Risk Appetite, Carry Trade and Exchange Rates

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Using exchange rate data from four different countries (time zones), we examine the relationship between the Yen exchange rate against major currencies (i.e. USD/JPY, EUR/JPY, GBP/JPY, AUD/JPY and NZD/JPY) and measures of risk appetite (i.e. the S&P500 index, Dow Jones Industrial Average index and the VIX index). Our results show the equity indexes, especially the Dow Jones Industrial Average, play a more important role in the determination of the Yen cross rates than VIX. The popular carry-trade currencies, i.e. NZD/JPY, AUD/JPY and GBP/JPY, are more affected by the US equity market than USD/JPY and EUR/JPY. While the long-term relationships are consistent across the four different time zones, the short-term dynamics are different. We find that the response of NZD/JPY, AUD/JPY and GBP/JPY to changes in the US stock market is much greater in the New Zealand and Australian zones than in the UK or US. Although the short-term relationship between exchange rates and the equity index is quite strong, the error correction speed is very sluggish. We also find evidence of asymmetric adjustment in the response of exchange rates to changes in global risk aversion. Carry trade currencies tend to appreciate gradually when conditions are favorable but fall sharply when market risk increases.

JEL classification: F31, G15

Key Words: Risk Appetite, Carry Trade, Exchange Rate, VIX, NZD, JPY

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1. Introduction

Over the past decade or so, one of the most popular investment and trading strategies in the currency market has been the so-called Yen-carry trade. In a typical Yen-carry trade, investors and traders borrow the Japanese Yen and sell it for high-yield currencies such as New Zealand Dollar (NZD), Australian Dollar (AUD) and Pound Sterling (GBP) in the spot FX market and then invest the proceeds in fixed income securities such as bonds, bills and bank deposits. Essentially, the yen-carry trade is equivalent to a foreign exchange (FX) forward or futures position. The maturity of the currency forward/futures contract depends on the maturity of the borrowing and lending positions. Similarly, a speculative trader who longs a NZD/JPY, AUD/JPY or GBP/JPY forward or futures contract can be regarded as engaging in Yen-carry trade. The former type is known as the canonical carry trade and the latter is known as the derivatives carry trade (see Gagnon and Chaboud 2007).

The Japanese Yen has been the most popular funding currency because Japan had the lowest interest rates in the world for over a decade. It is only until recently that the US federal funds rate has been slightly below the interest rate in Japan. NZD, AUD and GBP are the ultimate investment currencies due to their historical high yields (see Figure 1).

[INSERT FIGURE 1 ABOUT HERE]

The Yen-carry trade is not only popular among institutional traders and investors such as banks, hedge funds and pension funds, etc, but also for retail currency traders. The emergency of various internet-based margin trading platforms, e.g., igmarkets.com and fxsolutions.com, Forex.com among others, have reduced the dominance of EBS and Reuters 3000 dealing systems in currency trading and allowed retail traders to trade on narrow bid/ask spread and high leverage terms once only enjoyed by banks and other professional traders.

An essential feature of the carry trade is the use of leverage. Although many fund managers and households in Japan also invest in foreign securities for the higher yield or portfolio diversification purposes, these positions are usually not considered as carry positions as they use little or no leverage. On the other hand, carry traders tend to use high leverage (see Gagnon and Chaboud 2007, and Hattori and Shin 2009). Leverage is a double-sided sword as it can magnify losses as well as gains. With high leverage, carry traders' margin or collateral is very low. When the exchange rates move adversely, traders are faced with margin calls. If they do not top up the margins, they will be forced to close their trading position and realize the paper losses. Hence, the leveraged nature of carry trades creates positive feedback and volatility in the currency market.

During 2008 and early part of 2009, the height of financial crisis, the Yen-carry trades were unwound, the Japanese Yen appreciated against other currencies whereas the NZD and AUD crashed. However, since March 2009, the carry traders are back into the market again as the global economy recovers slowly and risk appetite increases.

Burnside et al. (2008) show that the average excess return of an equally-weighted carry trade strategy, based on up to 20 currencies and executed monthly over the period 1976 – 2007, was about 5% per year. Although the excess return was less than the average excess return of the equity market over the same period, the Sharpe ratio of the strategy was more than double that of the S&P500 during this period as the annualized volatility of the carry trade returns was much less than that for stocks. Gyntelberg and Remolona (2007) provide further evidence that carry take has been superior to equity investment.

The popularity and success of carry trade is in violation of the uncovered interest parity (UIP) hypothesis. According to UIP, the currency with higher interest rate is expected to depreciate against the one with lower interest rate. In reality, the opposite tends to happen. The currency with higher interest rate tends to appreciate against the one with lower interest rate. The violation of UIP is known as the forward premium puzzle, one of the major puzzles in international finance (see Froot and Thaler 1990 and Engel 1996).

Carry trade can have a huge impact on both the level and the volatility of the currencies involved. Commentators have argued that the virtually zero interest rate policy pursued by the Bank of Japan, the central bank of Japan, has fueled the carry trade and driven high interest rate currencies such as NZD and AUD often into overvalued territory.

The sharp growth in the Yen-carry trade and the appreciation of NZD and AUD can result in loss of export competitiveness for New Zealand and Australia. For example, as Japanese investors were taking advantage of widening interest rate differentials between Japan and New Zealand in 2004-2005 and again in 2007, Dr Alan Bollard, the Governor of the Reserve Bank of New Zealand, repeatedly warned the FX market participants that the NZD was significantly overvalued, but with no or little effect on speculator positions. There was a similar reaction at the few instances the Reserve Bank of New Zealand intervened in the currency market, failing to slow down the sharp appreciation of the New Zealand dollar. On the other hand, when the carry trade was unwound, as for example in late 2008, the NZD and AUD depreciated rapidly against the Japanese Yen and the US dollar.

The determination of the foreign exchange rate is a very complex issue. In the literature, various types of models have been put forward to explain the key drivers of exchange rates, e.g., purchasing power parity (PPP), uncovered interest Rate parity (UIP), the sticky price monetary model (Dornbusch 1976 and Frankel 1979), the productivity-based model (Stockman 1980, and Lucas 1982), etc. However, none of the models can satisfactorily explain the level and volatility of the FX rates witnessed in the market. Some models may do well for certain time horizons and currencies, but not for others (see Meese and Rogoff 1983, Cheung, Chinn and Pascual 2005).

Emphasizing the importance of investor risk appetite, Fama (1984), Hodrick (1989) and Dumas and Solnik (1995) adopt an asset pricing approach to the analysis of exchange rates. Following from this Brunnermeier et al. (2009) examine the association of funding liquidity risk and the crash risk of carry trade. They show that carry trade tends to incur losses when global risk increases and that the impact of increases in interbank (TED) spreads on carry trade is similar to that of increases in implied stock market volatility (VIX) but with less statistical power. They find that controlling for investor risk helps in some ways to resolve the forward premium puzzle in empirical tests of the UIP hypothesis.

We pursue this line of research further in this paper. In particular, we examine the relationship between the exchange rates of JPY against some popular currencies (i.e. USD/JPY, EUR/JPY, GBP/JPY, AUD/JPY and NZD/JPY) and measures of risk appetite (i.e. the S&P500 index, the Dow Jones Industrial Average (DJIA) index and the VIX index) using data from four different time zones - New Zealand, Australia, UK and US. Our results show that the equity index, especially the DJIA index, plays a more important role in the determination of the Yen cross rates than the VIX. The popular carry-trade currencies, i.e. NZD/JPY, AUD/JPY and GBP/JPY are more affected by the US stock market than USD/JPY and EUR/JPY. Although the long-term relationships between the exchange rates and the equity index are very consistent across the four time zones, the short-term dynamics are different. We find the short term response of NZD/JPY, AUD/JPY and GBP/JPY exchange rates to changes in the US stock market is much greater in New Zealand and Australia than in the UK or US. While the short-term relationship is fairly strong, the error correction speed is very sluggish. There is also an asymmetric response of exchange rates to changes in the market index. Carry trade currencies tend to appreciate gradually when conditions are favorable but fall sharply when market risk increases.

