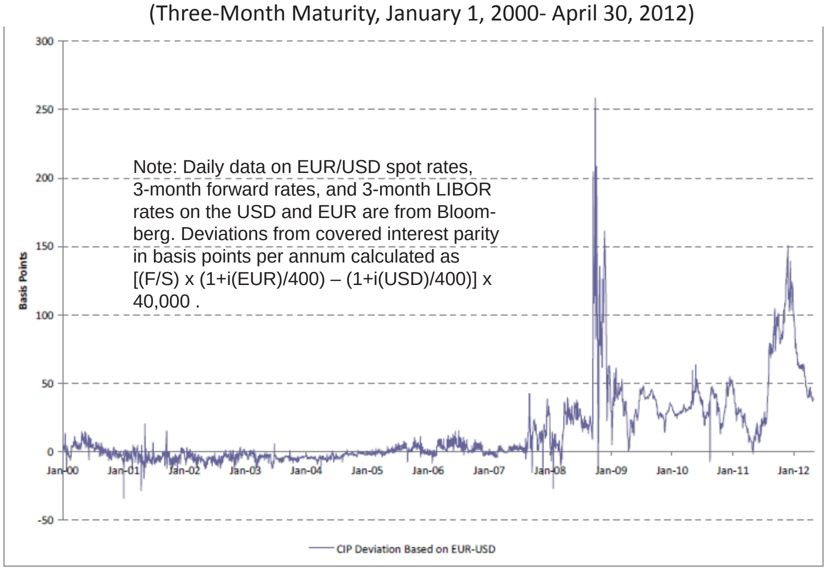
$$(i^L_t - i^H_t) - (f_t - s_t) = 0 \tag{3}$$

Equation 3 simply states that if CIP holds, then the returns to covered interest arbitrage, i.e., the returns to taking long positions in fully hedged high-yield currencies funded with short positions in low-yield currencies, should be zero.

Figure II-1

Deviations from Covered Interest Parity

(Three-Month Maturity, January 1, 2000- April 30, 2012)



Source: Richard M. Levich, "FX Counterparty Risk and Trading Activity in Currency Forward and Futures Markets", : June 27, 2012, page 23.

Up until the 2007-09 Global Financial Crisis, most econometric studies found that the CIP condition was a valid proposition in the majority of G-10 markets. Any deviations from CIP that did occur tended to be short lived—in seconds or minutes—and the magnitude of the excess returns that could have been earned from covered interest arbitrage tended to be miniscule. Once the global financial crisis hit in 2007, however, and particularly after the collapse of Lehman Brothers in the fall of 2008, heightened counterparty risk and the lack of funding liquidity combined to limit arbitrage activity.

Arbitrage-constrained covered interest-rate differentials jumped from near zero prior to the crisis to 25 basis points in the early stages of the crisis, and then shot up to over 200 basis points beginning in the fall of 2008 and into early 2009 (see Figure II-1). The Federal Reserve responded to the crisis-driven funding shortage by expanding its swap lines with other foreign central banks and this helped infuse the market with new liquidity, which helped ease arbitrageurs' concerns over counterparty risks. As a result of the Fed's aggressive actions, covered interest rate differentials began to move sharply lower in 2009 and beyond, but still remained above the near-zero readings that had prevailed pre-crisis.

Uncovered Interest Rate Parity

The UIP condition, or more accurately the *failure* of the UIP condition represents the bedrock of the FX carry trade. According to the UIP condition, the *expected* return on an unhedged (i.e., an uncovered) high-yield currency investment should equal the *expected* return on a low-yield currency investment. A high-yield currency might offer an initial yield advantage over a lower yielding currency, but over time the UIP condition contends that the yield advantage should be completely offset by an *expected* depreciation of the high-yielding currency versus the low-yielding currency. If the high-yield currency did decline in value to completely offset the initial yield advantage, it would rule out the possibility of earning positive excess returns on FX carry trades.

Mathematically, the UIP condition can be expressed in the following manner. The expected return on a low-yield currency investment (i^L_t) should equal the yield on a high-yield currency investment (i^H_t) plus the expected rate of depreciation of the high-yield foreign currency versus the low-yield currency (Δs^e_{t+1}):

$$i^L_t = i^H_t + \Delta s^e_{t+1} \qquad (4)$$

Equation 4 can be rearranged to restate the UIP condition in terms of the expected change in the exchange rate:

$$i^L_t - i^H_t = \Delta s^e_{t+1} \qquad (5)$$

According to Equation 5, the expected change in the high-yield currency's value should be reflected in the low-yield/high-yield interest-rate differential.

Equation 4 states that if UIP holds, then investors should be indifferent between owning low-yield versus high-yield currency investments because both investments would be expected to earn the same mean (average) rate of return over time. The high-yield currency might offer an initial yield advantage, but if it is assumed that the high-yield currency depreciates in line with UIP over time, then the high-yield currency investment should be expected to earn the same mean rate of return as the low-yield currency investment.

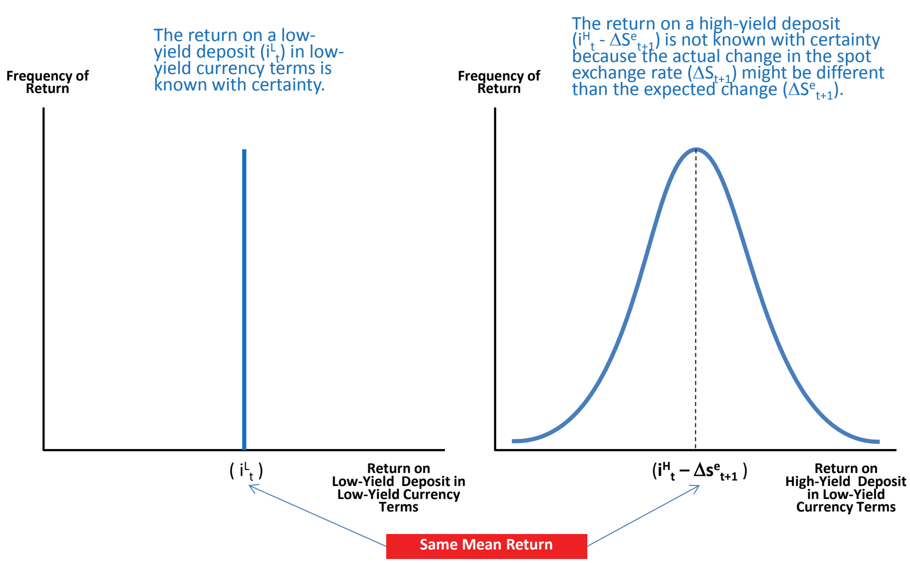
Although both the low and high-yield currency investments might offer the same mean expected return, the distribution of possible total return outcomes could differ quite widely. Consider the case of an investor who is based in a low-yield country. From this investor's perspective, the return on a low-yield currency money-market investment in low-yield currency terms (i^L_t) would be known with certainty. The return on a high-yield currency investment in low-yield currency terms ($i^H_t + \Delta s^e_{t+1}$), however, would not be known with complete certainty at any point in time because of the potential high variability in the high-yield currency's value—even if the mean return on the high-yield currency investment in low-yield currency terms is expected to match the return on the low-yield currency investment on average. From a low-yield country investor's perspective, the distribution of possible total return outcomes on the high-yield currency investment is likely to be far wider than the distribution of returns on the low-yield currency investment because of the potential high variability in the high-yield currency's value.

As illustrated in Figure II-2 and viewing expected-return outcomes in low-yield currency terms, although both low and high-yield currency investment might offer the same mean expected rates of return, their risk characteristics differ widely, with the high-yield currency investment offering the more variable rate of return. Risk-averse investors in the low-yield currency market would clearly prefer the certain rate of return that the low-yield currency investment offers over the uncertain

Figure II-2

The Impact of Increased Market Volatility on Low-Yield and High Yield Currencies

Depreciation of Currrencies against the U.S. Dollar from August-October 2008



Source: Bloomberg

short-term return prospects that the high-yield currency investment offers, even though the mean long-term expected rates of return on the two competing currency investments might be the same.

The UIP condition assumes that investors are *no*t risk averse and are therefore willing to take on the risk that the variability of return on the high-yield currency investment will be wider than the distribution of return on the low-yield currency investment. The UIP condition assumes that investors are only concerned about mean expected returns—if two assets offer the same mean expected return, then investors should be indifferent between owning one investment versus the other.

Risk-averse investors, on the other hand, would not be indifferent between the low and high-yield currency investments. If the return on the high-yield currency investment is expected to be far more variable than the return on the low-yield currency investment, then risk-averse investors should demand that the high-yield currency investment offer a risk premium or positive expected return that exceeds the return on the low-yield currency.

Mathematically, the risk premium (φ_{t+1}) can be expressed as the difference between the expected rates of return on the competing currency investments,

$$(i^H_t + \Delta s^e_{t+1}) - i^L_t = \varphi_{t+1} \tag{6a}$$

or as the nominal yield spread adjusted for the expected change in the exchange rate,

$$(i^H_t - i^L_t) + \Delta s^e_{t+1} = \varphi_{t+1} \tag{6b}$$

The UIP condition makes the assumption that the risk premium (φ_{t+1}) is zero. Hence, investors are assumed to be indifferent between owning high-yield versus low-yield currency investments as long as they offer the same mean expected returns. In practice, because high-yield currency investments are more risky, they should command a higher expected return, i.e., a risk premium that exceeds zero. In a way, the positive risk premium can be viewed as the positive excess return that investors should expect to earn if they are willing to take on the exchange-rate variability risk associated with FX carry trades.

The Forward-Rate Unbiasedness Hypothesis

The CIP condition describes how spot exchange rates, forward exchange rates and interest-rate differentials are linked. The UIP condition describes how interest-rate differentials and expected changes in spot exchange rates are linked. If both CIP and UIP hold, then it can be easily demonstrated mathematically that the forward exchange rate should be an accurate and unbiased predictor of the expected future spot exchange rate.

Theoretically speaking, if CIP holds, from Equation 2 above, the percent forward discount on the high-yield currency must equal the nominal interest rate differential between the low and high-yield markets:

$$(i^L_t - i^H_t) = (f_t - s_t) \qquad (2)$$

and at the same time, if UIP holds, as shown in Equation 5 above, then:

$$(i^L_t - i^H_t) = \Delta s^e_{t+1} \qquad (5)$$

Because the yield spread $(i^L_t - i^H_t)$ appears on the left side of both Equations 2 and 5, It then follows that the forward discount on the high-yield currency must also equal the expected change in the high-yield currency's value:

$$(f_t - s_t) = \Delta s^e_{t+1} \qquad (7a)$$

Because the expected change in the exchange rate (Δs^e_{t+1}) can be expressed as the difference between the expected level of the spot rate in period t+1 (s^e_{t+1}) and today's spot exchange rate (s_t), Equation 7a can be rewritten as:

$$(f_t - s_t) = s^e_{t+1} - s_t \qquad (7b)$$

In words, Equations 7a-b state that the market's expectation of the future change in the high-yield currency's value must be fully reflected in the forward discount on the high-yield currency. Because s_t appears on both sides of Equation 7b it follows that the forward exchange rate (f_t) must then equal the expected future spot exchange rate (s^e_{t+1}).

$$f_t = s^e_{t+1} \qquad (8)$$

If Equation 8 holds, then betting whether spot exchange rates in the future will lie above or below today's forward exchange rates should be an unprofitable endeavor. That is, the difference between f_t and s^e_{t+1} should be zero.

$$f_t - s^e_{t+1} = 0 \qquad (9)$$

As we discuss more fully below, Equation 9 fails to hold in most empirical studies of spot and forward exchange rates. Indeed, the overwhelming body of evidence from hundreds of studies suggests that the forward exchange rate has actually been both a poor predictor and biased predictor of the future spot exchange rate.

Ex-Ante Purchasing Power Parity

The CIP condition, the UIP condition, and the forward-rate unbiasedness hypothesis describe the equilibrium conditions that would prevail in the money and foreign-exchange markets in an ideal world. Specifically, these parity conditions describe how spot exchange rates, forward exchange rates, and relative interest rates are all linked internationally. These financial market linkages can be extended to the goods markets internationally via three other parity conditions, notably (1) the ex-ante purchasing power parity condition, (2) a parity condition that links interest-rate differentials and expected inflation rates and (3) real interest-rate parity.

According to the ex-ante purchasing power parity (PPP) condition, the expected change in the high-yield currency relative to the low-yield currency should equal the percentage difference between the expected national inflation rates of the low and high-yield economies, where $\pi^{e(L)}_{t+1}$ and $\pi^{e(H)}_{t+1}$ represent the expected inflation rates in the low and high-yield markets, respectively.

$$\Delta s^{e}_{t+1} = \pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1} \qquad (10)$$

Ex-ante PPP tells us that countries that are expected to run persistently higher inflation rates than their trading partners should expect to see their currencies depreciate over time, while countries that are expected to run relatively low inflation rates should expect to see their currencies appreciate over time. The ex-ante PPP and UIP conditions actually share some common ground, and therefore can be shown to be tightly linked. As discussed above, the UIP condition can be expressed mathematically from Equation 5 above as:

$$\Delta s^{e}_{t+1} = i^{L}_{t} - i^{H}_{t} \qquad (5)$$

while the ex-ante PPP can be expressed mathematically from Equation 10 above as:

$$\Delta s^{e}_{t+1} = \pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1} \qquad (10)$$

If both the UIP and ex-ante PPP conditions hold, it must then be the case that:

$$\Delta s^{e}_{t+1} = (i^{L}_{t} - i^{H}_{t}) = (\pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1}) \qquad (11)$$

What Equation 11 states is that countries that suffer high expected rates of inflation will tend to have higher domestic rates of interest relative to countries with lower expected rates of inflation. In turn, market participants expect that countries that suffer from higher expected rates of inflation will see their currencies depreciate over time in line with the expected differences in national inflation rates. And those exchange-rate expectations should be fully reflected in nominal yield spreads.

Real Interest-Rate Parity

If both UIP and ex-ante PPP both hold from Equation 11 above, it can be shown that real interest rates in high and low-yield markets should converge toward the same level. Mathematically from Equation 11 above, if

$$(i^L_t - i^H_t) = (\pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1}) \qquad (11)$$

then it must be the case that

$$i^L_t - \pi^{e(L)}_{t+1} = i^H_t - \pi^{e(H)}_{t+1} \qquad (12)$$

According to Equation 12 nominal interest rates adjusted for expected changes in national inflation rates should be the same across all markets if both UIP and ex-ante purchasing power parity hold. Since the gap between nominal yields and the expected inflation rate in each country is equal to the level of real interest rates in each market(r^L_t and r^H_t,respectively), it follows from Equation (12) that the level of real interest rates in each market must be the same:

$$r^L_t = r^H_t \qquad (13)$$

or more simply, real interest-rate differentials across all markets should gravitate toward zero:

$$r^L_t - r^H_t = 0 \qquad (14)$$

The proposition that real interest rates will tend to converge toward the same level across all markets (or that real interest-rate differentials should converge toward zero) is known as the real interest-rate parity (RIP) condition. RIP ties in with the UIP and ex-ante PPP conditions in the following manner. The UIP condition is an equilibrium condition that links *nominal* interest-rate differentials and expected changes in *nominal* exchange rates. The ex-ante PPP condition is an equilibrium condition that links the expected change in the *nominal* exchange rate and the difference in expected national inflation rates. From Equation (10) above, if ex-ante PPP holds, it follows from Equation 10 above that:

$$\Delta s^e_{t+1} = \pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1} \qquad (10)$$

And if ex-ante PPP holds, then the expected change in the *real* exchange rate (Δq^e_{t+1}), where *q* is defined as the real exchange rate, must equal zero since the difference between the left and right sides of Equation 10 must sum to zero:

$$\Delta q^e_{t+1} = \Delta s^e_{t+1} - (\pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1}) = 0 \qquad (15)$$

In words, Equation 15 maintains that if the expected change in the *nominal* exchange rate is fully offset by differences in expected national inflation rates, then the expected change in the *real* exchange rate (Δq^e_{t+1}) must be zero.

It can now be shown that the RIP condition is simply the *real* counterpart of the *nominal* UIP condition. From Equation (15) above, we have:

$$\Delta q^{e}_{t+1} = \Delta s^{e}_{t+1} - (\pi^{e(L)}_{t+1} - \pi^{e(H)}_{t+1}) \qquad (15)$$

and from the UIP condition in Equation 5 above, we know that:

$$\Delta s^{e}_{t+1} = i^{L}_{t} - i^{H}_{t} \qquad (5)$$

If we simply insert ($i^{L}_{t} - i^{H}_{t}$) for Δs^{e}_{t+1} in Equation 15, it can be shown with a little rearranging that the expected change in the real exchange rate should be fully reflected in the real yield spread between the low and high-yield markets.

$$\Delta q^{e}_{t+1} = (i^{L}_{t} - \pi^{e(L)}_{t+1}) - (i^{H}_{t} - \pi^{e(H)}_{t+1}) \qquad (16)$$

or more simply in real interest rate differentials terms

$$\Delta q^{e}_{t+1} = (r^{L}_{t} - r^{H}_{t}) \qquad (17)$$

In words, if real interest-rate differentials converge toward zero, and UIP and ex-ante PPP both hold, it follows then that the expected change in the real exchange rate should be zero as well.

International Parity Conditions — How Exchange Rates, Interest Rates, and Relative Inflation Rates Are Linked Internationally (Theoretically Speaking)

Figure II-3 describes how all of the key international parity conditions discussed above are linked. As illustrated, if all of the key international parity conditions held at all times, the expected change in the spot exchange rate would equal: (1) the forward premium (or discount), according to the forward-rate unbiasedness hypothesis; (2) the nominal yield spread, according to the UIP condition; and (3) the difference in expected national inflation rates, according to the ex-ante PPP condition.

The forward premium (or discount), in turn, would equal the nominal yield spread, according to the CIP condition, and differences in nominal yield spreads would reflect differences in expected national inflation rates. And if nominal yield spreads reflect differences in expected national inflation rates, then real interest rates across markets will tend to converge toward the same level. Thus, spot exchange rates, expected future spot exchange rates, forward exchange rates, relative interest rates, and relative expected inflation rates can be shown to jointly determine one another in an equilibrium setting.

If all of these parity conditions held, it would be impossible for a global investor to make money by shifting capital from one market to another. If forward exchange rates accurately predicted the future path that spot exchange rates will take, there would be no way to earn positive returns in forward-exchange speculation. If high-yield countries fell in value versus low-yield currencies exactly in line with the implied path predicted by nominal interest-rate spreads, all markets would offer the same currency-adjusted total returns over time. There would therefore be no incentive to shift funds from one market to another.

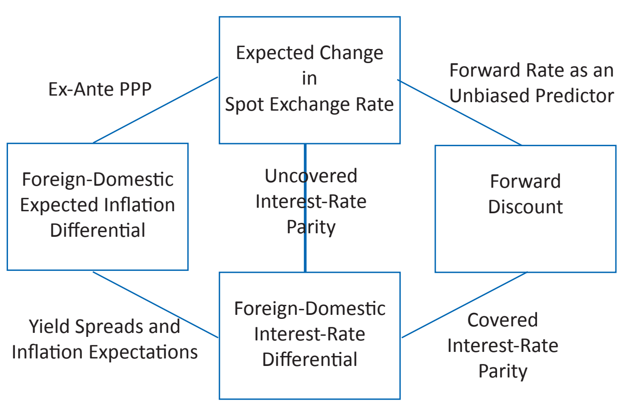
If, on the other hand, these parity conditions failed to hold in the real world, then this would open up the possibility for profitable opportunities from international investment. Most studies find that the key international parity conditions do indeed fail to hold—the CIP condition being the exception—at least up until the global financial crisis of 2007-09. The evidence clearly indicates that there are often large and persistent departures from UIP and ex-ante PPP, while the forward exchange rate has been found to be a poor and biased predictor of the future spot exchange rate. When these parity conditions fail to hold, the links in Figure II-3 break down, and when those links break down, profitable trading opportunities in the FX markets become available.

This is where FX carry trades come into the picture. Carry trades offer the opportunity for attractive risk-adjusted returns when the key international parity conditions break down.

Figure II-3

International Parity Conditions

How Spot Exchange Rates, Forward Exchange Rates,and Interest Rates



Source: Bloomberg

III — Empirical Evidence

The theory of uncovered interest parity (UIP) has been one of the most widely tested propositions in the field of international finance. Literally, hundreds of academic studies have tested whether UIP has held in both G-10 and emerging-market economies. Overwhelmingly, the evidence strongly suggests that UIP has not held, at least over short and medium-run time periods. Indeed, most studies have found that interest-rate differentials have failed to not only predict the future change in exchange rates, but have often gotten the direction of the exchange rate wrong.

While UIP suggests that high-yield currencies should depreciate over time relative to low-yield currencies, the evidence suggests that high-yield currencies have actually tended to rise in value instead of falling in value, while low-yield currencies have tended to fall in value instead of rising in value. The evidence thus suggests that the performance of high-yield currencies not only benefited from their relatively high yield, but also from outright gains in the value of high-yield currencies, gains that would not have been expected according to UIP. The opposite has been the case for returns on low-yielding currencies.

From a strategy standpoint, these findings suggest that investors would have benefitted by engaging in FX carry trades; i.e., taking on long positions in high-yield currencies that were fully funded with short positions in low-yield currencies.

While the returns from carry-trade strategies have generally been found to be attractive, carry-trade strategies have from time-to-time suffered significant losses over relatively short time spans, particularly during periods when market conditions were highly turbulent. Details on the risk/return performance of G-10 and emerging-market carry trades are discussed more fully below.

Empirical Tests of UIP – The Fama Regression

The uncovered interest rate parity condition cannot be tested directly and some assumptions must be made at the outset to test the proposition. In theory, if one wanted to empirically examine whether interest-rate differentials correctly reflected the market's expectation of the change in the exchange rate, the UIP condition should be tested by regressing the *expected* change in the exchange rate (Δs^e_{t+1}) on the interest-rate differential ($i^L_t - i^H_t$), plus a risk premium (ϕ_{t+1}) required by investors to buy and hold the risky high-yielding currency. If the UIP condition held in its pure form, then the estimated risk premium would be found to be zero.

Because arbitrage ensures that the interest-rate differential (in non-crisis environments) will equal the forward discount ($f_t - s_t$) according to the covered interest rate parity condition, the UIP-condition/forward-rate unbiasedness hypothesis could also be tested by regressing the expected change in the exchange rate (Δs^e_{t+1}) on the forward discount ($f_t - s_t$) plus the risk premium (ϕ_{t+1}). Equation 18 illustrates that the two approaches to test the UIP/forward-rate-unbiasedness hypothesis are essentially identical.

$$\begin{aligned}\Delta s^e_{t+1} &= \alpha + \beta(i^L_t - i^H_t) + \phi_{t+1} \\ &= \alpha + \beta(f_t - s_t) + \phi_{t+1}\end{aligned} \tag{18}$$

An analyst running these regressions would encounter a number of serious data-related issues. First, the *expected* change in the exchange rate is simply not observable. Although surveys of economists or FX analysts could be used as a proxy, analyst expectations might not be truly representative of exchange-rate expectations held by market participants as a whole. After all, most economists and FX analysts do not have "skin in the game" when it comes to trading in the FX markets. Second, there are no observable time series that can fully capture all risk-related factors that would need to be embedded in the estimated risk premium in Equation 18.

To get around these problems and to come up with a truly testable model that includes observable variables, most econometric tests of UIP (1) make the assumption that the risk premium is zero and (2) incorporate the assumption of rational expectations. According to the rational expectations hypothesis, market participants will use all available information to assess the likely future path that exchange rates will take. They might err in predicting the precise level or direction of the future exchange rate, but those errors, in theory, should balance out over time if market expectations are rational. If that is the case, actual outcomes and expected outcomes should broadly be the same, plus or minus a random error.

This is described mathematically in Equation 19 where the actual change in the exchange rate (Δs_{t+1}) is assumed to be equal to the change that the market expected (Δs^e_{t+1}) plus or minus a random disturbance term (u_{t+1}).

$$\Delta s_{t+1} = \Delta s^e_{t+1} + u_{t+1} \tag{19}$$

According to the rational expectations hypothesis, the random disturbance term (u_{t+1}) should average around zero, with positive and negative differences between actual and expected outcomes evening out over time. Thus, if the rational expectations assumption is valid, then the change in the exchange rate that the market expected should on average turn out to be the change that actually takes place.

The assumption of rational expectations allows a researcher to substitute the actual change in the exchange rate (Δs_{t+1}) for the expected change (Δs^e_{t+1}), thereby enabling the researcher to construct a testable model that regresses the actual change in the exchange rate on the interest-rate spread (or forward discount).

$$\begin{aligned} \Delta s_{t+1} &= \alpha + \beta(i^L_t - i^H_t) + \varepsilon_{t+1} \\ &= \alpha + \beta(f_t - s_t) + \varepsilon_{t+1} \end{aligned} \tag{20}$$

Equation 20 is often referred to as the Fama Regression, named after the University of Chicago Professor Eugene Fama's pioneering research on the UIP/forward-rate-unbiasedness hypothesis. Using the rational expectations hypothesis allows for data that is observable, but the regression equation now needs to be interpreted as a joint test of (1) whether the pure form of the uncovered interest rate parity condition holds (i.e., no risk premium), and (2) whether the rational expectations assumption is valid.

The Fama regression estimates how actual changes in exchange rates respond to variations in the interest-rate differential ($i^L_t - i^H_t$) or the forward discount ($f_t - s_t$). The regression model would find support for the UIP proposition if the interest-rate differential or forward discount were able to explain most of the actual change in the exchange rate in both magnitude and direction over time. This would be the case if the constant term (α) in the Fama Regression were estimated to be close to zero and if the estimate of the coefficient (β) on the interest-rate differential (or the forward discount) were close to 1.0.

If β is estimated to be close to 1.0, then the actual change in the spot exchange rate (Δs_{t+1}) would have matched the interest-rate spread ($i^L_t - i^H_t$) or the forward discount ($f_t - s_t$) in accordance with UIP. Another way of putting this is that the actual change in the spot exchange rate would have matched the change in the exchange rate that the market expected.

If instead the coefficient (β) on the explanatory variables were found to be close to zero, then actual changes in the spot exchange rate would have been found to be unrelated to the interest-rate differential (or the forward discount). If the coefficient were found to be less than zero, then changes in the spot exchange rate would move in a direction opposite to the path predicted by UIP. For a given yield spread between a high yield and low yield market, a high-yield currency would have tended to appreciate relative to the low-yield currency, and not depreciate as implied by UIP.

Empirical tests of Equation 20 strongly reject the UIP proposition that $\beta = 1$, with most studies finding β to be negative and significantly so. A survey of 75 studies on UIP conducted in the early 1990s by Froot and Thaler (1990) found that average estimate for β to be -0.88. A more recent study using data updated to the current period by Clarida, Davis and Pedersen (2009) found that estimates for β for most currencies versus the U.S. dollar for the entire 1990-2009 period continued to be significantly less than zero (see Column [a] of Figure III-1).

Figure III-1

Estimates of the Coefficient on the Forward Premium

Fama Regression for FX Single Pairs against the U.S. Dollar and 3x3 Baskets of High and Low-Yielding G-10 Currencies

		Volatility Environment	
Currency	**All**	**Low Vol.**	**High Vol.**
	[a]	[b]	[c]
AUD	-1.40	-7.12	5.65
CAD	-1.14	-0.72	-2.39
CHF	-2.78	-3.84	3.55
EUR	-3.07	-2.81	-1.13
GBP	0.87	-0.44	6.50
JPY	-2.56	-1.21	-1.34
NOK	0.43	-1.67	11.27
NZD	-1.52	-9.21	1.72
SEK	-1.52	-2.46	5.33
3x3 Basket	-1.21	-3.29	2.73

Source Richard Clarida, Josh Davis, Niels Pedersen, "Currency Carry Trade Regimes: Beyond the Fama Regression, NBER Working Paper 15523, November 2009, page 20, Table 4, http://www.nber.org/papers/w15523

Clarida et al.'s findings presented in Figure III-1 suggest that when U.S. interest rates were trading below those in most of the other G-10 countries, the dollar tended to depreciate, not appreciate as would have happened if UIP held. These findings apply more generally as well, with Clarida, Davis and Pedersen reporting a coefficient of -1.21 for a diversified G-10 currency portfolio consisting of long positions in the three highest yielding G-10 currencies that are fully funded with short positions in the three lowest yielding G-10 currencies over the 1993-2009 period. The negative coefficient indicates that high-yielding currencies tended to appreciate relative to low-yielding currencies, which would not have been the case if UIP were valid.

Estimates of Beta during Low and High Volatility States

Carry trades are risky and their performance often depends on the level of financial-market volatility. Clarida, Davis, and Pedersen (2009) take a closer look at the β coefficient estimates in the Fama Regression to see if β varies depending on whether FX market conditions are tranquil or turbulent.

The authors broke down the historical pattern of FX market volatility into four volatility states: a low-volatility state, consisting of the lowest 25% volatility readings; a high-volatility state, consisting of the highest 25% volatility readings; and two medium-volatility states. As shown in Column [b] of Figure III-1, in the lowest volatility state, the estimated β coefficients were found to be significantly negative, which suggests that high-yield currencies and carry trades in general tended to perform well during tranquil periods.

In contrast, in the highest volatility state in Column [c], the signs of the estimated β coefficients were found in most cases to be significantly positive on a bilateral exchange-rate basis versus the U.S. dollar. In most cases, the β coefficients in the high-volatility state were estimated to be well above 1.0, indicating that, in turbulent market conditions, low-yield currencies tended to appreciate versus their high-yield counterparts by more than the implied domestic-foreign yield spreads. This suggests that long high-yield/short low-yield currency trades have tended to generate significant losses during high-volatility periods. Figure III-1 shows that these findings hold up in the context of a 3x3 carry-trade basket as well.

Because high-volatility states have occurred less frequently than low-to-medium volatility states, at least for much of the past 20-30 years, long-run average estimates for the β coefficient in the Fama Regression have been found to be negative. That implies that the negative readings on the β coefficients reported for tranquil periods have tended to more than offset the positive estimates of β reported in turbulent periods. These findings would therefore support the case for undertaking carry-trade strategies from a *long-run* strategy standpoint. That is, over the long run, carry trades will tend to generate positive excess returns.

But those gains need to be viewed in the context that carry-trade returns can turn decidedly negative when market conditions turn more turbulent. The positive β estimates in high-volatility states indicate that when FX volatility spikes upward, those volatility spikes can and often do contribute to significant losses on carry-trade positions.

As Clarida et al.'s analysis suggests, FX carry trades are essentially a wager that FX volatility will remain low. Indeed a number of observers have likened the payoff of carry-trade positions to the payoff of short volatility positions. Investors who are short volatility stand to lose if volatility rises, but will stand to gain if volatility either remains low or declines.

An option trader who is short volatility collects an option premium. An FX carry-trade investor also collects a premium, which in this case is the positive yield spread between the high-yield and low yield currency. If FX volatility spikes higher, however, the carry trade position will suffer significant losses far exceeding the yield spread earned on the carry-trade position, resulting in large total return losses for the carry-trade investor.

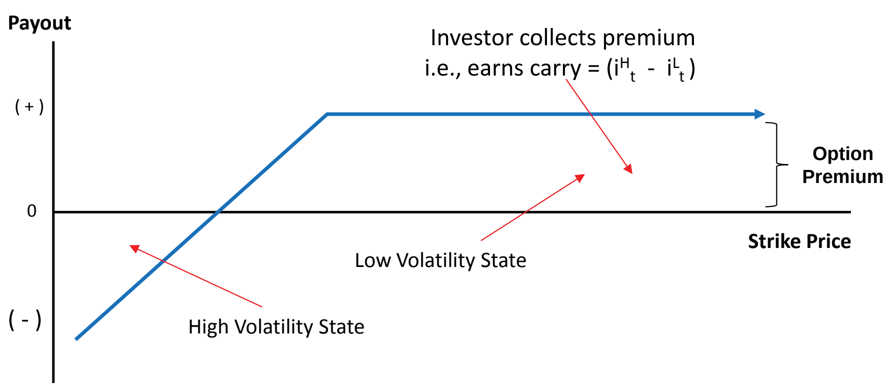
Figure III-2 illustrates this in the context of a trader who sells an out-of-the-money (OTM) put on a high-yield currency. As illustrated, an investor who sells an OTM put on the high-yield currency earns an option premium that is equivalent to the positive interest-rate spread on a carry-trade position. The position is profitable as long as FX market conditions remain tranquil. If market conditions become turbulent and the high-yield currency depreciates sharply, the OTM put on the high-yield currency will tend to suffer significant losses.

Since high-volatility episodes occur less frequently than low or moderate volatility states, the sale of an OTM put on the high-yield currency should earn modest positive returns over most time periods. But the option position will from time to time be subject to large losses when volatility spikes higher. It is because of this skewed or kinked distribution of option-like returns that a number of observers have likened FX carry trades to picking up nickels in front of a steamroller.

Figure III-2

Carry-Trade Payoff

Out-of-the-Money Put Option-Strategy Characteristics of FX Carry Trades



Source Bloomberg

Benefits of a Diversified Approach to the Carry Trade

Single-paired carry trades—long one high-yield currency and short one low-yield currency—have tended to generate Sharpe ratios that are not very high relative to other risky trading strategies. But most studies find that a multi-currency approach to carry trades can generate attractive risk-adjusted returns.

Clarida, Davis and Pederson (2009) shed light on the contribution that a diversified approach to carry trades can make to risk-adjusted returns by comparing the performance of five different carry-trade portfolios shown in Figure III-3. Portfolio 1 consists of a long position in the highest yielding G-10 currency and a short position in the lowest yielding G-10 currency. Portfolio 2 consists of equally weighted long positions in the two highest-yielding G-10 currencies and equally weighted short positions in the two lowest yielding currencies, and so on until we get to Portfolio 5.

The total return performance data in Figure III-3 represent excess returns because carry trades are fully funded strategies with equal exposure to the long and short positions in the carry trade. The reported excess returns (R^{CT}) are simply the positive carry ($i^H – i^L$) earned on the respective carry-trade portfolios adjusted for the weighted average change in the respective exchange rates.

Interestingly, the single-currency-pair currency trade of Portfolio 1 earned the highest average annual return of 4.98% but at the cost of incurring a considerably high annualized volatility of return of 15.06%, which generated a risk-adjusted excess return—the Sharpe Ratio—of only 0.33. This is a smaller Sharpe Ratio than what is typically associated with a simple buy-and-hold S&P 500 equity strategy (0.40), and is therefore is probably not high enough to justify allocating large sums to such trades.

Including additional currencies in the long and short currency baskets, however, would have significantly cut the volatility of the carry-trade strategy, and thus would have boosted the risk-adjusted performance of the G-10 carry trades. As we move down from Portfolio 1 to Portfolios 3 and 4, the average excess returns of the portfolios is reduced somewhat, but the volatility of return is cut by 40%-50%, pushing the Sharpe ratio for Portfolios 3 and 4 to over 0.50. This demonstrates that adding more currencies to a carry-trade portfolio can provide important diversification benefits for investors.

