Exploring the Yen Carry Trade: Investor’s Choice of Target Currencies

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Under the Direction of
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Abstract

Empirical studies have shown that carry trade plays an increasingly important role in driving exchange rate movements. Because carry trade can have an enormous impact on macroeconomic factors, understanding basic characteristics of carry trade will be useful for both researchers and policymakers in countries susceptible to carry trade speculations. Focusing on the yen carry trade, this paper seeks to determine what factors investors take into account when they choose target currencies. I accomplish this by estimating the relationship between carry trade volume and other economic and financial variables for nine selected countries in the Asia-Pacific region using a simple multiple regression model. I find that the interest rate differential and a country’s credit rating have statistically significant positive effects on carry trade volume while exchange rate movement does not affect the volume as strongly. The results also suggest that advanced economies are more prone to carry trade speculation, and therefore the risks of unwinding are greater in those countries.

Keywords: carry trade, unwinding, exchange rate, capital flow, interest differential

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1 Introduction

Carry trade gained attention from academia in recent years as it plays an increasingly important role in driving exchange rate movements (Galati, Heath, and McGuire, 2007). Loosely speaking, carry trade is an investment strategy in which an investor borrows from a country with a low interest rate and invests it in a country with a high interest rate. The currencies involved are called funding currency and target currency, respectively.

According to uncovered interest parity (UIP), any gains from this interest differential will be offset by the expected future depreciation of the target currency, eliminating the arbitrage opportunity. However, a number of empirical studies have shown that this is not the case; in fact, evidence shows that the reverse holds. As more investors engage in carry trade, more funds flow from funding to target countries. This leads to a depreciation in the funding currency and an appreciation in the target currency, which makes carry trade in that country even more profitable and attractive to investors. It has been shown that theoretically, if investors hold their carry trade positions indefinitely they will always make profits (Plantin and Shin, 2006).

Although this seems to be an easy arbitrage opportunity, unforeseen events such as a decrease in liquidity, a tightening of monetary policy, or a financial crisis sometimes causes investors to withdraw their assets in the target country. During these “unwinding” periods, investors convert the target currency back to the funding currency to repay their debts in the funding country. As a result, the target currency depreciates against the funding currency and the profits from carry trade decrease. Since these carry trade positions are highly leveraged, the profits of carry trade are extremely sensitive to the movements in exchange rates (Galati et al., 2007; Sy and Tabarraei, 2009). A small depreciation of the target currency could lead to a large loss to investors. The decreased profits would prompt even more investors to unwind their positions and eventually result in a sharp depreciation of the target currency. This circumstance leads to a saying among traders that target currencies “go up by the stairs and down by the elevator” (Plantin and Shin, 2006).
Figure 1: JPY/AUD Exchange Rate and Volatility

Note: The blue line depicts the exchange rate of Japanese yen against the Australian dollar. A downward movement is an appreciation of the yen. 30-day historical volatility is also shown in orange. Note the distinct episodes of unwinding in October 1998, May 2006, February 2007, and October 2008. These periods show sharp appreciations of the exchange rate as well as spikes in volatility.

Figure 1 illustrates the buildup and unwinding periods of the Japanese yen from 1995 onwards. Note that the high volatility periods are usually associated with the sharp strengthening of the yen (funding currency) against the Australian dollar (target currency) while the periods with low volatility are usually associated with slow buildups of the carry trade and the depreciation of the yen against the Australian dollar.

Perhaps one of the most extreme episodes of carry trade unwinding was on October 7–8, 1998, when the Japanese yen abruptly appreciated 13.4% against the US dollar (target currency) in only two days after a long period of depreciation. More recently, the Japanese yen rose against both the Australian dollar and the British pound by 10% in only five hours on October 24, 2008 (Jordà and Taylor, 2009). Aside from this, smaller unwinding episodes were documented in May 2006 and February 2007 (Gagnon and Chaboud, 2007; Jordà and Taylor, 2009). These smaller episodes are also captured by spikes in exchange rate volatility.
in Figure 1.

Despite these apparent risks, carry trade is still a popular investment strategy employed by both large financial institutions and retail investors (Galati et al., 2007). Carry trade can be implemented in a wide variety of ways. The simplest strategy involves exchanging the funds borrowed in one currency and investing it in short-term assets such as government paper or bank deposits in the target currency. When they reach maturity, these funds can then be exchanged back to the original funding currency. A more complicated carry trade strategy might involve other financial derivatives such as longing spots and shorting forwards on the target currency.

Regardless of the strategy, carry trade relies largely on interest differentials for its profitability. From this simplistic view, it seems like the choice of target and funding currency is clear: choose the pair with the highest interest rate differential. One would expect to see more funds flowing to countries with higher interest rates. Nonetheless, Brazil, with its interest rate averaged at 16.55%, still sees a smaller inflow of capital compared to Australia, whose average interest rate is only 5.36% (International Monetary Fund, 2009a) even after adjusting for commercial investments unrelated to carry trade.

Certain questions naturally arise from these observations. Why are some currencies more attractive than others as target or funding currencies? What factors affect the expected profits from carry trade? This paper seeks to shed light on these questions through an investigation of empirical relationship between carry trade volume and other economic and financial variables using a multiple regression model.

In estimating this relationship, I focus on the choice of target currencies used in the Japanese yen carry trade. The yen is the currency most cited as the funding currency for carry trade. This is due largely to Japan’s low interest rates since the 1990s and its relatively stable economy (Gagnon and Chaboud, 2007).\(^1\) Nine target countries are included in this study: Australia, Brazil, Indonesia, South Korea, Mexico, Malaysia, New Zealand, New Zealand, New Zealand,

\(^{1}\)Other popular funding currencies include the Swiss franc and the US dollar.
Philippines, and Thailand. The choice of countries included in this study is based on size of the yen carry trade volume as well as data availability.

As carry trade presents an immense effect on the exchange rates of currencies involved, it poses significant implications not only to investors but also to policymakers around the world. This is especially true in developing countries whose economic performance relies largely on exports. Capital inflow induced by carry trade and the resulting currency appreciation would affect the country’s competitiveness as an exporter. As a result, monetary authorities have to make an effort to intervene and prevent their currencies from appreciating too fast. At the same time, they have to prepare for the imminent episode of carry trade unwinding, an event which would be equally disastrous for the economy because of the high volatility in the foreign exchange market that would follow. Understanding what determines the choice of currencies used as instruments for carry trade will be a great asset for monetary authorities in developing countries as they will be able to adjust those factors to attract more or less capital through carry trade accordingly.