Our study is timely and relevant. In response to the worst financial crisis to hit the globe in decades, the US federal funds rate has been cut to between 0 and 0.25 percent per annum, bringing it lower than that in Japan. As a result, the US dollar has started to be used more widely as the funding currency in carry trade (IMF 2009, Page 4). The depreciation and increased volatility of the dollar can have significant implications for trade, investment and the world economy since the US dollar is the most important reserve currency of the world and is widely used for settlements in international trade and finance. Abrupt fluctuations in the US dollar can exert global destabilizing effects, ranging from shocks to international competitiveness - for example, Europe/UK and a number of small open economies including New Zealand look quite vulnerable at the moment as a result of the recent sharp depreciation of the US dollar - to the smooth functioning of the financial system.

The remainder of the paper is organized as follows: Section 2 provides some background on the AUD and NZD currencies and the AUD/JPY and NZD/JPY cross rate trading. Section 3 outlines our methodology. Section 4 discusses the data and empirical results. Section 5 concludes the paper.

2. The Yen-carry trade

The currency market is an ideal marketplace for speculative trading. It operates continuously 24 hours a day except the weekends. The liquidity is high and bid ask spreads can be as low as 2 pips. Leverage as high as 100 times is available for both professional traders and retail traders. According to statistics compiled by the Bank for International Settlements (BIS), the average daily turnover in April 2007 was USD 3.2

trillion, consisting of USD 1 trillion spot transactions, 0.4 trillion outright forwards and 1.7 trillion foreign exchange swaps.

The Japanese Yen has consistently been the third most heavily traded currency in the world over the past decade after USD and EUR. In 2001, it accounted for 22.7% of global reported FX market turnover. In 2004, it accounted for 20.2% and in 2007 it accounted for 16.5% (see BIS 2007, Page 17).

Although it is difficult to measure precisely the amount of Yen-carry trade positions, there are indications that the growth in Yen-carry trade was rapid over the past decade or so. For example, according to BIS data, net outward lending denominated in Japanese Yen increased from US$19 billion in 2004 to US$87 billion in 2005. McGuire and Tarashey (2006) argue that the data provide some evidence of yen carry trade positions.

Figure 2 shows the yen-denominated external assets of Japanese banks over the period January 2003 – December 2009. Figure 2 shows that by May 2008, these amounted to over US$311 billion before decreasing to about US$142 by December 2009.

[INSERT FIGURE 2 ABOUT HERE]

In the OTC currency derivatives market, the BIS (2007) report shows that the daily average OTC USD/JPY derivatives turnover was US$298 billion in April 2007, compared to US$169 billion in 2001. The majority of these transactions are outright forwards and FX swaps, currency options and swaps account for US$38 billion and US$3 billion respectively in April 2007. For EUR/JPY, the daily average OTC derivatives turnover was US$42 billion in April 2007 versus US$18 billion in April 2001. The average daily OTC derivatives turnover of Japanese Yen against other currencies increased from US$3 billion to US$27 billion.

Galati and Melvin (2004) argue that the rapid increase in FX turnover was probably a result of a rise in Yen-carry trade activities. The increase was especially robust for AUD and NZD.

Despite the small size of their economies, AUD and NZD are among the most actively traded currencies traded in the world. In terms of currency distribution of the reported FX market turnover by BIS (2007), the AUD accounted for 6.7% of the average daily turnover in April 2007, ranking the 6th after USD, Euro, Japanese Yen, Pound Sterling and Swiss Franc. NZD accounted for 1.9% and ranked 11th in the world even though New Zealand has a population of about 4.3 million and a GDP of about USD 110 billion as at December 2009.

In terms of instruments, spot trading accounted for 25.7% of currency trading involving AUD, the outright forwards accounted for 10% and the foreign exchange swap accounted for 64.3% as of April 2007. At the same time, New Zealand dollar spot, outright forwards and FX swaps accounted for 29.4%, 11.3% and 59.3% of the average daily turnover, respectively.

Demand for AUD and NZD tends to drive up the value of the currencies and the unwinding of the carry trades tends to cause the currencies to crash. Dramatic movements in exchange rates occur sometimes without fundamental news announcements (see Sachs et al. 1996, Fair 2002, Brunnermeier et al. 2009). In the currency market, this phenomenon is known as 'going up by the stairs and coming down by the elevator'. Over the past few years, both AUD and NZD have experienced significant volatility. For example, NZD plunged from 0.82 USD in early 2008 to 0.49 USD in March 2009 before recovering to 0.76 USD in October 2009 (see Figure 3).

[INSERT FIGURE 3 ABOUT HERE]

The sharp swing of the currency can have significant adverse impacts on growth and economic stability. In the case of New Zealand, this has led to calls for the reform of the monetary policy operating procedures as well as demands for a stable and competitive exchange rate. Similar to Australian policy, the Reserve Bank of New Zealand operates under an explicit inflation targeting regime. To keep inflation rate within the pre-agreed band, the official cash rate (i.e., an overnight interest rate) is set by the central bank.

Increases in interest rates in turn attract the inflow of foreign capital, putting upward pressure on the currency and worsening the current account deficit. Over the past 20 years or so, New Zealand has run high and increasing current account deficits (see Figure 4). Unlike other countries, the inflow of foreign capital has not been put into productive use. Instead, most of the capital inflows found their way into the housing market, driving up property values. Consumers have borrowed excessively against the value of property to spend using mortgage top-up schemes provided by the banks whereby credit-card debt can be converted into mortgages which have much lower cost of borrowing than unsecured personal loans.

[INSERT FIGURE 4 ABOUT HERE]

Today, New Zealand is one of the most heavily indebted OECD countries. Unlike the PIGS (Portugal, Italy, Greece and Spain) where the debt burden is due to the public sector, the debt situation in New Zealand is due to borrowing by the household sector for investment in property. Savings by the household sector have been declining steadily. According to Statistics New Zealand, households in New Zealand on average do not save anything out of current income but, instead, household debt was 154% of disposable income as at the end of March 2009. As of March 2009, the private sector's net foreign debt was NZ$183 billion, or 101.7% of New Zealand's GDP.[1] Residential mortgage debt accounts for 92% of the total household debt. As a result of the shortage of local savings, banks in New Zealand have been increasingly borrowing short-term wholesale funds

[1] As at March 2009, the banking sector accounts for about 75% of the net external debt in the private sector and the corporate sector accounts for about 25%. The official sector has a net external lending position of about NZ$6 billion, bringing the country's net external debt to NZ$176.6 billion, including of NZ$138.2 billion in international assets and NZ$314.8 billion in international liabilities. Hence, the gross external debt is 175% of NZ's GDP, one of the highest in the world. In comparison, Australia's gross foreign debt as at 30 June 2008 was 94.8% of its GDP and net foreign debt, about A$ was about 600 billion or 53% of GBP.

from overseas markets to meet the strong demand for mortgages. About 50% of the overseas borrowings have an original maturity of less than one year.

Rating agencies such as Standard & Poor's and Moody's Investors Service have recently put New Zealand on credit downgrade watch. To address the vulnerability of the banking system to global liquidity shocks and funding crises, the Reserve Bank of New Zealand recently imposed a new liquidity ratio rule for lenders. Under the new rule, effective in April 2010, banks and finance companies are required to maintain a core funding ratio of 75%, i.e., the ratio of retail deposit base and longer-term wholesale funding to total assets. According to the governor of the central bank, the new rule will restrict the access of banks to cheap wholesale funding, damp credit growth and reducing the need to increasing official interest rate to cool the economy.

The systemic financial risks associated with carry trade are exemplified by the recent experience of Iceland. To control the rate of inflation, the central bank of Iceland raised the interest rate from a low of 2.8% in February 2003 to15% by April 2008, attracting large speculative capital inflows. The rising value of property and the appreciation of the local currency encouraged households and firms to increase borrowing. Household debt increased from 177.1% of disposable income in 2000 to 221.1% of disposable income in 2007. Gross external debt increased from 180% of GDP in 2004 to 552% of GDP in 2007 and net foreign debt rose from 90% of GDP in 2000 to 243% in 2007 (see Danielsson and Zoega 2009).

