ESSAYS ON THE IMPACT OF CARRY TRADE ACTIVITY ON EXCHANGE RATE MOVEMENTS & MARKET VOLATILITY

by

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ABSTRACT

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by

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Average daily turnover in FX markets were raised to $1.9 trillion in April 2004, a rise of 54% at current exchange rates and 36% at constant exchange rates. One of the reasons for such a strong growth in turnover is carry trading where investors borrow money in a currency with low interest rates in order to invest in a currency with higher interest rates.

The first part of this thesis re-examines the relationship between the yen carry trade activity and the related financial variables. Although a recent study, employing structural vector autoregression methodology, finds that the U.S. stock market performance has a dominant impact in the activity of the speculative yen carry trade using monthly data, I illustrate that this finding is not robust when weekly data is introduced to the same methodology. Instead, I find that it is the fluctuations in the Japanese yen against the U.S. dollar exchange rate, rather than the interest rate spread between the two countries and the U.S. stock market performance, that determines the direction of the yen carry trade.

The second part of the thesis investigates the role of carry trade transactions on exchange rate behavior since these transactions change the supply and demand for currencies initiated by the opportunity to exploit interest rate differentials. The net

position of speculators in different currency futures are used as an indicator for carry trade activity. By employing vector autoregression methodology, the results indicate that exchange rates react instantaneously to shocks in speculators' positions and Granger causality tests suggest that these positions lead to price discovery in the spot market for exchange rates. Furthermore, out-of-sample forecasts perform better than the random walk model for three of the five currencies in our sample based on root mean square and mean absolute error forecasting evaluation criteria.

The last part investigates the dynamic lagged relationship between trading activity in currency futures and exchange rate volatility in the spot market using the net positions of trader in various currency futures markets. I use weekly high-low estimate of volatility, historical volatility, and conditional volatility from the GARCH (1, 1) process. The results point that in most cases while speculators and small traders in currency futures increase volatility in the corresponding spot markets, hedgers seem to decrease it as indicated by generalized impulse response functions. Also, in most of the cases, speculators' demand for futures increase in response to increased volatility in the spot market meanwhile hedgers' demand decrease.

DEDICATION

Dedicated to my grandparents;

Takfur, Kilara, Kalost, and Koharik

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CHAPTER 1

RE-EXAMINATION OF THE RELATIONSHIP BETWEEN THE YEN CARRY TRADE ACTIVITY AND THE RELATED FINANCIAL VARIABLES

1.1. Introduction

The strategy of borrowing money in a currency with low interest rates – “funding currency” – in order to invest in a currency with higher interest rates – “target currency” – is commonly known as currency carry trade in financial markets. The dynamics of this strategy is relatively straightforward. An investor initiates by borrowing a given amount in a low-interest-rate currency, then converts the funds into a high-interest-rate currency, and finally lends the resulting amount in the target currency at the high interest rate.

Theoretically, carry trades should not offer any profits at all due to Uncovered Interest Parity (UIP) condition, which states that the interest differential between countries should on average equal the expected change in the exchange rate. In other words, the difference in interest rates between two countries should reflect the rate at which investors expect the high-interest rate currency to depreciate against the low-interest rate currency. However, there is a well known empirical anomaly in foreign exchange markets, named the “Forward Premium Puzzle”, which the investors have been taking advantage of. This puzzle refers to the finding that the high-interest-rate currencies tend to appreciate relative to the low-interest-rate currencies and that indicates a rejection of the UIP hypothesis.

The yen carry trade has been the focus of the international financial markets since the official lending rate has been less than 1 percent for over a decade in Japan. As a result, investors have been treating the yen as a popular funding currency. On the other hand, some of the popular target currencies have been the Australian and New Zealand dollars, as well as the British pound sterling. Nishigaki (2007) investigates the relationship between the yen carry trade and the related financial variables in the U.S. and Japan by the structural vector autoregression (SVAR) methodology. Through analysis of impulse response functions and forecast variance decompositions, his primary finding is that the U.S. stock market performance, rather than the interest rate differentials between Japan and the U.S., has a dominant impact on the activity of yen carry trade. This paper is a reaction to his finding and illustrates that his discovery is not robust when an alternative data frequency, specifically weekly, is introduced to the analysis. Regardless, the objective is to explore the forces that may stimulate and/or depress the speculative carry trade activity.

This chapter is organized as follows. A conceptual framework of the speculative carry trade activity is discussed in Section 1.2. Some stylized facts are introduced in Section 1.3 followed by a brief literature review in Section 1.4. The data and the SVAR methodology are presented in Sections 1.5 and 1.6, respectively. Section 1.7 provides the empirical results while Section 1.8 presents robustness check. Concluding remarks are presented in Section 1.9.

1.2. Conceptual Framework

Although, there is an array of ways to employ carry trades, a simple currency carry trade is designed to take advantage of interest rate differentials across currencies by borrowing money in a currency with low interest rates in order to invest in a currency with high interest rates. To put it differently, this approach involves exchanging borrowed funds into the target currency in the spot market while other approaches rely on derivative contracts, including foreign exchange futures, forwards and interest rate swaps as well as more complex options (Galati et al., 2007). In fact, it is relatively straightforward to recognize that the use of forward contracts is equivalent to the strategy based on interest rate differentials. A currency forward contract is an obligation to buy or sell some amount of a currency at a specified future exchange rate on a specified future date. Currency forward contracts selling at a premium is an indication of forward exchange rates to be higher than the spot exchange rates whereas forward contracts selling at a discount point out that forward exchange rates is lower than the spot exchange rates. An investor selling currencies that are at a forward premium and buying currencies that are at a forward discount, is in essence treating currencies that are at a forward premium as funding currencies and currencies that are at a forward discount as target currencies. According to an equilibrium condition of international financial markets, called the Covered Interest Parity (CIP), the forward premium of one currency relative to another is equal to the interest rate differential between them (Cavallo, 2006). The CIP condition can be illustrated as

$$(1+i_t) = \frac{s_t(1+i_t^*)}{f_t} \quad (1)$$

Rearranging condition (1), we can arrive at

$$\frac{f_t - s_t}{s_t} = \frac{1+i_t^*}{1+i_t} - 1 \quad (2)$$

$$i_t^* - i_t \approx \frac{f_t - s_t}{s_t} \tag{3}$$

where i_t and i_t^* are the domestic and foreign interest rates, respectively, at time *t*, f_t is the forward exchange rate and s_t is the spot exchange rate, both at time *t*. Condition (3) postulates that the difference between two countries' interest rates is exactly reflected in the gap between the spot exchange rate and the forward rate. Thus, the forward premium or discount equals the interest rate differential. When the domestic interest rate is less than the foreign interest rate, forward price of the foreign currency will be below the spot price and when the domestic interest rate is greater than the foreign interest rate, forward price of the foreign currency will be higher than the spot price. This implies that currencies with a low interest rate are typically at a forward premium, whereas currencies with a high interest rate are typically at a forward discount (Cavallo, 2006). Hence, selling currencies that are at a forward premium is similar to borrowing currencies with low interest rates whereas buying currencies that are at a forward discount is analogous to investing in currencies with high interest rates.

Another famous condition in international financial markets relates interest differentials to an *expected* change in the spot exchange rate of the domestic currency. This can be illustrated as

$$1 + i_t = E_t\left[\frac{s_t(1+i_t^*)}{s_{t+1}}\right] = s_t(1+i_t^*)E_t\left(\frac{1}{s_{t+1}}\right) \tag{4}$$

By manipulating this condition, we can arrive at

$$i_t^* - i_t \approx E_t\left[\frac{(s_{t+1} - s_t)}{s_t}\right] = \frac{(E_t s_{t+1} - s_t)}{s_t} \tag{5}$$

where $E_t s_{t+1}$ is the expected value, at time *t*, of the future spot exchange rate at time *t+1*.

Condition (5) is known as Uncovered Interest Parity (UIP) which states that the interest differential between countries should on average equal the expected change in the exchange rate. Thus, according to UIP, if the domestic interest rate is greater than the foreign interest rate, the domestic currency is expected to depreciate and likewise, if the domestic interest rate is less than the foreign interest rate, the domestic currency is expected to appreciate. For instance, if the interest rate in Japan is 1 percent while it is 7.25 percent in Australia, the interest rate differential should represent the compensation that investors require to off-set currency risk, which includes the expected rate of depreciation of the Australian dollar against the Japanese yen. Thus, if expectations are rational, interest rate differentials between countries should be an unbiased predictor of future exchange rate changes.

Given that the UIP condition holds, the use of carry trade strategies by investors is puzzling to economists since it should not generate any predictable profits. Recall that in a currency carry trade, investors borrow funds in a low interest rate currency in order to invest in a high interest rate currency. According to the UIP condition, the currency with the low interest rate, funding currency, will appreciate and the currency with the high interest rate, target currency, will depreciate and thus leave investors with no predictable profits. However, empirical tests of the UIP assumption have soundly been rejected by researchers – at least for prediction horizons of a year or less – leading to an anomaly known as the “Forward Premium Puzzle”. This puzzle refers to the well-known finding that not only forward rates are biased predictors of future spot rates but also they are generally perverse: currencies that command a forward premium tend, on average, to depreciate, while those with a forward discount tend to appreciate (Meredith and Ma, 2002). Therefore, an investor who enters a carry trade is likely to make profits from two sources, (1) the interest rate differential between two currencies and (2) the appreciation of the high-interest-rate currency that was originally bought at a forward discount (Cavallo, 2006).

1.3. Stylized Facts

Official interest rates have been the lowest in Japan as well as in Switzerland over the past several years. Consequently, the Japanese yen (JPY) and the Swiss franc (CHF) have been considered as major funding currencies in carry trade transactions. On the other hand, the Australian dollar (AUD), the New Zealand dollar (NZD), and the British pound sterling (GBP) have been cited as some of the most popular target currencies since official interest rates in these countries have been on the rising side at least for the last five years. The U.S. dollar (USD) has resumed the role of being a target currency before 2001 and after 2004. Thus, it was a potential funding currency between 2001 and 2004. It has become a funding currency once again since late 2007. Figures 1.1 and 1.2 illustrate the movements of the official interest rates in funding and target currencies, respectively.

When we look at the movements of target currencies in Figure 1.3 against the funding currency, JPY, we observe that AUD, NZD, and GBP have been gaining strength since late 2000. The USD has been on the rising side as well, however, it seems to follow a much steadier path. Clearly these movements of the target currencies are in accord with the forward premium puzzle mentioned above. Furthermore, one can make inferences regarding the unwinding of the yen carry trades. An episode of unwinding of carry trades refers to a sudden reversal in investors' positions due to changes in interest rate expectations or volatility. These sudden reversals are expected to put tremendous pressure on exchange rates. Perhaps the best known example of such a sudden reversal of positions on exchange rates is most visible in Figure 1.4. The sharp appreciation of the yen against the U.S. dollar between 6 and 8 October 1998 is primarily attributed to the unwinding of carry trade positions. This was the sharpest move in major foreign exchange rate since 1974 and was accompanied by a significant spike in volatility: one-month implied volatility reached 40% and bid-ask spreads widened markedly (Galati et al., 2007).