This paper is organized as follows. Section 2 discusses related literature. Section 3 presents the theoretical framework and the related micro-foundation. I put forth the methodology used in this paper in Section 4. Section 5 covers data sources and descriptive statistics, while Sections 6 and 7 present results and analysis of the study. Finally, Section 8 concludes.

2 Literature Review

Because of its increasing popularity as a trading strategy, carry trade became a popular topic in economic literature in recent years. The majority of the literature looks at the most perplexing feature of carry trade: its deviation from the uncovered interest parity. Although theoretical explanation of the UIP and positive returns of carry trade might not be directly related to the focus of this paper, factors that cause the expected returns from carry trade to fluctuate will ultimately be the factors that affect investors’ choices of target currencies
as well. Therefore, these studies on the mechanisms of carry trade serve as an important micro-foundation for the study of an aggregated volume of carry trade, which is the focus of this paper. Apart from these theoretic papers, there are only a few studies that focus on comparing the volume across multiple country-pairs. This lack of papers can be attributed to the challenge of accurately measuring carry trade volume. In this section I first discuss literature related to different approaches of measuring carry trade volume. After that, I review existing studies on determinants of carry trade volume.

2.1 Measures of Carry Trade Volume

Tracking carry trade activity has been notoriously difficult largely because of the lack of formal definition of carry trade and the many forms carry trade could take. Carry trade could be implemented by any means from outright borrowing and lending to taking positions in financial derivatives. These different implementations of carry trade leave different footprints in the data.

One of the most widely accepted methods of measuring carry trade is through the derivatives market. In practice, few investors implement carry trade by actually borrowing and lending in the spot market. Instead, carry trade is usually implemented through financial derivatives, for example by longing spots and shorting forwards on the target currency (Brunnermeier, Nagel, and Pedersen, 2008). This approach proxies carry trade by the net open position of non-commercial traders in a particular foreign currency expressed as a fraction of the total open positions of non-commercial traders.\(^2\) Using this measure, more open positions imply higher carry trade volume. Galati et al. (2007) as well as McGuire and Upper (2007) note that even though the classification of traders might not be entirely accurate, this measure of carry trade provides the strongest link to carry trade activity as far as volume is concerned. Brunnermeier et al. (2008) also claim that this is the best publicly available

\(^2\)The focus is on non-commercial traders because by definition they are those using futures for speculative purposes (as opposed to commercial traders who use futures for hedging purposes) and hence is more relevant to carry trade activities.
data to measure carry trade volume.

Despite these desirable characteristics of derivatives market data, the available data from the US Commodity Futures Trading Commission (CFTC) only cover 6 currencies against the US dollar.\(^3\) Although much useful cross-currency information can be inferred from this (Brunnermeier et al., 2008), the data does not reveal much about the volume of the yen carry trade against currencies other than the US dollar.

One other possible way to proxy carry trade volume is to track the flow of capital through the international banking system. The Bank of International Settlements (BIS) provides statistics for foreign claims of Japanese banks by country (Bank of International Settlement, 2009), which suggests roughly the amount of Japanese yen that flows to other countries. In their paper, Galati et al. (2007) advocate the use of international bank flows to measure carry trade volume but recognize that they are not an ideal instrument to track carry trade activities. This is because they leave out carry trade operations that are done through derivatives and take into account other forms of investments that might not be related to carry trade such as corporate borrowing and lending. Gagnon and Chaboud (2007) also note that these statistics only provide an upper bound of carry trade, and this bound is likely to be far above the actual level of borrowing for carry trade. Despite these caveats, the BIS statistics are one of the few bilateral capital flow data available by currency which is crucial for this paper’s goal in comparing carry trade volumes across multiple country-pairs.

### 2.2 Similar Studies on Determinants of Carry Trade Volume

Of the studies that focus on carry trade volume, a number of them set the scope to the carry trade volume between one country-pair. Brzeszczynski and Melvin (2006) study carry trade between the US and Europe and measure the volume by number of trades in the foreign exchange market per time period. They find that changes in target interest rates do not significantly affect the number of tradings per day. Nishigaki (2007) focuses on the flow

\(^3\)The available currencies are the Canadian dollar, the Swiss franc, the Mexican peso, the British pound, the Japanese yen, and the euro.
of yen carry trade into the US. Using structural VAR model, he finds that, surprisingly, the effect of interest differential between the US and Japan on carry trade volume is not statistically significant. On the other hand, what seems to be affecting volume the most is economic conditions in the US as measured by the S&P 500 index.

On a bigger scope of empirical study on carry trade volume, literature in this area is quite limited to a group of advanced economies whose financial derivatives data are more readily available. Galati and Melvin (2004) use growth in exchange market turnover (i.e. amount of money converted between a currency-pair) to analyze carry trade volume in Australia, Canada, the Eurozone, UK, Japan, and Switzerland and find significant effects from both interest rate differentials and exchange rate movements. Klitgaard and Weir (2004) use net future positions and also find significant correlation between exchange rate trends and carry trade volume. They note, however, that correlation does not necessarily imply causation and there might be an endogeneity problem. Extending this result, Mogford and Pain (2006) add other asset prices such as oil and equity markets as explanatory variables. Brunnermeier et al. (2008) provide an extensive review of carry trade in Canada, Japan, Switzerland, UK, the Eurozone, and the US. They find the correlation between future positions and interest differential to be positive while the correlation between future positions and market volatility is negative.

In all, while results from these studies agree on the signs of each variable, the statistical significance of the estimates varies. Focusing on a new dataset that covers both developed and developing countries, this paper contributes yet another empirical result to the literature and adds additional insight to the findings.

3 Theoretical Framework

Following papers in this area such as Mogford and Pain (2006) and Nishigaki (2007), I posit that the volume of the yen carry trade in a particular target country is affected by interest
rate differential, exchange rate movement, country’s risk, and other unidentified factors that are country-specific (i.e. a country’s “fixed effects”). The relationship is given by

\[ CT_i = f(IN_T, FX_i, R_i, D_i); \]  

where \( CT_i \) is the carry trade volume in country \( i \), \( INT_i \) is the interest rate differential between Japan and country \( i \), \( FX_i \) is the percentage change of the exchange rate between country \( i \)’s currency against the Japanese yen, \( R_i \) is country \( i \)’s short-term credit rating, and \( D_i \) is a dummy variable for country \( i \). I will now discuss each factor in turn.

