Stanford University • August 2013

SIEPR policy brief

Stanford Institute for Economic Policy Research

on the web: http://siepr.stanford.edu

Assessing the Efficiency of Asset Markets through Analysis of the Currency Carry Trade

By Robert J. Hodrick

In a globally competitive world, capital market efficiency requires that investors seek out the highest risk-adjusted expected rates of return throughout the world. Capital should flow from countries with weaker investment prospects to countries with better investment prospects. Asset markets provide valuation cues to investors who move the capital. Monetary and fiscal policies affect interest rates, exchange rates, and other asset prices thereby influencing these investment decisions. Policymakers also base their decisions on observed asset prices. Given the important role asset prices play, everyone wonders whether asset markets provide the right cues for both investors and policymakers.

In an efficient asset market, the prices of assets imply expected returns that compensate investors for the risks they take, and no unexploited profit opportunities exist. If asset markets were known to be efficient at processing information and assessing risks, everyone would feel confident that capital was being allocated correctly making government intervention inappropriate. But, if evidence indicates that asset markets may be inefficient, there might be a role for some form of government intervention. Before intervening, it is important to correctly assess the efficiency of asset markets. Doing so is difficult because it requires an asset pricing model that identifies the sources of risks and explains the profitability of investments. In some recent research, I have examined a particular international investment—the currency carry trade. Here I explain what we

continued on inside...

About The Author

Robert J. Hodrick is a Visiting Scholar at the Stanford Institute for Economic Policy Research and the Stanford Graduate School of Business. He is the Nomura Professor of International Finance at the Columbia Business School and a Research Associate of the National Bureau of Economic Research. His research focuses on asset pricing with particular emphasis on currencies and equities.

can learn about testing asset market efficiency from this analysis.[1] My ultimate conclusion is that the preponderance of the evidence indicates that currency markets were probably not fully efficient during the past 30 years, but they are more efficient now than they were.

The Currency Carry Trade

Carry trade investors buy a high interest rate currency, like the Australian dollar, with funds borrowed in a low interest rate currency, like the Japanese yen. The "carry" is the positive interest differential. For example, borrowing yen at 0.25 percent per annum (p.a.) and investing in Australian dollars at 3.5 percent p.a. earns a return of 3.25 percent p.a.—unless exchange rates change. The carry trader in this example profits whenever the Australian dollar depreciates relative to the Japanese yen over the course of the year by less than the interest differential of 3.25 percent, and the carry trader loses if the Australian dollar depreciates by more than the interest differential. Since the volatility of currency depreciation is often 10 percent p.a. or more, investors face possible losses. The desirability of the carry trade rests on the investor's assessment of the future rate of depreciation of the high interest rate currency relative to the low interest rate currency. I use the yen in the example because it is a so-called "funding currency" with comparatively low interest rates. Estimates place the magnitude of the yen carry trade at over $1 trillion dollars, but the actual magnitude of any carry trade is impossible to know because the transactions are private.[2]

Predicting changes in exchange rates is notoriously difficult, and basic economic theory, such as the idea of uncovered interest rate parity that ignores risk premiums, suggests that the expected rate of depreciation of a high interest rate currency relative to a low interest rate currency should equal the interest differential. If this theory were true, the expected return to the carry trade would be zero, and the time series average of carry trade returns would also be zero. The data tell a different story.

Average Returns for the G10 Currencies

In our research, we consider several types of carry trades including a basic one in which the investor compares the interest rate in currency j to his base currency interest rate and invests in (borrows) currency j if that interest rate is higher (lower) than the base currency rate.[3]