3. Methodology

In this study, we employ an error correction model to examine the relationship between measures of global risk proxied by US equity market indicators and bilateral yen exchange rates. The equity market indices are the S&P 500 index, the DJIA index and the implied volatility VIX index. As the three indicator variables are highly correlated, especially the two equity indices, we opt for a simple bivariate estimation approach.

Firstly, the long-run relationship between the cross exchange rates and the indices is as follows:

$$\ln y_t = \alpha_0 + \alpha_1 \ln x_t + \varepsilon_t \qquad (1)$$

where y_t is the exchange rate; x_t represents the S&P500 index, the DJIA index or the VIX index; ε_t is the disturbance term; α_1 measures the long-term relationship. If α_1 is equal to one, the long-run adjustment is complete. Equation (1) is valid only in the long run.

Secondly, to examine the short-run relationship between exchange rate and the market index returns, we use the standard two-step Engle-Granger error-correction methodology. The error-correction representation is as follows:

$$\Delta \ln y_t = \beta_1 \Delta \ln x_t + \beta_2 (\ln y_{t-1} - \alpha_0 - \alpha_1 \ln x_{t-1}) + \nu_t \qquad (2)$$

where Δ is first difference operator; $\hat{\varepsilon}_{t-1} = (\ln y_{t-1} - \alpha_0 - \alpha_1 \ln x_{t-1})$ is the residual of the long run relationship given by Equation (1) and it represents the extent of disequilibrium at time $(t-1)$; and ν_t is the error term. β_1 captures the short-term response of the exchange rate to changes returns on the stock market index (i.e., within a one-day period); and β_2 measures the error correction adjustment speed when the exchange rates are away from their long-term equilibrium level in relation to the equity index.

We also consider the possibility for an asymmetric adjustment in the response of exchange rates; we do this by testing if there is a significant difference in the exchange rate adjustment dependent on whether the latest equity prices rose or fell but also whether exchange rates are above or below their long-term equilibrium relationship with the market index. The asymmetric short-run dynamic equations can then be expressed as follows:

$$\Delta \ln y_t = \delta_1^+ \Delta \ln x_t^+ + \delta_1^- \Delta \ln x_t^- + \delta_2 \lambda \hat{\varepsilon}_{t-1} + \delta_3 (1-\lambda) \hat{\varepsilon}_{t-1} + \eta_t \qquad (3)$$

where Δ denotes the first difference; $\hat{\varepsilon}_{t-1}$, the residual of the long run relationship given by Equation (1) captures the extent of disequilibrium at time $(t-1)$; and ν_t is the error term. The coefficients δ_1^+ and δ_1^- measure the differential response of exchange rates to rises or falls in the equity market index. δ_2 measures the error correction adjustment speed when the FX rates are above their equilibrium levels in relation to the equity market index and δ_3 measures the error correction adjustment speed when the FX rates are below their equilibrium levels in relation to the equity market index. Both signs of δ_2 and δ_3 are expected to be negative. λ is a binary indicator variable. It is equal to one if the residual error ($\hat{\varepsilon}_{t-1} = \ln y_{t-1} - \alpha_0 - \alpha_1 \ln x_{t-1}$) is positive and 0 otherwise.[2]

4. Data and Analysis of Results

4.1 The Data

This study examines four samples from four countries, namely, New Zealand, Australia, United Kingdom and the United States. Each sample contains five pairs of currencies against the Japanese Yen, i.e., NZD/JPY, AUD/JPY, USD/JPY, GBP/JPY and EUR/JPY. The equity market variables are S&P500 index, the Dow Jones Industrial index and the VIX index.

For the New Zealand sample, the daily time-series data of the exchange rates against NZD were downloaded from Reserve Bank of New Zealand website. The exchange rates were market mid-rates at 11:10am New Zealand time on each trading day. Based on these exchange rates, we compute the cross rates for USD/JPY, EUR/JPY, GBP/JPY and AUD/JPY for each trading day. The sampling period is from January 3, 2003 to December 30, 2009, covering a time span of six years. The sample size is 1,716 trading days. The bank does not provide the exchange rate against Swiss Franc (CHF); hence, CHF/JPY is not included in our sample.

Figure 5 shows the chart of the time-series data of AUD/JPY, NZD/JPY and the DJIA index and Figure 6 shows the chart of the time-series data of AUD/JPY, NZD/JPY and

[2] To detect the presence of asymmetric adjustment, we use the standard Wald test to determine if δ_1^+ is

the S&P 500 index. Figure 7 shows the chart of the time-series data of AUD/JPY, NZD/JPY and the VIX volatility index.

[INSERT FIGURES 5-7ABOUT HERE]

For the Australian sample, the daily exchange rate series were downloaded from the website of the Reserve Bank of Australia. The data are mid-points of buying and selling rates quoted around 4pm Sydney time on each trading day. Using the daily exchange of AUD against other currencies, we compute the daily exchange rate of USD/JPY, EUR/JPY, GBP/JPY, and NZD/JPY. The sampling period is the same as that for New Zealand sample and the sample size is 1,711 trading days.

For the UK sample, the daily time-series data of the GBP exchange rates against USD, JPY, EUR, AUD and NZD were downloaded from the website of the Bank of England. All the rates are the 4pm London close rates. Based on those rates, we compute the USD/JPY, EUR/JPY, AUD/JPY and NZD/JPY for the London time zone. The sampling period is from January 2, 2003 to December 31, 2009, and the sample size is 1,722 trading days.

For the US sample, the daily time-series data of the exchange rates were downloaded from the website of the Federal Reserve Bank of St Louis. The exchange rates are noon purchasing rates in New York for cable transfers payable in foreign currencies. According to the Federal Reserve Board, the exchange rates are certified by the Federal Reserve Bank of New York for customs purposes. They are also those required by the Securities and Exchange Commission (SEC) for the integrated disclosure system for foreign private issuers. "The information is based on data collected by the Federal Reserve Bank of New York from a sample of market participants". The sampling period is also January 2, 2003 to December 31, 2009, and the sample size is 1,751 trading days.

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different than δ_1^- and if δ_2 is significantly different from δ_3.

The daily S&P 500 index and the DJIA index data over the period January 2, 2003 to December 31, 2009 was downloaded from Datastream whereas the daily VIX close data over the same time period were downloaded from the CBOE website. The VIX is a measure of market expectation of future short-term volatility implied by the S&P 500 stock index option prices. It is widely regarded as the premier benchmark for the US stock market volatility and a leading barometer of investment sentiment in the world.

The sampling period of the FX rates in the New Zealand and Australian samples are lagged by one trading day due to the time difference between the two countries and the UK and USA.

Table 1 provides the descriptive statistics for the sample data. The table shows that the descriptive statistics are almost identical across the four samples for the various variables. The range for NZD/JPY, AUD/JPY and GBP/JPY is much larger than that for USD/JPY and EUR/JPY. For example, the NZD/JPY ranged from 44.9 yen to 97.6 yen over the six-year period. For AUD/JPY, the range is between 56.0 yen and 107.5 yen, whereas for USD/JPY the range is from 86.3 yen to 123.9 yen.

[INSERT TABLE 1 ABOUT HERE]

The pair-wise correlation coefficients among the variables are shown in Table 2. Since all four samples show very similar correlation coefficients, we only report those from the NZ and UK samples. As expected, VIX is negatively correlated with all other variables. VIX is known as the fear index in the market. Its correlation coefficients with the other variables range from 31.7% (for EUR/JPY) to 63.7% (NZD/JPY). Both the DJIA and S&P500 indexes are highly correlated with the exchange rates, except for USD/JPY. The correlation coefficients between USD/JPY and the stock indices are around 40%. For the other exchange rates, the correlations with the indices range from 82% to 92.5%. As for the correlations among the exchange rates themselves, the exchange rates are highly correlated with each other, except for the USD/JPY.

[INSERT TABLE 2 ABOUT HERE]

4.2 The Long-Term Relationship

To examine the long-term relationship between the exchange rates and the equity market variables, we estimated Equation (1) and the results are reported in Table 3.[3] To save space, the intercept estimates are not reported in the Table.