**Interest Rate Differential:** Interest rate differential is the key factor in determining the profitability of carry trade. With a few exceptions, most studies find a statistically significant effect of interest rate differential on carry trade volume. One exception is Brzeszczynski and Melvin (2006) where the authors find a strong effect of interest rate changes in weekly data but not in daily data. This inconsistency suggests that data frequency might affect the estimation results. Another exception is in Nishigaki (2007) where the author finds a positive but not significant effect of interest rate differential. Nonetheless, all studies find the effect to be positive. Using quarterly data, I expect to find a positive and significant relationship between carry trade volume and interest rate differential. In other words, other things being equal, a country with higher interest rate differential should experience a larger capital inflow from carry trade.

**Exchange Rate Movement:** As for exchange rate movement, Klitgaard and Weir (2004) find that an appreciation of a currency correlates strongly with an increase in net forward positions. However, the Granger-causality test shows that it is inconclusive whether one series lead the other. Nishigaki (2007) reports a similar result for the Granger-causality test. Galati and Melvin (2004) find that investors often invest in currencies that are appreciating, essentially betting on the currency’s long swings. As more investors target a particular
currency, the currency will appreciate even more. This appreciation in target currency drives up the profits of carry trade, inviting even more investors. This so-called “momentum trading” gives rise to the hypothesis that carry trade volume should correlate positively with the change in the exchange rate. Other things being equal, a country whose currency is appreciating should see a higher carry trade volume than a country whose currency is depreciating.

Credit Ratings: Aside from interest rate differential and exchange rate movement, I also introduce a new determinant of carry trade volume: country’s credit rating. Generally, a country’s credit rating reflects how susceptible the country is to adverse economic and financial conditions. Since these factors introduce more risk to carry trade investment in forms such as a higher probability of unwinding or inflation risk, I expect that a country with better credit rating would be more attractive to carry trade investment, other things being equal.

4 Methodology

In order to compare carry trade volume and its determinants across the 9 countries on a consistent basis, I use total claims by Japanese banks to proxy for carry trade volume. One disadvantage of using capital flow data is that the numbers also include other forms of investment aside from carry trade speculation. As a consequence, I need to control for non-carry trade transactions between each country and Japan and I achieve this by including trade volume into the estimation. The assumption is that the degree of economic interaction between two countries (i.e., non-carry trade transactions) should be reflected in the trade volume between the two countries.

The term $\log T_i$ introduced as a control variable on the right hand side and is the logarithm of the sum of US dollar value of exports and imports between country $i$ and Japan. To estimate the relationship posed in the previous section, I assume a simple semi-logarithmic
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functional form. The preliminary equation is as follow:

$$\log CT_{i,t} = \sum_{i=1}^{9} \alpha_i D_i + \beta_1 \text{INT}_{i,t} + \beta_2 FX_{i,t} + \beta_3 R_{i,t} + \beta_4 \log T_{i,t} + \varepsilon_{i,t}, \quad (4.1)$$

where $i$ is an index for each country, $t$ is the time period and the terms $\sum_{i=1}^{9} \alpha_i D_i$ is the countries’ fixed effects.

As it is true for much of empirical macroeconomic studies, it is important to note that explanatory variables on the right hand side are determined endogenously. That is, the covariance between the explanatory variable and the error term $\varepsilon_i$ is not zero. To see this, consider the movements in exchange rate. When viewed as a “price” for a currency, an exchange rate is determined by factors that affect the currency’s supply and demand. As more investors wish to hold the currency, carry trade volume and the demand for the currency also increase. In the short run, this will cause the currency to appreciate and therefore the movements in exchange rate is endogenous in this equation. The endogeneity of the interest rate can be explained similarly: as more capital flows into the target country, money supply increases and the interest rate will go down. Empirical and statistical discussion on the endogeniety of these variables can be found in Nishigaki (2007) and Mogford and Pain (2006).

There are several ways to work around this problem. An approach introduced by Nishigaki (2007) is the structural vector autoregression (SVAR) model. This model allows for endogeniety and makes minimal assumption on the structural form. Another approach that is available for time series data analysis is to estimate the variable of interest on lagged values of explanatory variables. Taking this approach, the equation becomes:

$$\log CT_{i,t} = \sum_{i=1}^{9} \alpha_i D_i + \beta_1 \text{INT}_{i,t-1} + \beta_2 FX_{i,t-1} + \beta_3 R_{i,t-1} + \beta_4 \log T_{i,t-1} + \varepsilon_{i,t}. \quad (4.2)$$

This ensures that the lagged explanatory variables are not correlated with the error term $\varepsilon_t$ since variables at time $t$ could not possibly affect variables at time $t - 1$. With this, the
identifying assumptions are satisfied.

While the SVAR approach seems to be suitable especially for macroeconomics purposes where no definite structural model can be determined, I decide to take a simpler approach and use multiple regression model in order to focus on the effect of the different factors on carry trade volume only.

5 Data and Descriptive Statistics

The data used in this paper is a panel data of nine countries (Australia, Brazil, Indonesia, South Korea, Malaysia, Mexico, New Zealand, Philippines, and Thailand) over time period 1995:I to 2009:III. The frequency of the data is quarterly. I exclude the identified unwinding periods during the Asian Financial Crisis from 1997:III to 1998:IV, as well as during the 2008 Financial Crisis from 2008:II to 2008:IV from the sample because the focus of this paper is on the buildup of carry trade rather than the unwinding. The countries are chosen based on the yen carry trade volume in those countries as well as data availability.

Carry Trade Volumes: The data for the yen carry trade volume as measured by total foreign claims of Japanese banks in the nine countries is from the Bank of International Settlements. The data is available on a semianannual basis before the year 2000 and on a quarterly basis afterwards. I impute the data for the second and fourth quarters for years before 2000 by taking an average of the volume of the two adjacent quarters. Looking at the most recent data in the third quarter of 2009, the yen carry trade volume varies from around 3.38 billion US dollars in the Philippines to 78.329 billion US dollars in Australia.