1.4. Literature Review

The empirical literature on carry trade is limited and the majority of the studies in the literature are, in fact, finance related. Researchers (e.g., Peltomäki, 2008; Burnside, Eichenbaum, and Rebelo, 2007; Burnside, Eichenbaum, and Rebelo, 2008; Moosa, 2008; Burnside, Eichenbaum, Kleshchelski, and Rebelo, 2008; Burnside, Eichenbaum, Kleshchelski, and Rebelo, 2006; Gyntelberg and Remolona, 2007) are mostly interested in exploring the risk and return relationship of carry trade activities. There are, however, a few empirical studies that are of interest to our current work. Inspired by the dramatic yen/dollar volatility of 1998, Cai et al. (2001) investigate the role of macroeconomic announcements and order flow, which is defined as the difference between the buyer-initiated and seller-initiated orders in foreign exchange transactions, in order to better understand the well-known yen volatility of 1998. Even accounting for a lengthy list of announcements and the actual interventions that occurred during 1998, authors find an independent role for order flow in explaining yen-dollar volatility and thus lend support to the claim that portfolio shifts were responsible for much of the volatility. In search of explaining the growth of turnover in foreign exchange markets between 2001 and 2004, Galati and Melvin (2004) conduct a regression analysis using the major traded currencies to test whether interest rate differentials or momentum trading have played an important role. The results indicate that both factors have significantly influenced the growth of turnover in FX markets. In a similar study, Brzeszczynski and Melvin (2006) investigate the ‘smile’ pattern of trading volume in the euro against the U.S. dollar, using weekly data from January 1999 to October 2003. Their regression model also suggests that momentum and interest differentials play a significant role in explaining trade activity. Brunnermeier et al. (2008) study the relationship between carry trades and crash risk of currencies. Using panel regressions and quarterly data from 1986 to 2006, authors find that high interest rate differentials predict negative skewness which indicates that carry trade returns have crash risk. Using time-series data on the exchange rates of eight major currencies relative to the USD, authors calculate realized skewness from daily FX rate changes, regress it on the interest rate differential and observe that the interest-rate differential is a statistically highly significant negative predictor of skewness. This implies that investing in high interest-rate currencies while borrowing in low interest-rate currencies deliver negatively skewed returns and this is an indication of crash risk for carry trades. In other words, in times of high interest rate differentials, carry trade investors that are long currencies might “go up by the escalator”, but occasionally “come down by the elevator”.

1.5. Data

The variables that are of interest to this study are the interest rate differential between the U.S. and Japan (*IRD*), global volatility indicator (*VIX*), the dollar against the yen exchange rate (*FER*), the U.S. stock price (*SUS*), and the Japanese stock price (*SJP*). The U.S. interest rate is the Fed Funds target rate whereas the Japanese interest rate is the Bank of Japan target policy rate, also known as the Uncollateralized Overnight Call Rate. *VIX* is the Chicago Board Options Exchange (CBOE) Volatility Index. It is an option implied volatility index conveyed by the S&P 500 stock index option prices and is considered to be a barometer of investor sentiment and market volatility since its inception in 1993. *VIX* is also known as "the fear index" among market practitioners. *SUS* is the S&P 500 index whereas *SJP* is the Tokyo Stock Price Index which is also commonly known as the TOPIX. Carry trade is measured by the net open positions of non-commercial traders in the yen futures market traded on the CME and is abbreviated as *IMR*. Nishigaki (2007) measures *IMR* as the ratio of long to short yen and so does this study.

The Uncollateralized Overnight Call Rate and the S&P 500 stock index data are acquired from Datastream Advance. The net open positions of non-commercial traders in the yen futures market is calculated from Commitment of Traders (COT) report provided by the Commodity Futures Trading Commission (CFTC). The COT report is released on Fridays and presents positioning data held at the close of business on the preceding Tuesday. The rest of the data are obtained from Global Financial Database. We compare results using two different sets of data frequency, monthly and weekly. Specifically, monthly data is end of month values whereas weekly data consists of values at the close of each Tuesday. The period under investigation is from January 1993 to January 2007. Thus, we have 180 monthly observations. All the variables, except *IRD*, are entered into natural logarithms.

1.6. Methodology

Our purpose is, firstly, to re-examine Nishigaki (2007) findings which is based on monthly observations. Prior to using the SVAR methodology, we tested the order of integration for all the time series using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. This will determine whether a reduced form representation in levels or in first differences is required. Table 1.1 shows the unit root test results. As shown in the table, both tests suggest that all the variables are integrated of order one, I(1), except the *IMR* which is integrated of order zero, I(0). Therefore, all the variables are entered in first differenced except the *IMR*. Next, we use the SVAR methodology to estimate the effect of financial factors on the carry trade.

An SVAR representation of the relationship between the six variables can be written as:

$$B_0 X_t = B(L) X_{t-1} + \varepsilon_t \qquad (1)$$

where $X_t =$ the column vector $(\Delta IRD_t, \Delta VIX_t, IMR_t, \Delta FER_t, \Delta SUS_t, \Delta SJP_t)'$

$B_0 =$ a 6×6 matrix of coefficients, reflecting contemporaneous relationships among the six variables

$\varepsilon_t =$ the column vector of structural error terms $(\varepsilon_t^{IRD}, \varepsilon_t^{VIX}, \varepsilon_t^{IMR}, \varepsilon_t^{FER}, \varepsilon_t^{SUS}, \varepsilon_t^{SJP})'$

$B(L) =$ a 6×6 matrix with elements equal to the polynomials $B_{ij}(L)$

$L =$ a lag operator

Pre-multiplying all terms by B_0^{-1}, we obtain the reduced-form VAR representation:

$$X_t = A(L) X_{t-1} + e_t \qquad (2)$$

where $A(L) = B_o^{-1} B(L)$ and $e_t = B_0^{-1} \varepsilon_t$

Notice that B_0^{-1} represents the matrix of contemporaneous responses of X_t to the structural shocks, $e_t = B_0^{-1}\varepsilon_t$ so $\varepsilon_t = B_o e_t$.

The SVAR utilizes the following expression for the variance-covariance matrix of the reduced-form VAR residuals, denoted by Σ, in order to identify the elements of B_0^{-1}.

$$e_t = B_0^{-1}\varepsilon_t \Rightarrow Ee_t e_t^{'} = B_0^{-1}E(\varepsilon_t\varepsilon_t^{'})(B_0^{-1}) \Rightarrow \Sigma = B_0^{-1}\Sigma_\varepsilon(B_0^{-1})' \qquad (3)$$

The total number of parameters to be estimated is 93. The right-hand side of equation (3) has 72 unknown parameters. However, 57 contemporaneous restrictions are provided by the assumed orthogonality of the shocks, normalization of the diagonal elements of B_0^{-1} to equal unity, combined with the estimated variance-covariance matrix of the reduced-form VAR (Σ_e), leaves 15 restrictions for exact identification of the unknown parameters.

Therefore, to identify the structural shocks from the reduced-form shocks, a number of restrictions have been imposed.

1. Shocks to other variables in the system have no effects on the interest rate differential between U.S. and Japan. Thus, *IRD* is to be the most exogenous variable in the system. This assumption leads to the restrictions $b_{12}(L) = b_{13}(L) = b_{14}(L) = b_{15}(L) = b_{16}(L) = 0.$
2. Chicago Board Options Exchange (CBOE) Volatility Index, *VIX*, is assumed to be affected only by shocks to *IRD*. This restriction is incorporated as $b_{23}(L) = b_{24}(L) = b_{25}(L) = b_{26}(L) = 0.$
3. Currency carry trade proxy *IMR* is influenced by shocks to *IRD*, and *VIX*, which yields the restrictions $b_{34}(L) = b_{35}(L) = b_{36}(L) = 0.$

4. S&P 500 stock index, *SUS*, and Tokyo stock price index, *TOPIX*, have no contemporaneous effect on the dollar against yen exchange rate, *FER*. This assumption is illustrated as $b_{45}(L) = b_{46}(L) = 0.$

5. *SUS* is assumed to be affected by shocks to *IRD*, *VIX*, *IMR*, and *FER*. This restriction is introduced as $b_{56}(L) = 0.$

6. Shocks to all other variables are assumed to affect Tokyo stock price index, *TOPIX*, and hence it is determined endogenously in the system.

With the above mentioned 15 restrictions, the system is exactly identified. The system of equations arising from these restrictions can be exposed as follows:

$$\begin{aligned}
\Delta IRD_t &= b_{11}u_t^{IRD} \\
\Delta VIX_t &= b_{21}u_t^{IRD} + b_{22}u_t^{VIX} \\
IMR_t &= b_{31}u_t^{IRD} + b_{32}u_t^{VIX} + b_{33}u_t^{IMR} \\
\Delta FER_t &= b_{41}u_t^{IRD} + b_{42}u_t^{VIX} + b_{43}u_t^{IMR} + b_{44}u_t^{FER} \\
\Delta SUS_t &= b_{51}u_t^{IRD} + b_{52}u_t^{VIX} + b_{53}u_t^{IMR} + b_{54}u_t^{FER} + b_{55}u_t^{SUS} \\
\Delta SJP_t &= b_{61}u_t^{IRD} + b_{62}u_t^{VIX} + b_{63}u_t^{IMR} + b_{64}u_t^{FER} + b_{65}u_t^{SUS} + b_{66}u_t^{SJP}
\end{aligned}$$

The restrictions can also be presented in the matrix form:

$$\begin{bmatrix} \Delta IRD_t \\ \Delta VIX_t \\ IMR_t \\ \Delta FER_t \\ \Delta SUS_t \\ \Delta SJP_t \end{bmatrix} = \begin{bmatrix} * & 0 & 0 & 0 & 0 & 0 \\ * & * & 0 & 0 & 0 & 0 \\ * & * & * & 0 & 0 & 0 \\ * & * & * & * & 0 & 0 \\ * & * & * & * & * & 0 \\ * & * & * & * & * & * \end{bmatrix} \begin{bmatrix} u_t^{IRD} \\ u_t^{VIX} \\ u_t^{IMR} \\ u_t^{FER} \\ u_t^{SUS} \\ u_t^{SJP} \end{bmatrix}$$

A detailed explanation of the reasons why the above ordering is deemed appropriate is provided below.

The first equation depicts the interest rate differential between the U.S. and Japan which we treat as exogenous to the other variables. The second equation shows the investor's sentiment or volatility in the US which is considered to be affected by *IRD*. The third equation demonstrates the investor's speculative carry trade observed in the yen futures contracts. It is assumed that this trade is influenced by shocks to *IRD* and *VIX*. Undoubtedly, we expect *IMR* to be affected by the interest rate differential between the U.S. and Japan. Higher Japanese interest rates would increase the cost of borrowing the yen and thus making such trades less attractive. On the other hand, it seems plausible to expect carry trade activity to flourish (deteriorate) during periods of low (high) volatility in the market. The forth equation depicts the nominal dollar against the yen rate. Firstly, *FER* is known to be affected by *IRD* due to interest rate parity condition. Secondly, Cairns et al. (2007) show that the dollar against the yen would depreciate if the *VIX* index increases. Thirdly, with regard to the relationship between *IMR* and *FER*, Mogford and Pain (2006) argue that a general build-up in long (short) positions would seem to be associated with an appreciation (depreciation) in the exchange rate. The fifth and sixth equations show the stock prices of the U.S. and Japan, respectively. Stock prices are considered to be affected by all the other variables. Nishigaki (2007) indicates that U.S. stock prices will go down if the federal funds rate rises with respect to a constant Japanese call rate, making the interest rate differential between the U.S. and Japan larger. On the other hand, the Japanese stock prices will go down when the Japanese call rate rises with respect to a constant federal funds rate, making the interest rate differential smaller. Moreover, with regards to the relationship between *VIX* and stock returns, Giot (2005) shows that positive stock index returns are associated with declining implied volatility, while negative stock index returns are associated with increasing implied volatility. Nishigaki (2007) states that if investors buy U.S. stock through the yen carry trade, then the US stock prices may decrease by the unwinding of the yen carry trade and the Japanese stock prices may increase because of the increase in capital inflow from the U.S. to Japan. And finally, stock prices may also be affected by *FER*. Aggarwal (1981) states that changes in exchange rates provokes profits or losses in the balance sheet of multinational firms and induces their stock prices to change.

The empirical method to recover the structural shocks from the observed variables is based on structural VAR analysis. The optimal lag length in the VAR system determined by Akaike, Schwarz, and Hannan-Quinn Information Criterion is 2.

1.7. Empirical Results

Figure 1.5 displays the impulse responses of *IMR* to a one-standard deviation innovation of a particular structural shock on all the variables over a 20-month period range. Notice that although the affect of interest rate differential between the U.S. and Japan (*IRD)* on the yen carry trade is on the expected direction, a larger differential leading to an increase in carry trade activity, it is statistically insignificant. Furthermore, we observe that a decline in carry trade activity could be due to a positive shock to “the fear index”, *VIX*. However, the impact of such a positive shock also seems to be statistically insignificant. The two variables that have a dominant impact on the speculative yen carry trade activity appear to be nominal dollar against the yen rate and the U.S. stock price. We detect that carry trade activity increases when the Japanese yen depreciates against the U.S. dollar and this impact of *FER* on carry trade is statistically significant. Additionally, we observe that a positive shock to the U.S. stock price, *SUS*, also flourishes the carry trade activity. This impact is also statistically significant.