[INSERT TABLE 3 ABOUT HERE]

Table 3 shows that the four samples produced almost the same results. The exchange rates seem to be more affected by the equity index than the VIX index. The DJIA index, in particular, has a closer long-term relationship than the other two measures of investor risk sentiment for all five exchange rates.

Among the five pairs of exchange rates, the NZD/JPY is affected strongest by the DJIA index with a coefficient close to 74%. GBP/JPY was second with a coefficient of 72.5%, followed by AUD/JPY with a coefficient of 70.8%. These three pairs of exchange rates were among the most popular investment currencies for carry traders. The long-term slope coefficient estimate for EUR/JPY is 50.2% and that for USD/JPY is 18.8%.

The slope coefficients in the regressions between the S&P 500 index and the five pairs of exchange rates were slightly lower than those between DJIA and the exchange rates. Once again, NZD/JPY has the highest coefficient at 67%. GBP/JPY came second at 66.5%. The estimates for AUD/JPY, EUR/JPY and USD/JPY are 62.3%, 43.5% and 19%, respectively.

[3] Prior to the estimation of the long-run model we have established that all series are I(1) processes and we have also tested for the presence of cointegrating relationships (see Table 3) between the market indicators and FX rates.

The VIX index has a negative long-term relationship with the five exchange rates. The sign is as expected as the VIX is widely known as the fear index in the market. An increase in the value of VIX indicates an increase in global risk aversion that is typically associated with a reduction in speculator carry positions (see Brunnermeier et al. 2009). However, we find that the strength of the relationship between VIX and exchange rates is not that strong. GBP/JPY appears to be the most affected by VIX with a coefficient estimate of -21.1% whilst EUR/JPY is the least affected with a coefficient of just 3.4%. For NZD/JPY, AUD/JPY and USD/JPY, the VIX coefficient estimates are -21.2%, -15.6% and -10.3%, respectively.

Our long-term relationship results based on four different samples show that the popular investment currencies of the carry trades, i.e. NZD/JPY, GBP/JPY and AUD/JPY, are significantly affected by the movements on Wall Street in the long run.

While VIX has a negative impact on the exchange rates, the association is not as strong as for the equity index. The effects of VIX can be interpreted in two ways: changes in the risk appetite of investors and the volatility of stocks. According to the former interpretation, a higher VIX volatility leads to traders unwind their carry trade positions as they lose their risk appetite. However, if changes in VIX are due to those in the actual volatility of the underlying stocks, the link between carry trade and VIX is less clear (see Burnside 2008). In fact, in most cases there is no statistical support for the presence of cointegrating relationships between exchange rates and the VIX index (see Table 3).

4.3 The Short-Term Relationship

The short-run dynamics are given by an error-correction model (ECM). The results of the symmetric ECM (Equation 2) are reported in Table 4. Since NZD/JPY, AUD/JPY and GBP/JPY are the most popular carry trade exchange rates, we only report the results for these three pairs in this sub-section. Further, since the DJIA index is found to be most closely associated with movements in exchange rates (see Table 3), we only show how the above three exchange rates respond to changes in the DJIA index in the short run.

The estimates of the error correction term coefficients, β_2, are negative and statistically significant. Thus exchange rates will adjust upwards when they are below the long-term equilibrium level in relation to the equity index and adjust downwards when the rates are above their long-term equilibrium level in relation to the equity index. However, the estimated values of these coefficients are small suggesting that the error correction adjustment is sluggish. Small estimates of error correction coefficients have typically been associated with the use of high frequency data. In addition, it is well established that exchange rates can over-shoot as they adjust towards long-term values.

As expected, the coefficient of the short-term relationship between the exchange rate and the DJIA index, β_1, is positive and statistically significant. Interestingly, the four samples show somewhat different results in terms of the short-term response of exchange rates to changes in the market index. For the New Zealand and Australian samples, the coefficients are much stronger than those for the UK and USA samples. For example, for the New Zealand and Australian samples, the short-term coefficients of the index for NZD/JPY are 56.9% and 43.5% respectively; in comparison the respective estimates are 28.1% and 32.9% for the UK and the USA samples. The same pattern is observed for AUD/JPY, the coefficients are 60.1%, 48%, 28% and 33.9% for the New Zealand, Australian, UK and USA samples, respectively. For GBP, the estimates are 32.3%, 25.9%, 19.5% and 21.7% for the New Zealand, Australia, UK and USA samples, respectively.

The above results show that on a short-term basis, the exchange rates are more affected by the movements on Wall Street in New Zealand and Australia than in the UK and the USA. A possible explanation for this finding may be due to the presence of larger numbers of noise traders in New Zealand and Australia. London and New York are among the biggest currency trading centers in the world whereas in New Zealand and Australia the FX trading to a large extent responds to what happened to the stock market in the US the previous night. According to the statistics published by the BIS (2007), in 2007, London and New York accounted for 34.1% and 16.6% of global reported FX market turnover, respectively. For New Zealand and Australia, the respective figures were 0.3% and 4.3%.

[INSERT TABLE 4 ABOUT HERE]

4.4 Asymmetric Adjustment Speed

The estimates of the asymmetric ECM (Equation 3) are reported in Table 5. We report two sets of results. In Panel A we only allow for asymmetry in the equilibrium adjustment whereas in Panel B we consider both short-run and equilibrium adjustment asymmetries in the response of exchange rates. Comparing the coefficients of error correction asymmetry, δ_2 and δ_3, we find that adjustment speeds are faster when exchange rates are below rather than above the equilibrium relationship. However the more interesting findings relate to the short-run estimates, δ_1^+ and δ_1^-. Consistent with previous evidence on carry trade behavior (e.g. see Brunnermeier et al. 2009), we find exchange rates fall faster when market prices are falling (or global risk is increasing) while they tend to appreciate gradually as market sentiment improves.

5. Conclusion

In this study, we have examined how the Yen exchange rates, i.e. USD/JPY, EUR/JPY, GBP/JPY, AUD/JPY and NZD/JPY are affected by the movement on Wall Street both in the long term and in the short term. We used data taken in four different time zones (New Zealand, Australia, UK and USA/New York) within a single trading day over a six year period.

Our results show that in the long term changes in the equity indexes have more influence on the exchange rates than the implied volatility VIX index. The long-term relationships are consistent across the four time zones and the popular carry-trade currencies. Among the exchange rates examined, popular carry trade currencies such as the NZD, AUD and GBP are more affected by the equity market than USD and EUR. The short-term dynamics, however, differ across time zones. In the short term, the exchange rates are more affected by the US equity market in New Zealand and Australia than in the UK and US. However, the error correction speed is very sluggish. We also find evidence of asymmetric adjustment in the response of exchange rates to changes in global risk aversion. Carry trade currencies tend to appreciate gradually when conditions are favorable but fall sharply when market risk increases.