The question then becomes whether the diversification benefits are sufficient to help carry-trade investors cope in high-volatility states. Clarida et al. show that taking a long position in a basket of high-yield currencies and a simultaneous short position in a basket of low-yield currencies would have reduced the downside risk associated with single-paired carry trades during low and high volatility states.

Figure III-3

Risk-Return Profile of Selected Carry-Trade Currency Baskets
(1992-2009)

Portfolio (Baskets)	**Mean Return**	**Volatily of Return**	**Sharpe Ratio**
1. 1x1	4.98	15.06	0.33
2. 2x2	2.82	11.11	0.25
3. 3x3	4.62	8.98	0.51
4. 4x4	4.34	7.81	0.56
5. 5x5	3.28	6.86	0.48

Source adapted from Richard Clarida, Josh Davis, Niels Pedersen, “Currency Carry Trade Regimes: Beyond the Fama Regression, NBER Working Paper 15523, November 2009, page 7, http://www.nber.org/papers/w15523

Clarida et al. examined how the five diversified carry-trade portfolios would have performed in two volatility states during the 1992-2009 sample period:

1. A Low Volatility state, when FX volatility was in the lowest quartile, and
2. a High Volatility State when FX volatility was in the highest quartile.

Figure III-4 reports how those individual carry trade portfolios performed in both high and low-volatility states. As one would expect, the reported Sharpe ratios on each of the carry-trade portfolios are considerably larger in low-volatility states. Portfolio 1 had the highest excess return in the low-volatility state, but this came at the expense of having the highest volatility of return. Despite this, Portfolio 1 still registered the best risk-adjusted return in the low-volatility state. It is perhaps more important to note that Portfolio 1 also had the worst excess return, the highest volatility of return, and the lowest Sharpe ratio in the high-volatility state.

Figure III-4

Risk-Return Profile of Selected Carry-Trade Currency Baskets

(1992-2009)

	Portfolio (Baskets)	**Mean Return**	**Volatily of Return**	**Sharpe Ratio**
High Volatility State				
1.	1x1	-9.75	20.72	-0.47
2.	2x2	-5.01	15.55	-0.32
3.	3x3	-1.89	12.47	-0.15
4.	4x4	3.37	10.72	0.31
5.	5x5	2.34	9.15	0.26
Low Volatility State				
1.	1x1	13.61	10.25	1.33
2.	2x2	6.06	7.45	0.81
3.	3x3	6.52	6.21	1.05
4.	4x4	5.76	5.27	1.09
5.	5x5	5.97	4.76	1.25

Source adapted from Richard Clarida, Josh Davis, Niels Pedersen, "Currency Carry Trade Regimes: Beyond the Fama Regression, NBER Working Paper 15523, November 2009, page 12, http://www.nber.org/papers/w15523

These results reinforce the notion that single-pair carry trades can be highly risky and that diversification does help reduce downside risks, but does not eliminate it. As shown in Figure III-4, Portfolios 2 and 3 also registered negative excess returns in the high-volatility state and the volatility of return was still quite high. Indeed, in most cases the volatility of return in the high-volatility state is roughly double the size of the volatility in the low-volatility state.

Portfolios 4 and 5 eke out modest positive returns in the high-volatility state, but the volatility of return continues to be highly elevated. The end result is that the reported Sharpe ratios for Portfolios 4 and 5 are not very attractive in the high volatility state.

What this data strongly suggest is that risk-adjusted returns will be poor in high-volatility states no matter how much diversification is incorporated into a carry-trade portfolio.

Risk/Return Analysis of a Diversified G-10 Carry Trade Basket

There are numerous ways to construct a diversified carry-trade portfolio. Typically, currencies are ranked according to the level of their money-market yield, with the investor choosing to be long the *x*-number of highest yielding currencies and short the *y*-number of the lowest yielding currencies. Equal weights can be assigned to each of the currencies within the baskets or the investor could choose to assign a higher weight to the highest yielder in the high-yield basket and to the lowest yielder in the low-yield basket, with descending weights applied to the remaining currencies in each of the baskets.

The ranking of currencies could also reflect other criteria, such as the level of their long-term interest rates, an average of the level of short and long-term interest rates, the change in the level of short and/or long-term interest rates, yield curve slopes, carry/risk ratios (the interest-rate differential divided by historical or implied FX volatility), etc. Carry-trade portfolios could also incorporate a multitude of bells and whistles to time entry and exit decisions into and out of the carry-trade positions. Different ranking, weighting and optimization methodologies will tend to generate different rankings across time and this will tend to translate into different risk-adjusted performances over time. We will have more to say about these various approaches in Part VI of this report.

In the analysis that follows, we will focus our attention on the risk/return performances of a carry-trade portfolio that consists of equally weighted baskets that are long the three highest yielding G-10 currencies and short the three lowest yielding G-10 currencies, with the currency-composition of the baskets changing as currencies move in and out of the high and low-yield baskets according to their interest-rate ranking.

Figure III-5

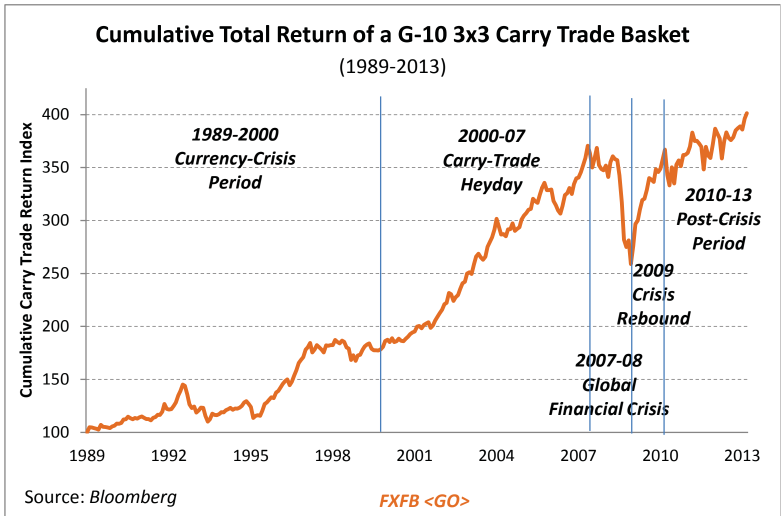


Figure III-5 plots the cumulative total return performance of this 3x3 G-10 carry-trade strategy for the 1989-2013 period. As shown, the average annual return was 5.9% for this 24-year period, with an annualized volatility of return of 9.3% for a Sharpe ratio of 0.63, which is roughly 50% greater than the 0.4 Sharpe ratio generated on a buy-and-hold S&P 500 equity portfolio. Moreover, the Sharpe ratio on the 3x3 carry-trade portfolio is two times greater than the Sharpe ratio that could have been generated on any single-pair currency carry trade. The higher Sharpe ratio arises from the fact that diversification across currencies in the long and short baskets helps to lower downside risks.

Although diversification across currencies helps to remove idiosyncratic risks associated with individual currency pairs, diversification cannot in and of itself remove all of the downside risks associated with FX carry trades. This is due in part to the fact that high-yielding currencies tend to rise and fall together as a bloc, and the same holds true for low-yielding currencies. Hence, the overall volatility of return on a diversified carry-trade portfolio can still be quite large.

The overall volatility of return does not fully capture the downside risks associated with FX carry trades. As shown in Figure III-6, carry-trade returns are not normally distributed. Rather, the distribution is fat-tailed and significantly skewed to the left. The negatively skewed fat left tail indicates that carry trades have suffered significant losses from time to time, and those losses have tended to occur more frequently and have been larger than what would have been expected had the distribution of returns been normal.

The negatively skewed fat left tail is what one would expect to prevail for a strategy that is akin to picking up nickels in front of a steamroller. Once in a while, you'll get too close to the steamroller and get rolled over in the process. Researchers have come up with a variety of risk-based indicators and overlay models that are designed to minimize the size of the left tails, and we will discuss them in Part VI of this report.

Figure III-6

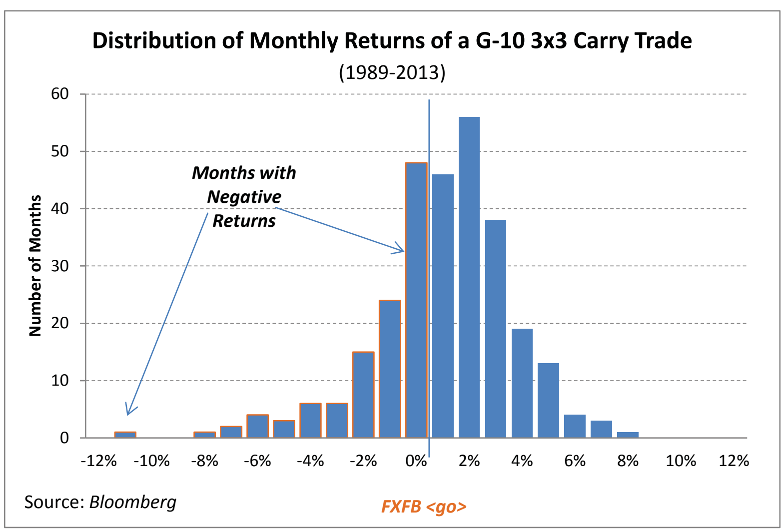


Figure III-7

Average Annual Return of a G-10 3x3 Carry Trade Position
(for Selected Periods from 1989-2013)

Period	Start Date - End Date	Number of Years	Avg. Annual Return	Annualized Std. Dev. of Return	Sharpe Ratio
EM Currency Crisis Episodes	Feb. 1989 - Dec. 2000	11.8	5.7%	8.3%	0.69
Carry Trade Heyday	Dec. 2000 - June 2007	6.5	10.6%	6.7%	1.58
Global Financial Crisis	June 2007 - Jan. 2009	1.6	-20.2%	17.2%	-1.17
Crisis Rebound	Jan. 2009 - Dec. 2009	0.9	38.2%	13.0%	2.94
Post-Crisis Period	Dec. 2009 - Apr. 2013	3.3	4.3%	10.8%	0.40
Total	**Feb. 1989 - Apr. 2013**	**24.2**	**5.9%**	**9.3%**	**0.63**

Source Bloomberg

The 2008 performance of carry trades during the Global Financial Crisis is indicative of the large downside risks that can occur when market conditions turn turbulent. Figure III-7 shows the average annual excess returns that could have been earned on a 3x3 G-10 carry-trade portfolio during five sub-periods since 1989 and the risk-adjusted returns (Sharpe ratio) associated with each period:

1989-2000 — a period characterized by the dollar's large move downward in the first half of the 1990s followed by a large up-move in the second half of the decade. The period was also characterized by a number of major EM currency-crisis episodes.

2001-2007 — a period characterized by relatively robust positive carry-trade performances.

2008 — the crash in carry-trade returns during the Global Financial Crisis.

2009 — the rebound in carry-trade performance in the period immediately following the 2008 crisis.

2010-13 — a difficult period for currency traders as global investors sought to regain their footing in the post-crisis era.

As shown in Figure III-7, a diversified G-10 carry-trade portfolio would have generated attractive returns risk-adjusted returns over both the 1989-2000 and 2001-07 periods, with 2001-07 quite clearly the heyday of the carry trade. It is indeed possible that the large risk-adjusted returns in 2000-07 might have encouraged investors to become too heavily overweight and too highly leveraged in the period leading up to the Global Financial Crisis. When the crisis eventually hit and those long and highly leveraged positions were forced to unwind, carry-trade returns were pushed deeper into negative territory in 2008.

A BIS study found that currencies that declined the most during the period leading up to and following the Lehman collapse in 2008 were the higher-yielding currencies in the G-10. The recovery of those higher-yielders from oversold positions, eventually contributed to impressive returns in 2009.

Figure III-8

Carry, Spot and Total Return of a G-10 3x3 Carry Trade Portfolio

(2010-2013)

Source: Bloomberg

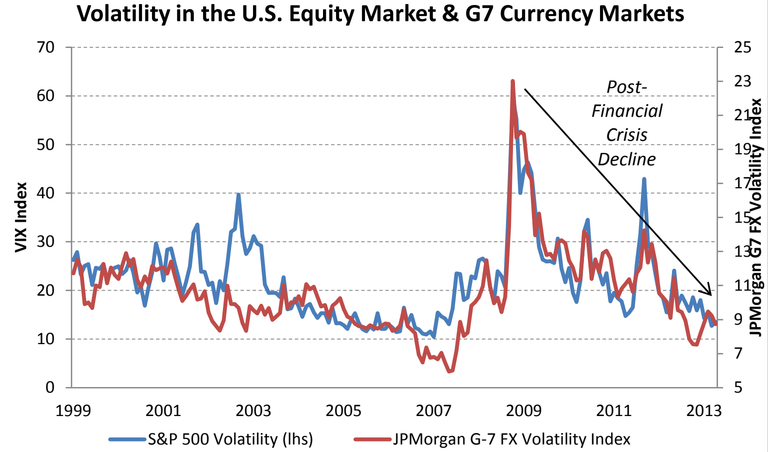
The 2010-13 post-crisis period has been especially challenging for G-10 carry trades. As shown in Figure III-8, the average annual total return on the 3x3 G-10 carry-trade portfolio has been only 4.3% per annum since 2010 while the annualized volatility of return has been quite high at 10.6%. The resulting Sharpe ratio of 0.4 is roughly 50% smaller than the Sharpe ratio reported during 1989-2000 and nearly four times less than reported during the 2001-07 so-called heyday of the carry trade.

What is noteworthy about the meager performance of G-10 carry trades in the post-crisis era is that it occurred at a time when equity and FX market volatility levels were trending lower (see Figure III-9), and as we demonstrated earlier, low volatility periods should have been positive for carry-trade performance. What might have been different this time is that the downward trend in market volatilities was pock-marked with a number of large volatility spikes—notably in the Spring of 2010, the Fall of 2011, and the Spring of 2012—as the global financial markets reacted to one upheaval after another.

Most likely, those volatility spikes not only pushed would-be carry traders to the sidelines during each of those periods, but it is highly possible that the recent high frequency of volatility spikes in the post-crisis era might be generating fears among would-be carry trade investors that future volatility spikes could be in the offing. It may take a while for global investors to regain their confidence before they are ready to initiate sizable G-10 carry trades once again.

Figure III-9

Volatility in the U.S. Equity Market & G7 Currency Markets



Source: *Bloomberg* *VIX, JPMVXYG7 INDEX<GO>*

Is G-10 Carry-Trade Performance Sensitive to the Inclusion or Exclusion of Certain Currencies?

In the analysis above, it was demonstrated that adding currencies to a carry-trade basket can boost long-run risk-adjusted returns. We now turn to the issue of whether the performance of G-10 carry trades hangs on the risk-return profile of certain key high or low-yield currencies—notably the high-yielding Australian and New Zealand dollars, which typically find themselves in the long basket of diversified G-10 carry trades, and the low-yielding Japanese yen and Swiss franc, which are typically included in the short basket.

Figure III-10

Average Annual Returns of Selected G-10 3x3 Carry Trade Baskets
(1989-2013)

Currency Universe	Average Annual Return	Annualized Std. Dev. of Return	Sharpe Ratio
Include all G-10 Currencies	5.9	9.3	0.63
Exclude Low Yielders (Sfr and Yen)	5.2	7.9	0.65
Exclude High Yielders (A$ and NZ$)	3.8	7.7	0.50
Exclude A$, NZ$, Sfr, and Yen	2.5	6.4	0.39

Source: Bloomberg

This raises an interesting issue for assessing the long-run performance of FX carry trades: Is it possible that the well-documented positive excess returns generated by FX carry trades over the long term might be currency-specific? That is, are there certain perennially strong or weak currencies that might account for the reported long-run positive excess returns associated with diversified G-10 carry trades?

For example, are the long-run excess returns generated by G-10 carry trades due solely to the extraordinary strong performance of the high-yielding Australia and New Zealand dollars? Or are they largely due to the perennially poor performance of the low-yielding Japanese yen and Swiss franc?

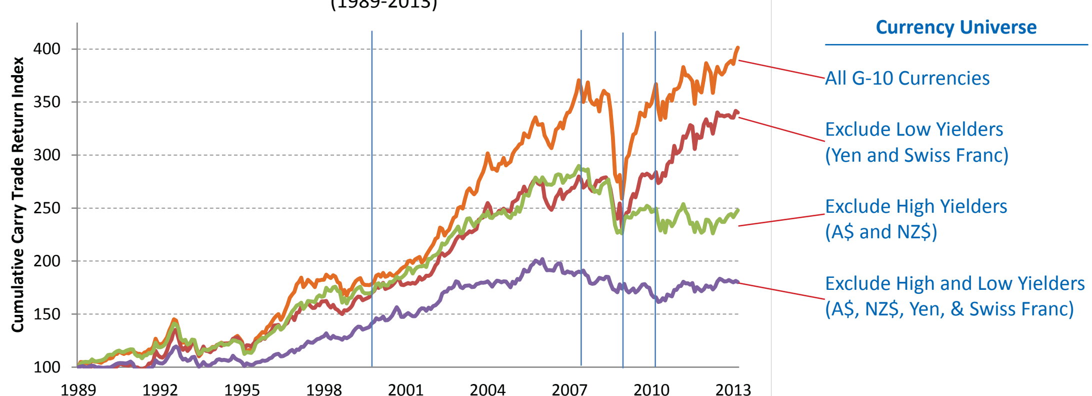
As it turns out, the ability of FX carry trades to generate positive excess returns over the long run is not dependent on the performance of a select group of high or low yielders. Even if we were to remove the A$, NZ$, yen, and Swiss franc from the universe of eligible currencies in a G-10 carry-trade basket, a G-10 carry-trade strategy would still have generated positive excess returns.

This is evident in Figures III-10 and III-11 where we report the total return performance of four differently structured G-10 carry-trade portfolios. When all G-10 currencies are included in the universe of currencies available for inclusion in the baskets, the average annual excess return on the G-10 carry-trade portfolio is 5.9% with an estimated Sharpe ratio of 0.63.

Now, let's exclude the perennially low-yielding Japanese yen and Swiss franc from the G-10 low-yield basket. As shown, the average annual excess return on this constrained portfolio would have been 5.2%, which is less than the unconstrained portfolio, but with a higher Sharpe ratio of 0.65.

Figure III-11

Total Returns of Selected G-10 3x3 Carry Trade Baskets
(1989-2013)



Source: *Bloomberg*

FXFB <GO>

Now let's exclude the perennially high-yielding Australian and New Zealand dollars (while re-inserting the yen and Swiss franc into the short basket) from the G-10 high-yield baskets. This strategy would have generated an average annual excess return of 3.8% for 1989-2013, with a Sharpe ratio of 0.50 for this constrained strategy. This is of course smaller than the risk-adjusted return on the unconstrained G-10 carry-trade strategy, but nevertheless the reported Sharpe ratio is higher than what could have been generated by a buy-and-hold position in U.S. equities (0.4).

Finally, let's exclude all four currencies. The average annual excess returns are lower as one would expect (just 2.5% per year), but nonetheless would still have generated a Sharpe ratio of nearly 0.40, which is roughly in line with the estimated Sharpe ratio for the U.S. equity market.

Summing up, although the long-run performance of carry trades is clearly optimal when all of the ultra-high-yielders and ultra-low-yielders are included in the long and short baskets, it appears that even the yield spread between the middle-of-the-road high and low-yielders is sizeable enough to generate attractive risk-adjusted returns over time. The fact that FX carry trades are able to generate positive excess returns over the long run with or without the ultra-high yielders and the ultra-low yielders, suggests that nominal interest-rate spreads—no matter how wide—are an important driver of long-run currency performance.

This raises the question why nominal yield spreads are such an important driver of long-run currency performance. One possible explanation is that in a low-inflation world, nominal yields serve as a good proxy for real yields.

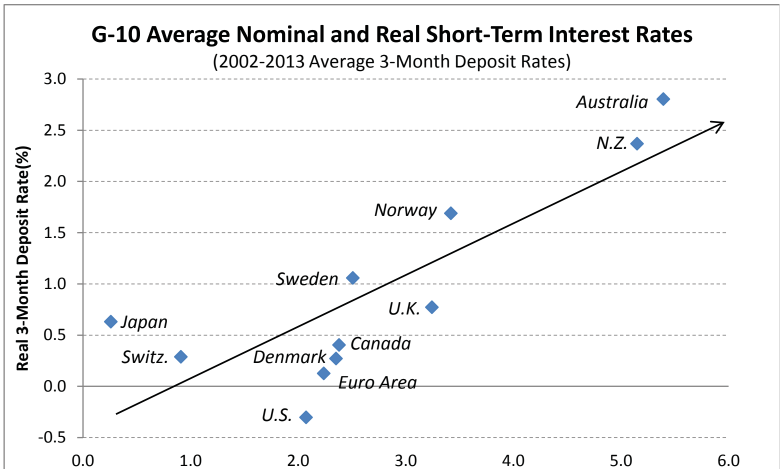
We show this in Figure III-12, where we plot the 2002-13 average nominal three-month interest rates of the individual G-10 currencies versus their respective real rates. (The real short-term interest rate is defined as the nominal money-market rate minus the year-over-year inflation rate.) Clearly, lower nominal rates are associated with lower real rates and higher nominal rates are associated with higher real rates.

Numerous academic studies have demonstrated that the trend in real yield spreads is a key driver of long-run trends in exchange rates, with currencies with higher real rates appreciating over time versus currencies with lower real rates.

With many, if not most, central banks in the world today either implicitly or explicitly targeting inflation as their primary policy objective, short-term interest rates have become an important tool to contain inflationary pressures. Central banks in inflation-prone countries will therefore tend to be more aggressive than central banks where inflation has already been licked. As a result, central banks in inflation-prone countries will tend to maintain high nominal interest rates—as well as high real interest rates—to insure that inflation does not rise above the central bank's implicit or explicit inflation target.

At the margin then, countries with higher *nominal* yields will therefore have higher *real* yields than their lower-yielding counterparts. Higher real yields in turn will tend to provide long-run support to the higher-yielding currencies. Carry trades therefore represent a way of capturing high real yields in the world financial markets.

Figure III-12



Source: *Bloomberg*

Economic Consequences of Persistent Violations of UIP

If uncovered interest rate parity is violated for a long period of time, are there economic consequences that will ultimately force a return back to UIP at some point in the foreseeable future?

If UIP violations do have economic consequences, then it should be possible to monitor all relevant economic indicators that are negatively affected by the long-run deviation from UIP. Such data could then be used to determine whether and when market forces or policy adjustments will come into play to force necessary changes in short-term interest rates and exchange rates that will restore UIP in the long run.

The economic consequences of persistent violations of UIP can be easily explained mathematically. According to UIP, the interest-rate differential between a high-yielding and low-yielding currency adjusted for the change in the high-yield currency's value should equal zero:

$$(i^H - i^L) + \Delta s_{t+1} = 0 \tag{21}$$

A violation of UIP in which the high-yield currency persistently outperforms the low-yield currency could be expressed in the following way:

$$(i^H - i^L) + \Delta s_{t+1} > 0 \tag{22}$$

Let's express the nominal yield spread between the high and low-yield markets as the sum of the real yield spread and the inflation differential:

$$(i^H - i^L) = (r^H - r^L) + (\pi^H - \pi^L) \tag{23}$$

with *r* referring to the real interest rate and π referring to the actual inflation rate in each country.

Substituting Equation 23 into Equation 22 expresses the deviation from UIP in terms of real yield spreads and inflation rates:

$$(r^H - r^L) + (\pi^H - \pi^L) + \Delta s_{t+1} > 0 \tag{24}$$

Let's first assume that real interest rates in the high and low-yield market are the same so that the real spread $(r^H - r^L)$ equals zero. Then the deviation in UIP (the inequality expressed in Equation 24) would simply reflect a persistent deviation from purchasing power parity; i.e., the inflation differential would exceed the change in the exchange rate:

$$0 + (\pi^H - \pi^L) + \Delta s_{t+1} > 0 \tag{25}$$

An overvalued exchange rate on purchasing power parity grounds would of course have negative consequences for the trade balance and economic activity in the high-yield market.

If, on the other hand, purchasing power parity is assumed to hold (i.e., $\pi^H - \pi^L = \Delta s_{t+1}$), then the inequality in Equation 24 could only be explained by the fact that the real interest rate in the high-yield market had to exceed the real yield in the low-yield market for a long period of time. Persistently high real interest rates in the high-yield market would of course then have negative consequences for domestic economic activity in the high-yield country.

Because persistent violations of UIP could give rise to (1) significant currency overvaluation on a PPP basis, (2) overly high real interest rates, (3) a significant deterioration in the trade and current account balance, and (4) significant weakness in domestic economic activity, it would appear highly unlikely that deviations from UIP could persist indefinitely. Eventually economic forces or policy adjustments should eventually come into play to force an eventual restoration of UIP in the long run.

Does UIP Hold in the Long Run?
Several studies have found that although uncovered interest-rate parity fails to hold over short and medium-term time periods, it does appear to hold better in the long run.

Most econometric tests of UIP attempt to find a linkage between short-term changes in exchange rates (normally over a three-month period) and the yield spread on short-term money-market instruments or short-dated forwards (normally with a three-month maturity). As discussed above, the UIP/forward-rate unbiasedness hypothesis is rejected in most cases, with the estimated β coefficient in the Fama Regression not only less than 1.0, but quite often less than zero.

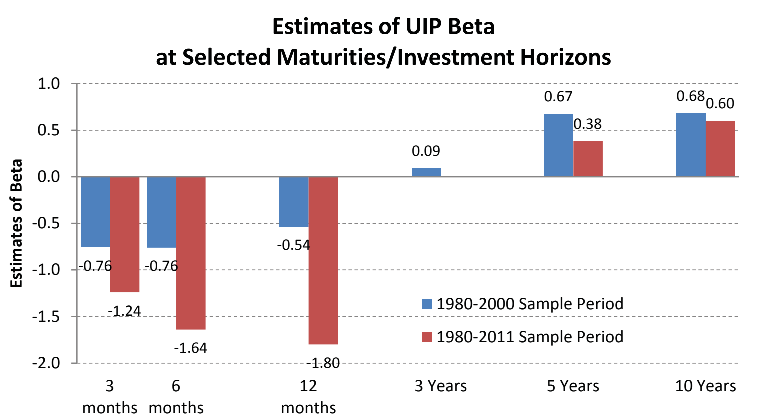
Chinn and Meredith (2004) and Chinn and Quayyum (2012) examined whether UIP might hold better over long-run horizons. They conducted econometric tests of the UIP condition for various maturities, ranging from 3, 6, and 12 months at the front end to 5-10 years at the long end of the maturity spectrum. Using a panel-regression methodology, their tests were conducted in the following manner: for the 12-month horizon, they regressed actual changes in G-10 exchange rates over 12-month periods against the corresponding 12-month yield spreads that had prevailed 12-months prior; for the five-year horizon, they regressed actual changes in G-10 exchange rates over five-year periods against the corresponding five-year yield spreads that had prevailed five years prior. The 2004 study analyzed data from 1980-2000, while the 2012 study extended the test period to 2011.

The estimated β coefficients for select time horizons for both the 2004 and 2012 studies are shown in Figure III-13. Their findings indicate that for short maturities ranging from 3-12 months, all of the estimated β coefficients were significantly less than zero, which is consistent with the empirical findings from most other studies that UIP fails to hold over short-to-medium-term time periods..

What is interesting about their findings, however, is that for the longer-term horizons ranging from 5-10 years, the estimated β coefficients were found to be significantly above zero, although still less than 1.0. These findings are thus consistent with the view that over the long run, there will be a tendency for exchange-rate changes to offset differences in long-term yield spreads, although the offset is likely to be less than complete.

For some currency pairs, there is evidence to support that UIP deviations do self-correct, while for others, large departures from UIP have persisted. Consider the high-yielding Australian and New Zealand dollars.

Figure III-13



Source: adapted from Chinn and Meredith (2004), "Testing Uncovered Interest Parity at Short and Long Horizons During the Post-Bretton Woods Era", NBER Working Paper No. 11077;and Chinn, Menzie D. and Saad Quayyum (2012).

Figure III-14

Carry, Spot and Total Return of a Australian Dollar/U.S. Dollar Carry Trade

(1999-2013)

Average Annual Returns

Total Return = 6.3%

Exchange Rate Return = 3.7%

Interest-Rate Carry = 2.5%

Performance

Annualized Standard Deviation of Return = 13.66%

Sharpe Ratio = 0.46

Source: Bloomberg

The long-run trends in the Australian dollar and New Zealand dollar carry-trade returns shown in Figures III-14 and III-15 demonstrate that deviations from UIP can be quite large even over long time horizons. The long-run positive excess returns come from the long-run appreciation of the A$ and NZ$ versus the U.S. dollar, as well as the cumulative yield spread earned from holding a long position in the higher-yielding A$ and NZ$ and a short position in the lower-yielding U.S. dollar. Hence, at least until the current time, there has been no offsetting movement in the A$ and NZ$ values to neutralize the yield advantage that these currencies have offered.

Figure III-15

Carry, Spot and Total Return of a New Zealand Dollar/U.S. Dollar Carry Trade

(1999-2013)

Average Annual Returns

Total Return = 6.2%

Exchange Rate Return = 3.3%

Interest-Rate Carry = 2.8%

Performance

Annualized Standard Deviation of Return = 13.77%

Sharpe Ratio = 0.45

Source: Bloomberg

Figure III-16

Carry, Spot and Total Return of a Euro/U.S. Dollar Carry Trade

(1999-2013)

Average Annual Returns

Exchange Rate Return = 0.7%

Total Return = 0.4%

Interest-Rate Carry = -0.2%

Performance

Annualized Standard Deviation of Return = 10.53%

Sharpe Ratio = 0.04

Source: Bloomberg

Other key currency pairs, however do exhibit a mean-reverting tendency in excess returns, which implies that UIP does hold when viewed from a long-run perspective. Consider the case of the euro-dollar exchange rate.

As shown in Figure III-16, there have been periods when deviations from long-run UIP have been quite large on both the upside and downside for the euro. But over the long run, those deviations have tended to even out, and for the most part UIP appears to be valid for this currency pair when viewed from a long-term perspective.

This suggests that deviations of the euro-dollar exchange rate from long-run UIP could be used as a valuation metric. For example, if the deviation from long-run UIP exceeds a certain threshold, say +/- 20%, it could signal that the move might be overdone and therefore ripe for a reversal. We will have more to say about using UIP deviations as a valuation metric in Part VI.

Emerging Market Carry Trades

Up until the past decade, most investors who undertook FX carry trades did so primarily in the G-10 currencies and avoided significant exposure to emerging-market (EM) carry trades. There was a litany of reasons that discouraged investors from undertaking EM carry trades, including:

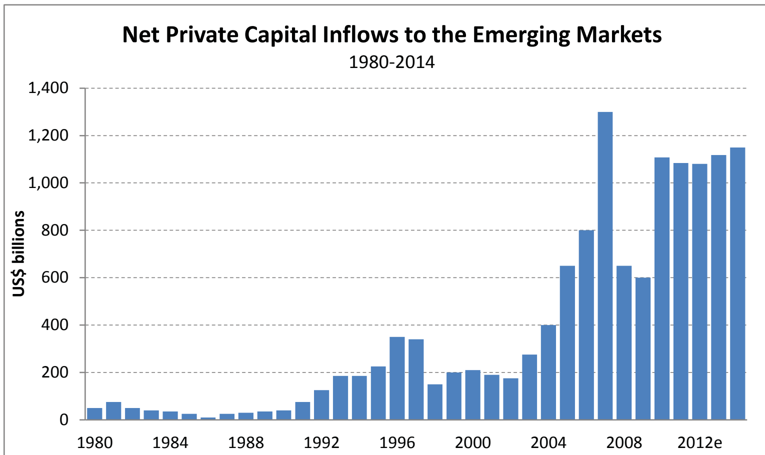
1. Greater perceived default risk in EM versus G-10 countries;
2. Significant restrictions on capital movements in and out of EM countries;
3. Limited size and liquidity of EM financial markets;
4. A lack of transparency and inadequate information flow in many EM markets;
5. Higher transactions costs;
6. Greater inflation risk;
7. Greater exposure to possible contagion and spillover effects emanating from crises elsewhere;
8. Low credit ratings, which might have inhibited fund managers in G-10 countries from allocating funds to EM currencies, particularly if internal management guidelines restricted investment exposure to low-rated entities;
9. Greater volatility of returns;
10. Greater exposure to event risk, regime shifts, and sudden policy reversals; and
11. Likely high levels of risk aversion on the part of international investors who might have been burned during the Mexican Peso Crisis in 1994-96, the Asian Financial Crisis in 1997-98, the Russian Crisis in 1998, and the large devaluation episodes in Brazil and Turkey in 1999.

Overall, even though emerging-market currencies might have offered relatively attractive nominal yields in the 1980s and 90s, many investors were wary of having significant exposure to what many believed at the time to be crisis-prone currencies. Investor caution was probably warranted as academic studies—for example, see Bansal and Dahlquist (2000)—found that estimates of the β coefficient in econometric tests of UIP for EM currencies were in most cases positive in the 1990s. This contrasted with the findings of negative β coefficient estimates for the G-10 currencies over the same period.

The positive β coefficient estimates for EM currencies imply that most EM currencies that traded at a forward discount did indeed decline in value as suggested by the UIP condition/forward-rate-unbiasedness-hypothesis, although the decline in EM currencies did not necessarily completely offset the yield advantage that the EM currencies offered. In contrast, the negative β coefficient estimates for the G-10 currencies over the same period implied that most G-10 currencies that traded at a forward discount actually tended to rise in value, thereby reinforcing the already positive yield advantage that the high-yield G-10 currencies offered. On a risk-reward basis, G-10 carry trades thus seemed to offer risk-averse fund managers with a more attractive investment opportunity in the period leading up to the 2000s.

The 2000s have seen a complete reversal in sentiment among global investors toward EM investments in general and EM carry trades in particular. This is evident in Figure III-17, where we plot the trend in net private capital inflows to emerging markets from 1980 to 2012. As shown, net private capital inflows to emerging markets averaged between \$100 and \$200 billion per year in the 1990s but then rose dramatically after 2002, peaking in 2007 at around \$1.2 trillion. Those flows plummeted in 2008 and 2009 during the depths of the Global Financial Crisis. Net capital inflows picked up strongly again in 2010-11 as investors were searching for higher yields than were available in the developed markets.