We find that the time series average carry trade returns are significantly different from zero, ranging from 2.39 percent p.a. for the Swedish krona-based investor to 4.10 percent p.a. for the U.S. dollar-based investor. These strategies have relatively low volatility and hence impressive Sharpe ratios, calculated simply as the average carry trade return divided by the volatility of the return. The Japanese yen-based investor has the lowest Sharpe ratio of 0.36, and the U.S. dollar-based investor has the highest Sharpe ratio of 0.81. For comparison, the expected excess return, or equity premium, on the S&P 500 is typically thought to be around 6 percent and the volatility of the return is around 15 percent for a Sharpe ratio of 0.4. If risk explains the Sharpe ratio of the S&P 500 but risk does not explain the comparable or higher Sharpe ratios of the carry trade, investors would have an arbitrage opportunity. They would get positive average

1 I explore these issues more formally in a forthcoming working paper, "The Carry Trade: Risks and Drawdowns," which is co-authored with Pierre Collin-Dufresne, Kent Daniel, and Zhongjin Lu (2013). Additional background material on the carry trade can be found in Chapter 7 of my textbook, *International Financial Management,* co-authored with Geert Bekaert.

2 See "What Keeps Bankers Awake at Night," *The Economist* (2007).

3 In my research with Collin-Dufresne, Daniel, and Lu, we focus on the G10 currencies, which are the Australian dollar, the British pound, the Canadian dollar, the euro, the Japanese yen, the New Zealand dollar, the Norwegian krone, the Swedish krona, the Swiss franc, and the U.S. dollar. Our sample covers January 1976 to May 2010, except for the Australian dollar and the New Zealand dollar, which start in October 1986. We substitute the Deutsche mark for the euro prior to 1999. While banks and hedge funds can do carry trades in the interbank market, which is not available to retail investors, retail investors can access carry trades through Power Shares Deutsche Bank G10 Currency Harvest Fund (ticker DBV) and Barclay's – iPath Optimized Currency Carry ETN (ticker ICI). Retail investors can also develop carry trades in the futures markets.

returns with low volatility and no exposure to risks. Thus, if risk explains both the equity premium and the average returns to the carry trade, the carry trade return must be exposed to risks.

Possible Reasons for Carry Trade Profitability

The finance profession reconciles the findings of apparent non-zero carry trade profits with high Sharpe ratios in five ways:

1. Time Varying Risk Premiums: If average carry-trade profits arise in an efficient market and are consequently expected by investors, carry trades must be exposed to risk factors. By risk, economists do not mean risk of loss, which is clearly present due to the uncertain change in the exchange rate. Rather, risk arises when the uncertain return on an investment cannot be diversified away within a large market portfolio because the return on the investment moves together with the pervasive, non-diversifiable factors that create the variance of the market portfolio.

The finance profession is divided about whether carry trades are exposed to risk factors. Our research examines the exposure of the carry trade to the three common equity market risk factors popularized by Fama and French (1993): the return on the market portfolio; the return on a portfolio that is long small stocks and short large stocks; and the return on a portfolio that is long high book-to-market stocks and short low book-to-market stocks. We find that these equity market risks explain very little of carry trade returns, but they are not the only sources of pervasive movements in portfolio returns. In exploring bond market risks we find that the carry trade is negatively related to the 10-year U.S. Treasury bond return in excess of the return on a 1-month Treasury bill, and it is positively related to the excess return of the 10-year bond over the 2-year bond. Still, these bond market risks leave much of the average return unexplained.

Carry trades are also known to do poorly in high volatile environments. In other research, I argue that aggregate volatility is a risk factor.[4] Because investors dislike increases in market volatility, they require higher expected returns on assets or trading strategies, like the carry trade, that have negative returns when volatility increases. One way to measure changes in volatility is to examine the return on a variance swap, a contract in which the buyer of the swap earns the difference between the realized variance of the S&P 500 and the implied variance in the S&P 500 option market calculated from the VIX. Consistent with investors' aversion to volatility, in the carry trade research, we find that carry trade returns are negatively related to the return on the variance swap.[5] In combination, though, these risks do not explain the average returns to the carry trade.