Figure 1.6 shows the impulse responses of all the variables to *IMR* shocks. In other words, we are now interested in to see the consequences of the unwinding of the yen carry trade. The significant impact of a sudden reversal of carry trade positions on the nominal dollar against the yen exchange rate catches our attention immediately. Specifically, we observe that the unwinding of the carry trade positions could lead to an immediate appreciation of the yen against the dollar rate. Furthermore, we notice that the *VIX* index could decline and the U.S. as well as the Japanese stock prices could increase in response to a sudden reversal of yen carry trade positions. However, these impacts are statistically not significant.

Table 1.2 reports the variance decompositions. The variance decomposition of *IMR* suggests that shocks to the U.S. stock price, *SUS*, explain about 11 percent of the variance of *IMR*, 6 months after a shock while shocks to *FER* explain about 10 percent of the variance of *IMR*. Notice that shocks to *IRD* explain less than 1 percent of the variance of *IMR*. It is also imperative to notice the ability of carry trades to influence the dollar against the yen rate. Table 1.2 displays that shocks in *IMR* explain about 15 percent of the variance of *FER*.

Table 1.3 provides the p-values for testing whether the coefficients for lagged values of a given variable are jointly equal to zero. According to the results, the very first variable that significantly Granger causes the movement of carry trade activity, *IMR*, is the Japanese yen per U.S. dollar exchange rate. The second variable is the S&P 500 stock index and the last variable is “the fear index”, *VIX*. However, notice that *IMR* does not Granger cause the exchange rate, *FER*, between Japan and US.

1.8. Robustness Check

The above results are consistent with Nishigaki (2007). However, we like to test the robustness of these results by changing the frequency of data used. The CFTC provides a breakdown of positions in futures through its COT report which is calculated from Wednesday to Tuesday and released to the public the following Friday since January 1993. Therefore, we decide to use weekly data for all the variables. In fact, using weekly observations, rather than monthly, seems much more relevant in this context since non-commercial traders, also known as speculators, continually change positions in the futures market in order to earn quick profits. Certainly, to this end, the use of daily data, or even hourly, would be preferred however data with such high frequency is only available commercially, not publicly. We decided to keep the sample period the same since the last financial crisis created significant instability in all the markets. Therefore, the sample period remains from January 1993 to January 2007. All the variables are again tested for unit root. The results are reported in Table 1.4. As before, all the variables are integrated of order one, I(1), at the 1 percent significance level except *IMR* which is integrated of I(0). Therefore, all the variables are entered in first differenced except the *IMR*. Akaike, Schwarz, and Hannan-Quinn Information Criterion indicate that the optimal lag length is 1.

We keep the ordering of the variables the same as before and repeat the SVAR to study the impulse response functions, variance decompositions and Granger causality. Figure 1.7 displays the responses of *IMR* to a one-standard deviation innovation of a particular shock on all the variables over a 20-week period range and contains ±2 standard error bands. Our results indicate that the nominal exchange rate still has a significant impact on carry trade activity. Specifically, we observe that when the Japanese yen depreciates against the U.S. dollar, yen carry trade raises. This may be explained by momentum trading, which results from investors betting on trend continuation. However, we fail to observe the significant impact of *SUS* on speculative carry trade activity. In fact, we see an opposite movement in carry trade compared to the monthly sample. That is, when a positive shock is introduced to *SUS*, the S&P 500 stock index, the carry trade activity declines. Therefore, we cannot verify the prominent finding of Nishigaki (2007). On the other hand, similar to Nishigaki (2007), we fail to detect the importance of the interest rate differentials between Japan and the U.S. in the speculative yen carry trade activity. However, when we look at Figure 1.8, which reveals the impulse responses of all the variables to *IMR* shocks, we still do observe the statistically significant impact of a sudden reversal of carry trade positions on the nominal dollar against the yen exchange rate. We see that the Japanese yen will appreciate against the U.S. dollar when investors unwind their positions. This finding is consistent with Nishigakis' and lends further support to the assertion that sudden exchange rate moves unrelated to news could be due to the unwinding of carry trade positions and/or portfolio shifts.

Table 1.5 reports the variance decompositions. The variance decomposition of *IMR* suggest that shocks to the dollar against the yen exchange rate explain about 3 percent of the variance in *IMR* six weeks after a shock and in fact the explanatory power of shocks to *FER* increases to 3.14 percent after 20 weeks. On the other hand, evidence suggests that U.S. stock price has no impact on the variance of the yen carry trade activity. However, we continue to see the ability of investors' carry trade positions to influence the dollar against the yen exchange rate. Table 1.5 displays that shocks in *IMR* explain about a remarkable 16.45 percent of the variation in *FER*[1].

Table 1.6 presents the p-values for Granger causality tests. We see that the only variable that Granger causes the movement of carry trade activity is the nominal exchange rate between Japan and the U.S. We also observe that the *IMR* has the ability to Granger cause the direction of the Japanese yen per U.S. dollar. Thus, we find bi-directional causality between the net open positions of non-commercial traders in the yen futures market and the Japanese yen per U.S. dollar.

1.9. Conclusion

Nishigaki (2007) investigates the relationship between the yen carry trade and the related financial variables in the U.S. and Japan by the SVAR model using monthly data and concludes that when a positive shock is introduced to the U.S. stock price, the yen carry trade activity increases. In this study, I tested the robustness of his results using weekly data and found out that the yen carry trade activity declines in response to a positive shock to the S&P 500 index. Therefore, we cannot confirm Nishigakis' eminent finding. Instead we observe the significant impact of the nominal dollar against the yen exchange rate on the speculative yen carry trade activity. In particular, we discover that when the Japanese yen depreciates against the U.S. dollar, the yen carry trade raises. Moreover, we find that the interest rate differential between the two countries do not affect the speculative yen carry trade activity. However, we still do observe the statistically significant impact of a sudden reversal of carry trade positions on the nominal dollar against the yen exchange rate.

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[1] Rearranging the data in the order of *FER*, *SUS*, *SJP*, *VIX*, *IRD*, and *IMR* in the SVAR system based on the Granger causality test do not alter the conclusions.

Table 1.1 Unit Root Tests

ADF Test Statistics	Intercept				Intercept and Trend			
Variable	**Lag**	**Level**	**Lag**	**First Difference**	**Lag**	**Level**	**Lag**	**First Difference**
IRD	3	-1.97	2	-4.21***	3	-2.05	2	-4.22***
ln(VIX)	0	-2.81*	0	-15.91***	0	-2.74	1	-12.03***
ln(IMR)	0	-4.79***	0	-14.13***	0	-4.88***	0	-14.09***
ln(FER)	0	-2.34	0	-12.89***	0	-2.65	0	-12.87***
ln(SUS)	0	-1.51	0	-13.08***	0	-1.25	0	-13.11***
ln(SJP)	0	-1.36	0	-11.15***	0	-1.19	0	-11.14***

PP Test Statistics	Intercept		Intercept and Trend	
Variable	**Level**	**First Difference**	**Level**	**First Difference**
IRD	-2.05	-11.53***	-2.12	-11.55***
ln(VIX)	-2.42	-19.35***	-2.34	-31.51***
ln(IMR)	-4.86***	-18.19***	-4.88***	-18.15***
ln(FER)	-2.60*	-12.89***	-2.91	-12.87***
ln(SUS)	-1.52	-13.08***	-1.25	-13.11***
ln(SJP)	-1.79	-11.26***	-1.70	-11.21***

Note: The lags in the tests were estimated through the Schwartz information criterion.
***H_o of a unit root is rejected at the 1%, **5%, and *10% level.

IRD = Interest Rate Differential between U. S. & Japan
VIX = CBOE Volatility Index
IMR = Ratio of Long to Short Positions in JPY Futures
FER = Ratio of JPY to USD
SUS = S&P 500 Stock Index
SJP = Tokyo Stock Price Index (TOPIX)

Table 1.2 Variance Decompositions

Variance Decomposition of D(IRD)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	100.000	0.000	0.000	0.000	0.000	0.000
6	89.439	2.839	1.103	0.356	4.932	1.328
12	89.279	2.887	1.158	0.361	4.946	1.366
20	89.277	2.887	1.160	0.361	4.946	1.366

Variance Decomposition of D(VIX)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.993	99.006	0.000	0.000	0.000	0.000
6	2.533	94.494	0.428	0.446	0.723	1.373
12	2.536	94.428	0.459	0.450	0.751	1.373
20	2.536	94.425	0.460	0.450	0.752	1.373

Variance Decomposition of IMR

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.094	0.013	99.892	0.000	0.000	0.000
6	0.512	0.768	76.085	10.479	11.320	0.833
12	0.880	0.962	74.470	10.200	12.633	0.851
20	0.907	0.976	74.378	10.186	12.695	0.854

Variance Decomposition of D(FER)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.238	0.328	16.545	82.887	0.000	0.000
6	3.066	0.681	15.563	71.953	8.683	0.051
12	3.081	0.682	15.573	71.921	8.687	0.052
20	3.081	0.682	15.574	71.920	8.687	0.052

Variance Decomposition of D(SUS)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	1.102	40.376	0.432	1.041	57.047	0.000
6	1.696	40.186	0.445	1.247	55.787	0.635
12	1.713	40.176	0.446	1.247	55.778	0.637
20	1.713	40.176	0.446	1.247	55.777	0.637

Variance Decomposition of D(SJP)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	1.173	16.082	0.000	0.000	3.030	79.712
6	1.714	16.293	1.430	1.476	3.530	75.553
12	1.727	16.267	1.523	1.482	3.593	75.406
20	1.727	16.266	1.525	1.483	3.590	74.399

Table 1.3 VAR Granger Causality Tests (P-values)

	D(IRD)	D(VIX)	IMR	D(FER)	D(SUS)	D(SJP)
D(IRD)	-	0.1461	0.2038	0.0621	0.5689	0.4856
D(VIX)	0.1274	-	0.0137	0.0490	0.3575	0.2053
IMR	0.5054	0.2157	-	0.1191	0.9555	0.2998
D(FER)	0.9651	0.7678	0.0000	-	0.8068	0.0712
D(SUS)	0.0088	0.8382	0.0027	0.0012	-	0.3767
D(SJP)	0.3877	0.2178	0.1575	0.9197	0.5827	-

Note: Table shows the marginal probabilities associated with the Granger-causality test. The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Table 1.4 Unit Root Tests

ADF Test Statistics	Intercept				Intercept and Trend			
Variable	**Lag**	**Level**	**Lag**	**First Difference**	**Lag**	**Level**	**Lag**	**First Difference**
IRD	0	-1.92	0	-27.26***	0	-2.03	0	-27.31***
ln(VIX)	0	-3.17**	0	-27.43***	0	-3.12	0	-27.42***
ln(IMR)	0	-6.20***	2	-18.45***	0	-6.33***	2	-18.44***
ln(FER)	1	-2.37	0	-22.01***	1	-2.69	0	-22.02***
ln(SUS)	1	-1.59	0	-22.88***	1	-1.31	0	-22.91***
ln(SJP)	1	-1.42	0	-23.38***	1	-1.27	0	-23.38***

PP Test Statistics	Intercept		Intercept and Trend	
Variable	**Level**	**First Difference**	**Level**	**First Difference**
IRD	-1.90	-28.48***	-1.98	-28.47***
ln(VIX)	-2.80**	-29.67***	-3.15**	-30.19***
ln(IMR)	-6.17***	-32.14***	-6.33***	-32.08***
ln(FER)	-2.35	-22.03***	-2.66	-22.03***
ln(SUS)	-1.53	-22.87***	-1.23	-22.91***
ln(SJP)	-1.56	-23.61***	-1.41	-23.61***

Note: The lags in the tests were estimated through the Schwartz information criterion.
***H_o of a unit root is rejected at the 1%, **5%, and *10% level.