Figure III-17

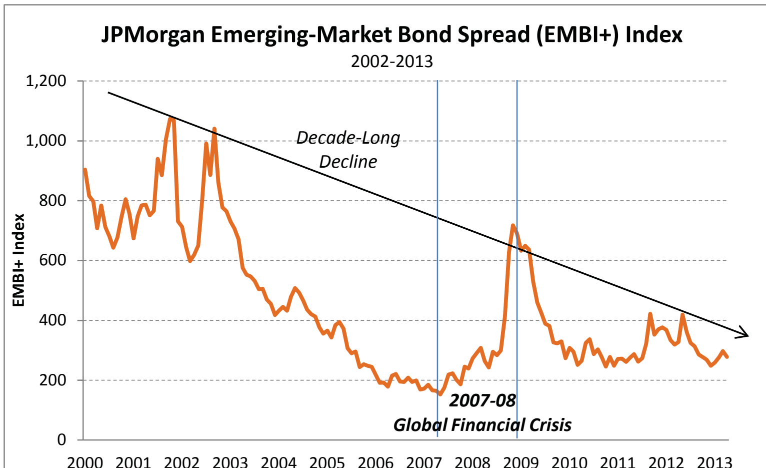


Source: adapted from Phil Suttle, Felix Huefner, Robin Koepke, "Capital Flows to Emerging Market Economies", IIF Research Note, January 22, 2013

The surge in interest in EM investments in the 2000s can be attributed to a number of factors, including:

1. GDP growth in many EM economies has picked up strongly and the pace of economic activity has been more stable as well;
2. Current-account balance positions in many EM countries have improved significantly;
3. A huge buildup of FX reserves by EM central banks (which can serve as an arsenal to defend against future speculative attacks);
4. More flexible exchange-rate arrangements;
5. Better management of monetary and fiscal policies, particularly the adoption of anti-inflation policies as part of inflation-targeting policy regimes;
6. Improved credit risk, as evidenced by better credit ratings, and lower default risk, as reflected in the decade-long decline in the EMBI+ spread (see Figure III-18);
7. The liberalization of many EM financial markets, which has been accompanied by a general improvement in EM market liquidity and the size of EM financial markets;
8. A significant improvement in EM government and private-sector balance sheets; and
9. Fewer crisis episodes, which had plagued EM currencies in prior decades.

Figure III-18



Source: *Bloomberg* JPEMSOSD INDEX<GO>

While improvements in EM fundamentals have clearly played a key role in the increased interest of global fund managers, there have been several financial developments in the G-10 markets that have been important in encouraging capital flows to emerging markets. These include:

1. Favorable liquidity conditions as reflected in the consequent low level of interest rates in the U.S., Europe, and Japan that encouraged investors to "search for yield" in the emerging markets;

2. Diminished opportunity to earn significant positive carry in G-10 carry trades, given the convergence in yield levels among many of the G-10 fixed-income markets; and

3. A general increase in investor willingness to take on greater risk, at least up until the 2008 Global Financial Crisis.

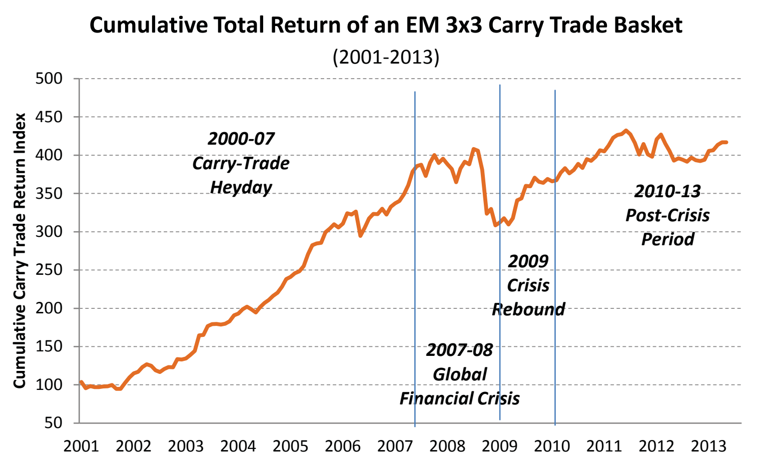
Global investors were also attracted to EM carry trades in the 2000s because they offered fund managers greater diversification opportunities for their carry-trade portfolios. This follows from the fact that the returns on EM carry trades were not highly positively correlated with the returns on G-10 carry trades.

Furthermore, EM carry trades offered considerably larger positive carry than could be earned on G-10 carry trades, and since 2001 at least, also offered the prospect of high-yield currency appreciation. Following the currency crises of the late 1990s, many EM currencies had become highly undervalued entering the new millennium. Those depressed levels not only reduced the downside-risk associated with high-yielding EM currencies, but also raised the probability that if the emerging-market fundamental backdrop were to improve, which it did, then high-yielding EM currencies were in position to rise in value back to their long-run equilibrium levels.

With both pull and push factors contributing to the greater interest in EM assets, and therefore to the increased flow of private capital to the emerging markets, the return on EM investments began to turn upward in the early 2000s, which attracted more and more new players as investors chased the higher returns that EM assets offered. This was especially the case for EM carry trades.

As Figures III-19 and 20 show, the average annual return on a 3x3 EM carry-trade portfolio (long the three highest yielding EM currencies and short the three lowest yielding currencies) for the 2001-13 period generated an average annual excess return of 12.3%, with an annualized standard deviation of return of 11.4% and a Sharpe ratio of 1.08.

Figure III-19



Source: *Bloomberg* FXFB <GO>

Figure III-20

Average Annual Return of an EM 3x3 Carry Trade Position
(for Selected Periods from 2001-2013)

Period	Start Date - End Date	Number of Years	Average Annual Return	Annualized Std. Dev. of Return	Sharpe Ratio
Carry Trade Heyday	Dec. 2000 - June 2007	6.5	23.0%	10.8%	2.13
Global Financial Crisis	June 2007 - Jan. 2009	1.6	-12.5%	16.7%	-0.75
Crisis Rebound	Jan. 2009 - Dec. 2009	0.9	20.0%	14.9%	1.34
Post-Crisis Period	Dec. 2009 - Apr. 2013	3.3	3.8%	7.2%	0.53
Total	**Feb. 1989 - Apr. 2013**	**12.3**	**12.3%**	**11.4%**	**1.08**

Source Bloomberg

Breaking down the broad trend in the EM carry-trade returns into four sub-periods, it is evident that the lion's share of gains occurred prior to the Global Financial Crisis. The average annual excess return on a 3x3 EM carry-trade portfolio for 2000-07 was an astonishing 23% with a Sharpe ratio of 2.13.

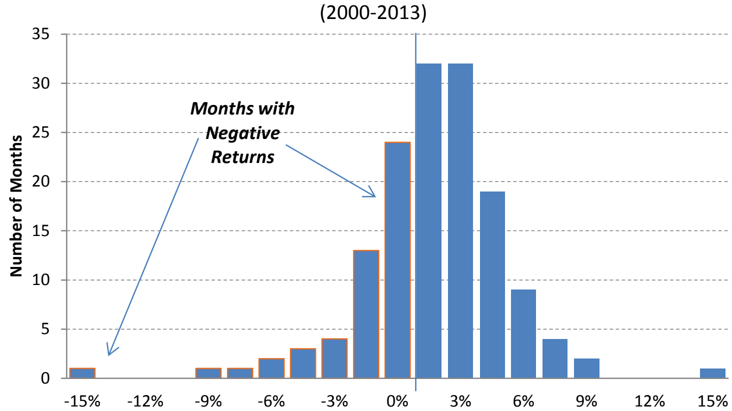
It is clear from Figure III-21 that the distribution of returns has a large negative skew, indicating that although the excess returns on EM carry trades have been significantly positive over time, EM carry trades are prone to crash from time to time and that the magnitude of those downside moves can and have been quite large. The largest downside move was in 2008, when the global markets melted down following the collapse of Lehman Brothers.

The Global Financial Crisis in 2008 saw the EM 3x3 carry trade lose more than 24% in just five months as investors headed for the exits and sought refuge in safer assets. Once the dust settled, the 3x3 EM carry trade recouped much of this lost ground in 2009 when it registered a one-year gain of nearly 20%.

In the post-crisis period, the 3x3 EM carry-trade portfolio has eked out modest returns of 3.8% per annum, and with the volatility of return easing as well, the Sharpe ratio has averaged around 0.53 over the 2010-13 period.

Figure III-21

Distribution of Monthly Returns of a EM 3x3 Carry Trade
(2000-2013)



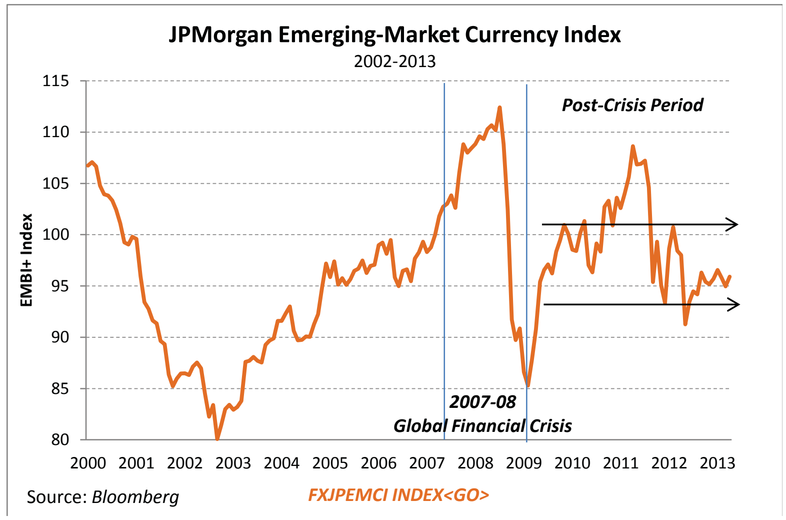
Source: *Bloomberg*

FXFB <go>

A number of factors are probably conspiring to contribute to the modest post-crisis performance of the EM carry trade. First, the level of positive carry earned on EM carry trades in the post-crisis era is a fraction of where it stood in the pre-crisis era. Short-term interest rates in the traditional EM high-yield markets are now in single digits after having been in double digits during the pre-crisis period.

Second, as shown in Figure III-22, EM currencies have become somewhat range-bound during the post-crisis period, which contrasts with the steady gains between late 2002 and the summer of 2008.

Figure III-22



Source: *Bloomberg*

Finally, the high frequency of volatility spikes might be dissuading investors from engaging in risky trading strategies such as the EM carry trade.

While EM carry trades as a whole have not been as attractive in risk-adjusted terms since the Global Financial Crisis, there are subsets of the EM currency-bloc that have. For example, a strategy of going long an equally weighted basket of four of the traditionally higher-yielding Asian currencies–the Indian rupee, Indonesian rupiah, Philippine peso and Thai baht–that is fully funded with a short position in U.S. dollars has generated average excess returns of 5.7% per annum since 2009, with an annualized standard deviation of return of about 5.0% for a Sharpe ratio of 1.15 (see Figure III-23).

Figure III-23

Carry, Spot and Total Return of a Asian/U.S. Dollar Carry Trade
(2009-2013)

Source: Bloomberg

Figure III-24

Average Annual Return of an Asia 4x1 Carry Trade Position
(for Selected Periods from 2001-2013)

Period	Start Date - End Date	Number of Years	Average Annual Return	Annualized Std. Dev. of Return	Sharpe Ratio
Carry Trade Heyday	Dec. 2000 - June 2007	6.5	7.0%	4.4%	1.59
Global Financial Crisis	June 2007 - Jan. 2009	1.6	-2.9%	5.7%	-0.50
Crisis Rebound	Jan. 2009 - Dec. 2009	0.9	13.3%	5.6%	2.36
Post-Crisis Period	Dec. 2009 - Apr. 2013	3.3	4.5%	4.7%	0.95
Total	**Dec. 2000 - Apr. 2013**	**12.3**	**5.5%**	**4.8%**	**1.14**

Source Bloomberg

Much of the attraction of the Asian carry trade comes not from the absolute total return earned on the strategy, but from the overall low volatility of the Asian currencies versus the U.S. dollar. The average annual excess returns come from an average yield spread of 200-300 basis points per annum over U.S. interest rates plus a modest, gradual appreciation of the Asian currencies versus the U.S. dollar.

When we break down the risk-adjusted returns on the Asian carry trade (see Figure III-24), what we find striking is that with the exception of the 2008 crisis period, the Sharpe ratios are quite robust: 1.59 for 2001-07, 2.36 for 2009, and 0.95 for 2010-13. The Sharpe ratio for the latter period is two to three times the Sharpe ratio for the G-10 and broad EM carry trades for the same period.

The attractiveness of the reported Sharpe ratios for the Asian carry trade owes much to the FX targeting policies of Asia's central banks. Asian central bank intervention in the FX markets is designed to both moderate upward pressure on the value of the Asian currencies versus the U.S. dollar and to minimize the overall volatility of the Asian currencies versus the dollar.

By minimizing the overall volatility of the Asian currencies versus the U.S. dollar, FX intervention policy has unintentionally helped lower the denominator of the Sharpe ratio—the standard deviation of return—which has worked to boost the reported Sharpe ratio on the Asian carry trade and thereby made this particular carry trade highly attractive for international investors.

IV — Carry Trades and Risk: Explaining the Long-Run Profitability of FX Carry Trades

Carry trades are essentially speculative bets undertaken by investors who believe that UIP will fail to hold over time. When undertaking a speculative carry-trade position, an investor is betting that a long position in a high-yield currency basket will, over time systematically outperform a comparable position in low-yield currency basket. By taking on a long position in a basket of high-yield currencies and a simultaneous short position in a basket of low-yielding currencies, a carry-trade investor earns the spread between the two baskets while at the same time betting that the high-yielding currencies will not depreciate versus the low-yielding currencies by an amount that exceeds the initial interest-rate spread.

Such bets have turned out to be profitable, on average, but not without exhibiting significant downside moves from time to time. Figure IV-1 reproduces Lustig and Verdelhan's (2008) research on the long-run performance of FX carry trades. The table highlights the average annual excess returns that could have been earned by investors if they had undertaken long positions in low, medium, and high-yielding currencies versus the U.S. dollar over the 1983-2008 period, and breaks down those excess returns by the contributions made by the change in the spot exchange rate and the annualized yield spread.

Lustig and Verdelhan sort the currencies into equally weighted bins or baskets, with Basket 1 consisting of currencies exhibiting the lowest or most negative yield spreads versus the U.S., and Basket 6 consisting of currencies exhibiting the highest positive yield spreads. Baskets 2-5 include currencies with yield spreads relative to the U.S. that fall in between the lowest and highest yielders.

As shown, the high-yield currencies in Basket 6 did, on average, depreciate versus the U.S. dollar, but not by enough to offset the wide yield spread favoring the high-yield currencies over the U.S. Similarly, the low-yield currencies in Basket 1 did appreciate versus the U.S. dollar on average, but not by enough to offset the yield disadvantage that the low-yield currencies were saddled with.

The end result was that each basket of successively higher yields outperformed all other baskets with lower yields, with the average annual excess returns on the high-yield currencies in Basket 6 significantly outperforming the excess returns on the low-yielding currencies in Basket 1. Simply stated, the primary factor driving excess returns on currency portfolios over time was the absolute level of short-term interest rates.

The positive excess returns enjoyed by the high-yielding currencies came at a cost, however, in the form of an asymmetric distribution of returns that is heavily skewed to the left. This can be seen in the bottom row of Figure IV-1. On average, the distribution of returns was negatively skewed for the higher-yielding currencies and positively skewed for the lower-yielding currencies. The negative

Figure IV-1

Long-Run Risk-Adjusted Performance of Low, Medium, and High-Yield Currency Baskets

(November 1983-July 2008)

	Currency Baskets						
	Low Yield		Medium Yield			High Yield	
	1	**2**	**3**	**4**	**5**	**6**	**Long 6/Short 1**
Change in Currency's Value	0.86	1.21	1.55	2.60	0.91	-1.68	--
Forward Disount (Carry)	-3.88	-1.29	-0.14	0.95	2.56	7.76	--
Excess Return	-3.02	-0.08	1.41	3.55	3.47	6.08	9.10
Sharpe ratio	-0.22	-0.14	0.02	0.30	0.25	0.36	1.02
Skew	0.10	0.08	-0.07	-0.17	-0.33	-0.29	-0.75

Source: Lustig and Verdelhan (2008)

skew indicates that high-yield currencies have exhibited large downside moves from time to time, larger than what would have been expected had the distribution of returns been normal.

Lustig and Verdelhan's estimates also shed important light on the risk/return attributes of a diversified carry-trade strategy--a strategy in which investors take a long position in the high-yield currency Basket 6 and a simultaneous short position in the low-yield currency Basket 1. Although the mean return on the diversified (long Basket 6/short Basket 1) carry-trade portfolio over the 1993-2008 period was a robust 9.1% per annum, which is higher than either Basket 1 or 6 individually, the negative skew in the distribution of returns on the diversified carry-trade position was -0.75, which was more negative than the negative skew in the high-yield currency Basket 6.

The reason why the negative skew associated with the diversified carry-trade portfolio was so large is that a carry-trade investor would have been doubly exposed by being long a negatively skewed basket and short a positively skewed basket. The large negative skew on this carry-trade portfolio highlights an unfortunate downside attribute associated with diversified carry trades—diversification alone will not remove the downside risks associated with FX carry trades.

Carry trades are not unique in terms of offering highly positive excess returns on average while suffering large downside moves from time to time. Many risky assets and trading strategies offer similar risk/return attributes. For instance, in our discussion above we likened carry trades to a short-volatility strategy, which tends to earn a premium or positive excess return as long as volatility remains low, but will post large losses if and when volatility rises. Many hedge-fund strategies are actually short-volatility strategies. In many respects, the premium earned on a short-volatility position represents a form of compensation (or excess return) that is awarded to investors willing to accept the potential of large downside moves inherent in risky trading strategies.

Estimating the Carry-Trade Risk Premium

Figure IV-2 illustrates—through the use of a conventional utility curve—what kind of positive excess return or risk premium would be required to induce investors to engage in FX carry trades. In theory, if carry trades are risky, then investors should be compensated in the form of a risk premium or higher expected return for bearing that risk. As shown in Figure IV-2, a utility curve traces out the level of satisfaction or utility that a fund manager receives from different levels of investment return. The utility curve is upward sloping because higher returns are preferred to smaller returns, although the gains in utility in response to ever higher investment returns are shown to rise at a diminishing rate. This is because investment managers are likely to gain more satisfaction, at the margin, from a rise in returns from say 5% per annum to 10% per annum than they would if returns rose from 105% per annum to 110% per annum.

Risk-averse fund managers generally pursue strategies that maximize their level of utility for a given expected rate of return. Two assets can offer the same mean expected return, but the utility that a fund manager receives from each of the two assets might differ greatly if the distribution of possible total return outcomes happens to be far wider for one asset than the other. To see this, consider a case where a fund manager is faced with two currency investment choices: (1) allocating funds to a low-yielding currency that offers a guaranteed payout or rate of return equal to R^L in low-yield currency terms or (2) allocating funds to a high-yielding currency that offers a return that resembles a binary lottery—in good times the return on the high-yielding currency investment in low-yield currency terms will equal R^H_4 and in bad times the return on the high-yield investment will equal R^H_1. The weighted average (mean) expected return on the high-yield currency investment in low-yield currency terms is assumed to equal R^H_M, which just matches the guaranteed return on the low-yield currency investment, R^L.

Both currency investments offer the same *mean* expected return ($R^L = R^H_M$), but the distribution of possible total return outcomes are far different, as is the associated downside risk. The high-yield currency investment has a far wider distribution of possible total-return outcomes: (R^H_4 - R^H_1) versus the certain return R^L on the low-yield currency investment. Hence, the high-yield currency investment would be the more risky alternative, even though its mean expected return will, over time, match the return on the low-yield currency investment. If investors only cared about mean expected returns and not the associated downside risks, they would be indifferent between allocating funds to one market versus the other. Risk-averse investors, however, care about the distribution of possible total-return outcomes and will gain greater satisfaction or utility from the certain return on the low-yield currency investment than they would from the more highly variable return associated with the high-yield currency investment.

Figure IV-2 illustrates a way to measure the higher level of utility that an investor receives from the certain payout on the low-yield currency investment versus the level of utility that the investor receives from the more highly variable payout on the high-yield currency investment. The level of utility or satisfaction that an investor receives from the low-yield currency investment can be found by first locating the low-yield currency investment return, R^L, and then look upward toward the utility curve to determine the level of utility that the investor receives from that certain return, which is shown as point *A* on the utility curve.

The level of satisfaction that the investor receives from the binary lottery payout associated with the high-yield currency investment is equal to the weighted average level of utility that the investor receives when the payout is low (R^H_1) and when the payout is high (R^H_4). The utility the investor receives from this weighted average binary lottery payout is shown as point *B* on the utility curve.

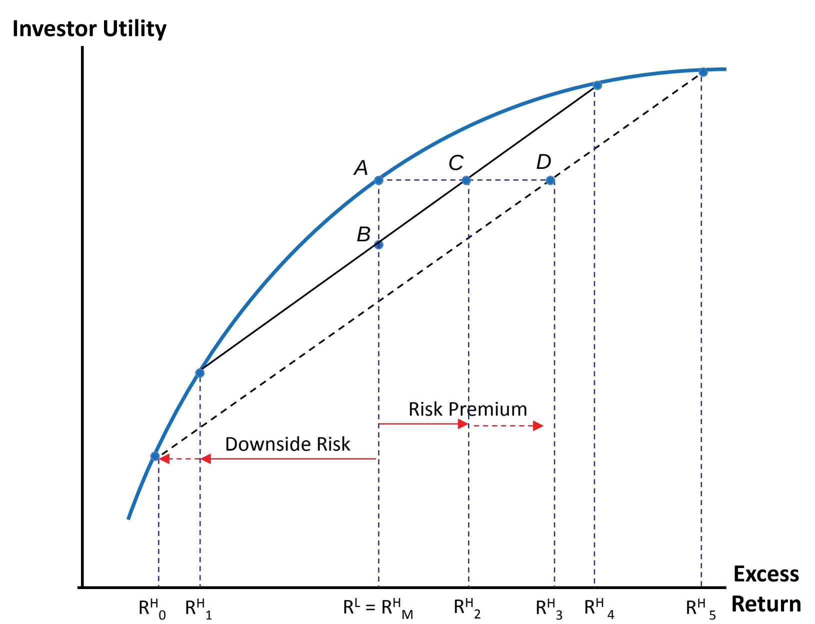
As shown, the investor clearly receives a higher level of utility (point *A* lies above point *B*) from the certain payout R^L versus the more variable payout on the high-yield currency investment, even though both investments have the same mean expected return.

Because risk-averse investors prefer the certain payout on the low-yield currency investment over the variable payout on the high-yield currency investment (point *A* lies above point *B*), the question then becomes is there a way to determine what amount of additional compensation or higher expected return could be appended to the average expected return on a high-yield currency investment that would make investors indifferent between allocating funds to the riskier high-yield currency investment versus allocating funds to the low-yielding currency investment? The utility curve in Figure IV-2 provides us with an answer to that question.

Investors would be indifferent between the two currency investments if the mean expected return on the high-yield currency investment was R^H_2 rather than R^H_M. This can be seen by first locating point *A* on the utility curve, which represents the level of utility that the investor receives from the certain payout R^L, and then look across to point *C*, which lies along the upward sloping straight line that pertains to the wide distribution of possible total return outcomes associated with the high-yield currency investment. At point *C,* the mean expected return on the high-yield currency investment (R^H_2) is now higher than the certain return

Figure IV-2

Long-Run Average Excess Returns as Compensation for Volatility and Downside Risk



Source: Gyntelberg and Hansen (2008)

on the low-yield currency investment (R^L). Investors need this extra compensation (R^H_2 - R^L) to make them want to hold the more risky high-yield currency investment.

Thus, at point *C* investors receive the same level of utility from the binary lottery payout associated with the high-yield currency investment as they receive from the certain payout on the low-yield currency investment (point *A* and point *C* represent similar levels of utility). What the utility curve diagram tells us is that given the wider distribution of possible total-return outcomes (R^H_4 - R^H_1) and the greater downside risks (R^L - R^H_1) associated with the high-yield currency investment, fund managers will be willing to allocate funds to the higher-yielding currency investment only if it offered a higher excess return or risk premium (R^H_2 - R^L) over and above what could be earned on the low-yield currency investment (R^L).

Figure IV-2 also provides us with a way to assess how changes in the volatility regime or in downside risk can affect the risk premium associated with long high-yield/short low-yield carry-trade positions. If the distribution of possible total-return payouts were to widen from (R^H_4 - R^H_1) to (R^H_5 - R^H_0), i.e., if volatility suddenly spiked sharply higher, and the associated downside risks worsened from (R^L - R^H_1) to (R^L - R^H_0), then the risk premium on the high-yield currency investment would need to be higher as well to reflect the increased risk associated with the high-yield currency investment. This rise in the risk premium is shown as a widening in the expected excess return on the high-yield currency investment from (R^H_2 - R^L) to (R^H_3 - R^L). The utility curve diagram thus indicates that the expected returns on FX carry trades will tend to be determined both by the state of FX volatility and market concerns about downside risks.

Other risk factors can also have an impact on carry-trade returns, and in the analysis below we discuss which risk factors and state variables have had the most success in explaining the excess returns to carry-trade strategies.

Many analysts have sought to identify what specific risk factors are priced into the cross-section of currency returns in general, and carry-trade returns in particular. The challenge has been to identify risk factors that have had a good track record in terms of explaining the performance of FX carry trades on both the upside and downside. In recent years there have been scores of studies investigating this issue, with some focusing on traditional equity-market risk factors such as the capital asset pricing model (CAPM) or the consumption based version of the CAPM model (CCAPM), while others have focused on risk factors unique to the FX market such as FX volatility, skewness, and liquidity risk. Other studies have focused on rare-disaster risk, loss aversion, limits to speculation, and possibly-higher-than-desired turnover and transaction costs as possible risk factors that might limit investor involvement in FX carry trades.

What is clear from all of this research is that no single risk factor is able to fully explain the positive excess returns earned by FX carry trades. Rather, it appears that FX carry trades are exposed to a variety of risk factors—volatility risk, crash risk, peso-event risk, etc.—that are priced into the expected returns on high and low-yield currencies. The key issue for analysts and market participants then is to determine which risk factors are the most statistically significant and economically important, and to recognize that the exposure of carry trades to identifiable risk factors might not be linear.

Indeed, several studies have suggested that the relationship between carry trades and identifiable risk factors might be nonlinear. When the state of financial market conditions has been broadly neutral or benign, carry-trade returns have exhibited a tendency to be weakly correlated with identifiable risk factors. But when the state of financial market conditions has turned turbulent, the correlation of carry-trade returns and identifiable risk factors has tended to rise dramatically.

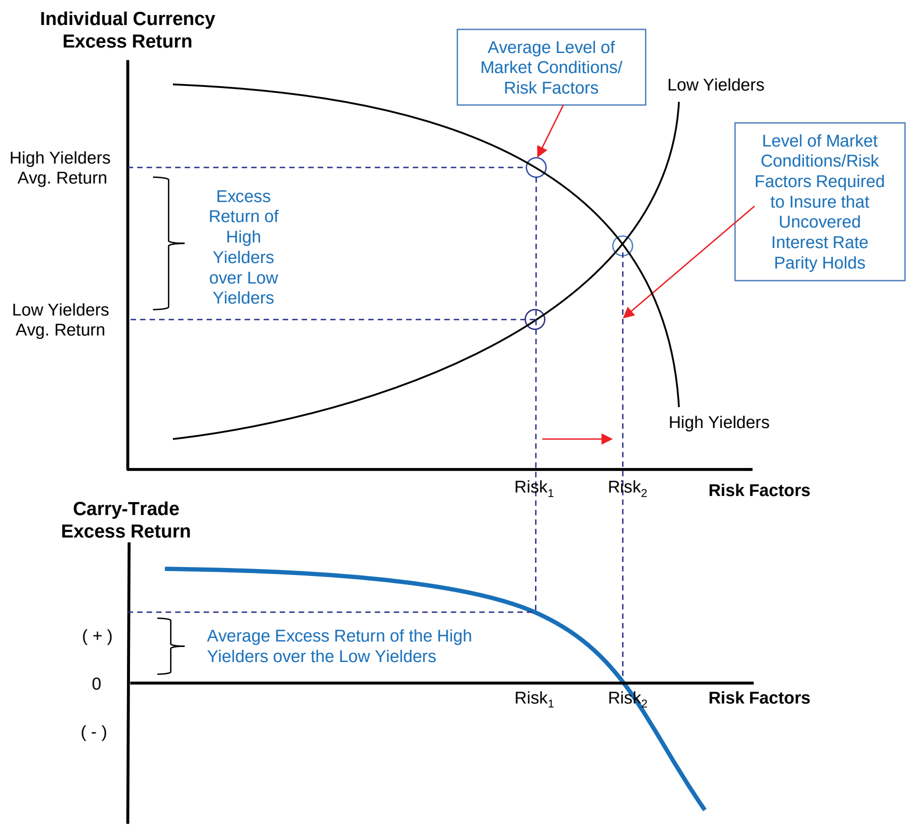
Figure IV-3 illustrates this phenomenon. As shown, high and low-yield currencies tend to respond differently to changes in select risk factors. High-yield currencies tend to respond poorly when asset prices fall sharply, FX and equity market volatility spike significantly higher, liquidity conditions tighten greatly, or consumption growth slows sharply relative to historical norms. Low-yield currencies, on the other hand, tend to respond positively to such developments.

Modest deteriorations in these risk factors are unlikely to materially affect the positive excess returns earned on strategies that are long high-yield currencies and short low-yield currencies. But during turbulent periods, when asset price trends and liquidity conditions are deteriorating sharply and volatility indicators are spiking significantly higher, the returns on long high-yield currency positions will tend to decline dramatically, while the returns on low-yield currencies will tend to rise as investors exit their risky high-yield currency positions in favor of safe-haven low-yield currencies. Hence, the nonlinear response of high and low-yield currencies to changes in risk factors depicted in Figure IV-3.

The end result is that during periods when most risk factors have been behaving relatively calmly, carry trades have tended to earn positive excess returns on average. During turbulent market conditions, however, when most risk factors are behaving badly, carry trades have tended to generate substantial losses. Since benign market conditions have tended to be the norm and turbulent market conditions have tended to be the exception, carry trades have on average earned positive excess returns when viewed from a longer-run perspective. The downside is that from time to time carry trades will suffer large losses when market conditions suddenly deteriorate. In the analysis below, we discuss which risk factors and state/regime variables have had the most success in explaining the positive excess returns and downside risks associated with FX carry-trade strategies.

Figure IV-3

The Response of High-Yield and Low-Yield Currencies to Changes in Risk Factors



Source: Bloomberg

Consumption Growth Risk and Carry-Trade Returns

One of the standard asset-pricing models in the field of finance is the consumption-based capital asset pricing model, or CCAPM for short. According to the CCAPM, risky assets tend to co-vary positively with consumption growth, while safe assets tend to co-vary negatively with changes in consumption growth.

Lustig and Verdelhan (2011) applied the CCAPM to the FX markets to explain the performance of FX carry trades and argued that the excess returns to carry trades tend to reflect compensation for U.S. consumption growth risk, just like other risky assets and strategies. This follows from the idea that in bad times when U.S. consumption growth is likely to be slow or negative, investors will tend to prefer safe over risky assets. Because high-yield currencies tend to be riskier than their low-yielding counterparts, the return on high-yield currencies will tend to perform poorly during periods of economic or financial distress as investors shed risky currencies in favor of safe assets. Low yield currencies, on the other hand, tend to be the beneficiary of those safe-haven flows, and hence tend to perform well during periods of distress.

Thus, in periods when U.S. consumption growth is weak, high-yield currencies will exhibit a tendency to underperform low-yield currencies, resulting in negative returns on FX carry trades. Because of this downside risk in distressed periods, FX carry trades, like other risky assets and strategies, need to compensate fund managers for this risk with a risk premium or expected excess return to induce them to participate in such risky investment strategies.

For the most part, U.S. consumption growth tends to be fairly stable over time, with significant periods of weaker spending only occurring during major economic slowdowns or downturns. Hence, there will only be a few instances where one could test the proposition that U.S. consumption growth risk is a key driver of carry-trade returns.

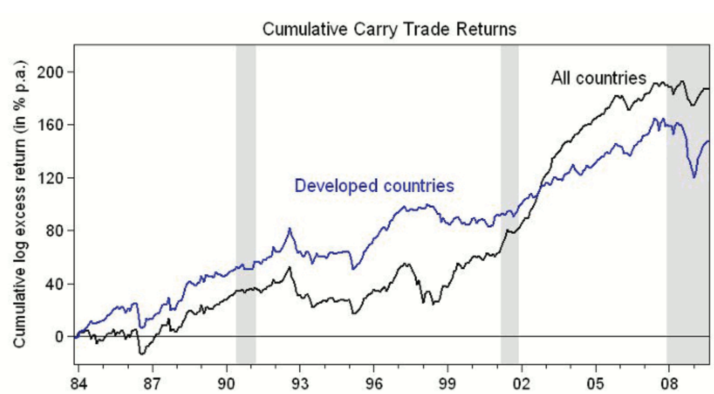
The Great Depression of 1929-32 and the Great Recession of 2008-09 fall into this category and there is an eerie similarity between the two episodes. Both carry- trade crashes were preceded by large and persistent positive excess returns leading up to the carry trade crashes. A recent study by Accominotti and Chambers (2013) finds that after a period of high positive excess returns in the 1920s, FX carry trades posted negative returns from 1932-39, a period of extraordinary weak growth. This pattern re-emerged during the Great Recession of 2008-09 when weak U.S. consumption growth coincided with a major decline in the performance of both G-10 and EM FX carry trades. Similar to the 1920s-1930s, carry trades had posted very high positive excess returns over the 2002-07 period, heading into the economic downturn and carry-trade crash.

While there is clearly a strong connection between extremely weak consumption growth and FX carry-trade returns, the relationship does not appear to be that strong during periods of mild changes in U.S. consumption growth. Menkhoff, Sarno, Schmeling and Schrimpf (2012) demonstrate that in other periods when FX carry trades suffered significant losses—1986, 1992, 1997-98 and 2006—the losses were registered at a time when U.S. consumption growth was relatively benign, i.e., no outright U.S. recession occurred at the time that those losses were recorded (see Figure IV-4). This suggests that the CCAPM does not represent a full explanation of the cyclical performance of FX carry trades, except perhaps during periods of extreme economic weakness.

Figure IV-4

Carry-Trade Returns and the U.S. Business Cycle

(Recession Shaded, 1984-2009)



Source: Lukas Menkhoff, Lucio Sarno, Maik Schmeling, Andreas Schrimpf, "The Risk in Carry Trades", 23 March 2011, http://www.voxeu.org/article/risk-carry-trades

FX Volatility Risk and Carry-Trade Returns

High and low-yield currencies have different risk characteristics, and those risk characteristics tend to be embodied in the yield spread between high and low-yielding markets. In addition to incorporating market expectations of future changes in exchange rates, the yield spread between high and low-yielding markets will often reflect market concerns about relative default risk, liquidity risk, fiscal soundness, central-bank credibility, and inflation risk. Because high-yield currencies tend to be perceived as risker than low-yield currencies on most of those counts, investors will be willing to buy and hold high-yield currencies only if they are compensated in the form of an attractive risk premium or excess return for taking on such risks.