2. Market Inefficiency: The high average profitability of the carry trade and its lack of exposure to basic risk factors could indicate an inefficient market. While it is hard to imagine sharp-eyed FX traders, who exchange more than $4 trillion a day in the FX markets, leaving money on the table, behavioral biases could be present. Investors may be irrationally too home biased or have too short a time horizon to fully exploit inter-country profit opportunities.

3. Learning About Policy: The third interpretation of the findings involves relaxation of the implicit assumption that investors have rational expectations. Learning by investors could reconcile the econometric findings with equilibrium theory. As monetary and fiscal policies evolve, investors may have to learn from past data, which would induce serial correlation in returns but not necessarily high average returns. Astute investors who learn quickly, though, might be able to front-run other slower

4 See Ang, Hodrick, Xing, and Zhang (2006).

5 Periods of high volatility are also often periods of illiquidity, and some researchers argue that the realizations of losses and the risk of being unable to exit the carry trade in illiquid financial crises explain carry trade profitability. Separating the volatility explanation from the illiquidity explanation is a challenge for future research.

learning investors, in which case the quick could invest in high interest rate countries profiting as slower moving capital flows into those countries causing currency appreciation. The risk aversion of the quick learning investors combined with limits to arbitrage would prevent them from fully exploiting the profit opportunities.

4. Negative Skewness and Drawdowns: *The Economist* (2007) characterized the carry trade investor as someone "picking up nickels in front of a steam roller," suggesting that the negative skewness in returns is mostly due to sudden large losses. Investors' dislike of this negative skewness could explain the average carry trade returns. To examine this possibility in our research, we define a drawdown to be the loss that an investor experiences from a peak (or high-water mark) in the cumulative return to the trough. We document that although carry-trade drawdowns are large, they generally occur over multiple days. Cumulative losses tend to be larger and faster than cumulative gains, but the data do not support the extreme steam roller view. Most large moves in exchange rates occur during periods of heightened volatility, and effective stop-loss orders could protect the investor from extreme drawdowns. We also examine the time it takes for the carry trade to recover to the previous high-water mark, which is often over several years. The questions facing the carry trader, therefore, become how do you know when to exit the trade to prevent losses and when do you have the faith to re-enter the trade. Rather than stopping losses, one can hedge against them.

5. Peso Problems: The perception of carry trade profitability could be illusory if there are so-called "peso problems" in the data analysis. Peso problems were originally interpreted as large events that did not occur in the sample but on which investors had placed prior probability. More generally, peso problems are situations in which the realizations of returns do not match the ex ante frequencies from investors' probability distributions of returns. Thus, if the data contain fewer negative carry trade returns than investors thought possible, the average returns would be higher than investors anticipated. The historical profitability of the carry trades would be a classic example of the admonition that past performance cannot predict future performance.

One way to assess this peso problem explanation is to hedge the extreme downside risk of loss due to possible depreciation of the investing currency by having the investor purchase insurance in the foreign currency options market. For example, suppose a USD-based investor is long British pounds. The investor loses if the pound weakens as the dollar price of the pound falls. To prevent large losses, the investor would buy pound put options conveying the right but not the obligation to sell pounds at a known strike price of dollars per pound.

In our research, we only have high-quality options data for a shorter sample, September 2000 to May 2010. The average returns to the unhedged carry trade are lower for this period, which is suggestive that more capital flowed into the trade. Nevertheless, the Sharpe ratio of the unhedged carry trade is 0.69 and remains substantially above the Sharpe ratio for the S&P 500. Although the average returns of the hedged carry trade strategies are positive, they are not significantly different from zero. Purchasing protection against large losses thus eliminated the profit. Comparing the maximum losses across the unhedged and hedged strategies, one sees that purchasing protection from large losses can be quite costly, as the maximum unhedged loss is 3.94 percent and the maximum hedged loss is 3.51 percent. As might be expected, large unhedged losses tend to occur during volatile times. A side effect of increased volatility is that it increases the cost of insurance. Thus, the largest hedged losses tend to occur

continued on flap…

immediately after the largest unhedged losses, when the cost of insurance is highest.