This BIS data is presented in Figure 2 along with the exchange rate for the yen. While the amounts of claims of Japanese banks vary from country to country, they seem to follow the same general pattern. They peaked in 1996 and began to fall around mid-1997 during the Asian Financial Crisis. The volume started to build up again in 2002 and continued for a long period before it suddenly dropped in the third quarter of 2008.
Figure 2: Foreign Claims of Japanese Banks by Country

Interest Rates: The interest rates for all countries are the money market rates, quoted in decimal points. The data comes from the International Financial Statistics provided by the IMF. Ideally, the data would be the yield of short term government bonds. However, this data does not exist for all the countries so I use money market rates instead. The correlation between bond yields (if data is available) and money market rates is 0.9764. This high correlation, along with the scatter plot of the rates presented in Figure 3, shows that the variables have almost a linear relationship and therefore money market rates could be used as a proxy for bond yields.

Figure 4 depicts the interest rates in the 9 countries over time. The interest rate in Brazil and Mexico were extremely high in the mid-1990s (89.48% for Brazil in 1995:I) but continually declined over time. Indonesia, South Korea, the Philippines, and Thailand maintained relatively high interest rates of around 14% in the mid-1990s in order to attract foreign investments (Bello, 1998). When the crisis hit in 1997, the IMF’s structural adjustment
Figure 3: Scatter Plot of Government Bond Yields versus Money Market Rates

Source: IMF, International Financial Statistics
Note: The slope of the estimated OLS is 0.9243, implying that a 1% increase in money market rate leads to a 0.9243% increase in government bond yield. There is clearly a linear relationship between the two rates. The $R^2$ statistics shows that more than 95% of variations in the bond yields can be explained by the money market rates.

package called for the countries to raise interest rates in order to attract foreign investments. South Korea, the Philippines, and Thailand raised their rates to over 20%. Indonesia’s interest rate peaked at 74.83% in 1998:III. Nonetheless, with an increase in risk aversions among investors, the carry trade volume went down in all the countries during this period. The interest rates in Australia and New Zealand remained roughly at 7% during this period. Figure 5 provides a clearer view for interest rates in Australia, South Korea, Malaysia, New Zealand, Philippines, and Thailand.

After the Asian Financial Crisis, Brazil’s interest rate remained the highest among the 9 countries. The interest rates in other countries fluctuated around 5–10% with the rates in South Korea, Malaysia, and Thailand being the lowest at below 5%. The interest rates for all countries dropped in 2008:III when the most recent financial crisis hit.
**Figure 4:** Interest Rates by Country

![Interest Rates by Country](image)

Source: IMF, International Financial Statistics

**Figure 5:** Interest Rates by Country, excluding Brazil, Indonesia, and Mexico

![Interest Rates by Country, excluding Brazil, Indonesia, and Mexico](image)

Source: IMF, International Financial Statistics
Exchange Rates: Historical exchange rates are closing prices from Bloomberg and are quoted as yen per unit target currency (so an increase in the exchange rate is an appreciation in the target currency against the yen). The change in the exchange rate is the percentage change from the last period, also quoted in decimal points.

**Figure 6:** Normalized Exchange Rates against the Japanese Yen by Country

Figure 6 shows the movements of exchange rates for the 9 countries against the Japanese yen. The rates are normalized so that the rate in 1995:I is 1. Exchange rates in Asian countries exhibit similar movements. High interest rates in the Asian countries attract foreign investors and the capital inflow drove up the exchange rates. The rates appreciated against the yen from 1995 through the onset of the Asian Financial Crisis, after which the rates dropped sharply. This was the unwinding period. At its lowest in 1998:II, the Indonesian rupiah stumbled down to 24% of its rate in 1995. After the crisis, the rates climbed up slowly partly due to carry trade activities. The Australian dollar and the New
Zealand dollar appreciated at a high rate during this period and peaked in 2007:II at around 170% of the rates in 1995.

The slow climb of the exchange rates throughout the 2000s came to a sudden stop with the latest Global Financial Crisis. The exchange rates for all countries depreciated sharply against the yen and this was the second large unwinding. The exchange rates in Australia, New Zealand, Brazil, and Mexico fell more than 40% within a period of 2 quarters. After the crisis, exchange rates in the 9 countries began to appreciate from 2008:IV onwards, suggesting that carry trade has begun building up once again.

**Credit Ratings:** As for the country’s credit rating, I construct historical data of Standard & Poor’s sovereign short-term credit ratings from Bloomberg’s news feed. There are two separate short-term ratings: one for liabilities denoted in local currency and the other for liabilities denoted in foreign currency. The ratings go from D, C, B, A-3, A-2, A-1, and to A-1++; with D meaning the country is in default and A-1+ meaning the country has “highest credibility in meeting its financial obligations.” To be able to use these letter ratings, I adapt a widely-used method of converting S&P long-term ratings into numerical values (used in Cantor and Packer (1996), among others) and assign numerical values as follows: D = 0, C = 1, and so on through A-1+ = 6. I then take an average of local- and foreign-currency short-term ratings to get country’s credit rating in each period.

Australia’s and New Zealand’s ratings stay at the highest rate of A-1+ during the entire sample period. Ratings for Asian countries follow a similar pattern of a sharp drop during the Asian Financial Crisis then moved back up slowly. The Philippines is the exception where the credit rating was downgraded during 2003–2005 and remained at B until now. The ratings for Brazil and Mexico were not affected by the Asian Financial Crisis but exhibited slow climbs similar to other Asian countries.

**Trade Volumes:** Data for trade volume comes from IMF’s Direction of Trade Statistics (DOTS) which provides quarterly data for a country’s exports and imports. The trade
volume between Japan and country \( i \) in a period is the sum of total import value from Japan to country \( i \) and total import value from country \( i \) to Japan in that period quoted in million of US dollars.

Among the countries in the sample, South Korea has the highest trade volume with Japan in all the periods while Brazil, Mexico, and New Zealand are the three countries with lowest trade volumes. This is consistent with the gravity model of trade which states that total trade volume between two countries is directly proportional to the countries’ sizes (as measured by GDP) and is inversely proportional to the distance between the two countries. For all the countries, trade volumes generally increases over time. There are 3 noticeable drops in the volume across all countries: (1) in 1997–1998 during the Asian Financial Crisis, (2) in 2001–2002 during the Japanese recession, and (3) in 2008 during the latest crisis.