Exposure to those risk factors becomes a serious problem during periods of economic and financial distress. During such periods, the possibility that one or more of the high-yield market's risk factors might turn ugly often compel investors to unwind their long positions in risky high-yield currencies in favor of the safe-haven assets of low-yielding currencies. This reallocation of currency portfolios away from high yielders is what causes the returns on FX carry trades to crash.

Researchers have analyzed a wide range of "state" variables that can help differentiate so-called good states (non-distressed periods) from bad states (distressed periods). Knowing what state variables are carry-trade friendly or not is important in managing the risks associated with FX carry trades.

Menkhoff, Sarno, Schmeling and Schrimpf (2012) find that bad states of the world can best be identified by unexpected increases in global FX volatility. They find that high-yield currencies tend to respond negatively to changes in FX volatility, while low-yield currencies tend to respond positively. That is, high-yield currencies tend to post negative returns when FX volatility is unexpectedly high, while low-yield currencies tend to post positive excess returns when FX volatility is unexpectedly high. As a result of this sensitivity to changes in the volatility regime, FX carry trades which are long the currencies that respond negatively to increases in FX volatility (the high-yielders) and short the currencies that respond positively to increases in FX volatility (the low-yielders) will be doubly exposed to the downside in such instances.

Menkhoff et al.'s study finds that changes in global FX volatility not only plays a role as a state variable that differentiates good from bad states of the economic and financial climate, but FX volatility also functions as a systematic risk factor that is priced into the cross-section of high, medium and low-yield currency returns. The authors first derive a composite measure of global FX volatility and then estimate volatility betas for low, medium, and high-yielding currencies that capture the sensitivity of low, medium, and high-yielders to changes in their composite measure of FX volatility. The authors adopt the methodology of Lustig and Verdelhan of sorting currencies into equally weighted baskets, with low-yielders placed in Basket 1, medium yielders in Baskets 2-4, and the highest-yielding currencies placed in Basket 5. Their results are reported in Figure IV-5.

Figure IV-5

Long-Run Performance and Estimated Volatility Betas of Low, Medium, and High-Yield Currency Baskets

(December 1983-August 2009)

	Currency Baskets					
	Low Yield		Medium Yield		High Yield	
	1	**2**	**3**	**4**	**5**	**Long 5/Short 1**
Mean Annual Return	-1.46	-0.10	2.65	3.18	5.76	7.23
Skewness	0.18	-0.23	-0.28	-0.55	-0.66	-1.03
Volatility Beta	4.34	1.00	-0.30	-1.06	-3.98	--

Source: Menkhoff, Sarno, Schmeling, Schrimpf, (2012) As shown, sorting by interest-rate spread versus the U.S., the average annual excess returns on the different baskets in U.S. dollar-terms tends to rise monotonically as we go from Basket 1 to Basket 5. We saw this same pattern in Figure IV-1, and as we argued above, the primary factor driving excess returns on currency portfolios in U.S. dollar terms has been the absolute level of the yield spread.

Menkhoff et al. argue that the reason that high-yield currencies offer higher excess returns is that they exhibit a higher degree of sensitivity to changes in global FX volatility. Figure IV-5 reports the authors' estimates of those sensitivities—the estimated volatility beta coefficients for Baskets 1 and 2 are positive, indicating that the returns of low-yielding currencies tend to rise during periods of heightened FX volatility, while the estimated beta volatility coefficients for Baskets 3-5 are negative, indicating that the returns of higher-yielding currencies tend to fall during periods of heightened FX volatility.

The volatility beta estimates indicate that diversified FX carry trades—which tend to be long the high-yielders in Basket 5 and short the low-yielders in Basket 1—will be doubly exposed to changes in global FX volatility. As before, these trading positions will be long currencies that weaken and short the currencies that strengthen when FX volatility rises.

Figure IV-6, which comes from Menkhoff et al.'s study, illustrates how FX carry trades tend to perform under different volatility states. The authors break down the entire sample of FX volatility changes into four subsamples—a low volatility subsample consisting of all data points when FX volatility was in the lowest 25% of all FX volatility readings recorded, a high volatility subsample consisting of all data points when FX volatility was in the highest 25% of all volatility readings recorded, and two medium subsamples consisting of low-to-medium and medium-to-high readings on global FX volatility.

Figure IV-6 plots the mean return on an FX carry portfolio (long Basket 5/short Basket 1) during each of those four subsample periods. As shown, carry-trade returns are highest in the low volatility subsample. Carry-trade returns remain positive in the two medium subsamples and, as expected, the returns do decrease monotonically as the volatility state rises from the lowest quartile to the higher volatility quartiles. Carry-trade returns are then shown to turn negative when FX volatility is in the highest volatility quartile. This chart demonstrates that periods of high volatility are not friendly to FX carry trades.

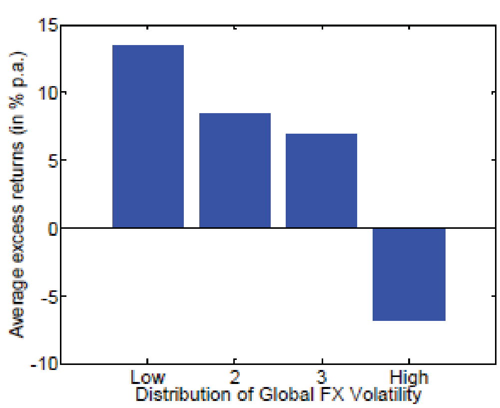
One way to interpret the findings in Figure IV-6 is that when FX volatility rises above some critical threshold level, FX carry trades are likely to become highly vulnerable to large downside moves. Analysts can use this information to construct a volatility-based overlay model or filter that could warn investors when it is time to exit a carry trade position. (We discuss how volatility-based filters can be used in managing the downside risks associated with FX carry trades in Part VI of this report.)

One of the dangers of using FX volatility as a risk filter or signaling device for timing entry and exit decisions is that low volatility readings today or in the recent past might understate the volatility risks facing investors tomorrow. Because carry trades tend to perform well in low-volatility states, investors might feel emboldened by a low-volatility environment to increase their exposure to carry-trade strategies, perhaps significantly so, and might also be en-

Figure IV-6

Carry-Trade Excess Returns in Low and High Volatility States

Distribution of Global Foreign-Exchange Volatility in Developed Countries



Source: Lukas Menkhoff, Lucio Sarno, Maik Schmeling, Andreas Schrimpf, "The Risk in Carry Trades", 23 March 2011, http://www.voxeu.org/article/risk-carry-trades

Figure IV-7

Correlation of Carry-Trade and Equity-Market Returns in Low and High FX Volatility States
(1995-2008)

FX Volatility Rank	Top 5%	15%	25%	35%	45%	55%	65%	75%	85%	95%	100%
Correlation	0.41	0.33	0.30	0.27	0.24	0.23	0.21	0.21	0.20	0.19	0.19

Source: Charlotte Christiansen, Angelo Ranaldo, Paul Söderlind, "The Time-Varying Systematic Risk of Carry Trade Strategies", 2010.

couraged to increase the amount of leverage they are willing to take at the same time. If a significant number of investors are encouraged by a favorable volatility environment and are thus drawn into taking on more aggressive, overly leveraged carry-trade positions at the same time, it could create a highly vulnerable situation where only a small sudden volatility shock could lead to a major unwinding of those positions, thereby triggering major carry-trade losses in the process.

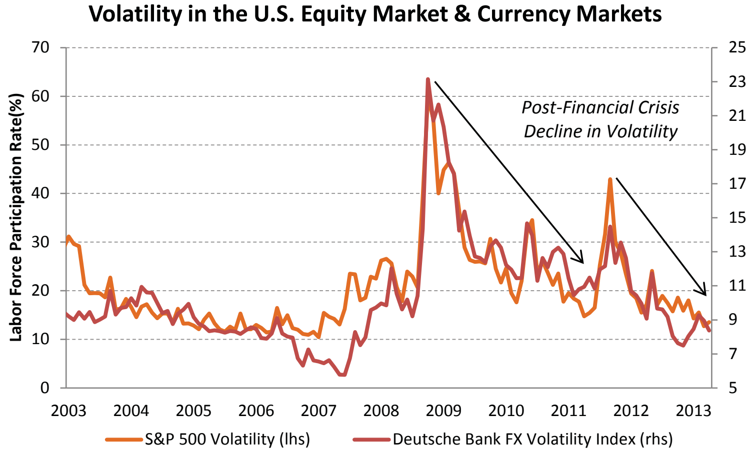
Richard Bookstaber (2011) refers to this dilemma as "The Volatility Paradox"—low volatility states tend to encourage complacency and greater risk taking, which then increases the vulnerability of those positions to a major downside move if and when the volatility regime changes. To a large extent, the seeds of the large losses recorded on all risky assets—including FX carry trades—during the Global Financial Crisis in 2008-09 were planted in the low-volatility environment that preceded the crisis.

Interestingly, low and high-volatility environments not only affect the absolute returns on risky assets and strategies, but also have an impact on the correlation of returns of those risky assets and strategies. A recent study by Christiansen, Ranaldo and Soderlind (2010) found that the correlation of carry-trade returns and the returns on the U.S. equity market has tended to be fairly low at around 0.19 during low-FX volatility states. Figure IV-7, which appeared in their study, reveals that the correlation of carry-trade returns and U.S. equity-market returns exhibits a tendency to increase steadily as the state of FX volatility shifts from a lower to a higher-FX volatility regime. In fact, when FX volatility is in the highest 5% of all volatility states, the correlation between carry-trade returns and the returns on the U.S. equity market is strongest at 0.41.

One of the reasons for this reported rise in the correlation of returns is that volatility spikes in the FX market tend to coincide with volatility spikes in the U.S. equity market. This can be seen in the co-movement of the S&P500 Volatility (VIX) index and Deutsche Bank's Global FX Volatility (CVIX) index. As shown in Figure IV-8, the VIX and CVIX indices do not move closely together in benign states, but when the volatility regime suddenly deteriorates, both the VIX and CVIX indices tend to become more highly positively correlated. This suggests that during periods of heightened FX and equity-market volatility, FX carry trades and the U.S. equity market will both tend to perform poorly—hence the increase in correlations in volatile environments.

Figure IV-8

Volatility in the U.S. Equity Market & Currency Markets

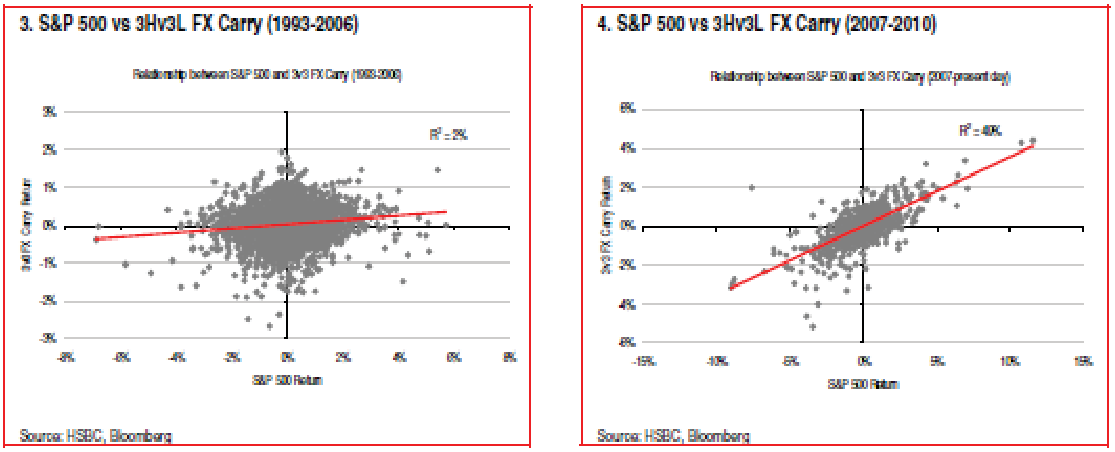


Source: *Bloomberg* ***VIX, CVIX INDEX<GO>***

Figure IV-9

Carry-Trade Excess Returns in Low and High Volatility States

Distribution of Global Foreign-Exchange Volatility in Developed Countries



Source: David Bloom et al., “Carry On — Carry Off; The FX Carry Trade”, HSBC Global Research Currency Weekly, 08 November 2010.

Christiansen et al.’s findings are supported by a recent research report by HSBC’s FX strategists (2010). As shown in Figures IV-9, the correlation of returns on a simulated G10 carry trade and the S&P index was a mere 2% between 1993 and 2006 when FX and equity market volatility were—on average—not extraordinarily high. When FX and equity market volatility soared over the 2007-2010 period, however, those correlations jumped to 49%.

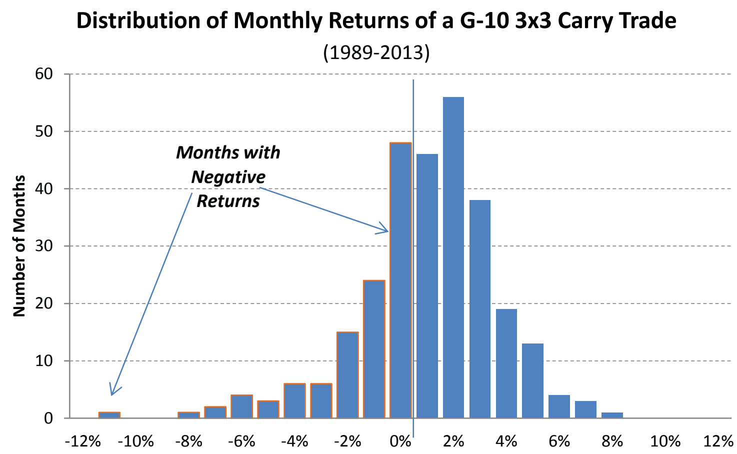
This has important implications for the role that FX carry trades might be expected to play in an otherwise diversified portfolio consisting of U.S. cash, bonds and equities. If one factors in the high average excess returns earned on FX carry trades coupled with the low *average* correlation between FX carry-trade returns and U.S. equity-market returns, this might lead some to believe that FX carry trades should be accorded the status of a separate asset class that should be incorporated in a broadly diversified multi-asset portfolio. While such reasoning would appear to make sense using *average* returns and correlations, the issue that investors must grapple with is that in bad states of the world when volatility is spiking higher in both the FX and equity markets, the performance of both FX carry trades and the U.S. equity market are likely to suffer in unison, perhaps significantly so. This means that in periods characterized by high FX and equity market volatility, FX carry trades will fail to deliver the favorable diversification benefits to a multi-asset portfolio that historical averages tend to promise.

Carry Trades and Crash Risk

As discussed above, FX carry trades can be likened to short-volatility trades because they tend to generate positive returns when volatility is low, but suffer losses when volatility is high and rising. When those losses are large, the decline in currency returns is referred to as a carry-trade crash.

There have been a number of classic episodes where FX carry trades suffered very large losses--the unwinding of long high-yield ERM/short Deutschemark trade in 1992, the unwinding of the infamous yen carry trade in 1998, and the dramatic decline in the value of many high-yield currencies during the Global Financial Crisis in 2008. Numerous other episodes of individual currency crashes have occurred from time to time.

Figure IV-10



Source: *Bloomberg*

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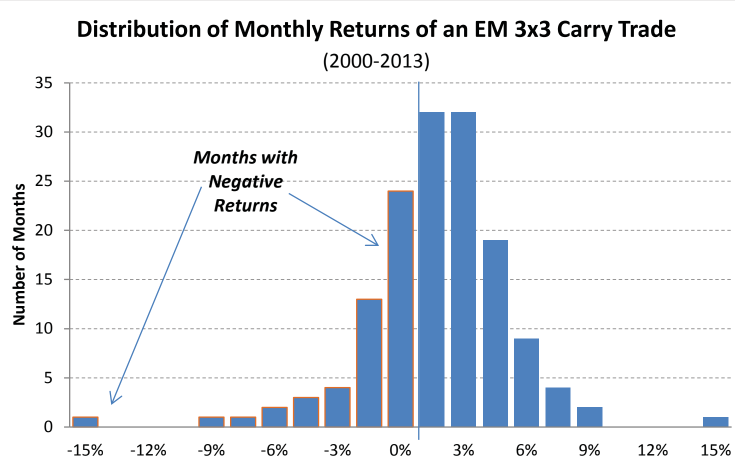
Broad diversified carry trades are not immune to crash risk. This can be gleaned from Figures IV-10 and IV-11 where we plot the distribution of returns for the G-10 (for 1989-2013) and emerging-market (2001-2013) 3x3 carry-trade portfolios. The first thing that jumps out on you when looking at these charts is that the distribution of G-10 and EM carry trade returns are not normally distributed, but rather are negatively skewed to the left, and significantly so. The negative skew indicates that there have been a number of instances where diversified G10 and EM carry trades suffered large losses over short periods of time, losses that turned out to be far greater than would have been expected had the distribution of returns been normal.

A recent study by Rafferty (2013) analyzes the skewness properties of high and low-yielding currencies. Following the methodology adopted by Lustig and Verdelhan (2008), Rafferty constructs five equally weighted baskets, assigning currencies according to the yield advantage or disadvantage that each currency enjoys relative to the U.S. dollar. Basket 1 contains those currencies with the lowest or most negative yield spread versus the U.S., while Basket 5 contains those currencies with the widest positive spread. Baskets 2-4 include currencies with medium yield spreads versus the U.S.

Figure IV-11



Source: *Bloomberg*

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Figure IV-12

Skewness and Kurtosis Properties
of Low, Medium, and High-Yield Currency Baskets
(February 1976-August 2011)

	Currency Baskets					
	Low Yield		Medium Yield		High Yield	
	1	**2**	**3**	**4**	**5**	**Long 5 / Short 1**
Mean Annual Return	-0.24	0.48	2.83	3.99	5.03	5.27
Skewness	0.09	-0.04	-0.14	-0.29	-0.30	-0.51
Excess Kurtosis	0.73	0.50	1.57	1.90	1.50	1.61

Source: Rafferty (2012)

The results from Rafferty's sorting exercise are displayed in Figure IV-12. As shown, the average annual excess returns on the five baskets tends to rise monotonically, with the low-yielding basket posting an average annual loss of -0.24% and the high-yielding basket posting a positive average annual positive excess return of 5.03%. These findings are similar to those reported by Lustig and Verdelhan and Menkhoff et al.

Regarding the crash properties of the low and high-yield currency baskets, Rafferty's findings indicate that the distribution of returns for Basket 1, the low-yielding group, has a modest positive skew, while Baskets 2-5 have a negative skew. The magnitude of the negative skew increases as we go from the middle-yielding currencies to the highest-yielding currencies. These findings indicate that high-yield currencies have been exposed to more frequent large downside moves than low-yielding currencies.

Taking into account both the excess return and skewness properties of the currency baskets in Figure IV-12, Rafferty argues that because high-yield currency are exposed to greater downside risk than their low-yielding counterparts (as reflected in the large negative skew in the distribution of high-yield currency returns), the high positive excess returns earned by high-yielders reflect a risk premium to investors who are willing to take on that crash (left tail) risk.

The need to be compensated for taking on crash risk holds in all asset classes, not just foreign exchange. Indeed, some economists make the case that part of the excess returns that equities have enjoyed over fixed income assets (the so-called equity risk premium) simply reflects compensation for taking on disaster or crash risk.

Rafferty's research indicates that exposure to crash risk applies to both individual bilateral carry trades and diversified multi-currency carry-trade portfolios. Figure 4.12 shows that a diversified carry trade that is long Basket 5 and simultaneously short Basket 1 would have earned an average annual excess return of 5.27%, which is essentially the sum of the returns on the two baskets. What is particularly noteworthy is that the distribution of returns on the long Basket 5/short Basket 1 trade has a large negative skew of -0.51, which is larger than the negative skew on any of the individual currency baskets, including Basket 5.

The reason for the large negative skew on the carry trade basket is that a strategy that is long negatively skewed currencies and short positively skewed currencies will tend to be doubly exposed to the downside if and when disaster strikes. That is, both the long position in high-yield currencies and the short position in low-yield currencies tend to decline in value at the same time when carry trades are exposed to a major downside event. Because both sides of the carry trade suffer at the same time, the large negative skew in the distribution of carry-trade returns cannot be diversified away.

Figure IV-13

Estimated Sensitivity of Low, Medium, and High-Yield Currencies to Global Skewness

(February 1976-August 2011)

	Currency Baskets				
	Low Yield		Medium Yield		High Yield
	1	**2**	**3**	**4**	**5**
Skewness Beta	-0.125	-0.062	0.046	0.027	0.114

Source: Rafferty (2012)

One of the interesting new areas that Rafferty addresses is how one can construct an aggregate measure of global skewness that can be used as a state variable in explaining the performance of high and low-yielding currencies in general, and carry-trade returns in particular. To capture the exposure that high and low-yield currencies might have to broad-based/global crash risk, rather than just idiosyncratic/country crash risk, Rafferty constructed an aggregate measure of global FX skewness from the individual skewness properties inherent in the world's major currencies versus the dollar.

Rafferty derives estimates of the sensitivity of low and high-yield currencies to this global skewness factor (see Figure 4.13) that suggest that low-yield currencies tend to rise in value when the global skewness factor turns more negative (i.e., the estimated skewness beta coefficient for the low-yielders is negative) while the high-yielders tend to decline in value when the global skewness factor turns more negative (i.e., the estimated skewness beta coefficient for the high-yielders is positive).

Rafferty's work indicates that aggregate crash risk as captured by his global skewness factor represents an independent source of risk that is priced into the cross section of low, medium, and high-yielding currencies. Rafferty's global skewness factor is *not* highly correlated with other risk factors such as Menkhoff et al.'s global FX volatility risk factor. This would suggest that both FX volatility risk and skewness (or crash) risk should be viewed as separate statistically significant and economically important risk factors that are priced into the cross section of currency returns.

Capital Asset Pricing Model (CAPM)

The traditional Capital Asset Pricing Model (CAPM) contends that the excess returns on all assets can be modeled as a function of the excess return on the broad U.S. equity market. This raises an interesting question—can the excess returns on low, medium, and high-yield currencies be explained by the excess returns on the broad U.S. equity market in both upside and downside moves.

If the CAPM framework could be applied to the FX markets we would expect to find that risky high-yield currencies would tend to perform as high beta assets, i.e., rising in value when the U.S. equity market is rising, and vice versa. Low yield currencies, which tend to behave as safe-haven assets, would likely be characterized as low beta or negative beta assets because their returns would exhibit a tendency to be weakly or negatively correlated with changes in the broad U.S. equity market.

While many market participants often look to the U.S. equity market to get a handle on which direction high and low-yield currencies might take, most academic studies find that the CAPM framework fails to adequately explain the differences in the cross section of low, medium, and high-yield currency returns. As shown in Figure IV-14, which is drawn from a study by Lettau, Maggiori and Weber (2012), if the CAPM framework were valid, we would expect to see substantial differences in the estimated equity-market beta coefficients for low (Basket 1), medium (Baskets 2-5), and high-yield currencies (Basket 6), with high positive beta readings for the high-yielders and low or negative beta readings for the low-yielders. But rather, the data indicate that the estimated "average" beta coefficients for low and high-yield currencies are not all that different. Hence, the traditional CAPM framework is unable to explain the cross-section of currency returns.

Lettau, Maggiori and Weber argue that although the traditional CAPM framework fails to explain the cross-section of currency returns, a downside-risk version of the CAPM framework does a far better job. Rather than trying to estimate the *average* sensitivity of currency returns to average changes in the broad U.S. equity market in both up and down cycles, the authors suggest that the estimated beta coefficients should be broken down into two parts—an *upside* beta coefficient that captures the sensitivity of currency returns to only upside moves in the broad U.S. equity market and a *downside* beta coefficient that captures the sensitivity of currency returns to only downside moves in the U.S. equity market. The reason for this separation is that the co-movement of currency returns with the U.S. equity market is not very strong in normal or favorable states of the world, but the degree of co-movement tends to be significantly stronger in bad states of the world when the U.S. equity market is turning down.

Defining bad states of the world as periods when the U.S. equity market is turning down, Lettau et al. find that while estimated upside beta coefficients tend to be quite similar for low, medium, and high-yielding currencies, there are substantial differences in the estimated downside beta coefficients. The authors find that the estimated downside beta coefficient is extremely small for low-yielders at around 0.02, while the estimated downside beta coefficient for high-yielders is significantly higher at 0.30. The significant differences in estimated downside betas for low and high-

Figure IV-14

Estimated Sensitivity of Low, Medium, and High-Yield Currencies to Changes in the U.S. Equity Market — Average versus Downside Beta

(January 1974-March 2010)

	Currency Baskets					
	Low Yield		Medium Yield			High Yield
	1	**2**	**3**	**4**	**5**	**6**
Average Beta (Entire Sample)	0.03	0.06	0.04	0.08	0.10	0.12
Downside Beta (Conditional on Bad Market Returns)	0.02	0.04	0.04	0.10	0.17	0.30

Source: Lettau, Maggiori and Weber (2012) yielders suggests that when the broad U.S. equity market turns down, high-yield currencies will tend to suffer significant losses, while low-yield currencies will tend to be relatively insulated from the down-moves in the U.S. equity market.

These findings indicate that high-yield currencies are riskier than their low-yielding counterparts because they tend to perform poorly at a time when other risky assets such as the broad U.S. equity market are performing poorly. Because of this downside risk, high-yield currencies should command a risk premium or higher expected return to induce investors to buy and hold them. Low-yield currencies, on the other hand, tend to play the role as a safe-haven hedge against a poorly performing U.S. equity market. Such currencies tend to be in strong demand in bad states of the world, but offer little in the way of positive excess returns in favorable states of the world.

When we construct a carry-trade portfolio that is long high-downside beta currencies (i.e., high-yielders) and short low-downside beta currencies (i.e., low-yielders) we find that carry trade returns tend to be weakly correlated with the U.S. equity market on average—with the average correlation of returns a mere 0.14. When the broad U.S. equity market is rising, the correlation of returns between the U.S. carry trade and the U.S. equity market is just 0.03. However, when focusing on just the downside moves in the U.S. equity market, the correlation of returns jumps up to 0.33. These findings suggest that downside moves in the U.S. equity market are a more important driver of carry-trade returns than upside moves.

Dobrynskaya (2010) suggests using another downside risk measure—the co-skewness of carry-trade returns with the U.S. equity market—to capture the sensitivity of currency returns to downside moves in the U.S. equity market. Co-skewness measures the extent to which the skewness in the distribution of returns on low, medium and high-yielding currencies can be explained by changes in U.S. equity-market volatility. When U.S. equity-market volatility is high, the distribution of low-yield currency returns tends to exhibit positive skewness, indicating that the co-skewness of low-yield currency returns tends to be positive. In the case of high-yield currencies, the distribution of currency returns tends to be negatively skewed when U.S. equity market volatility is high. Hence, the co-skewness of high-yield currency returns tends to be negative.

As shown in Figure IV-15, the estimated co-skewness measures for low, medium, and high-yield currencies is shown to range from +0.59 for low-yielders to a negative reading of -2.56 for high-yielders. The descending co-skewness properties—as we go from low to medium and then from medium to high-yielders—is evident. Since equity-market volatility tends to rise in bad states of the world, the co-skewness measure can be used as a downside risk measure to characterize the risk properties of low and high-yielders in general and carry trades in particular. Indeed, co-skewness measures can be used in conjunction with downside beta estimates to get a clearer picture of the downside sensitivity of carry trades to downside moves in the U.S. equity market.

Figure IV-15

Estimated Co-Skewness of Low, Medium, and High-Yield Currency Returns with Changes in U.S. Equity-Market Volatility
(1999-2009)

Currency Baskets	Low Yield **1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	High Yield **10**
Co-Skewness	0.59	-0.87	-1.47	-0.53	-0.99	-0.72	-1.14	-1.50	-1.55	-2.56

Source: Dobrynskaya (2010)

Can Crash Risk Be Hedged?

Investors have the ability to get rid of the negative skew associated with FX carry trades by purchasing puts on high-yield currencies and calls on low-yield currencies in the FX options market. In theory, one would expect that the cost of those options should reflect the downside risks associated with FX carry trades. If the downside risks are high, then the cost of insuring against those downside risks should be high as well.

As it turns out, the cost of downside risk protection via FX options has historically not been all that high. A number of academic studies have found that FX carry trades hedged against downside risk using either out-of-the-money (OTM) or at-the-money (ATM) puts on high-yielders/calls on low-yielders actually earned attractive positive excess returns over time, even after adjusting for the cost of the options.

Figure IV-16 compares the simulated returns on diversified FX carry trades over the 1999-2007 period that are hedged using deep-OTM (10 delta), OTM (25 delta) and ATM options. These results are drawn from a study by Jurek (2009). As one would expect, because deep-OTM options are the least expensive approach to insuring against downside risk, the excess returns to this form of downside risk-protected carry-trade strategy generated the highest mean return over the 1999-2007 period.

One of the reasons why deep-OTM option-protected carry-trade strategies did that well was that there were few large downside moves that needed to be protected against over the 1999-2007 period. Hence, deep-OTM option hedges were the least costly insurance protection policy available during a period when insurance protection policies on an after-the-fact basis were unnecessary.

Using deep-OTM options still came at a cost, however. Because deep-OTM options do not kick in until after a sizable move in high-yield and low-yield currency values has already taken place, there is a still significant negative skew in the distribution of hedged carry trade returns.

Hedging with ATM options generates a smaller but still positive excess return, but in this case the negative skew is eliminated by the option hedge. In fact, a hedged carry-trade portfolio using ATM options is reported to have a positive skew.

Figure IV-16

Option-Hedged Carry-Trade Returns Using Deep Out-of-the-Money, Out-of-the-Money, and At-the-Money Options

(January 1999-December 2007)

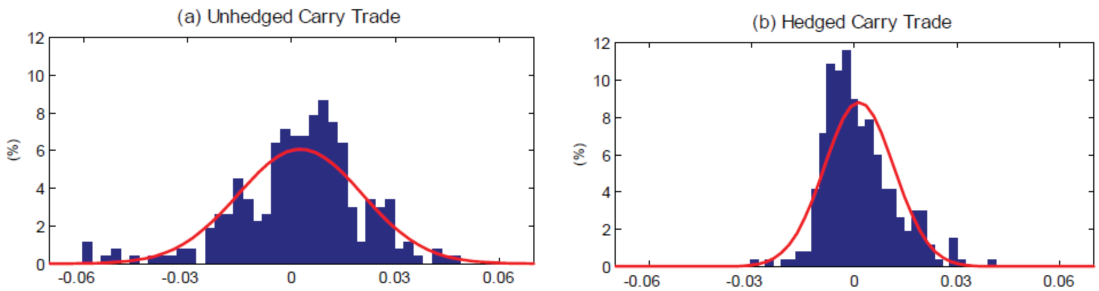
	Options		
	Deep OTM 10 Delta	**OTM 25 Delta**	**ATM**
Annual Excess Return	**3.85**	**3.11**	**1.62**
Standard Deviation of Return	4.19	3.78	3.00
Sharpe Ratio	0.92	0.82	0.54
Skewness	-0.19	0.24	0.91

Source: Jurek (2009)

Figure IV-17

Total Return Distributions of Unhedged and Option-Hedged Carry-Trade Portfolios

Distribution of Global Foreign-Exchange Volatility in Developed Countries



Source: A. Craig Burnside, Martin S. Eichenbaum, Isaac Kleshchelski, and Sergio Rebelo, "Do Peso Problems Explain the Returns to the Carry Trade?", NBER Working Paper No. 14054, June 2008, Revised January 2010, JEL No. F31, Figure 7.

Similar findings were reported in a study by Burnside, Eichenbaum, Kleschelski and Rebelo (2010). Their findings showed that although hedged carry trades have offered a smaller average annual return than their unhedged counterparts, the payoffs on the hedged carry trade have been far less volatile, reflecting the fact that ATM hedging eliminated the large negative payoffs associated with unhedged carry trades (see Figure IV-17).

These findings raise a number of important issues. First, why did the cost of insuring against downside moves in FX carry trades appear to be so cheap? In other words, why didn't the cost of insuring against downside risk cut the excess return on the hedged carry-trade position to close to 0% since in theory the hedge should have made the hedged carry-trade resemble something close to a riskless investment?

Caballero and Doyle (2012) provide some interesting insight into this issue. They note that because the returns on unhedged carry-trade portfolios tend to fall when the VIX index rises, carry-trade portfolios in theory could be hedged by purchasing long positions in VIX futures. Under such a hedging scheme, the gain on the long position in VIX futures should offset the loss on the FX carry trade. Caballero and Doyle find that this approach to hedging downside risk would have generated an average annual excess return close to 0%, just as theory would have predicted. This is significantly lower than the positive excess returns that could have been earned had the carry-trade position been hedged using OTM or ATM FX options. Why the cost of hedging using options proved to be so much cheaper than hedging using the VIX index remains a puzzle.

A second issue related to the cost of insuring against downside risk is that, if hedged, carry trades are able to post positive excess returns over time and are able to generate fairly attractive Sharpe ratios, then crash risk cannot fully explain why carry trades have been able to earn such high positive excess returns over time because that risk could have been hedged away at very little cost.

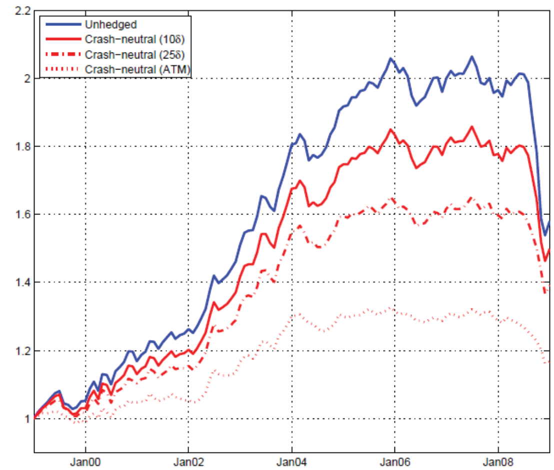
A possible solution to this second issue is that option hedges do not completely insulate carry trades from downside risks. Figure IV-18, which appeared in Jurek's study, indicates that both unhedged and hedged carry-trade portfolios experienced large downside moves during the 2008 Global Financial crisis. The option-hedged carry-trade strategies using 10 delta and 25 delta OTM options suffered large losses because those options did not kick in until carry trade returns had already suffered large losses in 2008.

Even the hedged carry-trade strategy using ATM options suffered significant losses in 2008, albeit considerably smaller losses than the hedged strategies using OTM options. But as Figure IV-16 shows, the smaller losses generated by the hedged carry trades using ATM options came at a longer-run cost—the overall gains on the ATM hedged carry trade were not all that robust for the 1999-2008 period, especially when compared with the OTM hedged carry trades.