IRD = Interest Rate Differential between U. S. & Japan
VIX = CBOE Volatility Index
IMR = Ratio of Long to Short Positions in JPY Futures
FER = Ratio of JPY to USD
SUS = S&P 500 Stock Index
SJP = Tokyo Stock Price Index (TOPIX)

Table 1.5 Variance Decompositions

Variance Decomposition of D(IRD)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	100.000	0.000	0.000	0.000	0.000	0.000
6	99.497	0.317	0.006	0.059	0.050	0.069
12	99.493	0.317	0.009	0.059	0.050	0.069
20	99.492	0.317	0.010	0.059	0.050	0.069

Variance Decomposition of D(VIX)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.013	99.986	0.000	0.000	0.000	0.000
6	0.019	98.854	0.014	0.019	0.993	0.097
12	0.019	98.847	0.021	0.020	0.993	0.097
20	0.019	98.845	0.023	0.020	0.993	0.097

Variance Decomposition of IMR

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.058	0.079	99.861	0.000	0.000	0.000
6	0.017	0.022	96.756	2.762	0.377	0.064
12	0.013	0.017	96.379	3.081	0.434	0.073
20	0.013	0.017	96.301	3.146	0.446	0.075

Variance Decomposition of D(FER)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.010	0.284	15.777	83.927	0.000	0.000
6	0.265	0.327	16.553	82.662	0.187	0.003
12	0.264	0.326	16.726	82.489	0.188	0.003
20	0.264	0.326	16.774	82.442	0.188	0.003

Variance Decomposition of D(SUS)

Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.115	48.992	0.120	0.002	50.768	0.000
6	0.128	48.420	0.132	0.476	50.432	0.408
12	0.128	48.413	0.146	0.477	50.425	0.408
20	0.128	48.411	0.149	0.477	50.423	0.408

Variance Decomposition of D(SJP)

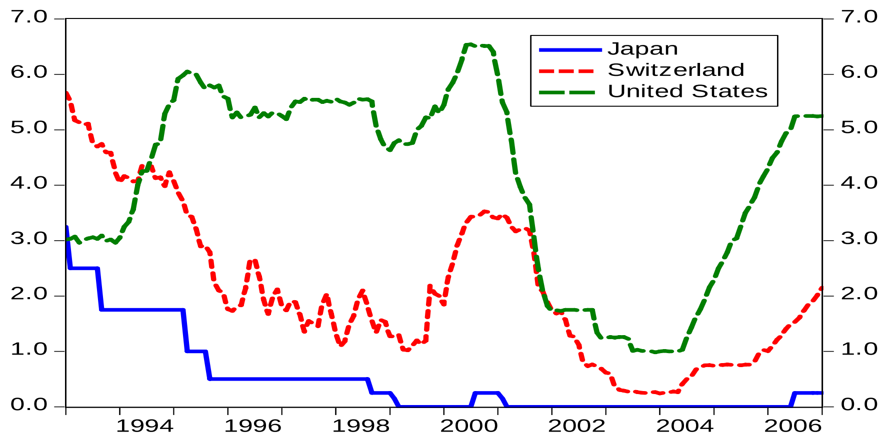
Period	IRD	VIX	IMR	FER	SUS	SJP
1	0.445	9.585	0.572	0.011	7.123	82.262
6	0.518	11.311	0.584	0.506	7.297	79.781
12	0.518	11.309	0.601	0.507	7.296	79.766
20	0.518	11.309	0.606	0.507	7.296	79.762

Table 1.6 VAR Granger Causality Tests (P-values)

	D(IRD)	D(VIX)	IMR	D(FER)	D(SUS)	D(SJP)
D(IRD)	-	0.9530	0.8452	0.1868	0.6729	0.3042
D(VIX)	0.1191	-	0.6492	0.3079	0.9552	0.1617
IMR	0.7274	0.6175	-	0.0434	0.5191	0.3359
D(FER)	0.4889	0.7179	0.0000	-	0.0586	0.0391
D(SUS)	0.7424	0.0169	0.1192	0.2873	-	0.2578
D(SJP)	0.4712	0.3893	0.5565	0.9082	0.0861	-

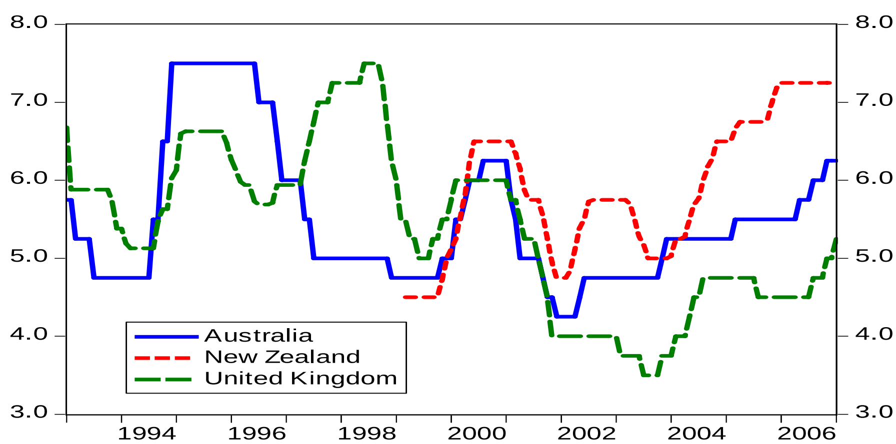
Note: Table shows the marginal probabilities associated with the Granger-causality test. The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Figure 1.1 Funding Currency Interest Rates



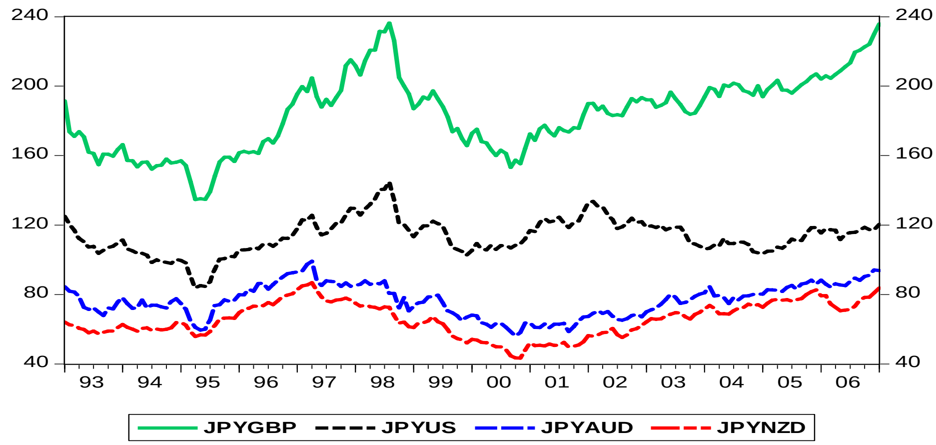
Note: Central bank target interest rates, in per cent; for the Japanese yen, BOJ target rate; for the Swiss franc, Libor target rate; for the U.S. dollar, the Federal Funds rate. Source: Bloomberg.

Figure 1.2 Target Currency Interest Rates



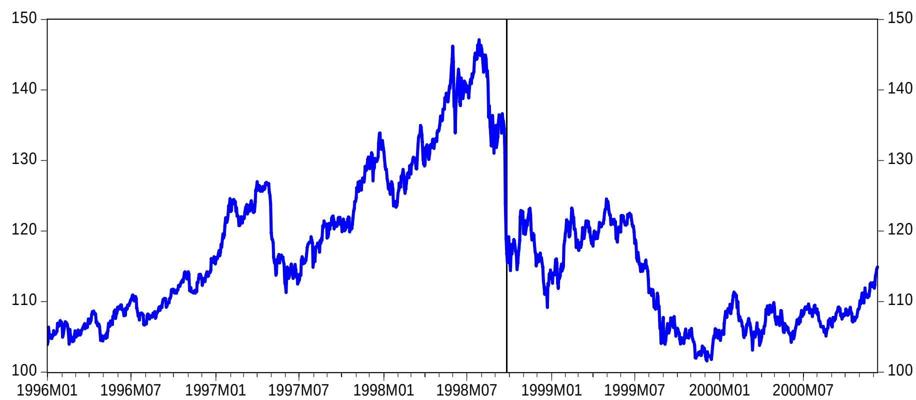
Note: Central bank target interest rates, in per cent; for the Australian dollar and the New Zealand dollar, cash rate; for the pound sterling, base rate. Source: Bloomberg.

Figure 1.3 Japanese Yen / Target Currencies



Source: Global Financial Data

Figure 1.4 Japanese Yen / US Dollar Exchange Rate



Source: Global Financial Data

Figure 1.5 Impulse Response of IMR

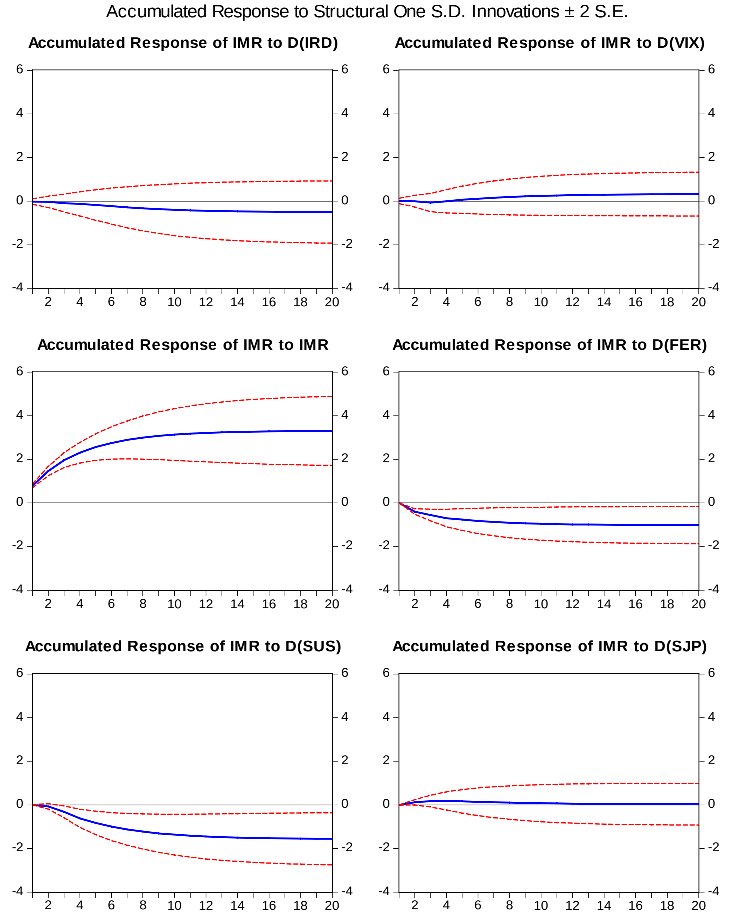
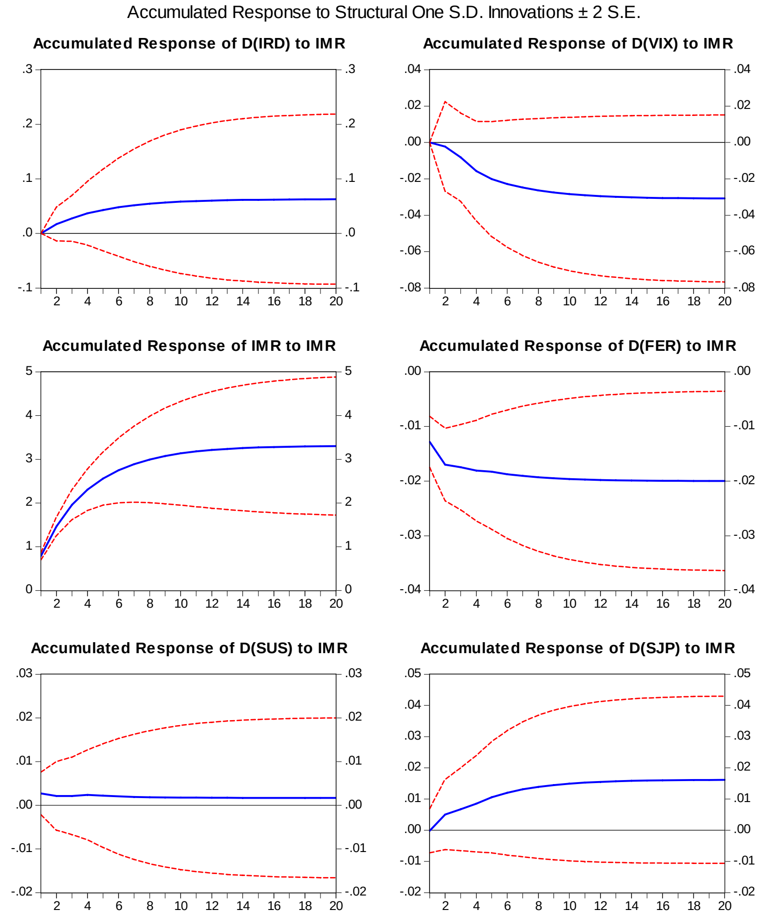


Figure 1.6 Impulse Responses to IMR



Note: *IRD* is the interest rate differential between the U.S. & Japan; *VIX* is the CBOE volatility index; *IMR* is the ratio of long to short positions in JPY futures; *FER* is the ratio of JPY to USD; *SUS* is the S&P500 stock index; and *SJP* is the Japanese Stock Price Index (TOPIX).