These drops in trade volume coincide with the carry trade volume as measured by foreign claims by Japanese banks. This suggests the possibility that the proxy for carry trade volume might be capturing part of other economic activities between Japan and other countries such as direct investments. Therefore, introducing the trade volume as a control variable and consider only part of foreign claims that are not explained by trade would make estimations more accurate.

6 Results

The estimation results for the main specification in Equation 4.2 along with alternative specifications for robustness test are shown in Table 1. The main specification is presented in Column I. The F-test for the null hypothesis that the intercept terms for all countries are all equal yields an F-statistic of 81.74 with a p-value of essentially zero. This supports my use of fixed effect model.

The estimated coefficient on interest rate differential \( \beta_1 \) is 1.739. This means that a 1 percentage point increase in the interest differential between a particular country and Japan
would lead to a 1.739% increase in carry trade volume in that country. To see the scale of this, if the Reserve Bank of Australia increases the target interest rate by 1 percentage point, Australia would see an additional capital inflow of 1.362 billion US dollar—the size of Maldives’s GDP. The standard error of 0.273 is small compared to the estimated value and the p-value is essentially zero. As a result, it is certain that interest rate differential has a positive effect on carry trade volume. This confirms the hypothesis that there is a positive and statistically significant relationship between carry trade volume and interest rate differential.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interpretation</th>
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<th>II</th>
<th>III</th>
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<td>INT</td>
<td>Interest differential</td>
<td>1.739***</td>
<td>1.035***</td>
<td>1.880***</td>
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<td></td>
<td></td>
<td>(0.273)</td>
<td>(0.282)</td>
<td>(0.275)</td>
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<td>FX</td>
<td>FX movement</td>
<td>0.217</td>
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<td></td>
<td></td>
<td>(0.207)</td>
<td>(0.224)</td>
<td>(0.215)</td>
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<tr>
<td>R</td>
<td>Credit rating</td>
<td>0.121***</td>
<td>0.232***</td>
<td>0.124***</td>
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<tr>
<td></td>
<td></td>
<td>(0.034)</td>
<td>(0.035)</td>
<td>(0.034)</td>
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<tr>
<td>logT</td>
<td>Log trade</td>
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<td></td>
<td>0.705***</td>
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<td></td>
<td></td>
<td>(0.074)</td>
<td></td>
<td>(0.077)</td>
</tr>
<tr>
<td>VIX</td>
<td>US stock volatility index</td>
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<td>(0.002)</td>
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<tr>
<td>Adjusted $R^2$</td>
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<td>0.856</td>
<td>0.832</td>
<td>0.859</td>
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</table>

Note: Estimated coefficients on country dummy variables are not reported. The results for the main regression specified in Equation 4.2 is presented in Column I. *** and ** signify statistical significance at the 99% and 95% confidence levels respectively. Testing for robustness, all alternative specifications yield positive and statistically significant coefficients for interest differentials, credit ratings, and trade volume. The coefficient of exchange rate movements is also positive but not statistically significant. Overall, the model explains roughly 86% of the variations in carry trade volume.

The estimated coefficient on the change in exchange rate $\beta_2$ is 0.217. This means that a 1% appreciation in the target currency would cause the carry trade volume to increase by 0.217%. Taking the high standard error of 0.207 into account, the estimated coefficient of exchange rate movement is not entirely precise and there is a probability of 0.296 that the true value for this coefficient is zero. The positivity of the estimated coefficient agrees with
previous literature. Although a similar study by Galati and Melvin (2004) found the effect of exchange rate movements on carry trade volume to be statistically significant, it is important to note that the countries included in the sample in Galati and Melvin (2004) are Australia, Canada, Eurozone, UK, Japan, and Switzerland. These large, advanced economies have some major differences from the countries in my sample. Because six out of nine countries in this study are developing countries who rely on exports, they tend to engage in foreign exchange intervention to smooth the movement of their currencies in order to remain competitive in export markets. This means that the movements of exchange rates in these countries are somewhat controlled, and the effect of exchange rate movements on the buildup of carry trade could be obscured.

The estimated coefficients for both credit rating and trade volume are positive and high relative to their respective standard errors. This supports the hypothesis that a country’s credit rating correlates positively with carry trade volume (and thus the country’s risk correlates negatively with the volume). A step upgrade of credit rating would lead to a 12.1% increase in carry trade volume, which is quite a large effect. The estimate is quite precise with p-value close to zero.

Lastly, trade volume, introduced as a control variable, also has a strong positive effect on the volume of carry trade.

**Robustness Test:** Columns II and III present alternative specifications for robustness test. The signs and statistical significances of all the covariates–interest differential, exchange rate movement, and credit rating–are the same in all specifications. This implies that the results are very robust. In Column II where trade volume is dropped, the effect of interest rate differential decreases, implying that there is an inverse correlation between interest differential and trade volume.

Figure 7 shows a scatter plot of log trade volume versus interest differentials. The correlation between $INT$ and log $T$ is $-0.436$. While it is ambiguous whether there is a systematic
negative correlation throughout the observations, it is evident that there are a few outliers, especially the observations of Mexico during the mid-1990s when the interest rates were extremely high and the trade volume between Mexico and Japan was still small.

Turning to Column III, I follow Nishigaki (2007) and include variables related to stock indices to account for financial conditions at the time. VIX is a measure of the implied volatility of the S&P 500 and is used extensively in literature to measure investor sentiment and global volatility (Cairns, Ho, and McCauley, 2007). My hypothesis is that the coefficient of VIX should be negative as investors should draw back funds when the market is volatile. Interestingly, the estimated coefficient is positive and statistically significant. The effect, however, is very small; a 1-point change in VIX would lead to a 0.6% change in carry trade volume. Perhaps this suggests that VIX is not a very good measure of global investor sentiment, but only measures the volatility in the US. Hence, a more volatile US market might make the yen carry trade look more attractive to investors.
7 Further Analysis

It is important to note that one of the main assumptions in the pooled estimation results is that carry trade volume in all the countries in the sample respond to changes in the right hand side variables in the same way. That is, the model assumes the same coefficients \( \beta \)'s for all countries. This might not be a realistic assumption and hence in this section I will relax the assumption by allowing differences in coefficients across groups of countries. I separate the nine countries into two groups according to the IMF: advanced economies (Australia, South Korea, and New Zealand) and emerging and developing economies (Brazil, Indonesia, Malaysia, Mexico, Philippines, and Thailand) (International Monetary Fund, 2009b).