Figure IV-18

Cumulative Total Return on Unhedged and Option-Hedged Carry Trades Using Selected Degrees of Downside Protection

(January 1999-December 2008)



Source: Jacub W. Jurek, "Crash-Neutral Currency Carry Trades, April 2009.

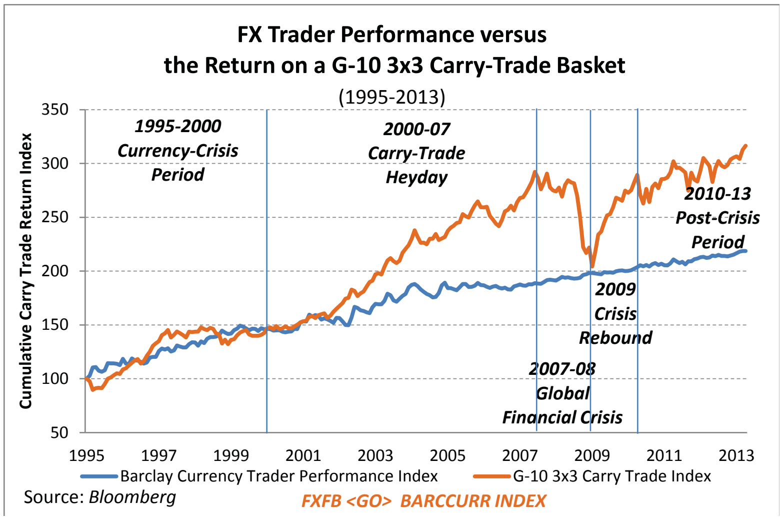
Carry Trades and Rare Disaster (Peso Event) Risk

A number of recent studies have examined whether market concerns about the possibility of a rare disaster that has failed to occur in sample might be playing a role in driving carry-trade excess returns. Rare disasters are low probability events that could lead to large losses should the rare events materialize. If the rare disaster fails to occur in sample, ex-post tests of uncovered interest rate parity would find that interest-rate spreads failed to predict future movements in exchange rates. On an ex-ante basis, however, interest-rate spreads might have embodied concerns about a possible rare disaster or event that would have triggered a major downside move in the exchange rate had the rare disaster actually materialized.

Investors fear negative outcomes and thus want to be compensated for pursuing strategies that face possible large downside moves. Loss aversion is high among fund managers because underperformance could not only make it difficult to recoup such losses in the future, but could also harm fund managers long-run career prospects. The long-run excess returns on FX carry trades might therefore reflect two related factors: (1) the weighted average probability of a rare disaster event and (2) the importance that investors attach to suffering losses in such a scenario. The greater the probability of such an event and the greater the degree of loss aversion on the part of investors, the higher the risk premium needs to be to induce investors to participate in FX carry trades.

All of this is difficult to test empirically because there are no observable time series data on either rare disaster probabilities or investors aversion to short-term losses. Even though it is difficult to test, we need to be mindful that these factors might nevertheless be important determinants of the large reported excess returns generated by FX carry trades.

Figure IV-19



Limits to Speculation Hypothesis—Are Carry-Trade Profit Opportunities Exploited by FX Investors? A recent Federal Reserve staff study (see Curcuru, Vega and Hoek, "Measuring Carry Trade Activity" July 2010) found that there is "not...convincing evidence that carry trade strategies (have been) adopted on a widespread and substantial basis." There may be a reason why FX managers as a group have chosen not to participate in FX carry trades in a meaningful way—they appear to place a great deal more emphasis on risk management than on return enhancement, so much so that they appear to prefer leaving money on the table rather than pursuing risky strategies such as FX carry trades that could leave their portfolios exposed to potentially large downside moves.

Figure IV-19 highlights the fact that FX investors as a group have not fully participated in FX carry trades. The chart compares the cumulative total-return performance of fund managers as a group against a diversified G-10 FX carry-trade strategy. The absence of strong positive co-movement between the two series suggests that the performance of FX investors as a group was being driven by other factors, including the use of alternative trading styles (such as momentum or valuation) or perhaps more importantly risk-management considerations designed to moderate the variability of portfolio returns. Indeed, the total-return profile generated by FX fund managers as a group appears to have been far more stable than a G-10 carry trade strategy.

Although FX carry trades outperformed the FX fund manager group since 1995, they did so by generating a great deal more variability in those returns. This can be seen in Figure IV-20 where it is shown that FX fund managers as a group posted an average annual return of 4.6% over the 1995-2010 period, while the average annual return on a simulated G-10 carry trade strategy was 6.6% over the same period. What is particularly noteworthy about the relative performance data is the differences in the annualized standard deviations of return—5.9% per annum for FX fund managers as a group versus 11.4% on the simulated G-10 carry trade strategy. Given the significant differences in reported return volatilities, FX fund managers as a group were able to generate more attractive Sharpe ratios than was generated by FX carry trades—0.8 for FX fund managers versus 0.6 for the simulated G-10 carry trade.

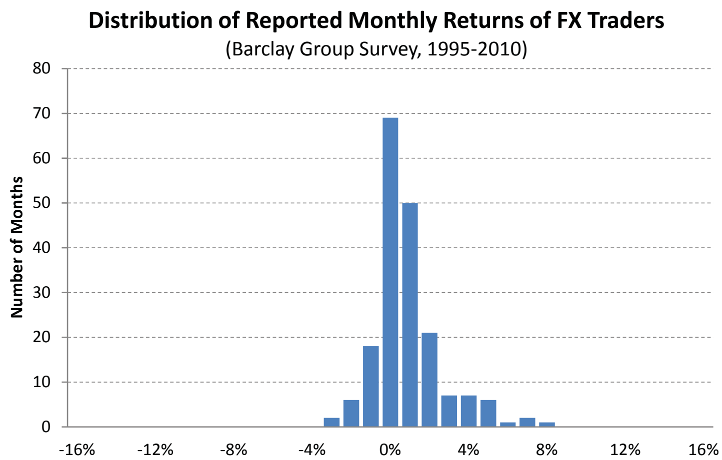
Figure IV-20

Risk/Return Profile of FX Traders and Simulated FX Trading Styles
(1995-2010)

	Cumulative Return	Average Annual Return	Standard Deviation	Sharpe Ratio
Barclay FX Trader Performance	102.10%	4.60%	5.90%	0.8
RBS Simulated FX Trading-Styles				
Carry Trade	170.70%	6.60%	11.40%	0.6
Valuation Based	84.10%	4.00%	9.20%	0.4
Trend Following	43.10%	2.30%	11.70%	0.2
Volatility Filter	62.70%	3.20%	13.30%	0.2

Source: Barclay Group; RBS; Bloomberg

Figure IV-21

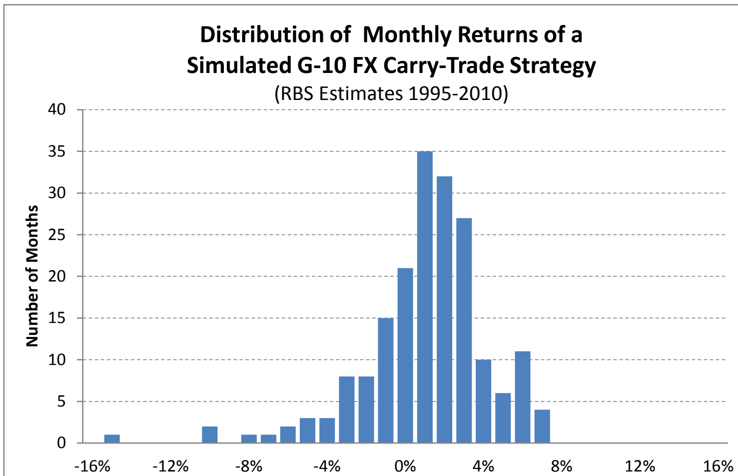


Source*: Barclay Group; Bloomberg* BARCCURR INDEX<GO>

What the total return and volatility data suggest is that FX fund managers as a group appear willing to sacrifice some upside return to avoid the possibility of large downside moves that a more aggressive carry-trade strategy would have entailed. Indeed, when we compare the distribution of actual returns generated by FX fund managers (Figure IV-21) with the distribution of returns on the simulated G-10 carry trade strategy (Figure IV-22), the one thing that jumps out is that the distribution of returns on the simulated G-10 carry trade strategy is substantially wider and far more negatively skewed than the distribution of returns reported by FX fund managers as a group.

The relatively tight distribution of total returns posted by FX fund managers suggests that they prefer portfolio stances that exhibit less volatility and, at the same time, do not entail significant negative skewness. If aversion to downside moves is substantial, risk-management considerations are likely to override total-return enhancement considerations in designing an FX portfolio strategy. Most fund managers recognize that in order to stay in business, they need to avoid potentially ruinous outcomes. That means that from a long-run, stay-in-business standpoint, it is in their best interest to conduct their business as constrained optimizers.

Figure iV-22



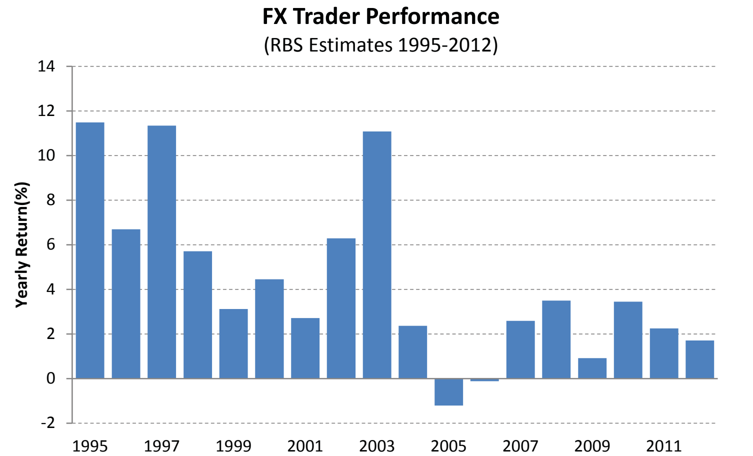
Source: *RBS; Bloomberg*

Figure IV-23

Risk/Return Profile of FX Traders
(1995-2013)

	Annual Return	Annualized Statndard Deviation	Sharpe Ratio
1995-2003	6.9%	7.2%	0.96
2004-2013	1.8%	3.0%	0.60
1995-2010	**4.3%**	**5.6%**	**0.78**

Source: Barclay Group; Bloomberg



Source: *RBS; Bloomberg*

Pursuing FX strategy as a constrained optimizer does come at a cost, however. As shown in Figure IV-23, dedicated FX fund managers as a group have reported a significant drop-off in their annual total-return performance over the past decade. As shown the average annual excess return of FX fund managers as a group has fallen from a 6.9% per annum rate over the 1995-2003 period to a mere 1.8% per annum rate over the 2004-13 period.

Another reason why FX fund managers might not pursue carry trades that actively is that their time horizon for making investment decisions tends to be quite short. According to some estimates, roughly 80% of all transactions on the world FX markets are opened and closed in just one week.

To be actively involved in FX carry trades, a longer investment time horizon is needed. One of the reasons this is the case is that although the annualized differences in yield between high and low-yield markets may appear to be quite wide, on a day-to-day basis even relatively wide yield spreads in annual terms are actually quite small in day-to-day terms, which can easily be swamped by day-to-day swings in exchange rates.

Consider the case where the short-term yield spread between a high and low-yielding market stands at 520 basis points on an annualized basis. Assuming 260 trading days in a year, that spread amounts to just 2 basis points per day, which can be easily swamped by daily changes in exchange rates. If an FX investor has a very short time horizon for making investment decisions, say 1-2 days or perhaps a week, the prospect of earning an extra two basis points per day is unlikely to materially affect the decision to be long or short the higher-yielding currency.

FX carry trade profits take time to accumulate—a carry trade is essentially a strategy that entails picking up nickels. Over the long run, those nickels can add up to meaningful dollars. But if investors have very short investment time horizons—and most FX market participants do indeed have very short time horizons—they will not have the patience to deal with the interim volatility that is entailed in picking up those nickels.

Still another reason why FX fund managers might not aggressively pursue carry-trade strategies is that many traders often place tight stops on their positions to limit potential downside losses. While tight stops makes sense as a risk-management tool, the initiation of those tight stops will likely result in carry trades getting frequently stopped out. And getting stopped out on a high frequency basis makes it difficult to pick up all those nickels over the long run.

Even if one could construct a scenario where FX managers might be willing to take a longer investment horizon and were willing to execute trades without tight stops, investors might still not want to aggressively pursue carry trades. That is because market participants appear to accept the notion that exchange rates are likely to move broadly in line with uncovered interest rate parity (UIP) even though the evidence suggests otherwise. Carry trades are essentially speculative bets that UIP will not hold. Therefore, if investors believe that UIP will hold, then there will be no reason why they would want to get involved in FX carry trades in the first place.

Research conducted by Froot and Frankel (1989) and updated by Chinn (2009 and 2012) find that in surveys of FX analysts, expectations of the future trend in exchange rates tend to be significantly influenced by interest-rate differentials or the forward premium/discount. That is, FX strategists, more often than not, expect that high-yield currencies will tend to decline in value versus low-yield currencies roughly in line with the interest-rate differential between the high and low-yield markets. In other words, on an ex-ante basis, FX analysts as a group expect that uncovered interest rate parity will largely hold.

This is not a problem of gradual learning in which FX analysts gradually come to realize that their forecasts were wrong and then adjust those forecasts to reflect the reality that UIP will not hold. Rather, the evidence from 25 years of survey-based tests indicates that FX analysts continue to get the direction of exchange rates wrong, just like the forward exchange rate gets the direction of the future spot exchange rate wrong. Indeed, survey-based expectations of the future spot exchange rate are often not that dissimilar from the expectations embodied in forward exchange rates.

Assuming most FX market participants share the same views as FX analysts, that implies that on an ex-ante basis, most market participants believe that UIP will broadly hold. And if that is the case, then on an ex-ante basis, investors would expect to earn a 0% return on carry-trade positions and would therefore have little reason to participate in FX carry trades. Thus, one of the key reasons why FX market participants might not want to get heavily involved in FX carry trades is simply they do not believe that betting against UIP will prove to be profitable.

Even if FX market participants believed that betting against UIP might be profitable, it is not evident that FX market participants will feel confident that those profits are worth chasing if they are not high enough on a risk-adjusted basis. Richard Lyons (2001) makes the case that most fund managers pursue risky strategies only if those strategies offer sufficiently attractive risk-adjusted returns, i.e., the expected Sharpe ratio on risky strategies needs to exceed a certain threshold level before investors will get seriously involved in such trades.

For example, a fund manager might set a Sharpe-ratio threshold level of 0.5 or greater that a risky strategy needs to achieve over the course of an investment cycle before they would be willing to seriously consider adding the firm’s risk capital to that particular strategy. Since the estimated Sharpe ratio on a buy-and-hold U.S. equity market strategy has been around 0.4 over the long run, a decision whether to allocate significant sums to FX carry trades or not would likely hinge on whether the carry-trade strategy has a good chance of generating a Sharpe ratio that significantly exceeds this 0.4 threshold.

Let’s assume that investors set a Sharpe ratio threshold level of 0.5 that all risky strategies must meet or exceed to be a serious candidate to be included in a diversified portfolio of risky assets and strategies. The 0.5 is actually not very high—many fund managers set considerably higher thresholds. We chose the fairly modest 0.5 threshold to make the following point: Carry-trade investors know at the outset what the prevailing yield spread is, but they do not know whether the exchange rate will rise or fall in value. If the prevailing yield spread relative to the current level of FX volatility is not high enough, then it might be difficult to hit a 0.5 target for the Sharpe ratio unless there is a highly favorable move in the exchange rate.

Consider the following example. Assume that the yield spread between a high and low-yielding currency is 250 basis points and the expected annualized volatility of return on the carry position is 10%. Thus, at the outset, the carry/volatility ratio (or carry/risk ratio) is estimated to be 0.25.

The Sharpe ratio on the entire carry-trade strategy, however, is equal to the positive carry plus the exchange rate return all divided by the volatility of return on the carry-trade strategy. From this definition, we can break down the Sharpe ratio into two parts—the carry/risk ratio and the exchange-rate-return/volatility ratio.

If a fund manager sets a targeted Sharpe ratio of 0.5 for the FX carry trade to meet or exceed, and the carry/risk ratio is known or estimated to be 0.25 at the outset, then the fund manager needs to be confident that the exchange-rate-return/volatility ratio will be 0.25 or higher. That is, the high-yield currency would need to appreciate by 2.5% per annum or more in order for the Sharpe ratio to meet or exceed the targeted threshold level of 0.5.

If fund manager set a Sharpe ratio threshold level of 1.0, then the high-yield currency would need to appreciate by 7.5% per annum versus the low-yield currency to make the carry-trade strategy a worthwhile undertaking on a risk-adjusted basis.

This simple example illustrates that the ability to meet or exceed a threshold target level for the Sharpe ratio depends on: (1) the known level of positive carry; (2) an estimate of the expected volatility of return on the entire carry-trade strategy, which can turn out to be higher or lower than anticipated; and (3) the expected change in the value of the high-yield currency versus the low-yield currency. The wider the initial yield spread and the lower the expected volatility of return, the less the need for the exchange rate to kick in to make the carry trade attractive on a risk-adjusted basis.

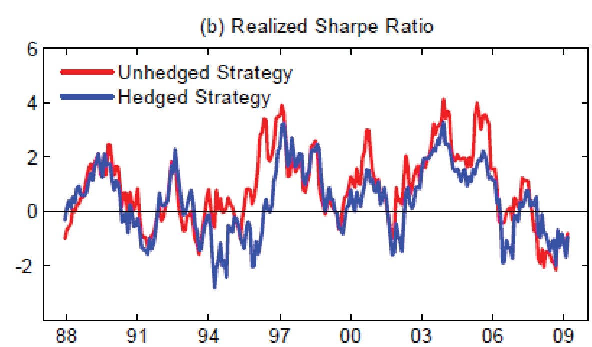
Historically, carry trades have on average generated Sharpe ratios that have exceeded 0.5. But as Figure IV-24 shows, drawn from a study by Burnside et al. (2010), there has been considerable variability in reported Sharpe ratios over time. Carry traders need to recognize that targeted threshold levels cannot be met in each and every year.

For instance, if the distribution of carry-trade returns were normal with a 5% expected annual excess return and an average volatility of return of 10%, a plus or minus one-standard-deviation move away from the mean would translate into a possible gain of 15% or a possible loss of 5%. A two-standard-deviation move would translate into a possible gain of 25% or a possible loss of 15%.

These moves suggest that a loss could be generated roughly 30% of the time by random movements around the mean excess return of 5%. We know, however, that carry-trade returns are not normally distributed, but rather are negatively skewed. That raises the odds that a carry trade will generate a loss in any given year by more than 30% of the time, even though the mean expected excess return would still be 5% per annum.

Figure IV-24

Sharpe Ratios of Hedged and Unhedged Carry Trade Portfolios
(February 1987-April 2009)



Source: A. Craig Burnside, Martin S. Eichenbaum, Isaac Kleshchelski, and Sergio Rebelo, "Do Peso Problems Explain the Returns to the Carry Trade?", NBER Working Paper No. 14054, June 2008, Revised January 2010, JEL No. F31, Figure 3.

Carry Trades and Transaction Costs

In calculating the risk-adjusted returns on any risky strategy, investors need to consider the level of transaction costs that might be entailed in pursuing such strategies. Normally, bid-ask spreads are fairly small in the FX markets and passively managed carry-trade portfolios do not entail a lot of turnover—the currencies that comprise the long and short baskets of a diversified carry trade portfolio do not change much from month to month.

For instance, the high-yielding Australian and New Zealand dollars are typically selected as currencies included in the long basket of a diversified G-10 carry-trade portfolio while the low-yielding Japanese yen and Swiss Franc are normally included in the short basket. With both the long and short basket not likely to change much on a month-to-month basis, portfolio turnover should not be a serious problem for most passively managed carry-trade portfolios.

Most studies that have compared the performance of passively managed carry trades with and without transaction costs have found that transaction costs do not eat into carry-trade profits by very much. In comparisons of Sharpe ratios reported on simulated FX carry trades with and without transaction costs, the consensus finds that the influence of transaction costs on carry trade risk-adjusted returns amounts to a modest decline in Sharpe ratios on the order of 0.1, or at most 0.2.

Portfolio turnover and the associated transaction costs could turn out to be far higher if carry trade strategies are aggressively managed, using an array of overlay models on a high frequency basis to limit downside risk. Currency overlay models typically consist of volatility filters, momentum models, or valuation measures to time entry and exit decisions into and out of FX carry trades. The signals emanating from those overlay models could trigger a large number of buy and sell signals, some of which may turn out to be correct, others which may turn out to be incorrect. A high frequency of buy and sell signals could result in a large run-up in portfolio turnover and transaction costs, and a considerable number of those recommended trades could turn out to be losing trades. Thus, one runs the risk that although overlay models are designed to limit the number of potentially large downside moves in sharply trending markets, those models can, at the same time, generate a lot of needless turnover and transaction costs on an after-the-fact basis when markets are trading sideways.

Part V — Constructing a Carry-Trade Portfolio

There are many ways to pursue carry-trade strategies in the FX markets. An investor could either select a specific currency to be long and a currency to be short or else choose to construct a diversified portfolio of long and short baskets of currencies from a sample of G10, EM, or regional currencies or from the entire universe of tradable currencies. In a diversified approach to an FX carry-trade strategy, the composition of currencies in the long and short baskets can change frequently as different currencies move in and out of the baskets as yield levels change.

In constructing diversified long and short carry-trade baskets, an investor will choose to go long the *x*-highest yielding currencies and short the *y*-lowest yielding currencies, with the *x* and *y* allocations not necessarily the same number. With no leverage, the weights must sum to 100% in each basket. With leverage, the weights could easily exceed the 100% threshold in each basket.

A popular approach is to go long the three highest yielding currencies and short the three lowest yielding currencies. The only thing required in order for the carry trade to be fully funded is that the dollar amount allocated to the long and short positions must be equal.

Some fund managers might prefer a simple diversified approach where the individual currencies making up the long and short baskets are equally weighted, while others might prefer to allocate a higher percentage weight to the very highest yielding currency in the long basket, with gradual declining weights assigned to the second and third highest yielding currencies and so on. The same methodology could be applied to the currencies making up the low-yield basket, with higher weights assigned to the lowest yielding currency and gradually declining weights to the other low-yielders.

Assigning different weights based on the magnitude of country yield levels has both advantages and disadvantages. Assigning more weight to the highest and lowest yielding currencies could favorably affect returns if there were sizable differences between their yield and the yield on other currencies within their respective baskets. The downside is that allocating too large a weight to the very highest and lowest yielding currencies could reduce some of the diversification benefits associated with a multi-currency approach to carry trading.

There are, of course, more sophisticated model-based approaches that could be used to select optimal weights for the currencies comprising the long and short baskets. For example, some fund managers rely on computer-based mean-variance optimization models to derive an optimal allocation of currencies that takes into account not only yield levels but volatility and cross-currency correlations as well.

Once it is determined what kind of carry-trade strategy and asset allocation methodology an investor wishes to pursue, an investor must choose among several different currency-ranking methodologies to determine which currencies are best suited to be included in the long and short carry-trade baskets. An investor could rank currencies simply on the basis of the positive carry that each currency offers, or the ranking could be done on the basis of which currencies offer the highest level of positive carry relative to the volatility of return that each currency is expected to be exposed to, i.e., their carry/risk ratio.

Ranking currencies on the basis of positive carry alone is normally done by comparing relative yield spreads in the one-to-three-month maturity ranges, but there is no reason why another maturity setting could not be chosen. On Bloomberg's FX Strategy Workbench (FXSW), 23 different maturity settings ranging from overnight rates to 8-year maturity yields are available to investors seeking different ways to rank currencies on the basis of positive carry alone.

Ranking Currencies by Carry/Risk Ratios

Unfortunately, ranking currencies on the basis of positive carry alone does have its disadvantages. Simply overweighting currencies that offer the highest yield does not guarantee that you are overweighting currencies that offer the highest *risk-adjusted* yield. Two currencies might offer the same positive carry relative to the U.S., but if one of those currencies exhibits a much higher level of volatility than the other versus the U.S. dollar, a risk-averse investor would tend to prefer investing in the currency exhibiting the lower level of volatility. That is, fund managers will tend to prefer investing in the currency offering the higher carry/volatility ratio, or more simply put, the currency offering the higher carry/risk ratio.

Risk-averse investors are interested in maximizing risk-adjusted returns. In terms of performance metrics, this means that investors are interested in achieving the highest Sharpe ratio as possible. There are three main components that go into the determination of a carry trade's Sharpe ratio: (1) the initial positive carry, (2) the actual change in the exchange rate, and (3) the volatility of return on the carry-trade strategy.

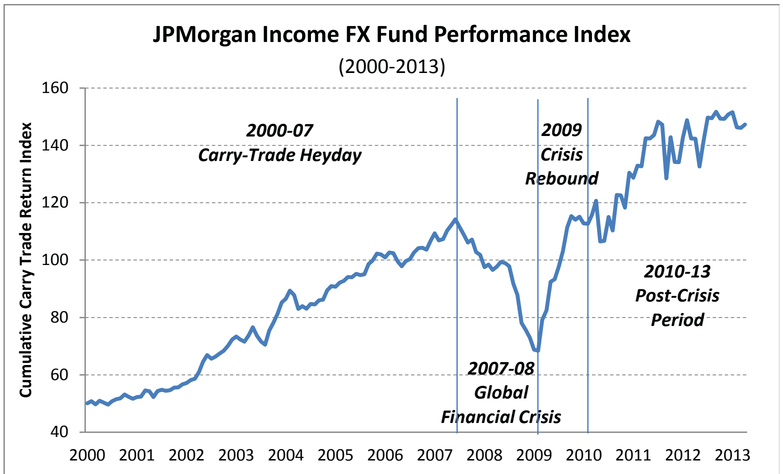
Of the three components, only the positive carry is known at the point in time when an investor undertakes the carry-trade position. The change in the exchange rate, which will play a key role in determining whether the carry-trade position will prove to be profitable, is unknown at the outset, as is the future volatility of return on the carry-trade position. Although the future volatility of carry-trade returns can be estimated using realized historical or option-implied volatility data, those volatility estimates, of course, can turn out to be wrong if volatility were to suddenly spike higher. Nevertheless, a case can still be made to use historical or option-implied volatility data as a benchmark to assess what volatility might look like in the future.

Armed with the known positive carry and an estimate of what the volatility of return on a carry trade might look like in the future, a fund manager would have two-thirds of the inputs needed to generate an estimate of what the carry trade's Sharpe ratio might look like in the future. What is missing, of course, is the other third of the required inputs needed to generate the carry trade's estimated Sharpe ratio—the likely future course of the exchange rate. The change in the exchange rate will determine whether the carry-trade strategy will prove to be profitable, not only in absolute terms, but in risk-adjusted terms as well.

What the carry/risk ratio tells us is what kind of exchange-rate move will be needed to meet or exceed a firm's mandated Sharpe ratio target or threshold level. Knowing the Sharpe ratio target level and the estimated carry/risk ratio, an investor can easily calculate what the exchange rate will need to do to meet or exceed the Sharpe ratio target. Currencies that have low estimated carry/risk ratios will not be viewed as being attractive because they will require the exchange rate to play a larger role in meeting or exceeding the fund manager's mandated target level for the Sharpe ratio. Currencies that offer high carry/risk ratios, on the other hand will tend to be viewed as attractive because they will be less dependent on exchange-rate appreciation to meet or exceed the mandated Sharpe ratio target.

JP Morgan's Income FX Fund (*IFXJPMUS Index* on Bloomberg) provides an example of a fund that has had success using carry/risk ratios as a ranking device in constructing a diversified carry-trade portfolio. The Income FX Fund analyzes carry/risk ratios of 14 G-10 currency pairs and then selects the four currency pairs that offer the highest carry/risk ratios. Long/short positions are then undertaken in those four currency pairs. As shown in Figure V-1, the total return performance of the Income FX Fund has been quite attractive, particularly in the post-Global Financial Crisis era.

Figure V-1



Source: *JPMorgan; Bloomberg* IFXJPMUS INDEX <GO>

Interestingly, one could construct a composite measure of global carry-trade attractiveness by combining individual carry/risk ratios into a single, composite global carry/risk index, which the ECB introduced in its annual Financial Stability Report in 2011. The ECB's Carry Trade Attractiveness Index looks at the trend in estimated carry/risk ratios for eight G-10 currency pairs and combines them into a single index. Their index is plotted in Figure V-2, with the estimates for 2012-13 updated by Bloomberg.

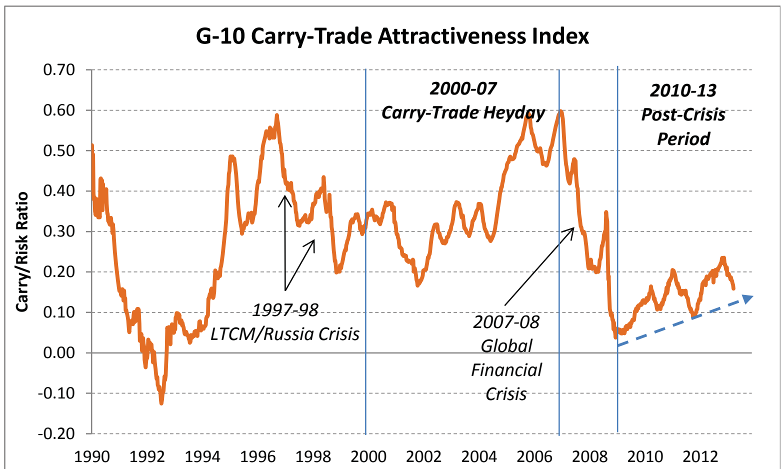
As shown, the trend in the ECB's index was highly favorable in the years leading up to the Global Financial Crisis. Not only was the trend favorable, but the absolute level of the ECB's carry/risk index was quite high as well. This indicated that the overall environment for pursuing FX carry trades was highly attractive, particularly over the 2002-07 period. The index had also risen to fairly high levels in 1995-98, which was the period leading up to the infamous unwinding of the yen carry trade in the fall of 1998.

The ECB's carry/risk index plummeted during the 2008 Global Financial Crisis, which coincided with the large losses that were incurred on global carry trades at that time. The index has since struggled to move higher over the 2009-13 period and, for the most part, has not been able to rise above the 0.2 threshold level on a sustained basis.

Two key factors explain this fairly low reading. First, with short-term interest rates having moved sharply lower in most G-10 nations since the onset of the Global Financial Crisis, positive carry has fallen sharply across the board, which has depressed the composite G-10 carry/risk ratio.

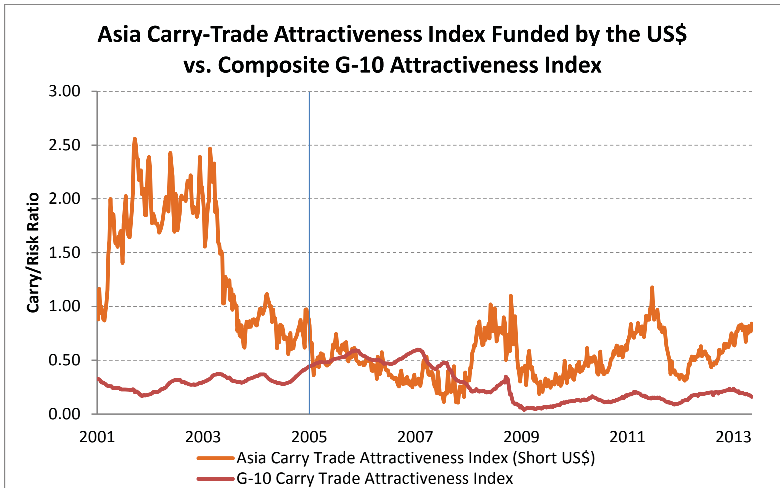
Second FX volatility, up until recently, had been fairly high, which further depressed the composite G-10 carry/risk ratio. While FX volatility has recently dropped significantly, the decline has not been enough to boost the composite G-10 carry/risk ratio by a meaningful amount. Hence, while it may be the case that some individual currency pairs might have offered attractive carry/risk ratios in the post-Global Financial Crisis era, the overall environment for

Figure V-2



Source: *ECB; Bloomberg* BloombergBriefs.com

Figure V-3



Source: *ECB; Bloomberg*

G-10 carry trades as reflected in the ECB's composite G-10 carry/risk ratio could not be characterized as one that has been carry-trade friendly.

While the overall environment for G-10 carry trades has not been especially attractive over the 2009-13 period, an Asian/U.S. dollar carry-trade tells a quite different story. We constructed an index of Asian carry-trade attractiveness by combining the individual carry/risk ratios for the Indian rupee, Indonesian rupiah, Thai baht and Philippine peso, all versus the U.S. dollar. After having been unusually high in the early 2000s as shown in Figure V-3, this Asian carry/risk ratio has averaged more than 0.5 since 2005, nearly twice as large as the G-10 carry/risk ratio over the 2005-13 period.

One of the reasons for the enduring attractiveness of the Asian carry trade owes to the rather low volatility of return on Asian carry-trade basket strategies. Asian central banks tend to intervene strongly in the FX markets in order to resist upward pressure on their currencies and to promote greater exchange-rate stability. Promoting greater exchange-rate stability, in turn, contributes to lower exchange-rate volatility, which, everything else being equal, tends to contribute to higher estimated carry/risk ratios.

Up until now we have focused on the virtues of ranking currencies on the basis of carry/risk ratios rather than simply the level of positive carry alone. Investors, however, need to be mindful of some of the shortcomings of using carry/risk ratios. The first is that carry/volatility ratios assume that the volatility of return is the sole source of risk in carry-trade strategies, which would be the case if the distribution of carry-trade returns were normal. This, of course, is not the case; the distribution of carry-trade returns tends to be skewed to the left, and significantly so.

Consider the following example. Assume that two currencies offer the same mean expected return over time and have similar standard deviations of return, but one currency's return distribution has a considerably fatter negatively skewed tail than the other. The currency exhibiting the more negatively skewed left tail would clearly be the more risky currency, yet the conventionally measured carry/risk ratio would not capture this skewness risk. Other risk measures such as downside deviation or maximum drawdown might prove useful as measuring sticks for comparing currencies that have different return distributions.

A second shortcoming of using carry/risk ratios to rank currencies has to do with the fact that the denominator has to be estimated—it is not known with certainty and those volatility estimates can turn out to be wrong.

Consider the following example. A long extended period of low and perhaps declining volatility will, everything else being equal, lead to a trend increase in carry/risk ratios. High and rising carry/risk ratios, in turn, are likely to attract large sums of speculative capital into carry trades, particularly if investors become overly complacent that the low volatility environment will persist indefinitely. In such a case, we might observe a steady build-up of ever larger net speculative positions and the greater use of leverage to extract as high a return as possible in the volatility-friendly environment.