Figure 1.7 Impulse Responses of IMR

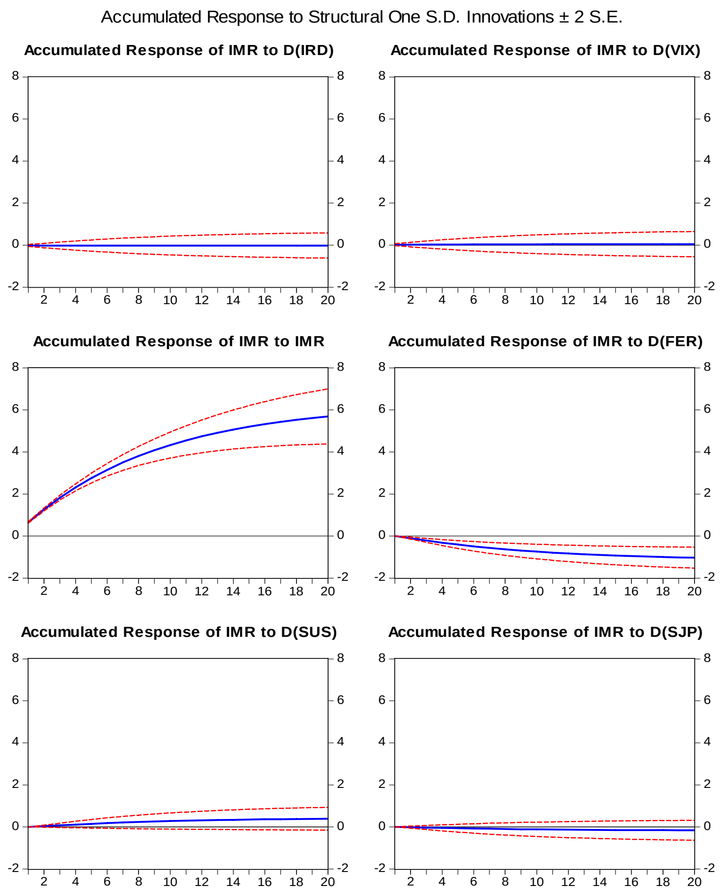
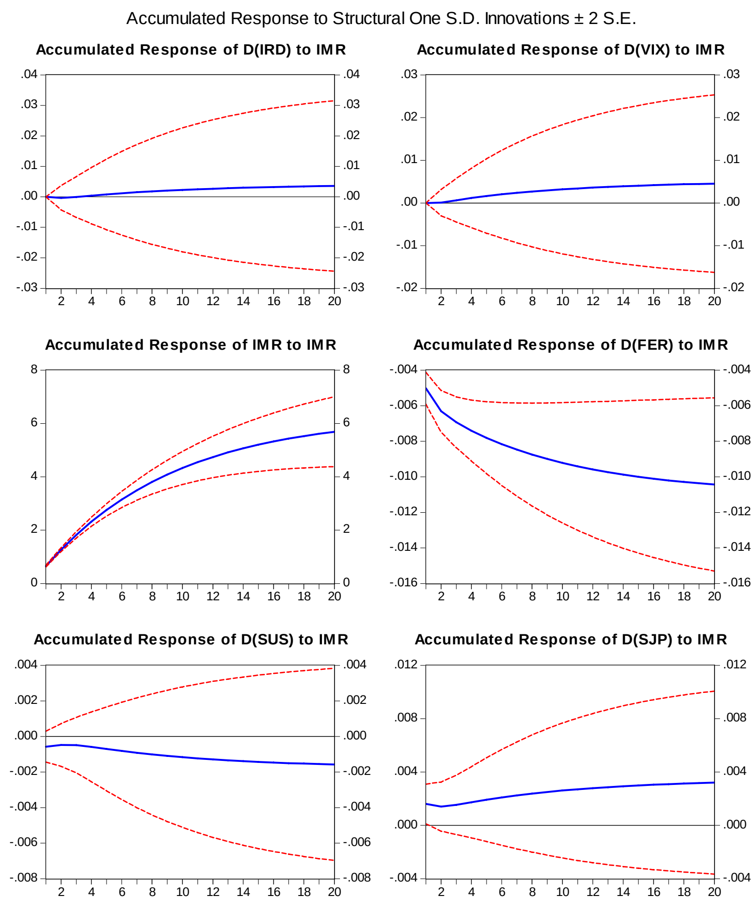


Figure 1.8 Impulse Responses to IMR



Note: *IRD* is the interest rate differential between the U.S. & Japan; *VIX* is the CBOE volatility index; *IMR* is the ratio of long to short positions in JPY futures; *FER* is the ratio of JPY to USD; *SUS* is the S&P500 stock index; and *SJP* is the Japanese Stock Price Index (TOPIX).

CHAPTER 2

CARRY TRADE, ORDER FLOW, AND EXCHANGE RATE BEHAVIOR

2.1. Introduction

The strategy of borrowing money in a currency with low interest rates – “funding currency” – in order to invest in a currency with higher interest rates – “target currency” – is commonly known as currency carry trade in financial markets. The dynamics of this strategy is relatively straightforward. An investor initiates by borrowing a given amount in a low-interest-rate currency, then converts the funds into a high-interest-rate currency, and finally lends the resulting amount in the target currency at the high interest rate. Thus, carry trade activity could have an important effect on exchange rate movements through changes in the supply and demand for currencies initiated by the opportunity to exploit interest rate differentials. As these strategies involve selling short funding currencies and at the same time, buying target currencies, they induce excess supply of the funding currencies and excess demand for target currencies (Cavallo, 2006).

According to the 2004 Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity conducted by the Bank for International Settlements (BIS), average daily turnover in foreign exchange markets rose to $1.9 trillion in April 2004, a rise of 54% at current exchange rates and 36% at constant exchange rates. This strong growth in turnover is attributed to (1) momentum trading whereby investors who took large positions in currencies that experienced a persistent trend of appreciation which induced an increase in hedging activity and further supported currency trades; (2) carry trading where interest rate differentials encouraged investments in high interest rate currencies financed by short positions in low interest rate currencies (Galati and Melvin, 2004).

However, precisely tracking the carry trade activity is a difficult task because it is hard to distinguish carry positions from other trades, as McGuire and Upper (2007) note. Nevertheless, BIS statistics may provide some insight since they include a currency breakdown of banks' international assets and liabilities. Furthermore, BIS statistics provide some evidence consistent with the role of the Japanese yen and the Swiss franc as funding currencies since official interest rates have been the lowest in Japan and Switzerland over the past several years. Data reveal that the total global yen-denominated claims reached $1.05 trillion in the first quarter of 2007 whereas Swiss franc-denominated claims have grown more steadily reaching $678 billion at the same period. Furthermore, Galati et al. (2007) state that the largest net flows of yen ($45 billion) over the period of 2002:Q2-2007:Q1 were from Japan to the Caribbean financial centers, which host a large number of hedge funds which in turn are expected to play a significant role for activity related to carry trades. During the same period of time, the largest cumulative net flows of Swiss francs ($19 billion) were from the euro area to the United Kingdom where banks passed much of this on to residents as well as non-residents. Moreover, the rise in Swiss franc claims is partly attributed to the Swiss franc-denominated mortgages in some eastern European countries such as Hungary, Poland, and Croatia. In fact, an estimated total of $15 billion was transferred from banks in the euro area to this region (Galati et al., 2007).

McGuire and Upper (2007) state that "[…] since carry trades involve foreign exchange transactions, data on open positions in exchange-traded FX futures in potential funding and target currencies provide the strongest evidence for carry trade activity". Particularly, data on the net open positions of non-commercial traders in different currency futures traded on the Chicago Mercantile Exchange (CME) have been the most widely used measure of carry trade activity in the futures market (Galati et al., 2007). Since net open positions of non-commercial traders are considered as the best indicator for carry trade activity, we are interested in studying the impact of these positions on exchange rate movements. First, the relationship in question is investigated using the Vector Autoregression (VAR) methodology and subsequent use of the impulse response functions as well as variance decompositions. Second, a multivariate Granger causality test, also known as a block exogenity test, is performed. And finally, out-of-sample forecast errors are produced using rolling regressions to test the forecasting performance of our microstructure model.

The organization of this chapter is as follows; the next section presents further discussions on the motivation of using the net open position of non-commercial traders in the foreign currency futures market to explain exchange rate movements. Section 2.3 introduces the essentials of the foreign currency futures market in the United States and Section 2.4 is a concise and selective review of the microstructure approach to exchange rates literature. The methodology and data are discussed in Section 2.5. Empirical results are presented in Section 2.6 and concluding remarks are provided in Section 2.7.

2.2. Order Flow and Exchange Rates

According to the traditional macro theories of exchange rate determination, a number of fundamental macroeconomic variables, such as income, money, interest rates and inflation, are expected to describe the way in which exchange rates evolve over time. For instance, the theory of purchasing power parity states (PPP), in the words of Frankel (1976), that the equilibrium exchange rate equals the ratio of domestic to foreign prices[2]. On the other hand, the theory of Uncovered Interest Parity postulates that the interest differential between countries should equal the expected the exchange rate[3]. These models of exchange rate determination assume that all macroeconomic information is publicly available and thus there is no private information. In other words, there is no role for trading activity for exchange rate determination since public information is already incorporated in the price. However, the landmark papers of Meese and Rogoff (1983a, 1983b) show that the percentage of monthly exchange rate movements that can be explained by macro models is very low and that their forecasting ability is even worse than a random walk. While subsequent studies have claimed to find success for various versions of fundamentals-based models, especially at longer horizons and over different time periods, the success of these models has not proved to be robust. For instance, a recent comprehensive study by Cheung, Chinn, and Pascual (2005) concludes that "the results do not point to any given model/specification combination as being very successful. On the other hand…, it may be that one model will do well for one exchange rate, and not for another." In fact, the failure of traditional models has led some researchers[4] to conclude that the main determinants of exchange rates are not macroeconomic.

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[2] $P_1 = \varepsilon P_2^*$, where P_1 is country 1's price level (in terms of its national currency), P_2^* is country 2's price level, and ε is the nominal exchange rate defined as the price of country 2 currency in terms of country 1 currency.

[3] A regression of exchange rate returns on the interest differential should give an intercept of zero and a slope coefficient of unity.

[4] Flood R.P. and A. K. Rose, "Fixing Exchange Rates: A Virtual Quest for Fundamentals", Journal of Monetary Economics, (1995), 36, 3-37.

In recent years, a new body of literature has developed that has sought to relax the strong assumption that all price-relevant information is available publicly and has instead stressed the importance of the process by which dispersed information becomes widely known to the market (Mogford and Pain, 2006). This particular body of literature, known as microstructure approach to exchange rate determination, is concerned with the transmission of information among market participants, the behavior of market agents, the importance of order flow, the heterogeneity of agents' expectations, and the implications of such heterogeneity for trading volume and exchange rate volatility (Sarno and Taylor, 2001). The key variable in micro-based exchange rate models is order flow which is essentially defined as the net of buyer- and seller-initiated transactions, and may be thought of as the net buying pressure (Lyons, 2001). It is contemplated that order-flow can communicate dispersed information about the fundamental determinants of exchange rates which the currency markets need to aggregate and should affect but may not yet be embodied in the currency exchange rates. Thus, a fundamental difference between macro and micro models is that while under the standard macro models exchange rates immediately react to shifts in macro aggregates without any change in investors' portfolio, the micro approach postulates the importance of the transmission link between information and exchange rates via order flow. In other words, micro-based models stress the significance of trading activity to explain the process through which spot rates are determined whereas such activity is deemed to be unimportant for the behavior of exchange rates under the traditional macro models. In any case, it would be realistic to treat microstructure models as a complement, rather than a substitute, to macro models since micro-based models transmit the information on fundamentals via the mechanism of trading. Evans and Lyons, in a series of papers, have theoretically motivated and empirically demonstrated a close contemporaneous relationship between daily exchange rate movements and order flow. The finding that order flow has more explanatory power than macro variables for exchange rate behavior gives some support to the importance of heterogeneous expectations (Bacchetta and van Wincoop, 2006).