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Figure 1: Official Interest Rates of Major Currencies

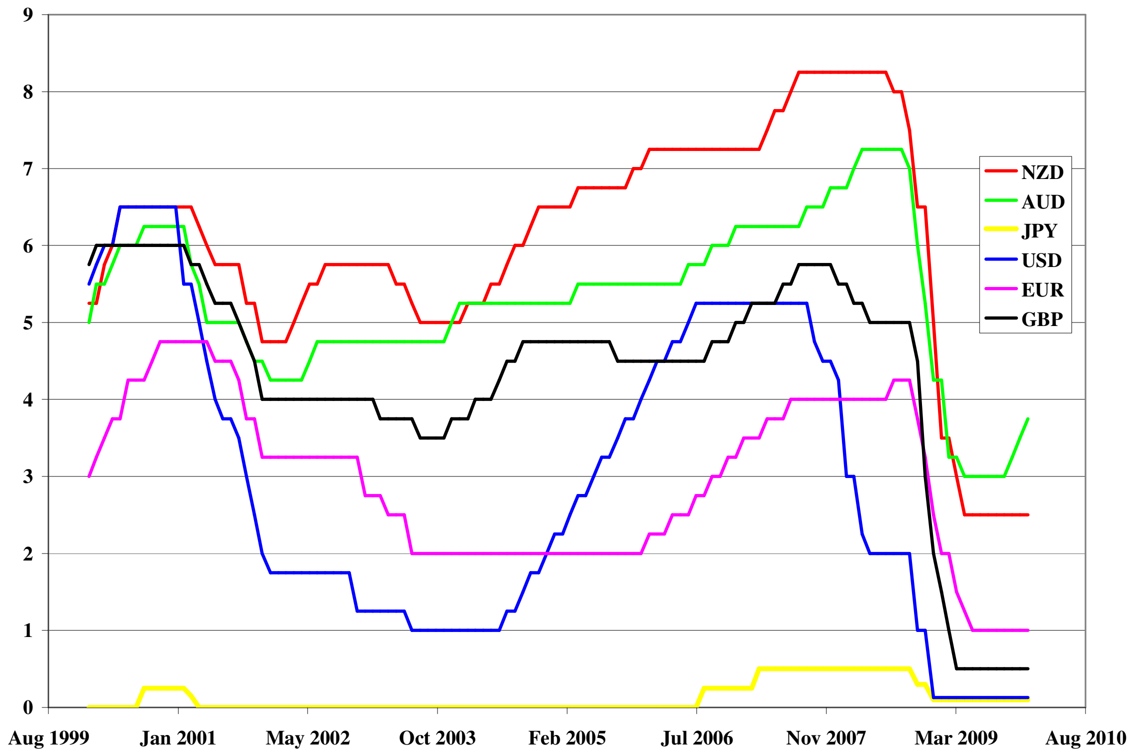
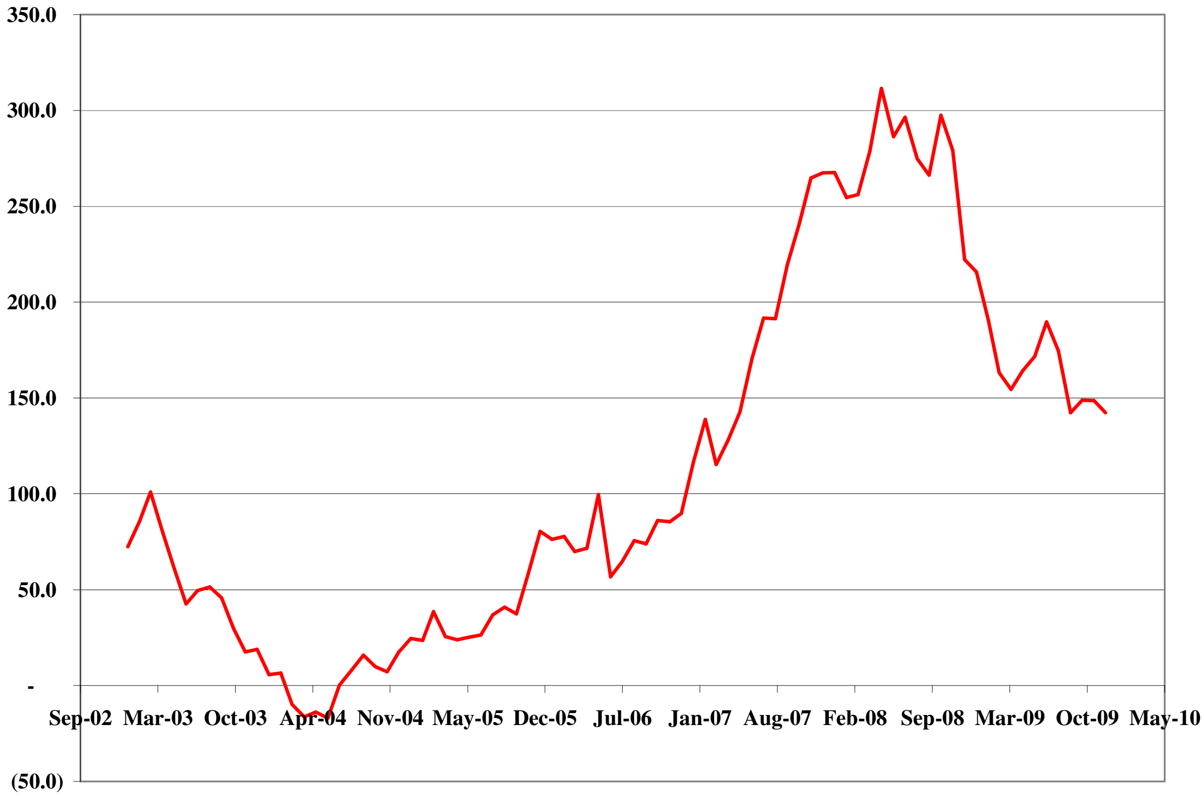


Figure 2: Yen-denominated net external assets of Japanese banks (in US$ Billions)



Source: Bank of Japan.

Figure 3: AUD/JPY and NZD/JPY exchange rates

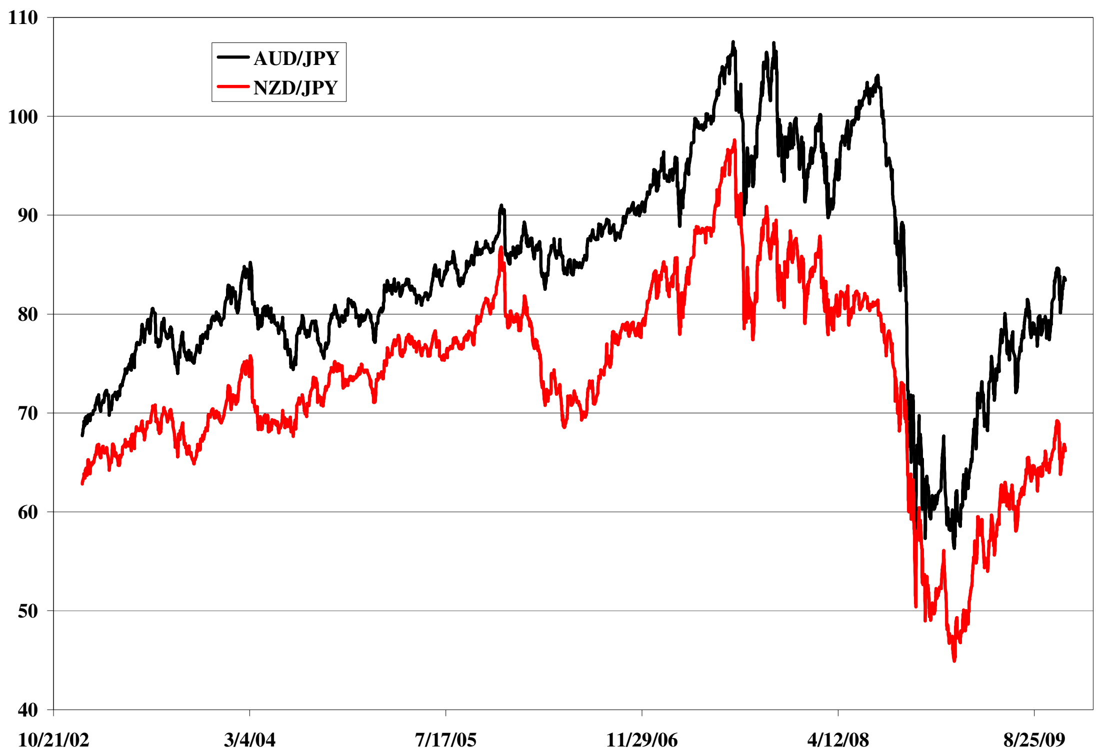


Figure 4: NZ current account balance as a percentage of GDP (as at year end)