With investors holding extremely overweight and overextended positions, they are highly exposed to a sudden shift in the volatility regime. If, indeed, the volatility regime shifts in an unfriendly way, investors will be forced to unwind their overextended positions as quickly as possible, with the resulting selling pressure contributing to large losses on the books of speculative accounts. Such a scenario played out in 2008 when the unwinding of speculative positions contributed to the meltdown in the world financial markets, and to the very large losses that were reported on FX carry trades.

As this example illustrates, reliance on carry/risk ratios to assess whether it is safe to engage in carry trades can be fraught with problems if and when the volatility regime suddenly shifts.

Ranking Currencies by Yield-Curve Factors

When looking at the impact that relative interest rates might have on the excess returns generated by carry-trade strategies, considering only the level of short-term interest rates (or the level of positive carry) runs the risk of missing out on other yield-related factors that might be driving currency returns.

Two additional yield-related factors have been found to have explanatory power as key currency return drivers: (1) the change in the level of short-term interest rates or interest-rate spreads, and (2) relative yield-curve slopes or relative term spreads.

Research by Ang and Chen (2010) finds that ranking currencies by the *change* in short-term interest rates captures the impact of policy-rate adjustments on exchange-rate changes. The authors find that going long currencies whose central banks have recently raised short-term interest rates and going short currencies whose central banks have recently lowered short-term interest rates has generated positive, risk-adjusted returns over time.

Ang and Chen also find that relative yield-curve slopes, which capture the market's expectations of the future course of short-term interest-rate spreads in competing markets, as well as relative term premia, has also been an important driver of exchange-rate changes as well. The authors find that going long currencies that have relatively flat yield curves and going short currencies that have relatively steep yield curves has generated positive risk-adjusted returns over time.

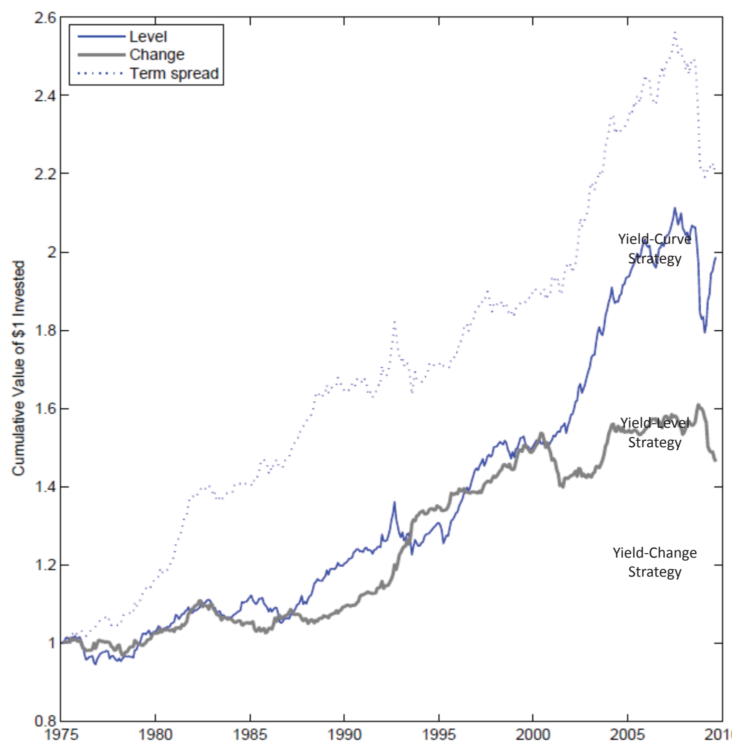
Figure V-4 plots Ang and Chen's findings on the cumulative returns generated by three different ranking schemes based on: (1) yield levels only (the traditional approach to pursuing FX carry trades), (2) changes in the level of short-term interest rates, and (3) relative yield-curve slopes. As shown, all of the yield-related ranking schemes would have helped generate positive excess returns on currency strategies over time.

While ranking currencies on the basis of relative yield-curve slopes has generated the highest absolute return over time among the three competing yield-related factors, the yield-curve ranking scheme lost considerable ground in the 2008 during the Global Financial Crisis and has since struggled to recover in the post-crisis period. As a basis for comparison, the traditional approach to carry trades—using yield level factors only to rank currencies—has managed to recover a significant portion of the ground lost in 2008.

Figure V-4

Estimated Cumulative Returns on Yield-Level, Yield-Change, and Yield-Curve Based Carry-Trade Strategies

(1975-2009)



Source: Andrew Ang and Joseph S. Chen, "Yield Curve Predictors of Foreign Exchange Returns", 13 March 2010, page 45, Figure 3, http://www2.gsb.columbia.edu/faculty/aang/papers/FXrets.pdf

Mean-Variance Optimization

In a typical carry-trade strategy that is long the three highest yielding currencies and short the three lowest yielding currencies, the number of long and short positions is set at the outset—three in each basket. Equal weights are typically assigned to each of the three currencies in the long and short baskets—i.e., one-third weights are assigned to the three currencies in each basket—and no effort is made to allocate more weight to the highest or lowest yielding currencies that make up the long and short baskets. Furthermore, neither volatility nor cross-currency correlation considerations are taken into account in selecting the currency composition of the long and short baskets.

Investors, however, can take into account all of these factors—relative yield levels, volatility of returns and correlation of returns—by adopting a mean-variance optimization (MVO) approach to currency asset allocation. The MVO approach to portfolio diversification was first introduced by Nobel Prize winner Harry Markowitz and incorporates information on expected returns, volatility of returns, and the cross-correlation of asset returns to derive an optimal asset mix that maximizes portfolio return, subject to a targeted level of portfolio risk.

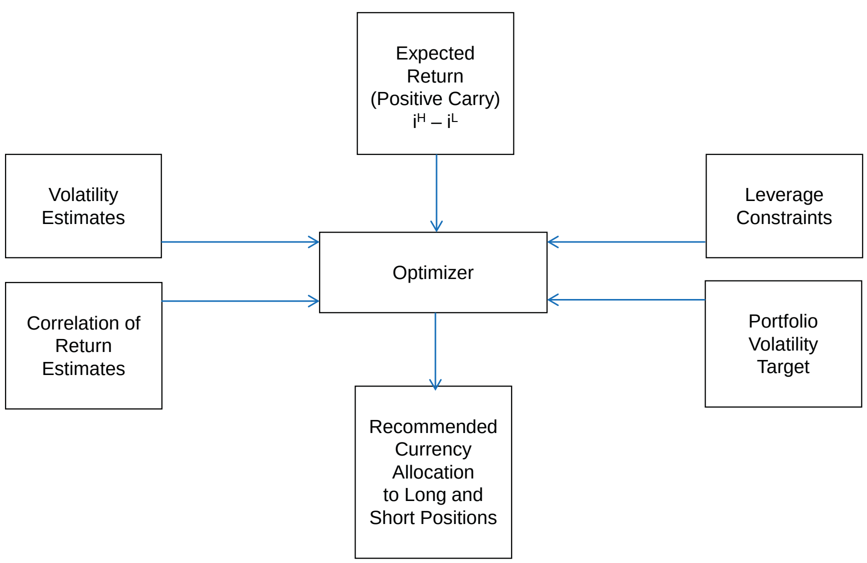
The Markowitz framework can be applied to the currency market in a similar way by incorporating information on expected returns, currency volatility, and cross-currency correlations to derive an optimal mix of long and short currency positions that maximizes currency portfolio return subject to a predetermined targeted level of portfolio risk.

Figure V-5 illustrates how a MVO model cranks out an optimal mix of long and short currency positions. As shown, an estimate of the expected return on individual currencies is one of the required inputs to generate the optimal mix of long and short currency positions.

Figure V-5

Mean-Variance Optimization

A Schematic Diagram



Source: Bloomberg; Adapted from Alvisi (2007)

The expected return on a carry-trade position $E(R_{CT})$ equals the interest-rate carry $(i^H - i^L)$ plus the change in the exchange rate (Δs_{t+1}):

$$E(R_{CT}) = (i^H - i^L) + \Delta s_{t+1}$$

To simplify the estimation procedure, it is normally assumed that spot exchange rates will tend to fluctuate randomly so that at any point in time the expected change in the exchange rate will be zero plus or minus a random error term:

$$\Delta s_{t+1} = 0 + \text{random error}$$

Armed with this assumption, the expected return on a particular currency will simply equal the positive or negative carry that the currency enjoys:

$$E(R_{CT}) = i^H - i^L$$

In addition to these estimates of expected returns, estimates of (1) the volatility of currency returns and (2) the expected correlation of returns are required as inputs in the optimization process. Usually historical data on volatility and correlation are used to derive estimates of expected volatility and correlation.

The model-based optimizer then combines and weights these three inputs and cranks out an optimal mix of long and short currency positions subject to a predetermined targeted level of portfolio volatility. The predetermined targeted level of portfolio volatility is typically set at a level that is broadly compatible with the investor's overall appetite for risk. As shown in Figure V-5, the optimal asset mix might also be influenced by internally imposed leverage constraints to prevent the optimizer from generating long and short allocations that are overly leveraged.

The MVO optimizer will tend to recommend small allocations to currencies that exhibit a high volatility of return, which would otherwise make it difficult to meet the predetermined targeted level of portfolio volatility. The MVO optimizer will also try to avoid having long exposures to currencies that are highly positively correlated with one another since having too much exposure to currencies with similar trending patterns will make it difficult to meet the targeted level of portfolio volatility. The optimizer will look instead for currencies that are weakly correlated or negatively correlated to help cut down the level of portfolio risk.

The MVO framework can actually create synthetic negatively correlated positions out of two highly positively correlated currencies. Consider the case of the euro and Swiss franc exchange rates versus the dollar, which are highly positively correlated and exhibit similar levels of return volatility. Where they do differ, however, is that in most instances the level of short-term yields in the Euro area has tended to exceed the level of short-term yields in Switzerland.

The optimizer can take this information and recommend taking on a long position in euros and a short position in Swiss francs (both versus the dollar). Assuming the euro and Swiss franc remain highly positively correlated, the long position in euros and the short position in Swiss francs will tend to be negatively correlated. Combining the negatively correlated long and short positions in a portfolio context will tend to reduce overall portfolio risk, which is what the optimizer is trying to achieve.

But at the same time, the optimizer recognizes the opportunity for gain. Since Euro area short-term interest rates tend to exceed short term interest rates in Switzerland, the implied long euro/short Swiss franc position will tend to earn positive carry over time. Thus, the optimizer is able to construct a synthetic position that earns positive carry at the same time that it helps reduce overall portfolio risk.

Interestingly a simple 3 X 3 carry trade ranking scheme would probably not have recommended a long position in the euro since the level of Euro area interest rates would probably not have been among the higher-yielding currencies. That is one of the chief advantages of the MVO framework—it searches for different mixes of currencies to take advantage of volatilities, correlations, and yield level considerations to come up with an optimal mix of long and short currency positions.

The MVO optimizer can also help select which currencies would be ideal as funding vehicles for FX carry trades. For instance, the Japanese yen and Swiss franc have consistently low yield levels that on the surface make them appear to be ideal funding currencies in a global carry trade. But because both currencies tend to be quite volatile versus the dollar, having extensive short positions in the yen and Swiss franc might make it difficult to meet the targeted level of portfolio volatility.

In such cases, the optimizer will tend to search for alternatives to the yen and Swiss franc such as the Singapore dollar. Singapore short-term yields are often not too dissimilar from those in Japan and Switzerland, but given the exchange-rate management policies of the Monetary Authority of Singapore, the Singapore dollar has an advantage over the other two—the volatility of the Singapore dollar versus the U.S. dollar tends to be considerably lower. The optimizer will use this information and tend to select the Singapore dollar as the ideal funding vehicle since this would help keep the portfolio's volatility of return close to the predetermined targeted level.

Like all models, the MVO framework does have its drawbacks. One potentially serious drawback is that future volatility levels might significantly exceed expected volatility levels. Allocations based on a low-volatility environment will clearly not be ideal in a high-volatility environment. The same applies to correlation estimates. Correlation levels among currencies tend to be significantly higher in high-volatility states than in low-volatility states. Finally, the recommended allocations by the optimizer can be highly sensitive to small changes in underlying assumptions on expected returns, volatilities, and correlations.

Recommended long and short allocations by MVO models might also generate more highly leveraged positions than a simple 3 X 3 carry trade portfolio would. In a typical 3 X 3 carry-trade portfolio, with one-third weights applied to each of the currencies making up the long and short baskets, the long positions will have an aggregate exposure of 100%, while the short positions will also have an aggregate exposure of 100%, resulting in a total leverage factor of 200%. Many MVO models tend to recommend leverage exposures far exceeding this amount. Indeed, one often sees MVO models with recommended leverage factors amounting to 400% or more (200% allocations or more to both the long and short baskets). For the individual currencies making up the long and short baskets, many MVO models can recommend long or short positions that are three to five times larger than the long or short positions that a simple 3 X 3 carry trade portfolio would recommend.

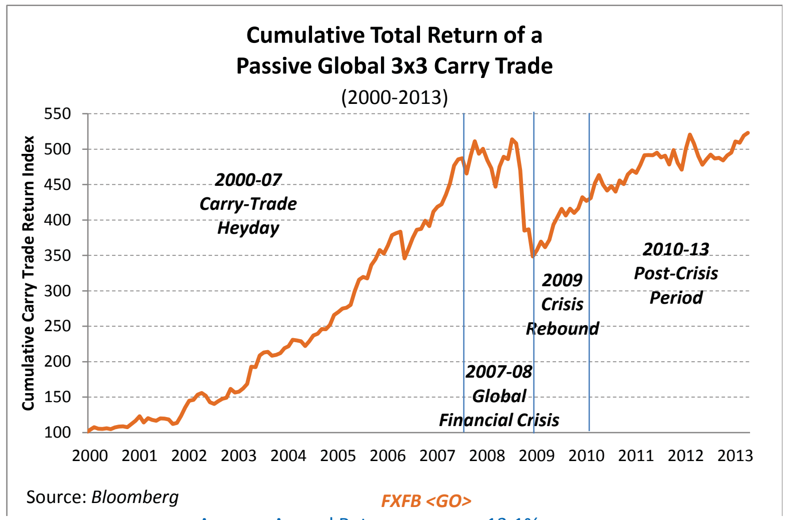
Leveraged positions of this magnitude are not a problem if you get the direction of exchange rates right. It becomes a serious problem if you get the direction of exchange rates wrong. This is one reason why MVO models tend to include leverage constraints on position taking in the optimization process, which is designed to insure that the overall portfolio is not overly exposed to an adverse move that could prevent the portfolio from meeting its predetermined targeted level of volatility.

Part VI — Downside Risk Management

As noted above, carry trades are essentially speculative bets, and as a result they offer upside opportunities as well as downside risks. Over the long run those speculative bets have generally paid off as FX carry trades—whether from a G-10, EM, or global perspective—have generated positive excess returns over time. This can be seen in Figure VI-1, where we plot the long-run excess returns on a simple 3 X 3 diversified carry-trade portfolio for all tradable currencies on a worldwide basis. As shown, the reported annualized excess returns were not only attractive in absolute terms, but in risk-adjusted terms as well.

A close look at the long-run performance reveals that, the global FX carry-trade portfolio FX carry-trade portfolio suffered large losses from time to time, particularly when global economic, liquidity, and financial-market conditions deteriorated sharply. Carry trades incurred significant losses during the 1992 ERM crisis, in 1998 with the infamous unwinding of the yen carry trade, in 2006 and then most recently in 2008 when the Global Financial Crisis drove the returns on most risky assets and strategies into negative territory. Those large losses suggest that a significant part of the long-run positive excess returns generated by FX carry trades might represent a risk premium awarded to investors for taking on the large periodic downside risks that tend to be associated with risky strategies such as FX carry trades.

Figure VI-1



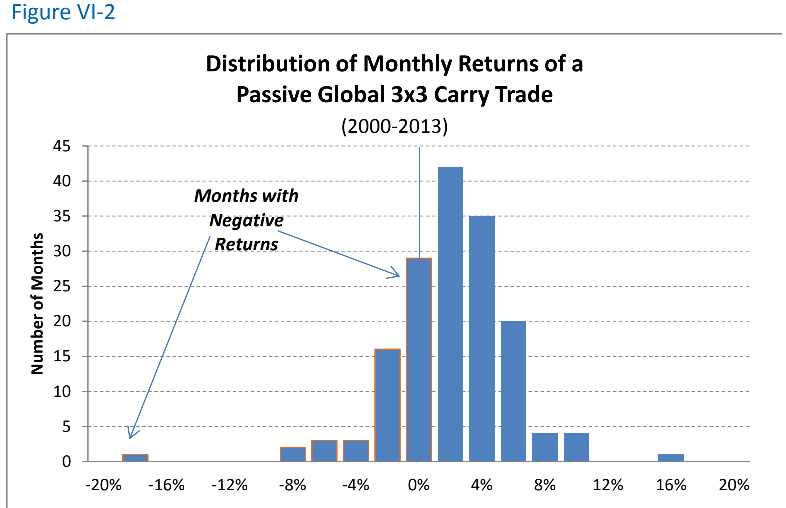
Source: *Bloomberg*

Average Annual Return	13.1%
Annualized Std. Dev. of Return	12.2%
Sharpe Ratio	1.08

The tendency for carry trades to experience periodic crashes reveals itself in the distribution of carry-trade returns. As shown in Figures VI-2, the distribution of global carry-trade returns does not conform to a normal distribution, but rather tends to be more peaked at the center with fatter tails that are negatively skewed. The negative skew and fat tails indicate that carry trades have tended to experience more frequent and larger losses than would have occurred had the distribution of returns been normal. The more peaked distribution at the center or around the mean return implies that carry trades have typically generated a larger than normal amount of trades that have resulted in small gains.

The fat tailed negatively skewed distribution conforms with the views of some observers who have likened carry-trade strategies to picking up nickels in front of a steamroller. Even though carry trades generate positive excess returns over the long run, the risk of getting run over by a steamroller has made many investors wary of playing the game. Fortunately, for those willing to play the game and stay in the game, those nickels do add up over time, which explains why carry trades have generated positive excess returns over the long run.

Figure VI-2



Source: *Bloomberg*

But to earn those nickels over time requires that investors have staying power. Unfortunately, when fund managers suffer large losses on their carry-trade positions during a major downside move, they might not be willing or able to jump back into the game that easily, even if the financial environment for carry trades once again turns favorable. That is because fund managers might face significant redemptions in response to large losses suffered during a carry-trade crash. With less capital to invest, fund managers' capacity to trade again in size could be limited.

In addition, with less capital on hand, fund manager's access to funding to finance leveraged carry trades might become limited as well. Even if fund managers were to weather a carry-trade storm in decent shape, suppliers of funding liquidity may have suffered losses during that storm, and thus might not be in a position to provide as much new financing for leveraged carry trades as they did in the past.

What this suggests is that although the performance data on carry trades suggests that investors could have earned a risk premium or positive excess return over time, that positive excess return would only have been earned if investors had the capital, patience, and risk tolerance to re-enter carry-trades after suffering a large loss. This is a problem that back-tested results often have—favorable back-tests assume that investors jump right back into a risky trading strategy after suffering a large setback.

Since risk-averse investors are not likely to jump right back into a risky strategy after suffering a major loss, it is vitally important for fund managers who want to stay in the game to have a number of risk-management systems in place to help minimize the magnitude of the losses when large downside moves occur. As such, market practitioners have come up with a variety of overlay models, trading systems, and crash protection indicators that that have had some success in helping investors cope with major carry-trade unwinds.

Figure IV-3 lists some of the more popular crash-protection indicators available to fund managers. For example, overlaying a technical-analysis-based moving-average crossover model on a cumulative total return carry-trade index—to time entry and exit decisions into and out of FX carry trades—has had some success in reducing both the volatility of return on carry-trade portfolios and the size of the negative skew in the distribution of carry-trade returns.

A number of practitioners have had some success using volatility filters such as the VIX index or FX volatility to time entry and exit decisions into and out of FX carry trades. Under this approach, if the level of volatility in the equity or FX markets were to rise above some critical threshold level, a signal would be issued to close the carry-trade position. Likewise, if those volatility measures traded below some critical threshold level, a signal would be issued to open a carry-trade position.

Some practitioners prefer liquidity and credit-spread filters to time entry and exit decisions. A popular measure is to track liquidity conditions in the U.S. financial markets via the TED spread, which is the yield spread between Eurodollar deposit rates and U.S. Treasury bill rates. A widening in the TED spread is normally associated with a

Figure VI-3

Carry- Trade Overlay Models, Crash-Protection Indicators, Risk-Appetite Indicators, and Risk-Management Systems

Methodology	Model
Momentum Overlay	Moving-Average Crossover Model
Volatility Filters	FX Volatility VIX Index
Liquidity Conditions	TED Spread Bid-Ask Spreads
Bond Market Credit Spreads	Baa Corporate/Treasury Spread High-Yield Spreads EMBI+
Equity Market Indices	U.S. Global
Yield Curve Factors	Yield Change Yield Curve Slope
Sentiment & Positioning Indicators	Risk Rversals Futures Market Positioning
Valuation Yardsticks	Purchasing Power Parity (PPP) Long-Run Uncovered Interest Rate Parity (UIP)

Source: Bloomberg

tightening in liquidity conditions and poor carry-trade performance. Because leveraged carry-trade positions require funding, movements in the TED spread above or below some critical threshold level could be used as a signaling device to enter and exit carry-trade positions. In a similar vein, investors can use movements in credit spreads such as sovereign credit spreads, credit default swap spreads, high-yield bond spreads and investment-grade bond spreads as signaling devices to time entry and exit decisions.

Other indicators that have been applied to carry trades to time entry and exit decisions include sentiment and positioning measures, yield-curve slope factors, and FX valuation readings. Some practitioners look to the broad trends in the U.S. or global equity markets for clues. We discuss all of these overlay models and risk-management systems more fully below.

Momentum Overlay Models

A wide variety of technical analysis-based momentum models can be used as an overlay on an otherwise passively managed buy-and-hold carry-trade strategy. Bloomberg's FX Strategy Workbench (FXSW) allows a user to apply a number of those models as an overlay on a carry-trade strategy, specifically: (1) relative-strength indicators, (2) Bollinger bands, (3) MACD, (4) rate of change indicators, (5) stochastics and (6) a moving-average crossover trading model. To illustrate how a momentum overlay model can be used to reduce the overall volatility of return on a carry-trade portfolio and shrink the size of the left tail in the distribution of carry-trade returns, we focus on how a simple moving-average crossover model can be used as a signaling device to time entry and exit decisions.

A moving-average crossover overlay model can be applied to FX carry trades in the following way. Simply construct an excess total-return index based on the cumulative total return on a diversified carry-trade basket. Excess total return indices are derived automatically on Bloomberg once a strategy is selected as illustrated in Figure1 VI-1 above. The trend in the cumulative excess total-return indices captures the combined influence of the cumulative interest-rate return (cumulative positive carry) earned on the carry-trade position plus the cumulative appreciation or depreciation of the high-yield basket currencies versus their low-yielding counterparts.

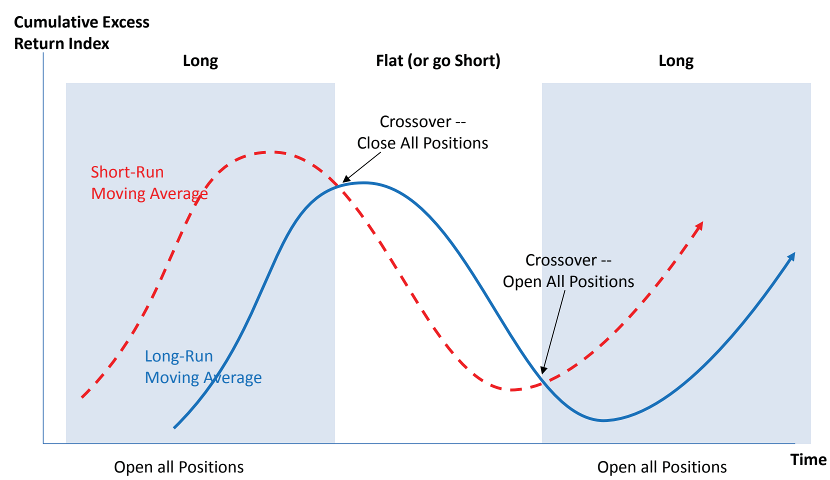
The next step is to select two sets of moving averages that are applied to the cumulative excess total-return index—a short-run (SRMA) and a long-run moving average (LRMA). When the SRMA of the carry-trade total-return index rises above its LRMA, the moving-average crossover model would recommend that the carry-trade position be opened. When the SRMA crosses below the LRMA, the moving-average crossover model would issue a signal to close the carry-trade position (see Figure VI-4).

To illustrate how the moving-average crossover overlay model could work in practice, let's assume that we choose a five-day moving average of the carry trade's total return index as our SRMA and a 30-day moving average as our LRMA. (Note that the 5-day and 30-day moving averages do not necessarily represent optimized moving averages. Other sets of moving averages could generate more attractive risk-adjusted returns. We are simply using 5 and 30-day moving averages for illustrative purposes.)

Figure VI-4

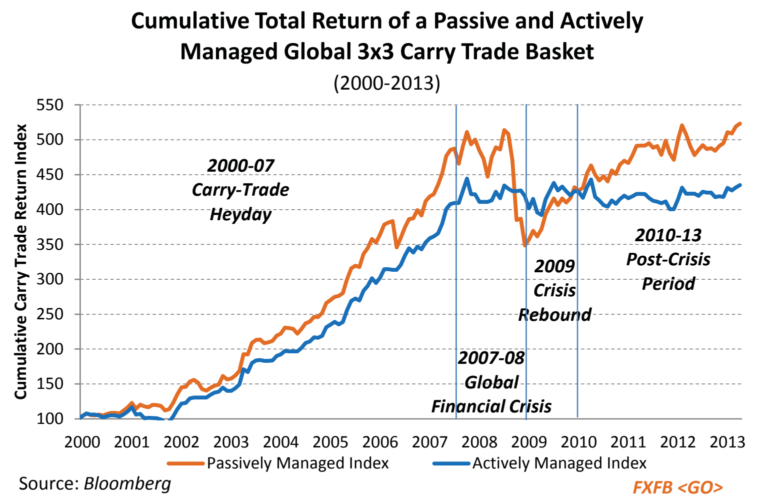
Actively Managing a Carry-Trade Portfolio with a Moving-Average Crossover Overlay

A Schematic Diagram



Source: Bloomberg

Figure VI-5



Source: *Bloomberg*

Risk-Return Performance of a Passive and Actively Managed Global 3x3 Carry-Trade Basket
(2000-2013)

	Passive	Actively Managed
Average Annual Return	13.1%	11.6%
Annualized Std. Dev. of Return	12.2%	8.5%
Sharpe Ratio	1.08	1.36

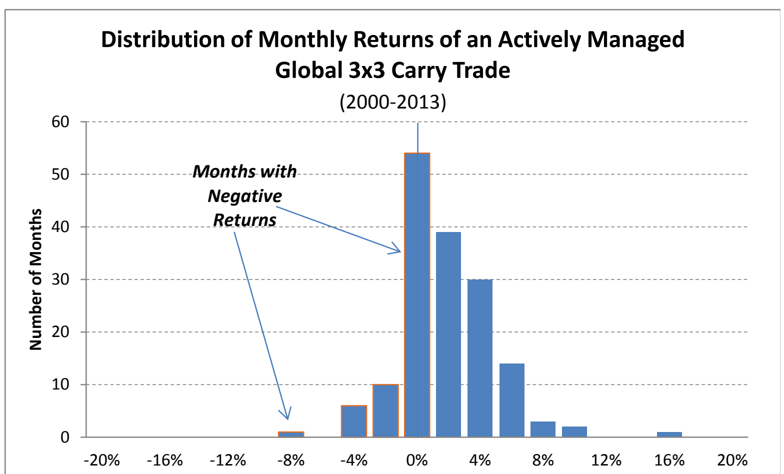
Source: Bloomberg

Figures VI-5 and VI-6 illustrate how a simple 5-day and 30-day moving-average crossover model could have helped reduce both the volatility of return and negative skew associated with a global carry-trade portfolio. As shown in Figure VI-5, a 5-day and 30-day moving-average crossover model overlaid on the passive 3 X 3 global carry return index would have cut down the size of most of the major drawdowns over the 2000-2013 period, enough so that the volatility of return on the carry-trade strategy using the moving-average overlay would have been more than 30% lower than the volatility of return on the passively managed global carry-trade portfolio (see Figure VI-5). That is, the moving-average overlay model helped shrink the volatility of return on the global carry trade from 12.2% per annum to 8.5%.

As Figure VI-5 shows, this lower volatility of return did come at a cost in terms of a moderate decline in the average annual total return earned on the strategy from 13.1% to 11.6%. When we combine the benefits of the overall decline in the variability of return on the global carry-trade strategy generated by the moving-average overlay model with the cost of the moderately smaller average annual total return, we see that the Sharpe ratio on the strategy using the overlay model is actually higher than the strategy that uses no overlay, increasing from 1.08 to 1.36.

In addition to lowering the overall volatility of return on the global carry-trade portfolio, the moving-average crossover overlay model helped cut down the size of the negative skew in the distribution of returns on the carry-trade portfolio. If we compare the distribution of returns of the actively managed carry trade in Figure VI-6 with the distribution of returns of the passive portfolio shown in Figure VI-2 above, it is quite apparent that the moving-average crossover model significantly reduced the number of episodes when losses would have been incurred.

Figure VI-6



Source: *Bloomberg*

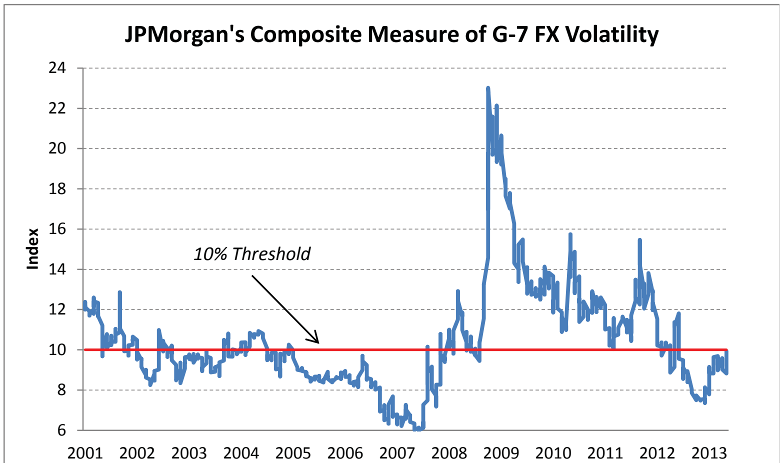
FX Volatility Filtered Carry Trades

In Part IV we discussed the impact that changes in FX volatility have on the performance of FX carry trades. We noted that high-yield currencies tend to respond negatively to changes in FX volatility, while low-yield currencies tend to respond positively to changes in the FX volatility regime. We noted that because FX carry trades tend to be long currencies that respond negatively to increases in FX volatility and short currencies that respond positively to increases in FX volatility, such trades will tend to be doubly exposed to the downside when FX volatility spikes higher.

Recognizing the sensitivity of FX carry trades to changes in the volatility regime, many market participants find it advantageous to monitor trends in FX volatility to help pinpoint the best time to enter into or exit from their carry-trade positions. Typically, an investor will establish a threshold level (or range) for FX volatility. If FX volatility rises above that threshold level, a signal will be issued to close out the carry-trade position. If FX volatility falls below that threshold level, a signal will be issued to invest in a carry-trade position.

There is no hard and fast rule what that threshold level or range should be, but it should be possible to hazard a guess. As shown in Figure VI-7, JP Morgan's composite measure of G-7 FX volatility hovered at or below the 10% level over much of the 2002-07 period when FX carry trades posted very attractive positive excess returns. G-7 FX volatility then rose sharply in 2008, rising significantly above the 10% level, and remained above that level for much of 2009-11. During the period that volatility traded above the 10% level, FX carry trades for the most part performed poorly. Since the spring of 2012, FX volatility has once again trended lower to levels below 10% and, not by coincidence, the returns to FX carry trades have begun to pick up again in tandem. Given the general tendency for carry trades to do well when FX volatility has traded below 10% and to do poorly when FX volatility has been trading above 10%, investors might want to consider a volatility threshold of around 10% to signal the best time to enter into and exit from FX carry trades.

Figure VI-7



Source: *Bloomberg* *JPMVXYG7 INDEX<GO>*

Equity-Market Volatility Filtered Carry Trades

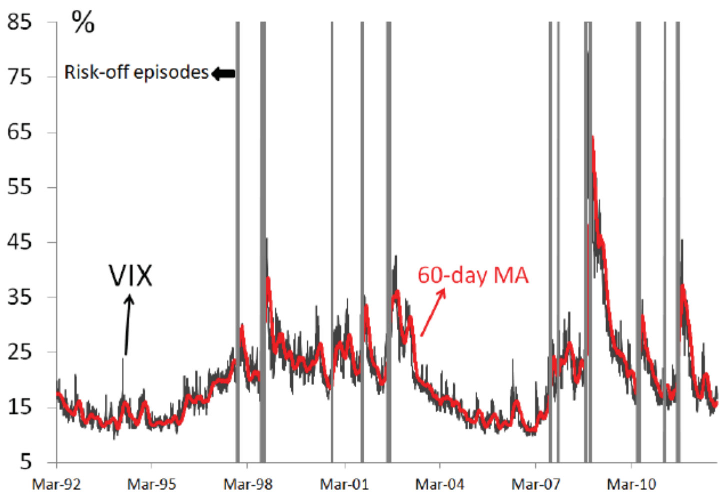
Investors can use trends in FX volatility as a filtering mechanism on a stand-alone basis or it can be used in conjunction with other risk-management systems. Some investment managers might prefer to have an integrated risk-management system in which portfolio adjustments will not be made unless they receive confirmation from more than one overlay model or risk-based filter. For instance, the VIX index of S&P 500 volatility could be used as an alternative indicator to time entry and exit decisions into and out of FX carry trades, or it can be used in conjunction with FX volatility readings for those who might prefer confirmation that all volatility measures recommend the same course of action.

The VIX index is widely used as a barometer of global risk appetite and academic studies generally find that carry trades tend to perform poorly in periods when the VIX index is rising. Similar to FX volatility, there is no hard and fast rule for what level (or range) of the VIX index should serve as the threshold for timing entry and exit decisions into and out of FX carry trades. For example, De Bock and Carvalho Filho (2013) identify Risk-off episodes as periods when the VIX index is trading 10 percentage points higher than its 60-day moving average. Because Risk-off episodes often coincide with periods when carry trades perform poorly, one could apply De Bock and Carvalho Filho's Risk-off rule-of-thumb to determine when it might be best to close out FX carry-trade positions.