Although, Lyons (2001) states "In FX, [however], the futures market is much smaller than the spot market; it is unlikely that a significant share of price determination occurs there (Dumas, 1996)", the role of foreign currency futures market in determining the behavior of exchange rates could be larger than expected since positions of traders are used as indicators for carry trade activity. Therefore, in this paper, I use the positioning data of traders on exchange-traded futures, which is publicly available, in contrast to the commercially available data used in similar studies of microstructure approach to exchange rate determination, to investigate the effect of net positions by type of trader on exchange rate behavior. Knowledge of a significant relationship between the position of traders in currency futures market and exchange rate movements might be useful to evaluate prospective financial stability conditions since the build-up and subsequent unwinding of speculative positions are associated with certain episodes of financial market instability such as the sharp appreciation of the yen against the US dollar between 6 and 8 October in 1998[5]. Thus, a proven relationship between positions of currency futures and spot exchange rates might be used to assess potential vulnerabilities in financial markets. To the best of the author's knowledge such an investigation has not yet been thoroughly performed in the microstructure literature of exchange rate

[5] Investigating the role of order flow, as well as macroeconomic announcements, to better understand the famous volatility of yen in October of 1998, Cai, J. et al. (2001) find out that portfolio shifts were responsible for much of the experienced volatility.

determination. Thus, this study is conducted with the intention of filling that gap. The next section introduces the essentials of the foreign currency futures market in the United States.

2.3. Foreign Exchange Futures Market

A futures contract, in general, is a binding agreement between a buyer and a seller to receive (in the case of a long position) or deliver (in the case of a short position) a commodity or financial instrument sometime in the future, but at a price that is agreed upon today. In the case of foreign currency futures contracts, the party taking a long position profits if the currency in the spot market appreciates against the dollar relative to the futures price. On the other hand, the party taking a short position gains if the currency depreciates in the spot market. In the U.S., foreign currency futures contracts are traded on the CME and are regulated federally by the Commodity Futures Trading Commission (CFTC), which is responsible for ensuring that prices and outstanding positions are communicated to the public. There are two known types of traders in the market; commercial and non-commercial. Commercial traders, such as pension funds, hedge funds or international companies, use currency futures to hedge their business operations because they might be concerned about exchange rate fluctuations. Thus, they are also known as hedgers in the market. Non-commercial traders, on the other hand, participate in futures markets simply to speculate on the direction of exchange rate movements and make profits. Therefore, non-commercial traders are described as speculators. It is important to mention that the groupings of these traders are based on self-identification and thus the distinction between commercial and non-commercial traders may be imperfect. Sanders et al. (2004) state that because position limits are placed on non-commercial investors, there may be some incentive for traders to self-classify as commercial. However, they suggest that reporting non-commercials most likely represent a relatively pure subset of total speculative positions. Traders in the futures market report their positions if they hold a number of contracts above the reporting level defined by the CFTC. Currently, the reporting level is set at 400 contracts for major foreign currency futures. Traders holding contracts below the reporting levels are classified as non-reportable traders (also known as small traders). The CFTC provides a breakdown of positions in futures through its Commitments of Traders (COT) report which is calculated from Wednesday to Tuesday and released to the public the following Friday since January 1993[6]. The net position in currency futures of each group of traders is defined as:

$$net_{j,t} = long_{j,t} - short_{j,t}$$

where *j* is either commercial or non-commercial traders, *t* is time, and *long* and *short* are the number of long contracts and short contracts, respectively, held in the foreign currency futures by trader type *j*. Figure 2.1 presents the movements of net non-commercial positions in major currency futures markets sampled monthly. The net positions are in units of 10,000 contracts. Although, the fluctuations are large, it appears that speculators are, on average, net long in British pound, Canadian dollar, and German mark-Euro combination. On the other hand, they seem, on average, net short in Japanese yen and Swiss franc. These outcomes are in accord with the observed interest rates for each currency, as seen in Figure 2.2. Official interest rates have been the lowest in Japan as well as in Switzerland over the past several years. Consequently, the Japanese yen and the Swiss franc have been considered as major funding currencies in carry trade

[6] Before January 1993, the CFTC used to report the commitments of each trading group bi-monthly.

transactions. On the other hand, the official interest rates, on average, in Canada, United Kingdom, and the Euro area combined with German overnight rate for Deutsche mark, have been 3.95, 5.06, and 3.53 percent, respectively as seen from Table 2.1. Thus, they have been treated as target currencies in carry trade dealings.

2.4. Related Literature Review

Since our objective is to study the impact of net positions in currency futures market on the spot exchange rate movements, we consider the relevant literature as the microstructure approach to exchange rate determination. Evans and Lyons (2002) analyze the ability of inter-dealer order flow data collected from Reuters Dealing 2000-1[7] to explain the daily variation of DEM/USD and JPY/USD[8] during a 4-month period from May to August 1996. Using a single equation Ordinary Least Squares (OLS) methodology, they regress the daily log change in each exchange rate on the daily change in interest rate differential – a proxy for fundamentals – and daily inter-dealer order flow. Their results indicate that order flow explain more than 60 percent of daily changes in the deutsche mark/dollar rate and more than 40 percent of the daily changes in the yen/dollar rate. However, when Sager and Taylor (2008) perform the Granger-causality test for the Evans and Lyons (2002) data, in order to test whether order flow precede exchange rate movements, they find that a significant Granger-causal relationship runs from exchange rate returns to order flow for both the mark-dollar and yen-dollar exchange rates. Nevertheless, in order to take account of the possible feed-back effects of exchange rates

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[7] Reuters Dealing 2000-1 was the most widely used *direct* electronic dealing system.

[8] We use the following ISO codes for currencies mentioned in the text: USD is US dollar, DEM is Deutsche mark, JPY is Japanese yen, GBP is British pound, CAD is Canadian dollar, CHF is Swiss franc, AUD is Australian dollar, SEK is Swedish krona, NOK for Norwegian krone, FF for French franc, BEF for Belgian franc, DKK for Danish krone, ITL for Italian lira, NLG for Dutch guilder.

on the order flow, a simple linear Vector Autoregression (VAR) model is employed by Payne (2003). He uses USD/DEM data set covering the activities of multiple dealers, as opposed to the operations of a single dealer, through Reuters Dealing 2000-2[9] over the week between October 6 and October 10, 1997. Payne (2003) findings suggest that order flow imbalance is still a key determinant of short-term exchange rate movements even when the possibility of feedback trading rules are taken into account. Froot and Ramadorai (2005) also investigate the relation between order flow and exchange rate returns repeating the analysis of Evans & Lyons (2002) but employing a data set containing more than 6 million FX transactions by more than 10,000 mutual funds over the period between January 1, 1994 and February 9, 2001 obtained from State Street Corporation[10]. They find out that international inflows are strongly and positively correlated with contemporaneous exchange rate returns. Rime (2001) uses weekly U.S. Treasury data for inter-dealer order flow of major participants[11] in the U.S. sector of the foreign exchange market during the period of July 1995 to September 1999. The currencies studied by Rime (2001) are the USD against DEM, JPY, GBP, CAD, and CHF. Based on a similar single equation OLS model of Evans and Lyons (1999), author concludes that order flow has a strong effect on price changes for DEM/USD, GBP/USD, and CHF/USD exchange rates. Rime (2001) also finds that the level of exchange rates and their respective cumulative order flow are positively co-integrated using single equation residual based tests. Berger et al. (2008) analyze minute-by-minute order flow

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[9] Reuters Dealing 2000-2 is an electronic *broking* system.

[10] State Street is one of the world's largest global custodians, responsible for approximately 7 trillion US dollars of institutional-investor portfolios.

[11] The data used by Rime defines a major participant – customers as well as dealers – as one with more than $50 billion equivalent in foreign exchange contracts, including spot, forward, and options, on the last business day of any quarter during the previous year (Rime, 2001).

and exchange rate returns on the Electronic Broking System[12] (EBS) platform for the EUR-USD and USD-JPY currency pairs from January 1999 through December 2004. Authors find a strong contemporaneous association between exchange rate returns and inter-dealer order flow at intra-daily and daily horizons. However, the association weakens at two and three-month horizons. Testing for co-integration, they find conflicting results using the Engle-Granger (1987) and Johansen (1988) tests. While the Engle-Granger test fails to reject the null hypothesis of no co-integration for either the euro or the yen, the Johansen trace test rejects (i.e. finds co-integration) for the euro but not for the yen. Similarly, Daníelsson et al. (2002) investigate the importance of order flow for exchange rate determination across various frequencies[13] using transaction-level information for EUR/USD, EUR/GBP, GBP/USD, and USD/JPY for 10 months in 1999 through 2000 obtained from the Reuters Dealing 2000-2. Akin to the previously mentioned study, they demonstrate that contemporaneous order flow significantly explains exchange rates, but at very high frequencies (less than one hour). Klitgaard and Weir (2004) analyze the relationship between the change in the net foreign currency futures positions of speculators in the Chicago Mercantile Exchange (CME) and the percentage change in the foreign currency per dollar exchange rate using a single equation OLS model for the period of January 5, 1993 through May 20, 2003. They find a strong contemporaneous relationship between weekly changes in speculators' net positions and exchange rate moves. However, they fail to find evidence of causality running from positions data to exchange rates.

[12] EBS dominates spot *brokered* inter-dealer trading in dollar/yen and is responsible for an estimated 90 percent of dollar/euro business (Chinn and Moore, 2008).

[13] 5-, 15-, 30-minutes, 1-, 4-, 6-hours, 1-day, and 1-week.

Several studies also explore the information content of disaggregated order flow in foreign exchange markets. For instance, Lyons (2001) employs three different end-users of order flow data: unleveraged financial institutions, leveraged financial institutions, and non-financial corporations. He obtains monthly customer trade data from Citibank covering the periods from January 1993 to June 1999 and studies the behavior of the USD/EUR and the USD/JPY. His findings suggest that while unleveraged investors are the key players in the USD/EUR market, flow of leveraged investors in the USD/JPY show the largest price impact. Furthermore, Marsh and O'Rourke (2004) use daily observations of Royal Bank of Scotland's customer order flow data for the period of August 1, 2002 and June 29, 2004 to study the following currency pairs: EUR/USD, EUR/JPY, EUR/GBP, GBP/USD, GBP/JPY, and USD/JPY. They disaggregate order flow for each exchange rate into four categories of customers: non-financials, unleveraged financials (such as mutual funds), leveraged financials and finally other financials which includes trades of small banks. They conclude that while order flows by non-financials are negatively correlated with exchange rate movements, flows by financials are positively correlated. Carpenter and Wang (2003) use tick-by-tick observations of all external FX transactions of a major Australian bank in the AUD/USD and EUR/USD exchange rates over a period of 45 days in 2002. Traders are disaggregated into 3 groups: central banks, non-bank financial institutions, and non-financial corporations. Authors observe that while central bank trades, in the case of AUD, seem to have the greatest impact on the exchange rate, central bank trades in the case of EUR are insignificant. However, the price impact of non-bank financial institutions is significant for both AUD and EUR. Non-financial corporations seem to have the smallest price impact except in the case of EUR. Bjønnes et al. (2003) examine the relationship between the Swedish krona-euro and order flow for the period of January 1995 through June 2002[14] with data provided by the central bank of Sweden, Sveriges Riksbank. Authors conclude that order flow initiated by large brokers that have maintained a local presence in the SEK/EUR market for an extended period has more price impact than the equivalent flow from relatively smaller banks that are less well established in the domestic market. This lends support to the assertion that informed order flow does appear to have a significant explanatory function for the exchange rate returns. The results of all the above mentioned studies are based on single equation OLS regressions.