Is It Just a USD Puzzle?

Because the USD-based investor compares the USD interest rate to nine foreign interest rates in the basic analysis, the investor is always either long or short the dollar versus some basket of currencies. To develop a dollar-neutral carry trade, we calculated the median interest rate of the nine non-USD currencies and took long (short) positions versus the dollar in the four currencies whose interest rates were greater (less) than the median. Profitability of the resulting portfolio consequently does not depend on common movements in the value of the dollar relative to all currencies. Interestingly, the return on this dollar-neutral carry trade portfolio appears to be fully explained by the return on the market portfolio and the return on the variance swap in the sense that the average residual return is insignificantly different from zero.

To capture the carry trade return due primarily to common movements of the dollar relative to other currencies we constructed a portfolio by first considering whether the dollar interest rate is less (greater) than the median interest rate. If it was less (greater), we took long (short) positions versus the dollar in the currencies whose interest rates were greater (less) than the median. The risk adjusted average return on this portfolio, which has exposure only to the bond market risk factors, is 8.13 percent p.a., indicating that common movements of the dollar account for much of the return to the general carry trade portfolio.

Conclusions

Analyzing the returns to the carry trade demonstrates how difficult it is to determine the efficiency of financial markets. One needs a model of the sources of risks and the nature of conditional exposures to those risks. A host of factors including the market return, the volatility of the market return, and the returns to long-term government bonds are pervasive sources of risks. Exposures to these risks can vary through time. Non-dollar carry trades are exposed to these factors and have no residual average return, but although U.S. dollar-based carry trades have some exposure to risks, they retain risk-adjusted average return. In the shorter sample, hedging the carry trade in the option market reduces the average return to zero, but the comparability of the maximum hedged and unhedged losses suggests that dollar-based investors feared larger carry trade losses that did not materialize in the sample, even though it contains the financial crisis. The early profitability of the carry trade in the 1980s and its declining profitability more recently are consistent with the idea that the market probably didn't fully exploit all profit opportunities. The decline in profitability since 2000, the conditional exposure of the carry trade to market risks during the financial crisis, and the inability to profit if one hedges large moves allow me to infer that the FX market is now closer to being efficient than it was 30 years ago.

References

Ang, Andrew, Robert J. Hodrick, Yuhang Xing, and Xiaoyan Zhang, 2006, The cross-section of volatility and expected returns, *Journal of Finance* 61, 259-299.

Bekaert, Geert, and Robert J. Hodrick, 2012, *International Financial Management, Second Edition,* Upper Saddle River, NJ: Pearson Education, Inc.

Carry on speculating: How traders have been triumphing over economic theory, *The Economist,* February 22, 2007.

Collin-Dufresne, Pierre, Kent Daniel, Robert J. Hodrick, and Zhongjin Lu, 2013, The carry trade: Risks and drawdowns," manuscript, Columbia Business School.

Fama, Eugene, and Kenneth French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3-56.

What keeps bankers awake at night, *The Economist,* February 1, 2007.

SIEPR *policy brief*

Stanford University
366 Galvez Street
Stanford, CA 94305
MC 6015

A publication of the
Stanford Institute for
Economic Policy Research

Non-Profit Org.
U.S. Postage
PAID
Palo Alto, CA
Permit No. 28

SIEPR

About SIEPR

The Stanford Institute for Economic Policy Research (SIEPR) conducts research on important economic policy issues facing the United States and other countries. SIEPR's goal is to inform policymakers and to influence their decisions with long-term policy solutions.

Policy Briefs

SIEPR policy briefs are meant to inform and summarize important research by SIEPR faculty. Selecting a different economic topic each month, SIEPR will bring you up-to-date information and analysis on the issues involved.

SIEPR policy briefs reflect the views of the author. SIEPR is a non-partisan institute and does not take a stand on any issue.

For Additional Copies

Please see SIEPR website at *http://SIEPR.stanford.edu*.