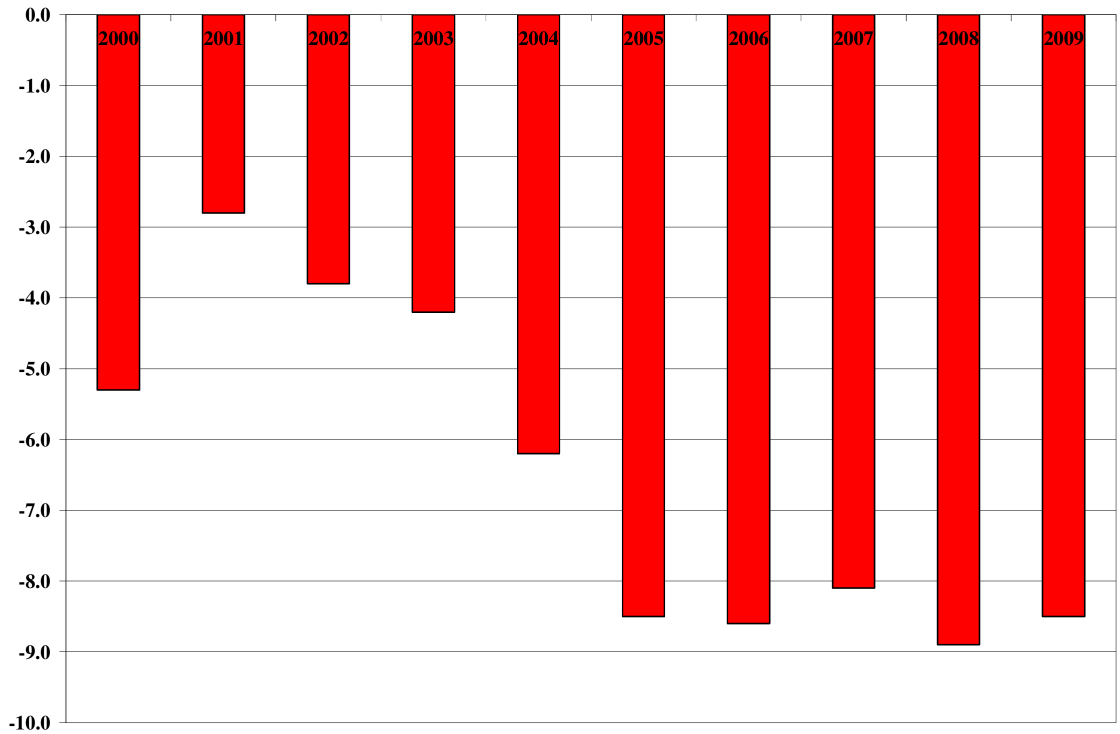


Figure 5: NZD/JPY, AUD/JPY vs the DJIA index

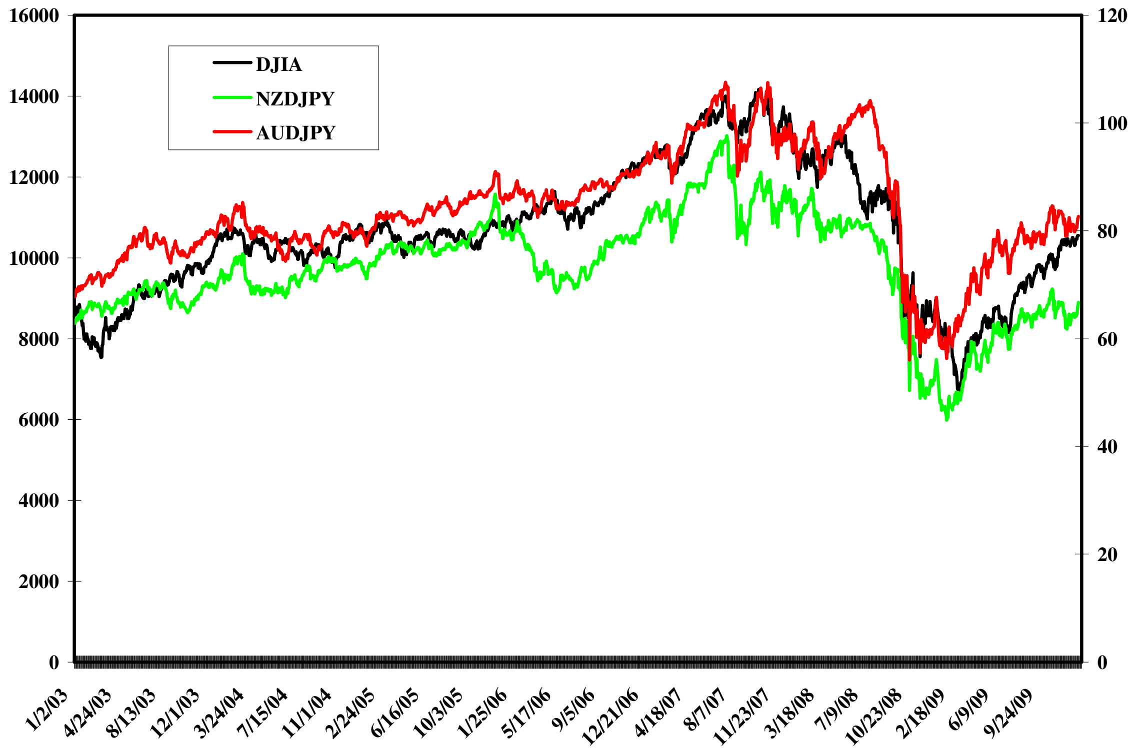


Figure 6: NZD/JPY, AUD/JPY vs the S&P 500 index

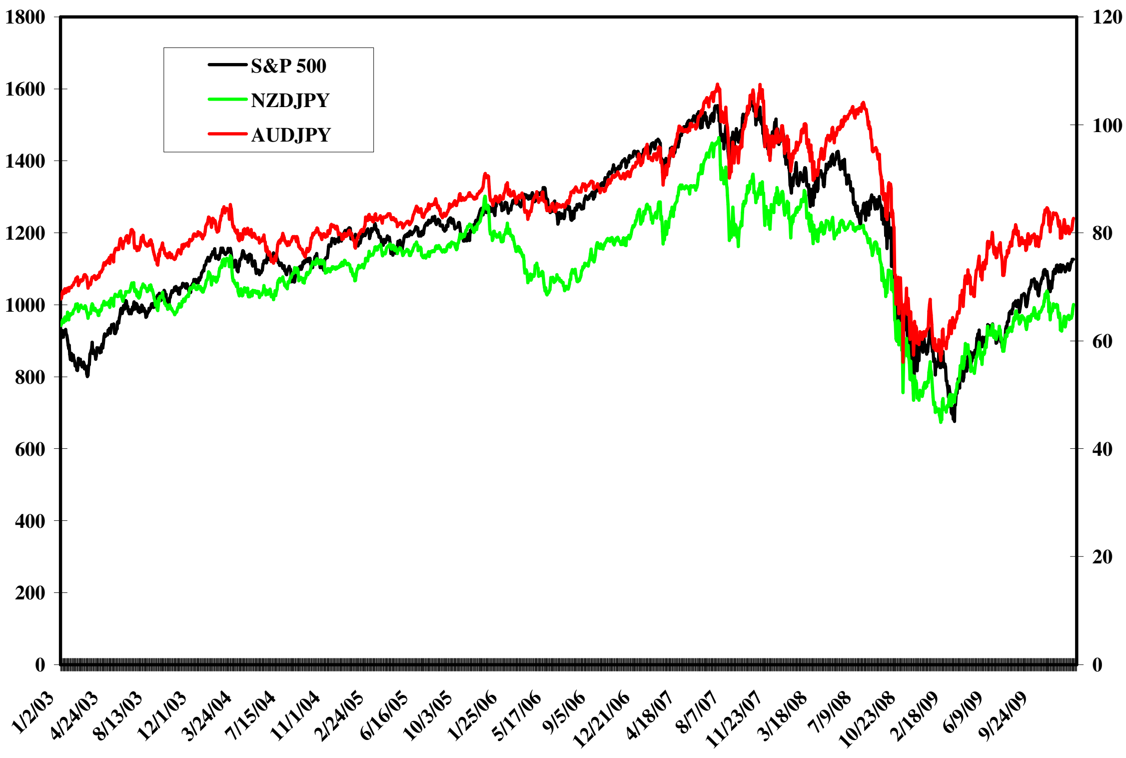


Figure 7: NZD/JPY, AUD/JPY vs the VIX index

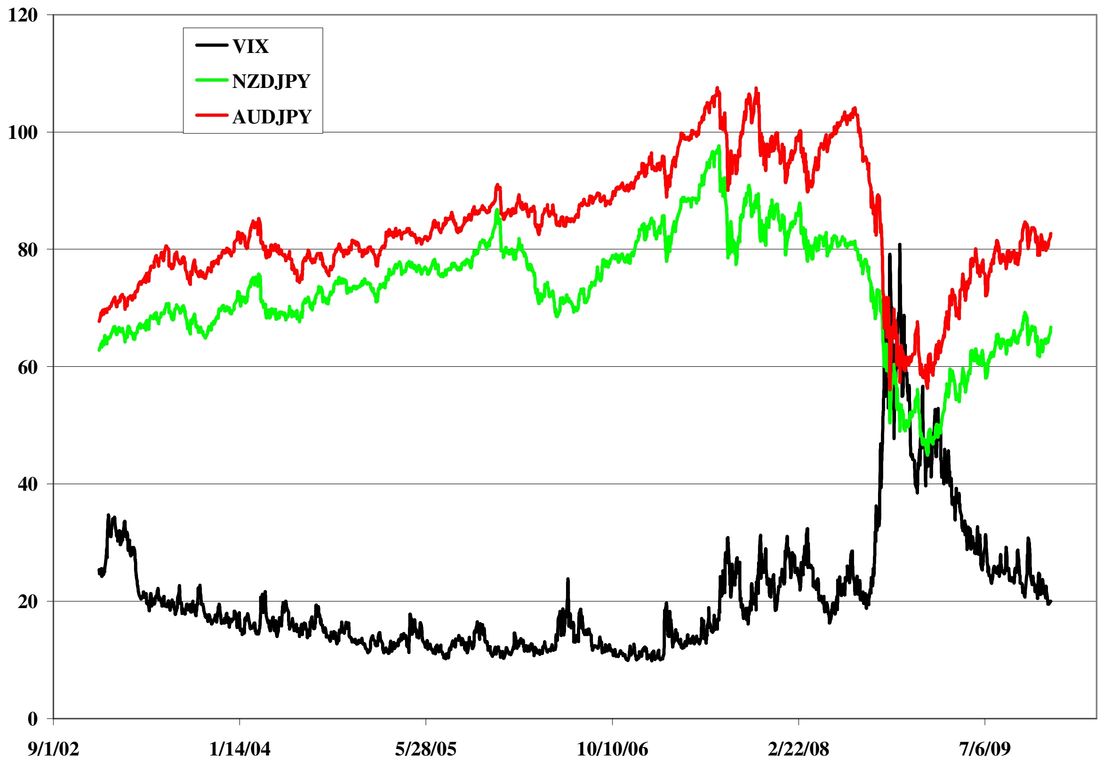


Table 1: Descriptive statistics

	S&P500	DJIA	VIX	NZD/JPY	AUD/JPY	USD/JPY	GBP/JPY	EUR/JPY
New Zealand Sample								
Mean	1,179.64	10,654.00	20.71	73.21	84.01	109.33	196.65	141.82
Median	1,190.21	10,539.97	17.47	73.58	82.92	109.95	199.78	137.09
Maximum	1,565.15	14,164.53	80.86	97.62	107.53	123.86	250.30	169.50
Minimum	676.53	6,547.05	9.89	44.89	56.01	86.25	121.61	114.52
Std. Dev.	197.55	1,595.53	10.98	9.70	10.45	8.93	27.62	13.04
Skewness	(0.13)	0.08	2.18	(0.38)	(0.00)	(0.67)	(0.64)	0.54
Kurtosis	2.24	2.46	8.72	3.23	2.80	2.59	3.03	2.20
Observations	1716	1716	1716	1716	1716	1716	1716	1716
Australian Sample								
Mean	1,179.64	10,654.00	20.71	73.18	83.99	109.30	196.60	141.79
Median	1,190.21	10,539.97	17.47	73.62	82.91	110.06	199.68	137.03
Maximum	1,565.15	14,164.53	80.86	97.44	107.62	123.89	250.45	169.62
Minimum	676.53	6,547.05	9.89	45.09	56.64	86.34	121.90	114.03
Std. Dev.	197.55	1,595.53	10.98	9.70	10.47	8.94	27.64	13.05
Skewness	(0.13)	0.08	2.18	(0.38)	(0.01)	(0.67)	(0.64)	0.53
Kurtosis	2.24	2.46	8.72	3.24	2.82	2.59	3.03	2.20
Observations	1711	1711	1711	1711	1711	1711	1711	1711
UK Sample								
	SP	DJI	VIX	NZD	AUD	USD	GBP	EUR
Mean	1,179.45	10,652.36	20.75	73.22	84.02	109.35	196.64	141.80
Median	1,190.16	10,539.85	17.54	73.63	82.97	110.02	199.69	137.09