Furthermore, studies have investigated the long-run relationship between the order flow and the corresponding spot exchange rate. Bjønnes and Rimes (2005) examine cumulated order flow using the direction of all the trades in Reuters D2000-1, D2000-2, & EBS for the period of March 2-6, 1998. They test only a subset of their exchange rates for co-integration, using the system-based Maximum Likelihood (Johansen) approach. They find weak evidence of co-integration for the NOK/DEM rate and stronger evidence for the DEM/USD rate. Killen et al. (2006) have data on the daily value of purchases and sales in the FF/DEM market from January 1998 to May 1998 (4 months) in the brokered inter-dealer market from EBS. They find significant evidence of co-integration between cumulative order flow and exchange rates using both the Engle-Granger (1987) and Johansen (1988) approaches. Boyer and Norden (2006) examine nine currencies, which are DEM, JPY, GBP, BEF, CHF, DKK, FF, ITL, and NLG, against the USD over a period of 83 business days from May 1 to August 31, 1996. This period coincides with

[14] For the period prior to January 1, 1999, authors use SEK/DEM.

Evans and Lyons (2002) study. Authors match spot exchange rates and daily inter-dealer order flows from the Reuters Dealing 2000-1 system. They focus on the maximum likelihood test for co-integration proposed by Johansen (1988) and Johansen and Juselius (1990). They find evidence of a stable long-run relationship for only a small number of major currencies and for two currencies that no longer exist (French franc and Dutch guilder). Lastly, Chinn and Moore (2008) use monthly data from January 1999 to January 2007 from the EBS for the USD/JPY and USD/EUR exchange rates to test for co-integration between the exchange rates, cumulative order flow and certain fundamentals data. Their conclusion points to an important role for cumulative order flow in determining long-term exchange rates but only in combination with monetary fundamentals such as interest rates, money, and inflation indices.

2.5. Data and Methodology

5.1. Data

Our focus, in this paper, is on the dynamic link between the order flow of non-commercial traders in the currency futures market and the spot exchange rates. Although, the term “order flow” is primarily defined as the difference between the buyer- and seller-initiated transactions, it has taken on different meanings in different settings. In this study, our purpose is in the extent to which futures traders provide a price discovery function so the order flow we are interested in is the net proprietary trading by the speculators on the floor of the currency futures market. I add the positions of non-reportable traders in my computations of net positions as well since Klitgaard and Weir (2004) states that non-reportable traders are treated as speculators based on discussions with market participants. The analyses cover the period from January 5, 1993 to

December 31, 2007. The five currencies studied in this paper for which futures contracts are traded on the CME are: the British pound (GBP), the Canadian Dollar (CAD), the euro (EUR), the Japanese yen (JPY), and the Swiss franc (CHF). These five foreign currency futures contracts are selected because they represent the most active currency futures markets in terms of overall trading volume. In order to make the sample size consistent across all the futures positions, I use the Deutsche mark (DEM) futures data from January 5, 1993 to December 29, 1998 to complete the Euro series. Andersen et al. (2007) and Wang et al. (2008) use the same approach to merge the German mark and the Euro series. We obtain futures positioning data for those currencies from the COT report which is calculated from Wednesday to Tuesday and released to the public the following Friday. Since net positions represent the outcome of weekly adjustments of trading strategies by traders, the daily exchange rates are averaged over the Wednesday-Tuesday interval to match the COT data. The exchange rate data is gathered from the Federal Reserve Bank of New York. We report the descriptive statistics for the net positions of non-commercial traders in the currency futures market as well as the descriptive statistics for the corresponding spot exchange rates in Table 2.1.

We observe from Table 2.1 that speculators, on average, take net long positions in the British pound, Canadian dollar, and the German mark-Euro combination futures. On the other hand, they are net short in the Japanese yen and Swiss franc futures. In fact, on average, speculators seem to take the largest net short position in Japanese yen and the largest net long position in German mark-euro futures. The smallest net short position is in Swiss franc futures while the smallest net long position is in British pound futures. Furthermore, among the net short positions, Japanese yen futures have the largest standard deviation while the Swiss franc futures have the smallest. On the other hand, among the net long positions, the smallest standard deviation belongs to the British pound followed by the Canadian dollar futures while the largest standard deviation belongs to the German mark-euro futures. Notice, normality is rejected for all the currency futures. We note that during the observed period exchange rates on the spot market have experienced major fluctuations. The Japanese yen has the largest fluctuation followed by the Swiss franc and the German mark-euro. On the other hand, the British pound followed by the Canadian dollar has the smallest fluctuation. Accordingly, the Japanese yen has the largest standard deviation while the British pound has the smallest one. Note that none of the spot exchange rates are normally distributed. The Jarque-Bera test provides evidence against the hypothesis of normality in all the exchange rates.

Lastly, Table 2.2 presents the contemporaneous relations between the net positions of speculators in foreign currency futures and their corresponding spot exchange rates. Notice all the correlations are negative indicating that increases in the number of long positions relative to the number of short positions in foreign currency futures lead to an appreciation of the foreign currency relative to the USD. As seen from the table, the correlations between the futures positions and exchange rates are relatively high, except for the Swiss franc. All the exchange rates are entered into natural logarithms. Furthermore, in the spirit of the Uncovered Interest Parity (UIP), I include interest rate differentials in my analyses. UIP states that the interest differential between countries should on average equal the expected change in the exchange rate. Thus, if the domestic interest rate is greater than the foreign interest rate, the domestic currency is expected to depreciate and likewise, if the domestic interest rate is less than the foreign interest rate, the domestic currency is expected to appreciate. Interest rate differential is the main engine of exchange rate variation in macro models of exchange rate determination. Here, I use the following central bank target interest rates; for the British pound, the bank rate, for the Canadian dollar, the target rate, for the Euro zone, the main refinancing rate[15], for the Japanese yen, the uncollateralized call rate, for the Swiss franc, the 3-month Swiss Libor target rate, and for the US dollar, the Federal Funds rate. The data on interest rates is gathered from Bloomberg.

5.2. Methodology

In order to test the dynamic relationship among the net position of speculators in currency futures market, exchange rate movements and interest rates, I use the following trivariate VAR representation:

$$IRD_t^{h-h^*} = \alpha_{10} + \sum_{i=1}^{p} a_{1i} IRD_{t-i} + \sum_{j=1}^{p} b_{1j} NP_{t-j} + \sum_{k=1}^{p} c_{1k} FX_{t-k} + \varepsilon_{1t}$$

$$NP_t^h = \alpha_{20} + \sum_{i=1}^{p} a_{2i} IRD_{t-i} + \sum_{j=1}^{p} b_{2j} NP_{t-j} + \sum_{k=1}^{p} c_{2k} FX_{t-k} + \varepsilon_{2t}$$

$$FX_t^h = \alpha_{30} + \sum_{i=1}^{p} a_{3i} IRD_{t-i} + \sum_{j=1}^{p} b_{3j} NP_{t-j} + \sum_{k=1}^{p} c_{3k} FX_{t-k} + \varepsilon_{3t}$$

where

$IRD_t^{h-h^*}$ = The interest rate differential between the U.S. and foreign country where h is the nominal dollar interest and h^* is the nominal nondollar interest rate during time period t

NP_t^h = The net position of speculators in currency h during time period t

FX_t^h = The spot foreign exchange rate for currency pair h during time period t

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[15] For the German Mark rate, I use the Germany overnight rate.

$\alpha_{i0} = 1\times3$ vectors containing constant terms

$\varepsilon_{it} =$ Disturbance terms

Prior to using the VAR methodology, I test the order of integration for all the time series using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results are presented in Table 2.3. Both the ADF and PP tests are in accord with each other for all the interest rate differential variables except IRD^{US-CH}. While the ADF test rejects the null hypothesis of a unit root at the 10 percent significance level for the difference between the Federal Funds rate and the Swiss franc Libor rate, the PP test rejects it at the 1 percent significance level. I decided to first difference the IRD^{US-CH} variable when entering it into the VAR system for Swiss franc[16]. Notice all the net position in foreign currency futures are integrated of order zero, I(0), and therefore entered into the VAR system in levels. Finally, both the ADF and PP tests reject the null hypothesis of a unit root at the 1 percent significance level for the natural logarithm of all the exchange rates. Hence, they are all first differenced when entered into the VAR system. We generate a dummy variable in the VAR system for the DEM and EUR grouping to control for the introduction of the official currency of the European Union in January 1, 1999.

One of the advantages of using VAR methodology is to employ innovation accounting in the form of impulse response functions and forecast error variance decomposition analysis to examine the relationships among economic variables. Impulse response analysis allows us to study the response of one variable to an impulse in another variable in a system that involves a number of further variables as well. If there is a

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[16] The empirical conclusions do not differ when the variable in question is not first differenced when entered into the VAR system.

reaction of one variable to an impulse in another variable we may call the latter causal for the former. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR system, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR. In addition to innovation accounting analysis, I perform a block exogenity test, also known as a multivariate version of the Granger-causality test, which tells us weather lags of one variable Granger cause any other variables in a given system. Thus, in carrying out the above mentioned econometric tests, one of the important factors is to properly determine the lag length of the variables in the models. Otherwise, it is realized that the incorporation of insignificant variables may over parameterize the model estimation, producing biased estimates and hence arriving at wrong inferences. Here, the lag order selection is based on Log Likelihood, Final Prediction Error, Akaike, Schwarz and Hannan-Quinn information criteria and a lag structure that is selected by at least three out of the five criteria is chosen for each model[17].

2.6. Empirical Results

6.1. Impulse Response Functions and Variance Decompositions

Figure 2.3 displays the generalized impulse responses to a one-standard deviation innovation of a particular shock on all the variables over a 20-week period range. We observe the following outcome in all the figures: that is, when a positive shock is

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[17] Based on this criterion, the optimum lag lengths are as follows; two for the Canadian dollar, Deutsche Mark-Euro, and Japanese yen equations, three for the British pound, and finally eight for the Swiss franc equation.

introduced to the net position of speculators in the foreign currency futures market, the corresponding currency in the spot market experiences an instantaneous appreciation which continues about 3 periods into the future. For instance, the pound experiences an immediate appreciation against the US dollar in the spot market when the net position of speculators in the GBP futures increases. Furthermore, we also notice that foreign currency futures react to shocks in the spot market. For instance, a positive shock, which indicates a sudden depreciation, say in the CAD per USD exchange rate, leads to a decrease in the CAD futures positions. These responses to shocks in the spot market are also instantaneous and last rather longer periods. Table 2.4 reports the variance decompositions. The variance decomposition of the spot rates, *FX*, suggests that shocks to the net position of speculators, *NP*, explain a significant percent of the variation in the spot rate. For instance, GBP speculators net positions in the futures market explain about 40 percent of the variation of the British pound per U.S. dollar exchange rate in the spot market. The net speculators positions of CAD futures explain 43 percent of the variation in the CAD/USD spot exchange rate. The net positions in the (DEM) EUR futures explain 37 percent of the variation in the (DEM) EUR/USD spot exchange rate while JPY speculators net positions in the futures market explain about 34 percent of the variation in the spot JPY/USD market. And lastly, the net positions of speculators in the CHF futures explain on average 45 percent of the variation in the Swiss franc per U.S. dollar exchange rate in the spot market.