Interestingly, there have been eleven distinct Risk-off episodes identified since 1992—five of which occurred between 1997 and 2002, and the other six which occurred between 2007 and 2011 as detailed in Figure VI-8. There were no Risk-off episodes identified between July 2002 and August 2007, a period characterized by very strong carry-trade returns. During the latter part of 2007, which marked the beginning of the Global Financial Crisis, and the four turbulent years that followed, there were six identifiable Risk-off episodes, and not surprisingly carry trades performed poorly over much of that period.

Figure VI-8

The VIX Index and Risk-Off Episodes
(1992-2012)



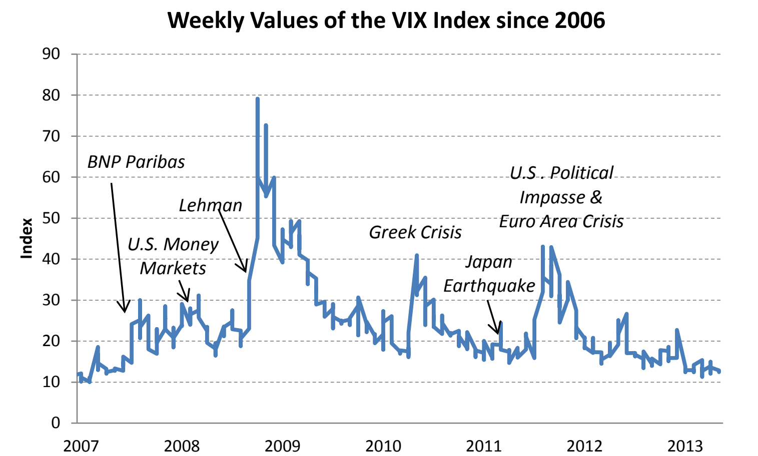
Source: Reinout De Bock and Irineu de Carvalho Filho, "The Behavior of Currencies during Risk-off Episodes", IMF Working Paper, WP/13/8, January 2013, page 8, Figure 2, http://www.imf.org/external/pubs/ft/wp/2013/wp1308.pdf

Initial Dates of Risk-Off Episodes

Episode	Date	Event
1	29-Oct-97	Escalation of Asian crisis
2	4-Aug-98	Concerns on Russian economy
3	12-Oct-00	Fear of slowing U.S. economy
4	17-Sep-01	9/11 Attacks
5	10-Jul-02	Fear of slowing U.S. economy
6	10-Aug-07	BNP Paribas halts withdrawals from three money market mutual funds
7	12-Nov-07	Disruptions in USD money markets
8	17-Sep-08	Lehman failure
9	6-May-10	Greek crisis
10	16-Mar-11	Uncertainty over impact of Japan's March 11 Earthquake
11	4-Aug-11	Confrontation over U.S. debt ceiling and deterioration of crisis in euro area

While the trend in the VIX index may be helpful in timing entry and exit decisions into and out of FX carry trades, the high frequency of volatility spikes in the VIX index that have occurred in recent years may help explain why investors cut back on their exposure to carry trades in the post-Global Financial Crisis period. As shown in Figure VI-9, the VIX index initially experienced a large number of volatility spikes in 2007 and early 2008 prior to the explosive rise in the VIX index in the fall of 2008, following the Lehman collapse. The VIX index receded for a while in 2009, but then spiked up again on six separate occasions—twice in 2010, twice in 2011 and twice in 2012.

Figure VI-9

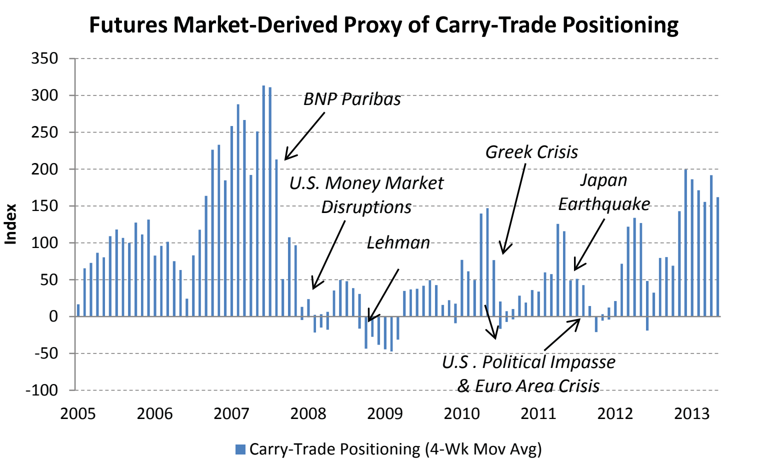


Source: *Bloomberg* VIX INDEX<GO>

When volatility spikes are both large and frequent, investors tend to become less confident in engaging in risky trades that are highly sensitive to volatility shocks. That may explain why a proxy indicator used to track net speculative positions in G-10 carry trades on the IMM—long A$ and NZ$ and short yen and Swiss franc futures contracts—fell off so sharply between late 2007 and early 2012 relative to the large level of position taking that marked the 2006-07 period leading up to the Global Financial Crisis (see Figure VI-10).

Interestingly, as the VIX index started to trend lower beginning in mid-2012 from levels in the mid-20s to levels in the mid-teens in early 2013 (see Figure VI-9), net speculative positioning in FX carry trades on the IMM began to pick up (see Figure VI-10). Evidently, the decline in the VIX index, reflecting a recovery in global risk appetite, might have helped to rekindle interest in risky assets and strategies such as the carry trade. It is not a coincidence that the performance of both the U.S. equity market and global carry trades picked up noticeably when the volatility spikes stopped.

Figure VI-10



Source: *Bloomberg* .ADLRGN, .NZLRG, .JYLRG, .SFLRG G INDEX<GO>

Liquidity Conditions and Carry Trades

Liquidity is an important driver of returns on all risky assets, including the return on FX carry trades. The term "liquidity" has often been used in a variety of contexts. For carry trades, liquidity conditions are considered to be favorable if leveraged investors can easily access funds from banks to finance their speculative positions and if FX traders can move in and out of long and short positions easily without affecting market prices. Finally, liquidity conditions are considered to be favorable if bid-ask spreads are comfortably within historical norms.

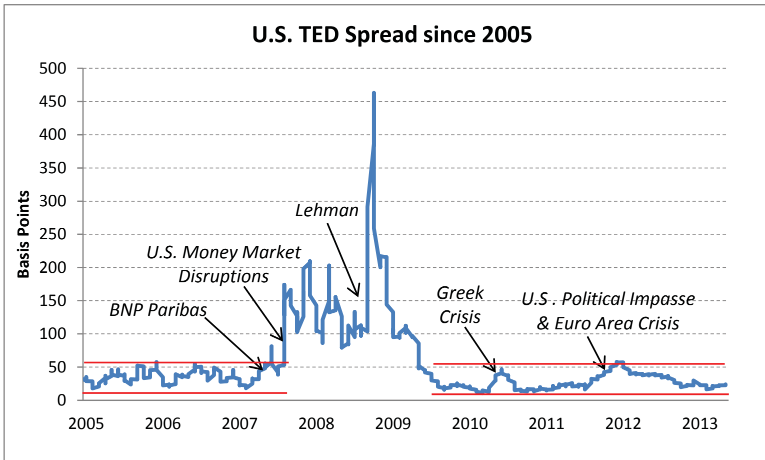
Liquidity conditions are deemed to be unfavorable when investors face greater difficulty in accessing funds from their counterparty banks. When there is less funding available to finance leveraged positions, investors might be forced to unwind their speculative positions. Such position shifts could trigger a major sell-off in the prices of risky assets.

When liquidity dries up, it tends to reveal itself in a variety of ways. First, bid-ask spreads tend to widen significantly—in the fall of 2008, following the collapse of Lehman, the FX markets experienced a four-fold widening in bid-ask spreads in a number of major currency pairs, according to a study by Melvin and Taylor (2009). Second, the TED spread, which is often viewed in the market as a barometer of U.S. liquidity conditions, tends to widen, in some cases significantly so. In 2007-08, the TED spread jumped from an average of around 30 basis points to a peak of over 460 basis points (see Figure VI-11). The rise in the TED spread reflected both a decline in the willingness of banks to lend funds on an uncollateralized basis and a flight into U.S. Treasury bills by investors seeking refuge from the turmoil in the markets at the height of the Global Financial Crisis.

Because volatility spikes and liquidity squeezes tend to go hand in hand, one might consider using changes in the TED spread as an indicator to confirm whether the signals coming from changes in FX volatility readings and/or the VIX index should be acted upon or not. While FX volatility and the TED spread exhibit a tendency to move together, the FX volatility study by Menkhoff et al. (2012) discussed above found that the correlation of the two series is only around 0.19. Menkhoff et al. found that changes in FX volatility have done a better job of explaining carry-trade unwinds than have changes in the TED spread. Brunnermeier et al. (2009) reported similar results, finding that changes in the VIX index had more explanatory power than the TED spread in anticipating carry-trade crashes.

One of the reasons why the TED spread may underperform other indicators in explaining carry-trade unwinds is that the TED spread does not experience anywhere near the variability that the VIX index or FX volatility undergo. This can be seen in Figure VI-11. Outside of the 2007-09 period, the TED spread has tended to trade within a fairly narrow range, both before and after the Global Financial Crisis. This may be due to the fact that the Federal Reserve, though its policy actions, can directly influence both the level and trend in the TED spread, something the Fed cannot do in the cases of the VIX index or FX volatility. Hence, if the Fed's policy actions work to smooth fluctuations in the TED spread, then such actions might make the TED spread a less useful indicator to assess the level of stress in the financial markets.

Figure VI-11



Source: *Bloomberg*

GB3, US0003M INDEX<GO>

Bond Market Credit Spreads and Carry Trades

Bond-market credit spreads tend to widen during periods of declining risk appetite and increasing financial stress. Credit spreads broadly reflect a number of risk factors—the risk of default, liquidity risk, and general business-cycle risk. In periods of financial distress a wide range of financial indicators tend to turn up in unison—FX volatility and the VIX index move higher, the TED spread widens, and key credit spreads, including: (1) the investment-grade Baa Corporate/Treasury bond yield spreads, (2) below-investment grade high-yield bond spreads, and (3) emerging-market sovereign bond yield spreads (as captured by JP Morgan's EMBI+ index) all widen in tandem.

Similar to the TED spread, bond-market credit spreads widen in periods of distress as investors seek safety in less risky assets such as Treasury bonds. Because carry trades also tend to suffer in such periods, investors might find it useful to monitor trends in key credit spreads to get a better handle on whether the financial environment for FX carry trades is favorable or not.

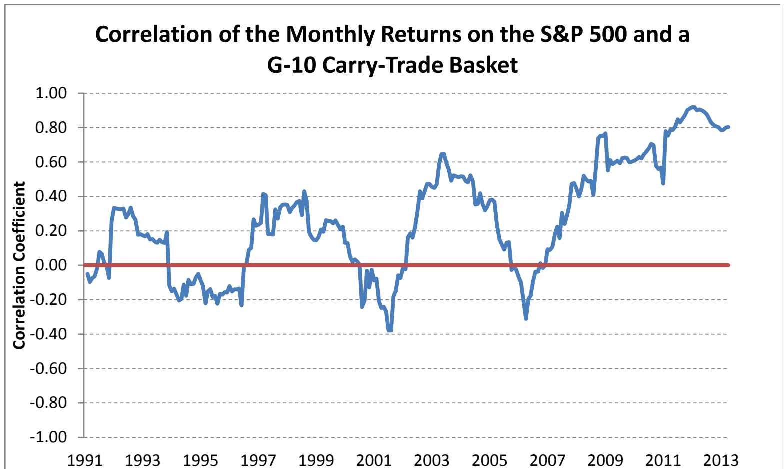
Carry Trades and the Stock Market

During normal periods, carry-trade returns and equity-market returns are not highly positively correlated. Although some positive co-movement can be observed from time to time, the correlations are nevertheless not significant when financial conditions are broadly benign.

When financial conditions deteriorate and volatility spikes higher, however, the correlation between carry-trade returns and equity-market returns tends to pick up sharply. Given this asymmetric pattern in the correlation of the two series, investors might want to consider creating a time series that tracks the rolling correlation in the returns on carry trades and the returns on the U.S. equity market (see Figure VI-12) to help assess whether the financial environment for carry trades is turning favorable or not. If the rolling correlation rises above some threshold level, it might be signaling that the environment for carry trades is turning less favorable, and thus it may be time to close out existing carry-trade positions.

Looking forward, investors should consider keeping a close watch on this time series. The recent rise in the correlation of carry-trade and equity-market returns to fairly lofty levels might be an indication that global equity market trends are now exerting a greater influence on carry-trade returns than was the case in the past. For instance, the rise in the rolling correlation of carry-trade and equity-market returns in 2009-11 would have correctly signaled to investors to avoid FX carry trades during that period. Unfortunately, that still high level of correlation in 2012-13 would have incorrectly signaled to investors to continue to avoid FX carry trades in this latter period, even as FX carry- trade performance began to turn upwards. This illustrates the need for confirmation from other risk-management indicators.

Figure VI-12



Source: *Bloomberg*

Yield Curve Factors as an Overlay

In Part V we noted that carry-trade portfolios can be structured in a traditional manner by establishing a long basket consisting of high-yield currencies and a short basket consisting of low-yield currencies. The traditional approach, therefore, views differences in the *level* of short-term interest rates as the primary driver of relative currency performance. We noted, however, that other yield-related factors have also been found to have had success in explaining the relative performance of currencies—notably differences in *changes* in the level of short-term interest rates and differences in relative yield-curve slopes.

Changes in the level of short-term interest rates capture the impact of short-term changes in monetary policy on exchange rates. Empirical studies find that countries that experience a relative rise in their short-term interest rates tend to see their currencies appreciate and vice versa. Regarding the relative steepness of yield-curve slopes as a driver of currency returns, studies find that countries with relatively flat or inverted yield curves tend to see their currencies appreciate in value, while countries with relatively steep yield curves tend to see their currencies depreciate in value. The reason for this effect of the yield-curve slope on currency values owes to the fact that relatively flat or inverted yield curves are normally associated with tight monetary policies, which should be positive for a currency's value, and vice versa.

Research by Ang and Chen (2010) finds that strategies that combine all three yield-related factors—yield level, yield change, and yield-curve slope—into a single diversified currency portfolio would have provided higher Sharpe ratios and less negative skewness than traditional carry trades based solely on yield levels. The better risk-adjusted performance on the more diversified strategy reflects a number of factors. First, while the traditional carry trade based on yield levels alone exhibits significant negative skewness, the rate change and the yield-curve slope strategies exhibit positive skewness. Second, the returns on the different yield-related strategies are not highly correlated with one another (see Figure V-13).

The differences in reported skewness and the evidence of low correlations suggest two paths that investors can follow. First they can construct a diversified portfolio that combines all three yield-related factors into a single strategy. Or, second, they could use the yield change and yield-curve slope factors as risk filters to modify positioning in a traditional carry-trade strategy based on yield levels alone when conditions warrant. This latter approach could work in the following manner.

An investor would first rank currencies on the basis of yield levels alone, as in a traditional carry trade. In order for currencies to be included in the long basket, not only would their yield level need to be relatively high, but there would need to be supporting evidence from the yield-change and yield-curve slope factors to confirm the initial positioning. For example, if a high-yield country started to push short-term interest rates lower, or if the yield curve in the high-yield market was steep relative to other markets, then yield-change and yield-curve slope factors would not support the decision to be overweight that particular high-yield currency. An investor could then kick that high-yielder out of the long basket of the carry-trade portfolio. Only those currencies that have high-yields, stable-to-rising short-term interest rates, *and* relatively flat yield curves would qualify as currencies that warrant being included in the high-yield basket.

A similar exercise in reverse could be applied to currencies being selected for the low-yield short basket. If all yield-related factors are important drivers of currency returns, then the yield-change/yield-curve filtered carry-trade strategy should perform better than its unfiltered counterpart.

Figure VI-13

Correlation of Returns on Yield-Curve Factor Strategies

	Yield Level	Yield Change	Yield-Curve Slope
Yield Level	1.00	--	--
Yield Change	0.06	1.00	--
Yield-Curve Slope	-0.70	-0.11	1.00

Source: Andrew Ang and Joseph S. Chen, "Yield Curve Predictors of Foreign Exchange Returns", 13 March 2010, Table 2, page 38.

Sentiment and Positioning Indicators

Most fund managers today keep a watchful eye on sentiment and positioning data to help determine whether certain currencies might appear to be heavily overbought or oversold. If sentiment and positioning is perceived to be overstretched in the case of certain currencies, this could suggest that those currencies, at some point in the immediate future, might become vulnerable to a sudden reversal in trend.

Brunnermeier, et al. (2009) find that carry-trade crashes tend to be preceded by the buildup of net speculative positions. Nevertheless, overstretched readings on sentiment and positioning do not in and of themselves trigger a carry-trade crash. Rather, carry-trade crashes are normally triggered by a major liquidity or volatility shock. Once a crash is triggered, the magnitude of the downside move could be influenced by how overly stretched the readings on sentiment and positioning were in the period leading up to the crash.

This raises an interesting question: Could investors use information on sentiment and positioning to help assess the vulnerability of their carry-trade positions to a sudden crash? That is, can extremes in investor sentiment and positioning help predict currency crashes in the near future?

While it would be ideal if one could construct a reliable early warning system based on sentiment and positioning data to help predict the onset of a major currency crash, the evidence unfortunately suggests that sentiment and positioning data have very little *predictive* value in terms of anticipating the future direction of exchange rates. Although there exists a positive *contemporaneous* relationship between sentiment and positioning data on the one hand and the trend in exchange rates on the other, there is no statistically significant relationship between lagged data on sentiment and positioning indicators and future exchange-rate movements.

For example, consider the case of FX risk reversals. FX traders often use information on currency risk reversals to get a better handle on whether the FX market might be attaching a higher probability to a large currency depreciation than to a large currency appreciation, or vice versa. A risk reversal is a currency option position consisting of the purchase of an OTM call and the simultaneous sale of an OTM put, both in equal amounts and both with the same expiration date. A negative risk-reversal reading would indicate that OTM puts were more expensive than OTM calls. This would occur if the market were attaching a higher probability to a large currency depreciation than to a large appreciation. From a positioning standpoint, a negative risk-reversal reading would indicate that market participants were willing to pay more to insure against the risk that the currency will fall sharply in value than they were willing to pay to insure against the risk that the currency will rise in value.

Movements in risk-reversal readings over time should therefore reflect shifts in market sentiment regarding which direction exchange rates would likely take. If risk-reversal readings moved deeper and deeper into negative territory, this might suggest, everything else being equal, that market sentiment toward that currency was turning more negative, and hence vulnerable to crash.

The key question is whether investors can use this information to help anticipate whether and when a currency might suddenly decline sharply in value. Unfortunately, the answer is “no”. Academic studies find that there is a high positive correlation between “contemporaneous” movements in risk-reversal readings and the trend in exchange rates, but no statistically significant relationship exists between lagged risk-reversal readings and future changes in exchange rates. Therefore, risk-reversal readings may be capable of confirming an exchange rate’s trend, but are not capable of predicting it.

Nor is there evidence that overly stretched risk-reversal readings can be reliably used as a contrary indicator. A Bank of England study by Copeland and Talbot (1999) on the unwinding of the yen carry trade in the fall of 1998 found that dollar/yen risk reversals failed to provide an early warning of the dramatic unwinding of long-dollar/short-yen carry-trade positions that was about to occur.

FX market participants also closely monitor weekly changes in net positions of speculative accounts in the FX futures market to (1) glean whether speculative flows are moving in and out of particular currencies, which would indicate whether speculative capital flows were exerting significant upward or downward pressure on currency values; and (2) assess whether speculative positions in certain currencies might be overbought or oversold. If speculative positions were overstretched, this might raise the probability that a major event or shock could prompt a sudden unwinding of those overstretched positions, and in the process, trigger a major reversal in the prevailing exchange-rate trend.

Studies by the Federal Reserve Bank of New York (Klitgaard and Weir, May 2004) and the Bank of England (Mogford and Pain, Spring 2006) find that there exists a strong positive *contemporaneous* relationship between exchange-rate movements and changes in net positions of speculative accounts. That is, a buildup of long speculative positions in a particular currency tends to be associated with an appreciation of that currency, and vice versa.

Nevertheless, the New York Fed and Bank of England studies find that changes in net speculative positions "do not lead" changes in exchange rates. Nor do extremes in investor positioning—i.e., large overbought or oversold readings—correctly anticipate major currency reversals. As we saw in the case of risk reversals, the FX market simply does not tip its hand ahead of time as to the direction it intends to take.

Valuation Extremes and Carry-trade Returns

In a typical carry-trade cycle, a gradual widening in short-term interest-rate differentials, whether induced by higher yields in target markets or lower yields in funding markets, attracts an inflow of capital to the higher-yielding markets, and those inflows, in turn, exert upward pressure on target-country currencies. The combination of wider spreads and currency appreciation causes the returns on carry trades to steadily increase, which attracts still more capital inflows as investors seek to capitalize on the excess returns available on higher-yielding currencies. Those excess returns have, at times, persisted for long periods of time—the positive excess returns earned on the yen carry trade between the Spring of 1995 and the Fall of 1998 and the large reported gains on both G-10 and EM carry trades between 2002 and 2007 are just two episodes where carry-trade returns have been both large and persistent.

But those large and persistent currency gains can have economic and financial consequences for the high-yield country. If carry-trade related capital flows drive high-yield currencies deep into over-valued territory on a purchasing power parity (PPP) basis, this can eventually lead to a serious loss of trade competitiveness that, over time, can lead to an unsustainable deterioration in trade and current-account balances. Eventually, the overvaluation of the high-yield market currencies will be corrected either as supply and demand forces come in to play or through deliberate policy adjustments designed to weaken the currency's value.

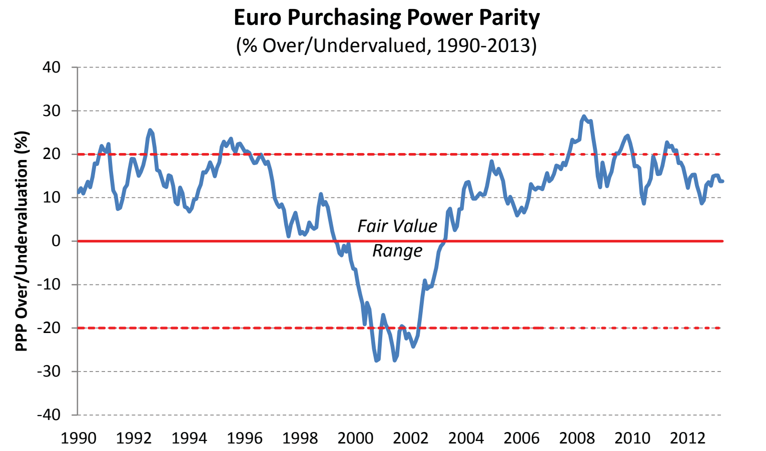
Prior to the inevitable exchange-rate correction, not only will there be visible signs of large deviations from PPP at the peak of the carry-trade cycle, but there may also be visible signs of persistent departures from long-run UIP as well. When cumulative positive excess returns on FX carry trades persist for long periods of time, the deviations from long-run UIP can end up being extraordinarily large. But just like PPP, large and persistent deviations from UIP can have serious economic and financial and are therefore not sustainable.

Large deviations from UIP tend to occur when real yields in high-yield markets lie persistently above the level of real yields in low-yield markets, or if the inflation rate in high-yield markets were persistently higher than the inflation rate in low-yield markets. Both of these developments would inevitably have a negative impact on high-yield countries growth prospects, which over time will eventually be corrected through market forces or policy adjustments.

Because economic forces and/or policy adjustments should eventually correct large misalignments from PPP and long-run UIP, the question for fund managers is how to account for these large misalignments in their assessment of the attractiveness of carry-trade strategies. Most large downside moves in carry-trade returns are triggered by volatility shocks or liquidity squeezes that force highly exposed, leveraged investors to unwind their carry-trade positions. While the volatility shock or liquidity squeeze might be the spark that triggers a carry-trade unwind, it is possible that the vulnerability of carry-trade strategies to that sudden shock might have been apparent ahead of time in the measured deviations from PPP and long-run UIP. That is, the more overvalued a currency might be relative to PPP or long-run UIP, the move vulnerable that currency might be to a sudden decline in global risk appetite. If so, measured deviations from PPP and long-run UIP could be used to help assess the downside risks associated with FX carry trades, not necessarily as a timing device, but as a vulnerability indicator.

PPP and long-run UIP deviations would provide a useful measure of downside risk if both PPP and UIP were valid long-run propositions. As we discussed in Part III, recent studies have found more support for UIP as a valid proposition over the long run rather than short or medium-term time horizons. Similarly for PPP, although the weight of empirical evidence indicates that there can be sizable and persistent departures from PPP in both the short and medium run, in the long run there exists a tendency for exchange rates to gravitate toward their PPP fair-value levels. The consensus among most empirical studies is that PPP deviations do indeed dampen over time, with estimates placing

Figure VI-14



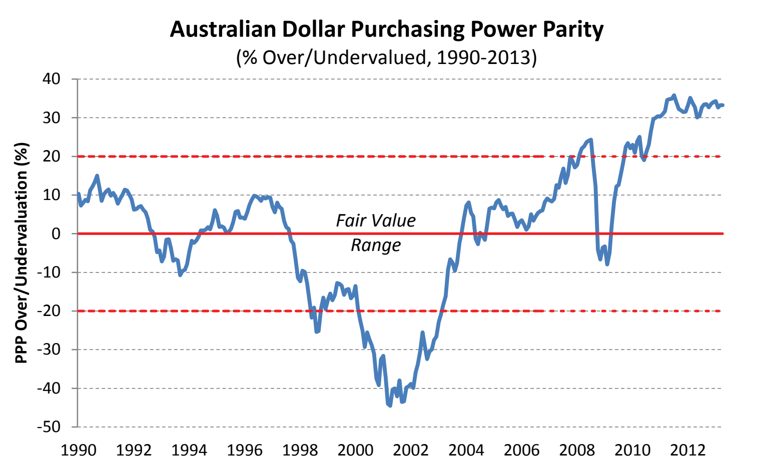
Source: *Bloomberg* BPPPCOEU INDEX<GO>

the half-life of PPP deviations at around 3-5 years, i.e., it should take roughly 3-5 years to narrow a given PPP deviation by roughly 50%.

Different currencies, of course, tend to mean-revert toward their PPP values at different speeds. Consider the case of the euro/dollar exchange rate in Figure VI-14, which has traded inside a +/- 20% band around its estimated PPP level for most of the past 20 years. The euro briefly traded below the +/- 20% PPP band in 2000-01, and then traded above it for brief intervals in 2007-08, 2009 and 2011. For most of the time, however, the euro/dollar exchange rate has exhibited a tendency to mean revert toward its PPP fair value level.

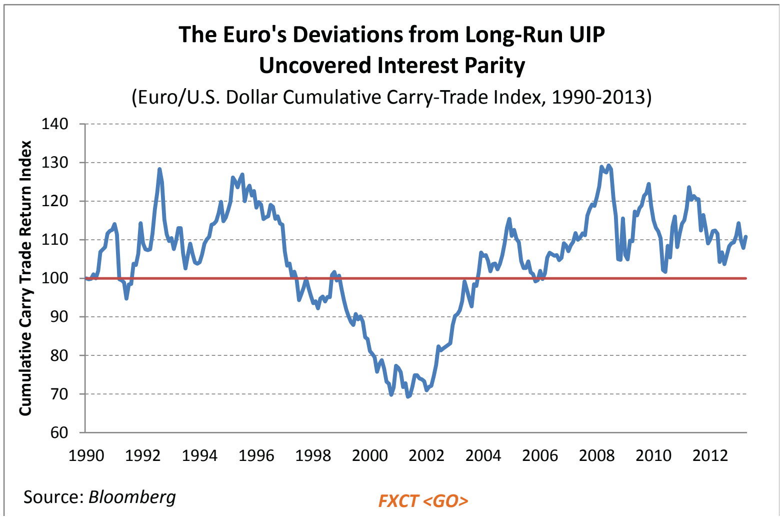
The Australian dollar, on the other hand, has tended to experience larger and more persistent deviations from its estimated PPP fair value levels versus the U.S. dollar. As shown in Figure VI-15, the Australian dollar traded well below its +/- 20% band for a 3-4 year stretch between 2000-03 and actually reached an extreme undervaluation reading exceeding -40% at one point. Between early 2010 and mid-2013, the Australian dollar traded above its +/-20% PPP band, and reached extreme overvaluation readings exceeding +30% for much of the 2011-13 period.

Figure VI-15



Source: *Bloomberg* BPPPCOAU INDEX<GO>

Figure VI-16

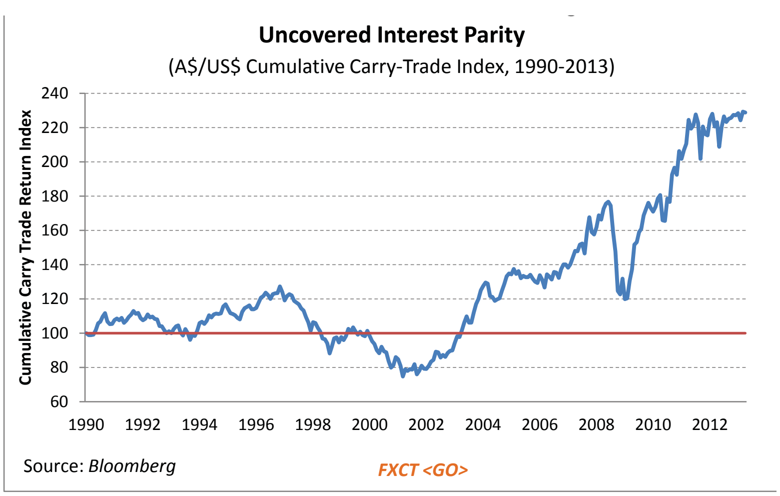


Source: *Bloomberg*

Similar pictures emerge when we compare the euro's and Australian dollar's performance versus the U.S. dollar from a long-run UIP valuation perspective. The Euro/dollar exchange rate exhibits a clear tendency for deviations from UIP to self-correct over time, i.e., there are no excess returns to be earned by going long euros/short dollars or the reverse from a long-run perspective (see Figure VI-16). In other words, over the long run, movements in the euro/dollar exchange rate have tended to offset any differences that have existed in cumulative interest-rate spreads between the U.S. and the Euro area.

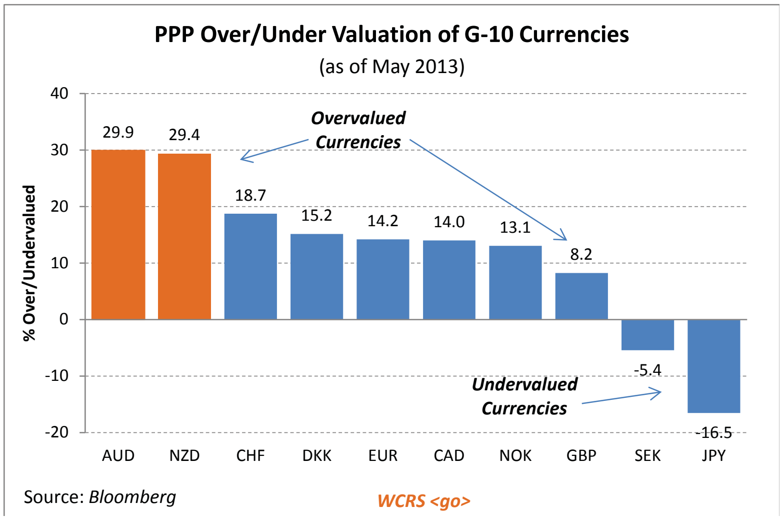
That hasn't been the case for the Australian dollar/U.S. dollar exchange rate. As shown in Figure VI-17, there have been persistent deviations in the Australian dollar's value from UIP since 2003. Through much of the 1990s and early 2000s, the Australian dollar's movements versus the U.S. dollar offset differences in cumulative Australia-U.S. interest rate spreads. Beginning in 2003, however, the Australian dollar tended to rise relative to its long-run UIP fair-value level. There was a brief sharp downward correction in the Australian dollar's value toward its long-run UIP level in 2008 as investors shed risky investments during the Global Financial Crisis. But beginning in the spring of 2009, the Australian dollar resumed its advance to the point that in 2013, its overvaluation had reached its most extreme reading on a UIP basis.

Figure VI-17



Source: *Bloomberg*

Figure VI-18



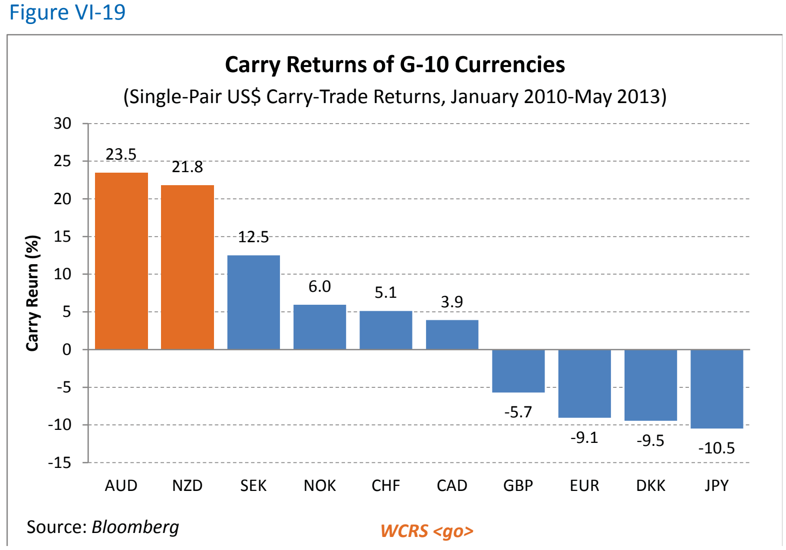
The overvalued readings on the Australian dollar and the New Zealand dollar on both PPP and long-run UIP grounds would appear to pose a dilemma for carry-trade investors. Most carry-trade ranking methodologies, whether based on simple carry, carry/risk ratios or MVO, would likely rank the A$ and the NZ$ at the top of the G-10 in terms of offering the most attractive positive carry or expected returns. Yet both currencies are among the most overvalued currencies on a PPP basis (see Figure VI-18) and a long-run UIP basis.

Because both of these currencies have been overvalued for some time now, investors might have felt that being overweight both currencies might not have been a prudent portfolio posture. Yet, had investors actually cut their exposure to both currencies, the returns on their carry-trade positions would have suffered. This is evident in Figure VI-19 which shows that over the 2010-2013 post-crisis period, the Australian and New Zealand dollars have earned the highest carry returns (cumulated positive carry plus the cumulative change in currency value versus the U.S. dollar over the 2010-13 period) among all G10 currencies. Investors would have been better off ignoring the PPP and long-run UIP misalignments over this three-year period, at least on an after-the-fact basis.