Maximum	1,565.15	14,164.53	80.86	97.64	107.36	124.09	250.11	169.47
Minimum	676.53	6,547.05	9.89	45.13	56.65	86.15	120.36	112.81
Std. Dev.	197.77	1,597.12	11.02	9.72	10.48	8.93	27.65	13.07
Skewness	(0.13)	0.08	2.18	(0.38)	(0.01)	(0.67)	(0.64)	0.53
Kurtosis	2.24	2.46	8.68	3.23	2.81	2.59	3.03	2.21
Observations	1,722	1,722	1,722	1,722	1,722	1,722	1,722	1,722
USA Sample								
	SP	DJI	VIX	NZD	AUD	USD	GBP	EUR
Mean	1,180.11	10,657.65	20.66	73.25	84.04	109.34	196.75	141.85
Median	1,190.33	10,543.22	17.44	73.70	82.97	110.05	199.65	137.18
Maximum	1,565.15	14,164.53	80.86	97.53	107.36	124.09	250.29	169.47
Minimum	676.53	6,547.05	9.89	45.16	56.65	86.12	120.53	113.00
Std. Dev.	197.77	1,598.10	10.90	9.69	10.45	8.91	27.61	13.05
Skewness	(0.14)	0.07	2.19	(0.38)	(0.01)	(0.66)	(0.64)	0.53
Kurtosis	2.24	2.45	8.81	3.23	2.81	2.59	3.04	2.20
Observations	1,751	1,751	1,751	1,751	1,751	1,751	1,751	1,751

Table 2: Correlation Coefficients

New Zealand Sample							
	S&P500	DJIA	VIX	NZD/JPY	AUD/JPY	USD/JPY	GBP/JPY
DJIA	98.7%						
VIX	-57.0%	-49.1%					
NZDJPY	91.0%	88.8%	-63.7%				
AUDJPY	92.5%	92.5%	-52.3%	92.4%			
USDJPY	47.7%	41.6%	-54.3%	62.0%	45.4%		
GBPJPY	85.0%	81.9%	-63.0%	90.4%	81.0%	81.5%	
EURJPY	86.6%	88.4%	-31.7%	82.8%	94.1%	40.9%	76.6%
UK Sample							
	S&P500	DJIA	VIX	NZD/JPY	AUD/JPY	USD/JPY	GBP/JPY
DJIA	98.7%						
VIX	-57.0%	-49.2%					
NZDJPY	90.9%	88.7%	-63.6%				
AUDJPY	92.4%	92.4%	-52.4%	92.4%			
USDJPY	47.8%	41.8%	-54.3%	62.1%	45.4%		
GBPJPY	85.0%	82.0%	-62.8%	90.4%	81.0%	81.5%	
EURJPY	86.5%	88.4%	-31.8%	82.8%	94.2%	40.9%	76.7%