One possible way to extend the analysis is to perform estimation on each subset of data with the following equations:

\[
\log CT_{it} = \sum_{i=1}^{9} \alpha_i D_i + \beta_{1,A} INT_{it-1} + \beta_{2,A} FX_{it-1} + \beta_{3,A} R_{it-1} + \beta_{4,A} \log T_{it-1} + \varepsilon_{t,A} \quad (7.1)
\]

\[
\log CT_{it} = \sum_{i=1}^{9} \alpha_i D_i + \beta_{1,E} INT_{it-1} + \beta_{2,E} FX_{it-1} + \beta_{3,E} R_{it-1} + \beta_{4,E} \log T_{it-1} + \varepsilon_{t,E} \quad (7.2)
\]

where the subscripts \( A \) and \( E \) of the coefficients are for advanced and emerging economies respectively. Note that this model assumes that the variances of the error terms are the same for observations in each group:

\[
\text{var}(\varepsilon_{t,A}) = \sigma_A^2 \quad \text{and} \quad \text{var}(\varepsilon_{t,E}) = \sigma_E^2. \quad (7.3)
\]

To be able to compare the effects of the explanatory variables on carry trade volume between advanced and emerging economies, it is of interest to combine equations (7.1) and
(7.2) together using a dummy variable. The new model becomes

$$
\log CT_{i,t} = \sum \alpha_i D_i + \beta_{1,E} INT_{i,t-1} + \beta_{2,E} FX_{i,t-1} + \beta_{3,E} R_{i,t-1} + \beta_{4,E} \log T_{i,t-1} \\
+ \delta_1 (A_i \times INT_{i,t-1}) + \delta_2 (A_i \times FX_{i,t-1}) + \delta_3 (A_i \times R_{i,t-1}) \\
+ \delta_4 (A_i \times \log T_{i,t-1}) + \varepsilon_{i,t},
$$

(7.4)

where $A_i$ is a dummy variable whose value is 1 if country $i$ is an advanced economy and value 0 otherwise. Indeed, the estimated coefficients from both estimations will be identical (although the standard errors will be different). That is, $\beta_{1,A}$ in equation (7.1) which measures the extent to which carry trade volume changes with the change in interest rate in advanced economies will be equal to $\beta_{1,E} + \delta_1$, and so forth. The model in (7.4), however, allows a direct statistical test for differences between advanced and emerging economies.

Apart from the difference in interpretation, the model in (7.4) also assumes a stronger assumption about the variance of the error term that

$$
\text{var}(\varepsilon_{i,t}) = \sigma_A^2 = \sigma_E^2 = \sigma^2.
$$

(7.5)

This assumption needs to be tested in order for this model to make any sense. The F-test for the null hypothesis that $\sigma_A^2 = \sigma_E^2$ yields a p-value of 0.177, so the assumption of the model in (7.4) cannot be rejected.

The estimation results for model in (7.4) are shown in Table 2. The estimated coefficient on interest differentials in emerging economies is 1.394. This suggests that with a 1% increase in the interest differential, emerging economies will experience a 1.394% growth in carry trade volume. This number is not much different from the pooled estimation result because the pooled result is, to some extent, a weighted average of the separate results. The standard error is quite low compared to the estimate and the p-value for the null hypothesis that the true value of the coefficient is zero is close to zero.

Focusing on the coefficient of the interaction variable $A \times INT$, the estimated coefficient
Table 2: Separated Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT</td>
<td>1.394***</td>
<td>(0.280)</td>
<td>0.000</td>
</tr>
<tr>
<td>FX</td>
<td>0.187</td>
<td>(0.240)</td>
<td>0.438</td>
</tr>
<tr>
<td>R</td>
<td>0.143***</td>
<td>(0.040)</td>
<td>0.000</td>
</tr>
<tr>
<td>log T</td>
<td>0.391***</td>
<td>(0.097)</td>
<td>0.000</td>
</tr>
<tr>
<td>A × INT</td>
<td>3.378*</td>
<td>(1.733)</td>
<td>0.052</td>
</tr>
<tr>
<td>A × FX</td>
<td>0.172</td>
<td>(0.453)</td>
<td>0.705</td>
</tr>
<tr>
<td>A × R</td>
<td>-0.064</td>
<td>(0.086)</td>
<td>0.460</td>
</tr>
<tr>
<td>A × log T</td>
<td>0.602***</td>
<td>(0.148)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

N 432

R² 0.867

Note: Estimated coefficients on country dummy variables are not reported. *** and * signify significances at the 99% and 90% confidence levels respectively. The results suggest that the effect of interest rate differential on carry trade volume is much stronger among developed countries. Country’s credit rating, on the other hand, might be more important in determining carry trade volume in developing countries. Overall, the model accounts for 86.7% of the variations in carry trade volume.

is 3.378. This means that a 1% increase in the interest differential will lead to a 3.378% increase in carry trade volume in advanced economies in addition to the baseline increase of 1.394% in emerging economies. Therefore, advanced economies will see a total of 1.394% + 3.378% = 4.772% increase. This is more than three times the effect in emerging economies.

The standard error for this interaction variable is 1.733 and the p-value is 0.052, which is borderline significant at the 95% level. All these results lead to the conclusion that carry trade volume in advanced economies are more sensitive to changes in interest rate differentials than the volume in emerging economies. There are many possible reasons for this apparent difference; one of them is that the higher interest rate in developing countries might merely reflect the higher risk of investing in those countries and the changes in interest rate in developing countries might not necessarily be in line with other economic fundamentals.

The estimated coefficient for the changes in exchange rates is still positive and does not vary much from the pooled estimation result. Neither the coefficient for the variable FX nor the coefficient of the interaction term A × FX are statistically significant. Considering only the estimates, the effect of exchange rate movements is more pronounced in advanced
economies. This finding is consistent with the explanation mentioned earlier that developing countries intervene in the foreign exchange markets more heavily than advanced economies.

As for the country’s credit rating, the estimated coefficient of the term $R$ is 0.143 with a relatively low standard error of 0.040. This suggests that a step change in an emerging economy’s credit rating will lead to a 14.3% change in carry trade volume. The coefficient of the interaction term $A \times R$ is -0.064. This means that the effect of a step change in credit rating in an advanced economy will lead to only a 7.9% change in carry trade volume—almost half of the effect in emerging economies. This suggests that a country’s credit rating is an important factor that investors look into when they choose target currencies among developing countries, but the credit rating does not seem to play such an important role in determining carry trade volume in developed countries.