But this trend cannot go on forever. Eventually the PPP and long run UIP misalignments will take their toll. The question of course is when will that day of reckoning happen? This raises an interesting issue for investors—how should fund managers balance the potential rewards from earning positive carry on an FX carry trade with the downside risk warnings coming from extreme valuation readings on PPP and long run UIP? An investor actually has several options that can be pursued.

First, an investor can choose to ignore the valuation readings, which would have been the right strategy over the 2010-2013 period. Second, the investor can cut back on some, but not all of the portfolio's exposure to the overvalued high-yield currencies. Third, investors can completely close out all carry-trade positions where valuation readings are excessive and go flat. Fourth, if valuation readings were excessive, an investor could consider closing out the carry-trade position and replace it with a PPP valuation

Figure VI-19



strategy. In a PPP valuation strategy, an investor undertakes long positions in the *x*-most undervalued currencies according to PPP in the G10 and short positions in the *y*-most overvalued currencies according to PPP in the G-10.

Another option for an investor to consider is to wait for confirmation signals coming from other crash-protection indicators (such as FX volatility or the VIX index) before making a move. Carry trades tend to perform poorly when volatility indicators such as FX volatility and/or the VIX index rise above critical threshold levels. PPP valuation trades, on the other hand, tend to perform well when volatility spikes higher. Therefore, investors might want to wait for these volatility measures to cross critical threshold levels before making a portfolio switch from a carry trade to a PPP valuation trade.

The carry-trade risk/reward grid depicted in Figure VI-20 offers a number of useful insights in to how best to position a portfolio when carry and valuation readings reinforce one another, and when they differ. The grid compares two factors that play an important role in driving the carry-trade decision making process—PPP valuation readings on a particular currency and the amount of positive or negative carry that a currency offers. As shown, we plot two alternative PPP valuation readings at the top—overvalued and undervalued—and two carry (or carry/risk) readings along the side—high positive carry and low positive (or negative) carry.

The ideal situation for any currency to find itself in would be to be located in the upper right-hand corner of the carry-trade risk/reward grid. That is, investors would prefer to be overweight currencies that are undervalued on a PPP basis and therefore offer more opportunities for upside gains, and at the same time offer high positive carry. In the early 2000s a significant number of G-10 currencies were probably situated in the upper right corner of this grid. For example, the euro and Australian dollar started the new millennium at significantly undervalued PPP readings (see Figures VI-14 and VI-15 above), having weakened sharply versus the U.S. dollar in the second half of the 1990s when the U.S. tech boom drove both the U.S. equity market and the dollar sharply higher.

Many EM currencies also started the new millennium at depressed levels, having had lost considerable ground in the second half of the 1990s following the Asian financial crisis of 1997-98 and the large currency devaluations in Brazil and Turkey a couple of years after. With U.S. and Japanese yields at extraordinarily low levels during the first half of the 2000s, which made the dollar and yen attractive as funding currencies, this created an environment that was highly favorable for FX carry trades. It is highly unlikely that we will see a return to such a favorable environment again on a global scale any time soon.

The lower left-hand corner of the carry-trade risk/reward grid represents the least favorable place that a currency would like to be located in—highly overvalued and offering low positive or negative carry. Many currencies probably found themselves in this corner heading into the global financial crisis in the fall of 2008. A number of G-10 and EM currencies had become overvalued in the large run-up in currency values in 2002-07, and interest-rate differentials, which had already started to narrow heading into the crisis, narrowed further once the crisis hit. With many currencies offering less positive carry (and declining carry/risk ratios) and were, at the same time, significantly overvalued on a PPP basis, both G-10 and EM carry trades were vulnerable to large downside moves heading into the crisis. Once the crisis hit, most of those currencies came under heavy selling pressure.

Figure VI-20

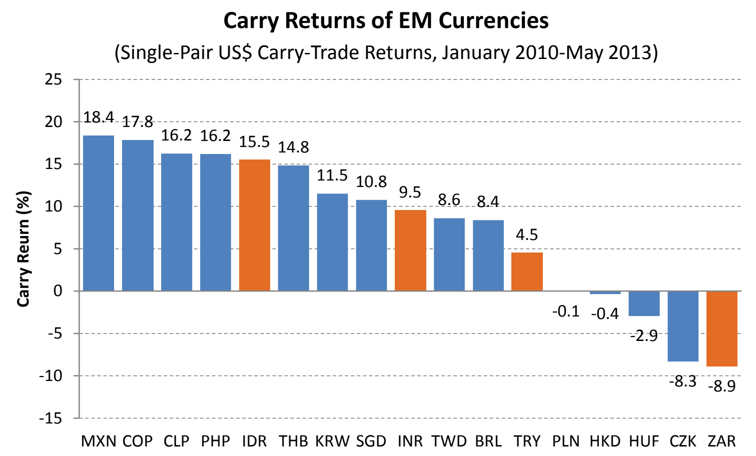
Carry-Trade Risk/Reward Grid
Balancing Positive Carry versus
Currency-Valuation Considerations

	PPP Overvaluation	PPP Undervaluation
High Positive Carry	Ambiguous	Favorable Mix
Low Positive Carry (Negative Carry)	Unfavorable Mix	Ambiguous

Source: Bloomberg

It is in the upper left and lower right-hand corners of the risk/reward grid where the appropriate course of action is a bit ambiguous. Currencies that fall in upper left corner offer high positive carry but, at the same time are significantly overvalued on a PPP basis. As mentioned above, the Australian dollar and New Zealand dollar fall into this area of the grid at present. In the lower right corner of the grid, currencies that fall in this area exhibit low positive or negative carry, but at the same time are significantly undervalued on a PPP basis. The U.S. dollar today probably fits into this corner of the grid.

Figure VI-21



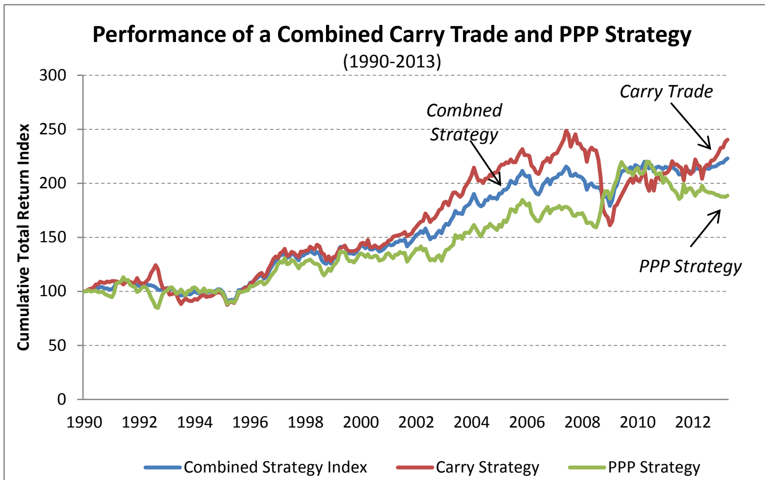
Source: *Bloomberg* WCRS <go>

As for EM currencies, many of the high-yield EM currencies that performed so well in 2002-07 have not fared all that well in the past three years. Currencies such as the Indian rupee, Indonesian rupiah, Turkish lira and South African rand have been among the weakest performing EM currencies in terms of generating attractive carry returns over the 2010-13 period (see Figure VI-21). Many of these currencies have probably fallen into the lower left corner of the risk/return grid—the positive carry that these currencies previously offered was cut sharply, and their PPP valuation readings were pushed toward unsustainably high levels during the go-go years of 2002-07.

Knowing where currencies lie in the carry-trade risk/return grid does not specifically tell you when a carry-trade unwind is likely to take place, nor does it tell you what specific strategy an investor should pursue to avoid what could be an imminent large downside move. That is, the grid is not intended to be used as a timing device. Instead, what the grid tells an investor is simply where the balance of opportunities and risks lie. The grid should be useful for an investor to help determine whether an aggressive or conservative portfolio stance is warranted given information on valuation readings and positive carry.

From a strategic point of view, there are several ways that investors can integrate PPP considerations into their carry-trade strategies. First, they could adopt a conservative posture by simply allocating 50% of their FX portfolios to a passively managed carry-trade strategy and allocating the other 50% to a passively managed PPP strategy. The combined passive 50/50 mix actually offers an attractive risk-adjusted return over time that exhibits few of the large downside moves that a 100% allocation to a carry-trade strategy would have exhibited (see Figure VI-22). Carry-trade returns tend to be negatively correlated with the returns on a PPP strategy. Briere and Drut (2009) estimate that the correlation between the two strategies is -0.32. Combining assets that are negatively correlated into a single portfolio will tend to significantly reduce overall portfolio risk.

Figure VI-22



Source: *Deutsche Bank; Bloomberg* DBHTG10U, DBPPPUSF INDEX<GO>

One of the additional advantages of combining a PPP valuation strategy with a carry-trade strategy is that the distribution of returns on the combined strategy (See Figure VI-23) does not exhibit the extreme negative tail risk associated with FX carry trades alone (Figure VI-24). The distribution of returns associated with PPP valuation strategies tends to be positively skewed (Figure VI-25), which offsets the extremely negative-skewed distribution of carry-trade strategies.

Combining carry and PPP valuation trades into a single portfolio can also help insulate the combined strategy from sudden sharp declines in global risk appetite. The returns on carry trades tend to be negatively correlated with changes in the VIX index, which makes carry trades vulnerable to a crash when risk appetites suddenly decline. On the other hand, the returns on PPP valuation strategies tend to be positively correlated with changes in the VIX index.

The different sensitivities of the carry-trade and PPP valuation strategies to changes in the VIX index opens up the possibility of adopting a more aggressive approach to integrating PPP considerations into a carry-trade portfolio. An investor could design a regime-switching model using the VIX index as a filter to determine whether the volatility regime is more favorable to carry trades or more favorable to PPP valuation trades.

Using the VIX index as a filter, an investor could choose to allocate 100% of their risky assets toward carry trades when the VIX index is trading at levels below some pre-specified threshold level or range. If the VIX index rises above that threshold level or range, the regime switching model would recommend closing out the carry-trade position and open up a PPP valuation trading position. Since PPP valuation strategies tend to perform well when the VIX index is rising, adopting such a change in portfolio positioning should have a positive impact on overall portfolio performance.

Figure VI-23

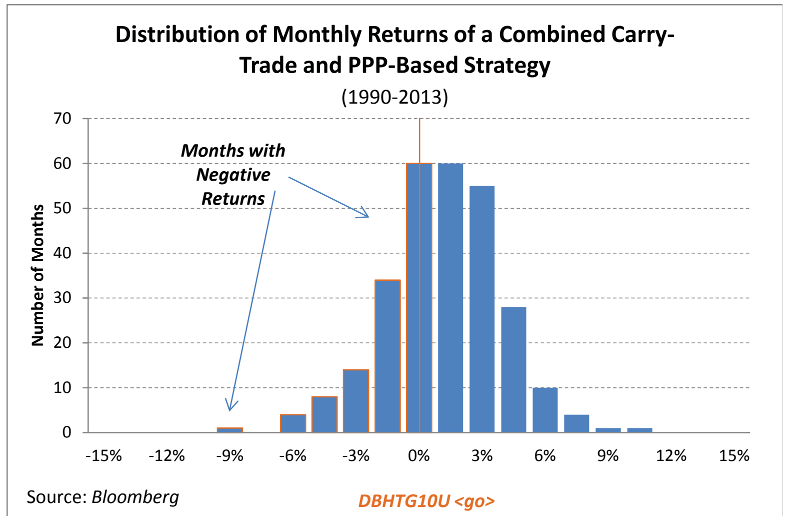


Figure VI-24

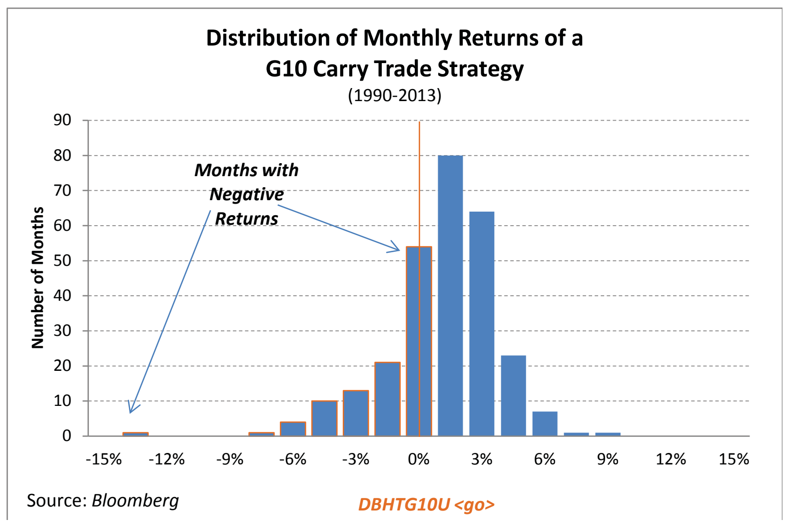
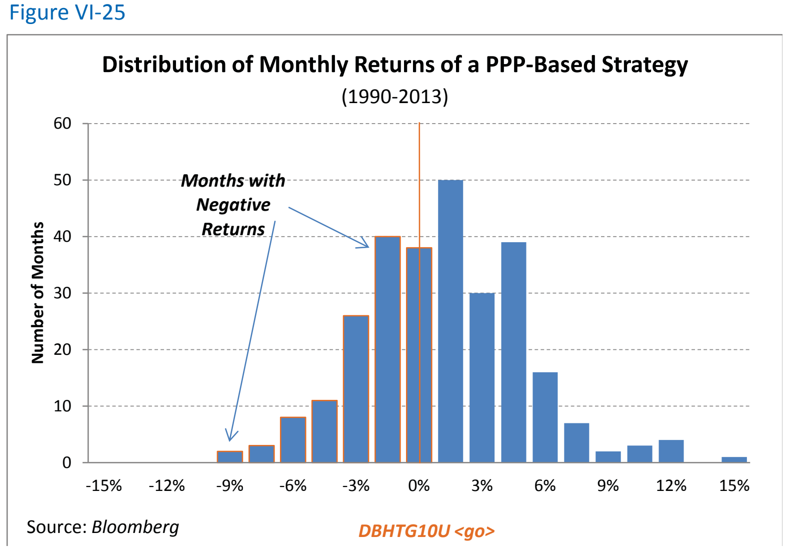


Figure VI-25



A final way of integrating PPP considerations into the carry-trade decision making process has to do with the ranking of currencies in the construction of high and low-yield carry-trade baskets. Whether currencies are ranked on the basis of simple carry, carry/risk ratios, or via a quantitative MVO model, the general presumption is that the expected return (whether risk-adjusted or not) on the individual currencies that will make up the high and low-yield baskets is strictly determined by the level of positive or negative carry. That is, the expected return on a given currency (which for illustrative purposes we will call Currency *A)* in U.S. dollar terms is assumed to be equal to the positive or negative carry that Currency *A* offers:

$$E(R^A) = I^A - i^{US}$$

From a true total-return perspective, the expected return on Currency *A* should equal the positive or negative carry that the currency offers "plus" the expected change in the exchange rate:

$$E(R^A) = (I^A - i^{US}) + \Delta s^e_{t+1}$$

It is customary in generating carry-trade expected returns, however, to assume that the exchange rate will follow a random walk, i.e., at any point in time that the expected change in the exchange rate will be 0%.

$$\Delta s^e_{t+1} = 0 + \text{random error}$$

Armed with that assumption, most carry-trade ranking methodologies simply rank currencies on the basis of positive carry alone. The random-walk assumption might be a realistic assumption if exchange rates do not deviate too far from their PPP fair value levels. If, however, exchange rates deviate significantly from their PPP fair value levels, it is probably not realistic to expect that exchange rates will randomly fluctuate around a 0% expected change, when it is more likely the case that exchange rates will eventually mean revert toward their PPP fair value levels.

If an exchange rate is trading within a +/- 10% range around its estimated fair value level, it will be so close to its fair value that there will probably be little concerted pressure for it to move up or down. That is, the exchange rate will probably exhibit a tendency to fluctuate randomly. If the exchange rate rises significantly above its +/- 10% range, fundamental forces should inevitably come in to play that will cause it to move back inside the +/- 10% range. The greater the deviation from the PPP fair-value range, say 20%-30% or more, the greater the chance that fundamental forces will require a correction in the exchange-rate's over or undervaluation.

Thus, if it is accepted that large deviations from PPP are not sustainable, it might make sense to take into account PPP deviations into the derivation of expected changes in exchange rates. When exchange rates lie inside the +/- 10% band it might be appropriate to assume that the expected change in the exchange rate is 0%. Thus, ranking by positive carry alone would be fine in such instances. When exchange-rate deviations are at extreme readings, however, it might make sense to alter the assumption on the expected change in the exchange rate from 0% to some estimated rate of depreciation in the overvalued currency's value to reflect the likelihood that the exchange rate will inevitably need to correct.

Consider the following example. Let's assume that the half-life of PPP deviations is around 3-5 years, which is broadly consistent with the econometric estimates found in most studies. That means that for a given PPP misalignment, 50% of that misalignment will tend to be corrected in 3-5 years' time. Let's further assume that a currency, which we will call Currency *A* is overvalued by 30% on a PPP basis versus the U.S. dollar. Thus, we should expect Currency *A* to fall roughly 15% versus the U.S. dollar over the next 3-5 years.

Now let's assume that yield levels in Currency *A* are 300 basis points above U.S. yields. If it is assumed that the exchange rate will fluctuate randomly around a zero mean expected rate of change, the expected return on a long-Currency *A*/short-U.S. dollar position would be 3.0% per annum, or simply the initial positive carry. But a 0% expected change in the exchange rate is not really a realistic expectation with Currency *A* being so overvalued. A more realistic expectation is that Currency A will fall by 15% over the next 3-5 years. If Currency *A* falls by 15% over the next 3 years and it is assumed that the decline is distributed evenly over that three-year period, then the annualized expected depreciation would be 5% per annum. The expected return on Currency *A* would then be the sum of the initial 3% positive carry less the expected 5% annualized depreciation of Currency *A* for an all-in expected return loss of -2% per annum, not +3% as in the random walk case.

If the 15% decline in the value of Currency *A* takes place over a 5-year period, and the decline is assumed to be distributed evenly, then the expected rate of depreciation of Currency *A* versus the U.S. dollar would be 3% per annum. In such case the expected return on Currency *A* would be the sum of the initial positive carry of 3% less the 3% annual expected depreciation of Currency *A*, which would yield an expected all-in return of 0% per annum.

What this example illustrates is that when exchange rates are at extreme valuation readings it may make more sense that currency rankings should not only reflect yield considerations, but should also reflect the fact that fundamental forces will eventually move to correct the extreme valuation readings. Figure VI-26 provides a simple illustration of how PPP valuation readings can be incorporated into the ranking of currencies in the construction of carry-trade portfolios.

In the first column we rank currencies the traditional way by yield-spread considerations alone. In Columns 2-4 we estimate the annualized rate of depreciation/appreciation that should be expected to bring about a 50% correction in PPP misalignments over a five-year horizon. In Column 5, we add the expected change in the exchange rate in Column 4 to the positive carry readings in Column 1 to come up with PPP-adjusted expected returns on all currencies listed. A similar ranking scheme can be implemented by those who prefer ranking currencies by carry/risk ratios instead of positive carry alone.

As shown in Figure VI-26, currencies B and C with yield spreads of 3% and 4% would be preferred over the 2% yield spread offered by currency A, based solely on positive-carry considerations. But because Currency A was not expected to depreciate, it would be the preferred currency on the basis of PPP-adjusted expected returns

Investors can use such a table either to explicitly rank currencies or as a cross-check to assess whether traditional carry or carry/risk ranking schemes make sense or not.

Figure VI-26

A Framework for Integrating PPP Mean-Reversion Expectations into Expected Currency Returns

Currency	Yield Spread	PPP Overvaluation	Number of Years to Reach 50% of Fair Value	Expected Change in Exchange Rate	PPP-Adjusted Expected Returns
	(1)	(2)	(3)	(4)	(1) + (4) = (5)
A	2.0%	0%	5	0.0%	2.0%
B	3.0%	15%	5	-1.5%	1.5%
C	4.0%	30%	5	-3.0%	1.0%

Source: Bloomberg

Part VII — Tying the Pieces Together

There are numerous ways that investors can pursue carry-trade strategies in the FX market. They can focus their attention on the G-10 or on EM carry trades or they could adopt a global perspective in allocating long and short positions in a broadly diversified carry-trade portfolio. Regional-based carry trades have attracted a great deal of interest, particularly those focused on the Asian region where FX volatility has tended to be lower than elsewhere in the world.

Still others have chosen to adopt a more eclectic stance, by selectively taking on cross-currency carry-trade positions in individual currency pairs that just happen to be this month's "flavor of the month." Finally, investors can gain exposure to FX carry trades by investing in ETFs that have exposure to particular carry-trade strategies, or by investing in one of the many tradable indices constructed by leading investment banks that have exposure to actively traded carry-trade positions.

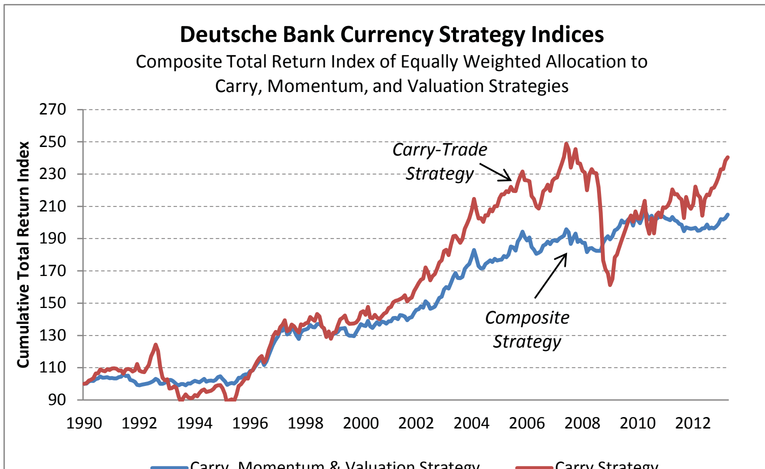
Once an investor has selected the set of currencies that they can draw from in constructing their carry-trade portfolios, decisions have to be made on how the long and short positions should be designed and built. For example, investors need to decide on how many currencies should be included in the long and short baskets. Investors need to decide on whether the individual currency exposures in the long and short baskets should be equally weighted, or whether greater weight should be assigned to the highest and lowest yielders, with gradually descending weights to the other members of the high and low-yield currency baskets.

Investors also need to decide whether currencies should be ranked by the positive carry that they earn, by their carry/risk ratios, or perhaps by a quantitative-based mean-variance optimization model. If the latter course is chosen, investors need to decide on a volatility target for their carry-trade portfolio and what kind of leverage constraints need to be applied to guard against the possibility that the optimizer might recommend long and short positions that are too highly leveraged.

Once the currency ranking and currency selection decisions are made, investors must then decide whether (and how) the carry-trade portfolio's downside risk should be actively managed. Some investors might prefer to have a passive allocation to FX carry trades without any overlay model or risk-management system.

For instance, investors might have exposure to other FX trading styles such as momentum and valuation strategies, which tend to be weakly correlated with FX carry-trade strategies. Therefore, an investor might expect to achieve diversification benefits through passive allocations to all three strategies, and at the same time reap the long-run returns that each strategy offers. Deutsche Bank's Currency Return Index (DBCRUSI Index on Bloomberg) captures the long run gains from an equally weighted portfolio consisting of passively held long positions in those three strategies (see Figure VII-1).

Figure VII-1



Source: *Deutsche Bank; Bloomberg* DBCRUSI, DBHTG10U INDEX<GO>

Other investors might want to take a more active role in managing the downside risks to their carry-trade portfolios. Part VI of this report surveyed the wide range of overlay models, volatility filters, yield-curve related factors, and valuation yardsticks that can be appended to an otherwise passively managed carry-trade portfolio to help time entry and exit decisions into and out of FX carry trades. These crash-protection indicators and risk-management systems can be

Figure VII-2

Carry-Trade Scorecard
(with Hypothetical Signals)

	Currency Ranker				Valuation Yardsticks		Currency Specific Risk Factors		Regime / State Variables				
Currency	**Carry**	**Carry/ Risk Ratio**	**Term Spread**	**Yield Change**	**PPP**	**Long-Run UIP**	**Moving Avg. Overlay**	**Futures Market Position-ing**	**FX Volatility**	**VIX**	**TED Spread**	**Bond Spread**	**Global Carry/ Risk**
A	Long	Long	Close	Close	Short	Short	Close	Long	Long	Long	Long	Long	Short
B	Long	Long	Close	Close	Short	Short	Close	Long	Long	Long	Long	Long	Short
C	Short	Long	Close	Close	Long	Long	Close	Short	Short	Short	Short	Short	Long
D	Short	Short	Close	Close	Long	Long	Close	Close	Short	Short	Short	Short	Long

Source: Bloomberg

applied in a purely quantitative manner, where carry-trade positions are automatically reduced or increased as risk factors or regime variables shift. Or they can be applied in a more judgmental manner, in which investors carefully weigh the signals coming from a variety or risk factors and regime variables and then, after careful deliberation, come to a decision on the best course of action.

A purely judgmental approach might rely on a scorecard approach as shown in Figure VII-2. A scorecard could identify key risk factors that need to be closely watched. For each risk factor, an investor can make an assessment whether the direction that risk factor is taking is positive or negative for carry-trade positioning. An investor adopting a judgmental approach to risk management might also want to produce a periodic “Carry Trade Watch” research report that focuses on economic and financial market trends to help assess the balance of risks that FX carry trades face (see Figure VII-3).

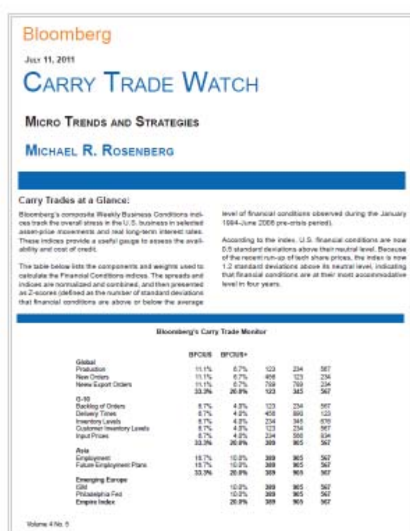
A purely quantitative approach focuses on the same risk factors as a judgmental approach except that the quantitative analyst is seeking to build a mechanical rules-based model that automatically alters the risk profile of the carry-trade portfolio when risk factors and regime variables issue a signal to change the asset mix. Because of its mechanical nature, a quantitative approach has its advantages and disadvantages.

Figure VII-3

Carry Trade Watch
Assessing the Balance of Fundamental Trends and Risks in the FX Market

Research Topics & Themes

- Economic Indicator Watch : High and Low Yielders
- Consensus Economic Forecasts : High and Low Yielders
- Monetary Policy Watch
- Risk Monitor
- Valuation Yardsticks
- Performance of Carry-Trade Overlay Models
- Strategy Review
- Correlation Analysis
- Portfolio Analysis
- Capital Flow Monitor
- Investable Carry-Trade Performance Indices


Bloomberg
July 11, 2011
Carry Trade Watch
Micro Trends and Strategies
Michael R. Rosenberg
Carry Trades at a Glance:
Bloomberg's Carry Trade Monitor

Source: Bloomberg

Changes in momentum, volatility, liquidity, and valuation yardsticks do indeed have a strong impact on the performance of FX carry trades. There is no disagreement on this. The key issue, however, has to do with specificity. At exactly what threshold level does a change in volatility, momentum, etc., signal that the financial environment for carry trades is turning less friendly. For example, does there exist a specific threshold level for the VIX index that when crossed, all carry positions should be closed? Is there a specific moving-average crossover model that investors can count on to signal when it is best to enter and when it is best to close a carry-trade position?

There are, of course, no hard and fast rules-based models that will work in all environments. The key issue is to devise trading and risk-management systems that will work reasonably well in most financial environments. To come up with such trading and risk-management systems, market participants often rely on backtesting, which usually represent simulations of a variety of trading and risk-management systems that are overlaid on conventional unhedged carry-trade portfolios. By overlaying a variety of crash-protection indicators on the original carry-trade return time series, the simulations search for strategies that could have avoided large downside moves in the past. That is, with the benefit of hindsight, the resulting risk-adjusted positive excess return on the simulated crash-protected, carry-trade strategy turns out to be high not only in absolute terms, but relative to the original unhedged carry-trade position. But this outcome had to be the case since the backtest was designed to search for model-based signals that would have successfully avoided all or most of the major downside moves that actual unhedged carry trades were exposed to.

The problem with backtests is that they are often designed to explain and capture market moves that occurred in a particular environment in the past that may not be repeated in the same manner in the future. Threshold levels for volatility, valuation, and liquidity indicators that worked well in the past might not work well in the future. Momentum models that worked well in the past when markets were highly trending might not work so well if markets exhibit less trend-persistence in the future.

What all of this suggests is that with the benefit of hindsight, it is not that difficult to construct simulated carry-trade portfolios with built-in crash protection that could have earned attractive risk-adjusted returns in the past. The key issue is whether those simulated returns represent a reliable guide to the likely prospects for actual realized gains in the future when those simulated models are put to the test.

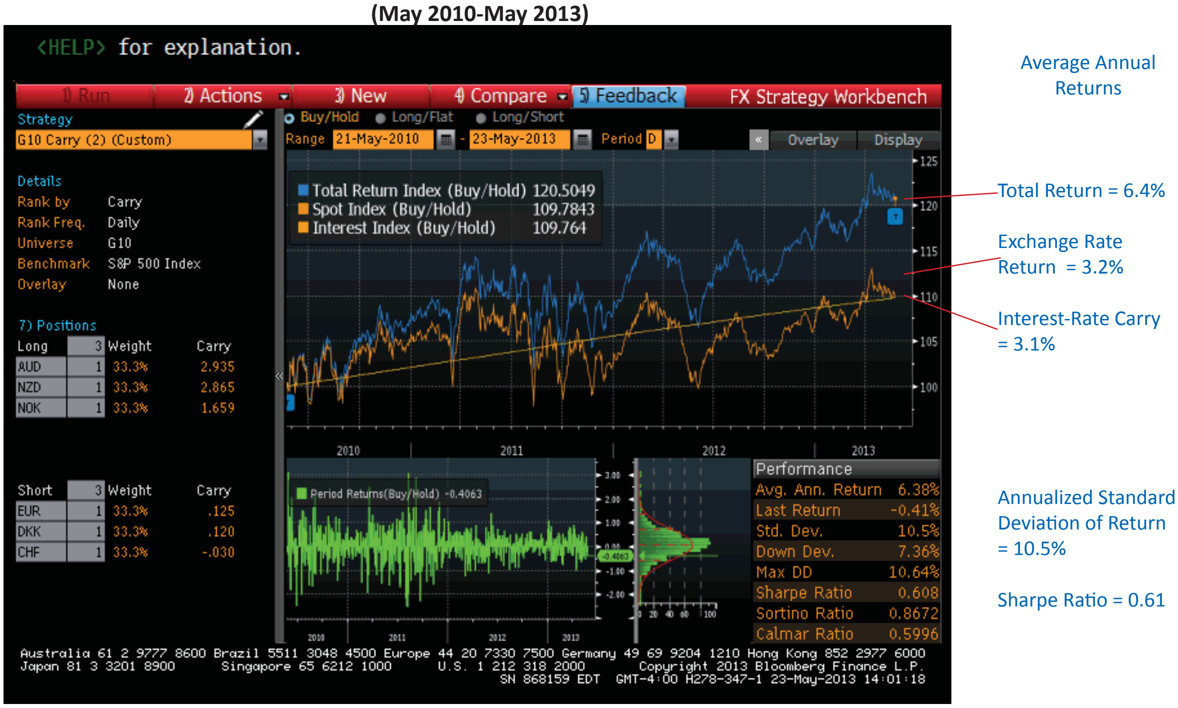
When relying on specific crash-protection indicators to limit downside risk, one runs the risk that a signal to open or close a carry-trade position could turn out to be a false-positive or false-negative signal. A false-positive signal would be one where a crash-protection indicator might suggest that the financial environment for carry trades is favorable, when in fact it is not. A false-negative signal would be one where a crash-protection indicator suggests that the financial environment is unfavorable, when in fact it is favorable.

One way to minimize the problem of false positives and negatives from a single indicator is to look for confirmation from a group of indicators. By waiting for signals from more than just one crash-protection indicator, an investor avoids placing too much weight on just one mechanical rules-based risk-management tool.

All of these issues apply to both quantitative and judgmental approaches to downside risk management. The advantage of a quantitative approach is that it imposes discipline on the downside risk-management decision-making process. If a model signals “sell”, you sell. An investor relying on a judgmental approach might not act quickly enough if market conditions are changing rapidly. The problem with a quantitative approach, of course, is that models that might have performed well in a prior environment, might not be suitable in a new, less-hospitable environment. Indeed, relying solely on such models can lead to potentially large whipsaw losses when the financial market environment is changing.

Figure VII-4

Carry, Spot and Total Return of a G-10 Carry Trade
(May 2010-May 2013)



The post-Global Financial Crisis period is a case in point. The 2010-12 period saw more frequent episodes of volatility spikes than what occurred prior to the onset of the crisis. As discussed in Part VI of this report, De Bock and Carvalho Filho (2013) found just five episodes when the VIX index rose more than 10 points above its 60-day moving average between 1992 and 2007, a 15-year period. Yet over the 2007-11 period, a mere five-year stretch, there were six such episodes. As such, the greater frequency of volatility spikes in the latter period would have made the VIX index a less useful guide to time entry and exit decisions into and out of FX carry trades.

Indeed, as Figure VII-4 shows, G-10 carry trade returns were highly variable over the mid-2010 to mid-2012 period, with little evidence of positive trend persistence. This more volatile behavior in carry-trade returns made it difficult to apply moving-average overlay models to time entry and exit decisions into and out of carry trades. Hence, as the environment changed, market-timing indicators, that might have worked well in the past, ceased working in the current period.

In a way, the recent behavior of FX carry-trade returns conforms closely to the Adaptive Markets Hypothesis pioneered by Andrew Lo of MIT, whose research applies the theory of evolution and natural selection to the financial markets. According to the theory of evolution, the long-run success of any species depends on its ability to adapt to its changing environment. Those species that cannot adapt tend to die out. The same reasoning applies to investments and trading strategies.

Some investment strategies perform well in certain environments, and less well in others. The 2002-07 period was a very favorable environment for FX carry trades. Global risk appetite was high, carry/risk ratios were high, economic growth was strong, and financial conditions were highly accommodative. The 2008-12 period was a more challenging period. Carry-trade returns were down and the volume of carry-trade activity dropped off sharply.

But this challenging environment will not last forever. At some point, the financial environment will turn more friendly and new opportunities will arise, thereby helping carry trades to recover some of their lost luster.

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