Table 3
Long-term relationship between the exchange rate and equity market: FMOLS estimates

$$\ln y_t = \alpha_0 + \alpha_1 \ln x_t + \varepsilon_t$$

	NZD/JPY	AUD/JPY	USD/JPY	GBP/JPY	EUR/JPY
New Zealand Sample					
S&P500	66.9% (-4.546)*	62.3% (-4.893)*	18.9% (-3.549)**	66.5% (-4.196)*	43.5% (-3.05)***
DJIA	73.7% (-4.381)*	70.1% (-5.544)*	18.7% (-3.582)**	72.5% (-4.178)*	50.2% (-3.413)**
VIX	-18.2% (-2.731)	-10.6% (-2.687)	-10.3% (-3.467)**	-21.1% (-2.801)	-3.4% (-2.388)
Australian Sample					
S&P500	66.9%	62.5%	19.0%	66.5%	43.5%
DJIA	73.8%	70.8%	18.8%	72.5%	50.3%
VIX	-18.5%	-10.9%	-10.5%	-21.4%	-3.6%
UK Sample					
S&P500	66.5%	62.3%	18.8%	66.2%	43.4%
DJIA	73.6%	70.6%	18.6%	72.2%	50.2%
VIX	-18.1%	-10.6%	-10.3%	-20.9%	-3.3%
US Sample					
S&P500	66.6%	62.2%	18.7%	66.2%	43.4%
DJIA	73.5%	70.5%	18.4%	72.2%	50.2%
VIX	-18.1%	-10.5%	-10.2%	-21.1%	-3.3%

Notes: The numbers reported are slope coefficients of the long-term relationship between (log) exchange rates and measures of global risk proxied by (log) US equity market indicators of investor risk sentiment. All regression equations include a shift dummy for the financial crisis period. The numbers in brackets are the tau-statistic of the Engle-Granger cointegration test accounting for the presence of deterministic terms (constant and shift dummy); * indicates significance at the 1% level; ** 5% level; *** 10% level. Engle-Granger statistics are only reported for the New Zealand sample as they are almost identical across samples.

The results for the intercept and the shift dummy for the financial crisis period are not reported in the table to save space.

Table 4
Short-term relationship: symmetric adjustment speed

$$\Delta \ln y_t = \beta_1 \Delta \ln x_t + \beta_2 (\ln y_{t-1} - \alpha_0 - \alpha_1 \ln x_{t-1}) + \nu_t$$

	β_1		β_2		
	Coefficient	T-value	Coefficient	T-value	Adj. R^2
New Zealand Sample					
NZD/JPY	0.569	28.27	-0.023	-5.15	0.323
AUD/JPY	0.601	29.85	-0.038	-6.13	0.348
GBP/JPY	0.323	20.82	-0.017	-3.99	0.204
Australian Sample					
NZD/JPY	0.435	21.80	-0.023	-5.20	0.224
AUD/JPY	0.480	24.91	-0.036	-6.12	0.273
GBP/JPY	0.259	16.35	-0.017	-4.03	0.139
UK Sample					
NZD/JPY	0.281	12.82	-0.030	-6.09	0.102
AUD/JPY	0.280	12.66	-0.049	-7.32	0.107
GBP/JPY	0.195	11.73	-0.019	-4.25	0.080
US Sample					
NZD/JPY	0.329	15.60	-0.028	-5.92	0.135
AUD/JPY	0.339	15.84	-0.046	-7.07	0.144
GBP/JPY	0.217	13.26	-0.018	-4.32	0.097

Table 5
Panel A: Short-term relationship with asymmetric error correction adjustment

$$\Delta \ln y_t = \delta_1 \Delta \ln x_t + \delta_2 \lambda \hat{\varepsilon}_{t-1} + \delta_3 (1-\lambda)\hat{\varepsilon}_{t-1} + \eta_t$$

	δ_1	δ_2	δ_3	Adjusted-R^2	Wald-Statistic
New Zealand Sample					
NZD/JPY	0.569 (28.12)	-0.013 (-2.11)	-0.032 (-5.11)	0.311	4.41**
AUD/JPY	0.601 (29.95)	-0.019 (-2.34)	-0.060 (-6.58)	0.352	10.97*
GBP/JPY	0.323 (20.83)	-0.022 (-3.68)	-0.012 (-1.98)	0.204	1.41
Australian Sample					
NZD/JPY	0.435 (21.83)	-0.017 (-2.59)	-0.029 (-4.75)	0.224	2.10
AUD/JPY	0.480 (24.92)	-0.032 (-4.02)	-0.042 (-4.67)	0.273	0.565
GBP/JPY	0.259 (16.35)	-0.024 (3.98)	-0.010 (-1.72)	0.139	2.55
UK Sample					
NZD/JPY	0.282 (12.88)	-0.019 (-2.77)	-0.054 (-7.16)	0.104	4.32**
AUD/JPY	0.281 (12.74)	-0.034 (-3.78)	-0.068 (-6.75)	0.110	6.13*
GBP/JPY	0.195 (11.72)	-0.021 (-3.33)	-0.017 (-2.69)	0.080	0.21
US Sample					
NZD/JPY	0.329 (15.65)	-0.016 (-2.36)	-0.039 (-5.98)	0.137	6.17*
AUD/JPY	0.341 (15.90)	-0.033 (-3.77)	-0.062 (-6.39)	0.145	4.98**
GBP/JPY	0.217 (13.24)	-0.021 (-3.41)	-0.016 (-2.55)	0.096	0.37

Notes:
The Wald statistic tests the hypothesis of asymmetry in the error correction response, $\delta_2 = \delta_3$;
* indicates significance at the 1% level; ** 5% level; *** 10% level.

Table 5
Panel B: Short-term relationship with asymmetric adjustment

$$\Delta \ln y_t = \delta_1^+ \Delta \ln x_t^+ + \delta_1^- \Delta \ln x_t^- + \delta_2 \lambda \hat{\varepsilon}_{t-1} + \delta_3 (1-\lambda) \hat{\varepsilon}_{t-1} + \eta_t$$

	δ_1^+	δ_1^-	δ_2	δ_3	Adjusted-R^2	Wald-Statistic
New Zealand Sample						
NZD/JPY	0.450 (14.16)	0.678 (22.373)	-0.001 (-0.08)	-0.047 (-6.76)	0.332	22.87* 19.03*
AUD/JPY	0.519 (16.55)	0.677 (22.65)	-0.007 (-0.08)	-0.072 (-7.38)	0.356	11.58* 20.98*
GBP/JPY	0.276 (10.63)	0.385 (15.68)	-0.014 (-2.05)	-0.021 (-3.02)	0.207	7.69* 0.41
Australian Sample						
NZD/JPY	0.341 (10.87)	0.525 (17.26)	-0.006 -(0.88)	-0.041 (-5.99)	0.230	15.08* 11.06*
AUD/JPY	0.433 (14.49)	0.525 (18.15)	-0.025 (-2.88)	-0.048 (5.11)	0.275	4.28** 2.84***
GBP/JPY	0.216 (8.48)	0.299 (12.15)	-0.018 (-2.64)	-0.017 (-1.74)	0.141	4.52** 0.04
UK Sample						
NZD/JPY	0.168 (4.92)	0.393 (11.73)	-0.007 (-0.865)	-0.054 (-7.16)	0.113	19.04* 16.85*
AUD/JPY	0.213 (6.28)	0.346 (10.41)	-0.024 (-2.43)	-0.078 (-7.25)	0.113	6.86* 11.93*
GBP/JPY	0.115 (4.35)	0.271 (10.44)	-0.009 (-1.25)	-0.029 (-4.15)	0.087	14.56* 3.48***
US Sample						
NZD/JPY	0.229 (6.90)	0.424 (13.27)	-0.005 (-0.63)	-0.051 (-7.10)	0.144	15.37* 17.74*
AUD/JPY	0.288 (8.65)	0.390 (12.11)	-0.025 (-2.61)	-0.070 (-6.71)	0.147	4.26** 8.81*
GBP/JPY	0.133 (5.06)	0.296 (11.64)	-0.009 (-1.23)	-0.029 (-4.13)	0.104	16.42* 3.51***

Notes:
The Wald statistics test the hypotheses of short-term asymmetry and error correction asymmetry, $\delta_1^+ = \delta_1^-$ and $\delta_2 = \delta_3$, respectively; * indicates significance at the 1% level; ** 5% level; *** 10% level.