The standard error of the coefficient for the interaction term $A \times R$ is very large compared to the estimated value that the estimated value is not statistically different from zero. A possible reason for this is that in my sample both Australia and New Zealand have A-1+ rating throughout the periods and Korea’s rating varies in a small range from A-2 to A-1+ with a brief period of an A-3 rating.\footnote{South Korea was once downgraded to B and C ratings during the Asian Financial Crisis but these periods were excluded from my estimation.} This might not give enough variation in the sample to give more precise estimates. Credit ratings for developing countries, on the other hand, cover a wide range from D to A-1+. This gives enough variation in the sample that the estimate turns out to be quite precise.

8 Conclusion

The objective of this paper is to investigate the relationship between the yen carry trade volume and other economic and financial variables. I achieve this by employing the multiple regression model using panel data for 9 target countries over a period of roughly 15 years. This paper provides empirical evidence of a positive and statistically significant relationship
between carry trade volume and interest rate differentials. The effect of changes in interest rate differential appears to be larger in developed countries than in developing countries. Exchange rate movement, surprisingly, has very small effect on carry trade volume. This finding contradicts some of the previous findings but is likely due to the difference in countries included in the sample. Lastly, I find that a country’s credit rating correlates positively with carry trade volume and this relationship is much stronger in emerging economies.

These findings all suggest that developed countries are more prone to carry trade speculations than developing countries. While this might seem natural because risks of investing in developed countries are generally lower due to larger trade volume and deeper, better developed market structures in the countries, the results also imply that the risks of carry trade unwinding is greater in developed countries. Furthermore, as these developed countries tend to have stronger economic linkages with the rest of the world, carry trade unwinding in these countries could easily translate into another global financial crisis.

There are several areas for improvement in this study. Using international bank flows to measure carry trade volume has a number of limitations. These flows capture investments that are not carry trade and leave out carry trade performed through other means such as financial derivatives. Therefore, finding a better proxy for carry trade volume will greatly improve the accuracy of the results. BIS data is measured on a quarterly basis and using higher frequency data would reveal more information about the determinants of carry trade volume. Lastly, including more countries in the sample would also be beneficial as this would introduce more variation in some of the variables possessing large standard errors, resulting in a more precise estimation.

\[^5\]Brunnermeier et al. (2008) provide empirical and theoretical support that speculators’ positions increase exchange rate crash risk due to carry trade.
References


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A Unwinding Periods in 1997–98 and 2008

In this paper I discussed in detail the mechanisms and various factors that affect the buildup of the yen carry trade in several target countries. To ensure that the estimated coefficients represent the relationship between variables in the buildup periods, I exclude the two unwinding periods in 1997:III to 1998:IV and 2008:II to 2008:IV to separate the effects of explanatory factors during the buildup period and the effects during the unwinding period which could be drastically different. This exclusion is due to this paper’s limited scope on carry trade buildup and in no way intend to suggest that unwinding is unimportant. Unwinding is indeed one of the most fascinating aspects of carry trade and in this section I account for these two episodes of unwinding to illustrate what might cause the unwinding and, consequently, how vulnerable carry trade is to financial and economic shocks.

A.1 The 1997–98 Unwinding Episode

In early 1990s, Asia attracted much attention from investors around the world with its prosperous economic outlook. During the years 1990–95, China, Malaysia, Singapore, South Korea, and Thailand who boasted average annual GDP growths of more than 8% were among the fastest growing economies of the world. High yields in these countries draw capital in from foreign investors looking for high returns. It was approximated that during the period, Asia attracted almost half of the total capital inflow to developing countries. The economic boom was well recognized in both the Eastern and Western hemispheres. The World Bank and the International Monetary Fund, in their annual meeting in 1993, described these so-called Asian tigers as “fine examples for the rest of the world” (Dale, 1993). Scholars tried to make out what made these countries so successful in terms of economic growth and attempted to reproduce the “miracles” in other regions including Latin America, Africa, and Eastern Europe.

This promising atmosphere prompted investors to jump along on the bandwagon. Most of
them engaged in short term investment for their share of quick profits. Investors borrowed from abroad where interest rates were lower and invested in these high yield countries. Carry trade. At the time, most Asian currencies were pegged to the US dollars which helped accelerate this speculative trend since the investors were not exposed to exchange rate risks.

In what McKinnon and Pill (1996) call an “overborrowing syndrome”, the Asian countries experienced steady growth of foreign debt and rise of asset prices to an unsustainable level. At one point, the bubble burst. Asset prices plummeted, making it hard for debtors to meet their financial obligations and eventually investors started defaulting. Highly leveraged loans amplified this effect and caused a widespread panic. In response, financial institutions reacted quickly by cutting back credits to the Asian countries. The sudden decrease in credit availability, often called a “credit crunch”, led to further defaults and bankruptcies.

The effect of the ongoing financial crisis was detrimental to Asian currencies. Unnerved by unpredictable economic outlook in the region, investors tried to unwind their positions and invest in a more stable place such as the US or Europe. As a result, the foreign exchange market was flooded with unwanted Asian currencies. To keep the capital from fleeing out of the country, the central banks followed the IMF’s advice to raise interest rates to a very
high level. The Philippines, South Korea, and Thailand raised the interest rates to more
than 20% while Indonesia’s peak rate in 1998:III was 74.18%.

Additionally, in order to keep the local currencies pegged to the US dollar (or to keep the
exchange rate stable in the case of managed float), central banks in the affected countries
had to buy their excess domestic currency and gradually run down the country’s foreign
reserves. Table 3 shows the percentage change in foreign reserves between December 1996
and December 1997. Most of this loss was due to the central banks’ attempt to defend the
continually depreciating currencies. In a period of one year, Laos, the Philippines, South
Korea, and Thailand lost roughly a third of their foreign reserves.

<table>
<thead>
<tr>
<th>Country</th>
<th>ΔFXR (%)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>−30.61</td>
<td>July 2, 1997</td>
</tr>
<tr>
<td>Indonesia</td>
<td>−9.12</td>
<td>August 14, 1997</td>
</tr>
<tr>
<td>South Korea</td>
<td>−38.65</td>
<td>December 24, 1997</td>
</tr>
<tr>
<td>Philippines</td>
<td>−27.45</td>
<td>March 15, 1998</td>
</tr>
</tbody>
</table>

*Source: IMF, International Financial Statistics*

*Note: The table shows changes in foreign exchange reserves for each country between December 1996 and December 1997. The date on the rightmost column is the date when each country’s monetary authority announced a change in its exchange rate regime. These dates are compiled by Wong (2000). The local currencies all depreciate after this date in all four countries.*

These measures taken by the monetary officials, however, did not stop the panicked
investors from withdrawing funds out of the countries. Particularly, higher interest rates
have very small effects on capital inflow especially in emerging economies when risks are
high as previously noted in Section 7. Because the foreign reserves were finite and high
interests were damaging the economies in recession, the governments could not sustain such
measures for long. Thailand was the first to float the exchange rate on June 2, 1997, and other
countries quickly followed suit (see Table 3). With central banks still trying to intervene to
smooth the transition, the Asian currencies gradually depreciated, making the foreign debt
denoted in foreign currencies grew in terms of local currencies.
The cause of the 1997–98 unwinding episode can be attributed to the change in perceived risks in the target countries. When the bubble burst in the first half of 1997, creditors had to tighten the credits available, which led to a series of further defaults and economic downturn. As more funds were withdrawn from the region, the risk that the central banks would eventually break the exchange rate peg increased. Chang and Velasco (1998) compare this to a classic bank run case in which investors rush to exchange funds in local currencies to more stable ones such as the Japanese yen or the US dollar.

A.2 The 2008 Unwinding Episode

The most recent unwinding episode in 2008 brought attention back to carry trade and underscored the massive volume of speculative trading in the foreign exchange markets. In 2006, outstanding foreign exchange contracts which account for only a part of carry trade were reported to be more than $40 trillion (Gagnon and Chaboud, 2007), only $6 trillion short from the size of the world’s total GDP in 2006.

As the financial world became rapidly interconnected, it also became more fragile. The unwinding in 2008 is similar to the one in 1997–98 in that both were caused by a sudden credit crunch during financial crises. However, while the credit crunch of the 1997–98 began in countries used as target countries for carry trade, the credit crunch in 2008 started off in a country that was not directly involved with the yen carry trade—the United States.

In response to an impending recession due to the September 11 terrorist attacks and the dot-com bubble burst in March 2000, the Federal Reserves steadily cut the federal funds rate to a very low level. The federal funds rate climbed down from 6.50% in 2000:III to 1% in 2003:IV. Interest rates were also relatively low in other parts of the world around the time. Low interest rates discouraged savings and encouraged investing. In his remarks in March 2005, Bernanke posited that the US dollar’s status as the main reserve currency and sophisticated financial markets in the country made the United States the destination for global investments. Funds pour into the country even after the dot-com bubble burst. The
United States’ current account deficit grew from 4.16% of GDP in 2000 to 5.59% of GDP in 2005. Credits became easily available and subprime lending more than doubled from around 8% to 19% of all mortgages in a one-year period between 2003 and 2004.

**Figure 9:** US Federal Funds Rate

![Federal Funds Rate Graph](image)

*Source: IMF, International Financial Statistics*

Taking advantage of easy credits and the housing boom, Americans took loans they could barely afford and hoped that the house prices would continue to go up. Most subprime borrowers obtained adjustable-rate mortgages which allowed them to borrow at a low rate for a specified period of time before adjusting to the market rate.

The economic boom in the early 2000’s prompted the Federal Reserves to raise the interest rate from 2004 to 2006. Higher interest rates made it harder for borrowers with adjustable-rate mortgages to pay back loans, and some started to default. This caused a widespread panic in the housing market and house prices that were at an unusually high level during the bubble plummeted. With numerous foreclosures, subprime lenders faced significant losses and many of them had to declare bankruptcy. Investors tried to recover their funds back from various investment institutions and withdrew a total of $144.5 billion from mutual funds in the week of September 15, 2008 whereas withdrawal of the previous week amounted to only $7.1 billion (Gullapalli and Anand, 2008).

As credit availability suddenly decreased in the United States, the US dollar also ap-
preciated sharply. This sharp appreciation suggests that there must be a significant flow of foreign currencies into the United States at roughly the same time as the credit crunch. One explanation for this is the existence of the dollar carry trade due to low interest rates in the United States in early 2000s (McKinnon, Lee, and Wang, 2009). Investors who engaged in carry trade by borrowing cheap funds from the United States and investing them overseas had to unwind their positions. This, in turn, decreased demand for target currencies, caused the target currencies to depreciate, and decreased the profits from carry trade funded by any currency, including the Japanese yen.

**Figure 10:** Comparison of Yen’s REER and Dollar’s REER

![Comparison of REER](image)

*Source: Bank of International Settlements*

Figure 10 clearly illustrates the effect that the unwinding of the dollar carry trade had on the yen carry trade. The figure compares the real effective exchange rate (REER) of the Japanese yen to that of the US dollar. The US dollar’s REER began appreciating in August 2008, while the Japanese yen’s REER was still depreciating and it was not until the next period in September 2008 that the yen carry trade began to unwind and the yen began to
appreciate.\textsuperscript{6}

The cause of the 2008 unwinding episode of the yen carry trade was the credit crunch that originated in the United States. This credit crunch caused dollar carry trade unwinding and depreciation in target currencies, which ultimately caused the yen carry trade unwinding. Interestingly, the US dollar’s REER appreciated from trough to peak only 13\% while the Japanese yen’s REER appreciated 31\% over the same period.

Carry trade, as demonstrated, is highly vulnerable to shocks of all kinds. In light of the most recent financial crisis, many advanced economies lowered their interest rates down to help stimulate the economy. This, according to some economists, has started to build up a new wave of carry trade across many possible country pairs. This makes carry trade even more fragile and vulnerable to shocks. Like a small match that could burn down a forest, a small shock in the farthest part of the economic linkage could cause the whole carry trade buildup to crumble.

Indeed, as the financial world becomes more integrated, it becomes imperative that investors and economists become aware of the financial and economic conditions in all the parts of the world. It is even more important that policy makers recognize that their decisions affect not only the local region, but the world as a whole.

\textsuperscript{6}Daily data would better illustrate this causal effect but such data is not readily available.