6.2. Granger Causality Tests

For block exogenity test, I perform the Wald test, which is a multivariate version of the Granger causality test, because Granger causality test is of limited usefulness in a

VAR system. Granger causality test describes the bilateral relationships between independent and dependent variables in a single equation, holding all else constant. However, even if a specific independent variable does not Granger-cause a particular dependent variable, it may still influence that same dependent variable through its interaction with the other variables in the system. Block-exogeneity tests generalize Granger causality, indicating whether the lagged independent variables jointly affect a particular dependent variable. Enders (1995) suggests calling this multivariate generalization of Granger causality test as "block causality" test. Table 2.5 provides the p-values for testing whether the coefficients for lagged values of a given variable are jointly equal to zero. According to the test results, in each case, the net position of speculators in the currency futures market, NP^h, significantly Granger-causes the corresponding foreign exchange rate, FX^h, in the spot market. We also notice, in some cases, causality running in the opposite direction. For example, in the case of GBP, and CAD futures, the net positions of speculators are Granger-caused by the movements of the spot GBP and CAD rates against the USD in the foreign exchange market. Hence, there is bi-directional causality between the net position of speculators in CAD futures and CAD/USD rates as well as between the net position of speculators in British pound futures and GBP/USD rates. The reverse causality from the spot market to the futures market is not observed in the Deutsche mark-Euro combination, the Japanese yen and the Swiss franc rates. Thus, there is only one-way causality running from the net position of mark-euro, yen and franc speculator futures to the (DEM) EUR/USD, JPY/USD and CHF/USD spot rates, respectively. Furthermore, we observe that the interest rate differential between the U.S. and Switzerland Granger-causes the spot rate of CHF/USD in the foreign exchange market. We also note that the same is true for the interest rate differential between the Federal Funds rate and the Main Refinancing rate for Europe. In summary, we find that, despite the fact that the size of the currency futures market is small compared to the over-the-counter market[18], the positions of speculators in the foreign currency futures lead to price discovery in the 'cash' market for exchange rates.

6.3. Out-of-Sample Forecasting

It is well known in the empirical exchange rate literature that findings of good in-sample fit do not often prove durable. Thus, this study adopts the convention in the empirical exchange rate modeling literature of implementing "rolling regressions" established by Meese and Rogoff (1983a). That is, estimates are applied over an initial data sample, out-of-sample forecasts are constructed, then the sample is moved up, or "rolled" forward one observation before the next set of forecasts are produced. Thus, the number of observations in the regression stays constant across forecasts. This process continues until all the out-of-sample observations are exhausted. This procedure has the potential benefit of lessening parameter instability effects over time. We evaluate the forecasting performance of our model to the random walk model by using two popular measures in the exchange rate literature; the root mean squared error (RMSE) and mean absolute error (MAE).

$$\text{RMSE: } \sqrt{\sum_{t=T+1}^{T+h} (\hat{y}_t - y_t)^2 / h}$$

$$\text{MAE: } \sum_{t=T+1}^{T+h} |\hat{y}_t - y_t| / h$$

[18] According to the 2007 Bank of International Settlements Triennial Survey, average daily volume in exchange-traded currency products totaled 72 billion compared with 2,319 billion in over-the-counter products.

where $\hat{y}$ and y are the forecast and true series, respectively and h is the number of forecasts. The RMSE is the square root of the average of the squared differences between forecasts and observations whereas MAE is the average of the absolute differences between forecasts and observations. While both measures are similar to each other, the RMSE is more sensitive to large errors. In other words, it gives greater weight to large errors than to small errors in the average.

It is important to recall that our model includes interest rate differentials as a conventional macroeconomic variable. To this end, the model resembles that of Chinn and Moore (2008) who employ several macroeconomic variables in addition to the order flow data obtained from EBS and thereby creating a hybrid model. Thus, our forecasts incorporate a macroeconomic variable into our microstructure exchange rate model. Our out-of-sample forecast period is from June 26, 2007 to December 31, 2007. Forecasts are generated at horizons of 1-, 3-, 6-, 9-, and 12-week(s) ahead using rolling regressions. Our goal is to find out whether our microstructure model provides smaller RMSE and MAE than the random walk (RW) model. Table 2.6 shows, for each currency pair, and for each forecasting horizon, the RMSE and the MAE. The table revels that our somewhat hybrid model beats the random walk model at every horizon into the future for the GBP, CAD, and DEM-EUR exchange rates. The same inference, however, cannot be made for the JPY. The random walk dominates over our hybrid model. While the RMSEs for the random walk model is consistently lower than our model for the CHF rate, the MAEs of our model beats the MAEs of the random walk model for all the horizons into the future. Thus, our conclusion is that the net position of speculators in the foreign currency futures market accompanied with interest rate differentials has the ability to forecast the direction of the spot exchange rates better than the naïve random walk model for three of the five currencies under investigation in this study.

2.7. Conclusion

The microstructure approach to exchange rate determination is relatively a recent phenomenon in the exchange rate literature. It stresses the importance of heterogeneous traders who act on their own bits of private information, as well as on public information. The most important variable in the microstructure model of exchange rate determination is order flow. In this study, net positions of speculators in the foreign currency futures market are treated as order flow since these positions reveal the buying and selling pressure in the currency futures market. Firstly, we found out that exchange rates react instantaneously to shocks in speculators positions and that the net positions explain a significant variation in the exchange rates. Secondly, we tested for causality between the variables and showed that the position of speculators in the foreign currency futures market lead to price discovery in the spot market for exchange rates. Thirdly, the out-of-sample performance of our microstructure model reveled that the net position of speculators in the foreign currency futures market has the ability to forecast the direction of the spot exchange rate for GBP/USD, CAD/USD and (DEM) EUR/USD better than the simple naïve random walk model at every horizon under investigation. Therefore, it seems that currency speculators in the futures market have enough bits of useful information to allow them to change their net positions in a way that changes the direction of those exchange rates. It is a bit thought provoking that our somewhat hybrid model, since it includes a macro as well as a micro variable, forecasts the direction of the above mentioned currencies to some extend better than the random walk model but fails to do the same for the Japanese yen and the Swiss franc. Remember that data on net speculative positions in the various foreign currency futures are widely used to measure carry trade activity in the market. During the period under investigation, both the Japanese yen and the Swiss franc were considered to be funding currencies because of the significantly low interest rates they had. On the other hand, the British pound, Canadian dollar and the Euro were on the list of target currencies with high interest rates. It is attention-grabbing that our model does well in forecasting those currencies that speculators were, on average, net long and does poorly for those currencies that speculators were, on average, net short.

Table 2.1 Descriptive Statistics

Net Positions of Speculators	GBP	CAD	(DEM) EUR	JPY	CHF
Mean	0.9150	1.3485	1.8000	-1.9700	-0.8481
Median	0.6280	1.0813	1.6026	-2.3339	-0.9111
Maximum	11.2469	9.9612	14.1542	8.5882	5.9113
Minimum	-5.2210	-8.7049	-9.2017	-18.6459	-9.3381
Std. Dev.	2.7563	2.9213	4.4890	4.1205	2.7150
Skewness	0.9128	0.0116	0.2231	-0.2184	-0.1036
Kurtosis	4.2319	3.3763	2.9990	3.8759	2.6231
Jarque-Bera	158.4678	4.6437	6.5040	31.3023	6.0265
Probability	(0.000)	(0.098)	(0.038)	(0.000)	(0.049)

Exchange Rates	GBP/USD	CAD/USD	(DEM) EUR/USD	JPY/USD	CHF/USD
Mean	0.6133	1.3649	1.1955	113.642	1.3925
Median	0.6215	1.3723	1.0992	113.980	1.3729
Maximum	0.7283	1.6128	1.8810	147.140	1.8250
Minimum	0.4738	0.9168	0.6728	81.120	1.1005
Std. Dev.	0.0567	0.1450	0.3709	10.254	0.1720
Skewness	-0.4304	-0.5333	0.3075	-0.0128	0.4663
Kurtosis	2.3805	2.7398	1.5435	3.7495	2.2519
Jarque-Bera	183.34	196.48	407.43	91.675	233.00
Probability	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Interest Rates	U.K. Bank Rate	Canadian Target Rate	German Overnight & Euro Area Main Refinancing Rate	Japanese Call Rate	3-Month Swiss Libor Rate
Mean	5.0593	3.9451	3.5251	0.4593	2.0400
Median	5.2500	4.2500	3.2500	0.2500	1.8383
Maximum	7.5000	8.4700	8.9000	3.2500	5.6680
Minimum	0.5000	0.2500	1.000	0.0000	0.2429
Std. Dev.	1.4951	1.6756	1.5165	0.6656	1.3342
Skewness	-1.3250	0.0810	1.1892	1.9119	0.5901
Kurtosis	5.3737	3.1834	5.0529	6.0289	2.5506
Jarque-Bera	107.58	0.5090	83.9091	202.26	13.5576
Probability	(0.000)	(0.7752)	(0.000)	(0.000)	(0.001)

Note: A net position is defined as the long open interest less the short open interest and is in units of 10,000 contracts.

Table 2.2 Correlation Matrix

Net Position of Speculators	Exchange Rates				
	GBP/USD	**CAD/USD**	**(DEM) EUR/USD**	**JPY/USD**	**CHF/USD**
GBP	-0.6184				
CAD		-0.2901			
(DEM)EUR			-0.6345		
JPY				-0.2485	
CHF					-0.0066

Table 2.3 Unit Root Test

	Augmented Dickey-Fuller		Phillips-Perron	
Variables	**Level**	**First Difference**	**Level**	**First Difference**
IRD $^{US-GB}$	-2.46	-30.14***	-2.46	-30.05***
IRD $^{US-CA}$	-3.32**	-29.25***	-3.34**	-29.22***
IRD $^{US-(DE)EU}$	-3.98***	-29.38***	-3.70***	-30.16***
IRD $^{US-JP}$	-2.21	-28.07***	-2.14	-29.37***
IRD $^{US-CH}$	-2.79*	-19.11***	-4.39***	-77.17***
NP ^{GBP}	-6.05***	-25.77***	-5.42***	-29.05***
NP ^{CAD}	-5.00***	-24.48***	-4.62***	-24.31***
NP $^{(DEM)\ EUR}$	-4.95***	-25.86***	-4.15***	-29.61***
NP ^{JPY}	-5.99***	-25.54***	-5.46***	-27.25***
NP ^{CHF}	-7.03***	-23.25***	-6.48***	-23.90***
ln(FX $^{GBP/USD}$)	-0.96	-18.79***	-0.81	-21.81***
ln(FX $^{CAD/USD}$)	0.70	-22.33***	0.79	-22.27***
ln(FX $^{(DEM)\ EUR/USD}$)	-0.90	-27.58***	-0.91	-27.58***
ln(FX $^{JPY/USD}$)	-2.51	-22.95***	-2.51	-22.93***
ln(FX $^{CHF/USD}$)	-1.40	-21.76***	-1.22	-20.65***

Note: ***H_o of a unit root is rejected at the 1%, **5%, and *10% level. *IRD* is interest rate differential, *NP* is net positions, and *FX* is foreign exchange rate.

Table 2.4 Variance Decompositions

Explained Variable	Horizon (weeks)	GBP			CAD			(DEM) EUR			JPY			CHF		
		IRD	**NP**	**FX**	**IRD**	**NP**	**FX**	**IRD**	**NP**	**FX**	**IRD**	**NP**	**FX**	**IRD**	**NP**	**FX**
IRD	**1**	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00
	5	98.94	0.44	0.60	99.88	0.11	0.00	99.48	0.51	0.00	99.84	0.05	0.09	99.60	0.17	0.21
	10	98.62	0.75	0.61	99.81	0.17	0.01	97.50	2.49	0.00	99.80	0.10	0.09	98.36	0.82	0.81
	15	98.52	0.86	0.61	99.77	0.21	0.01	94.95	5.04	0.00	99.79	0.11	0.09	98.33	0.82	0.83
	20	98.46	0.91	0.61	99.76	0.22	0.01	92.35	7.64	0.00	99.78	0.12	0.09	98.33	0.83	0.83
NP	**1**	0.52	99.47	0.00	0.05	99.94	0.00	0.27	99.72	0.00	0.18	99.81	0.00	0.02	99.97	0.00
	5	1.85	96.98	1.15	0.12	98.80	1.06	0.26	99.73	0.00	0.04	99.39	0.56	0.05	99.55	0.39
	10	2.14	96.81	1.03	0.12	98.68	1.18	0.24	99.75	0.00	0.02	99.31	0.65	0.61	98.67	0.71
	15	2.23	96.75	1.00	0.12	98.65	1.21	0.23	99.76	0.00	0.02	99.29	0.68	0.62	98.56	0.81
	20	2.26	96.73	0.99	0.12	98.64	1.22	0.21	99.77	0.00	0.02	99.28	0.69	0.62	98.54	0.83
FX	**1**	0.95	36.65	62.38	0.85	39.56	59.57	0.00	31.41	68.58	0.00	30.88	69.11	0.00	47.72	52.27
	5	2.05	40.60	57.33	0.82	43.56	55.61	0.07	37.06	62.85	0.27	34.70	65.02	0.63	52.46	46.90
	10	2.06	40.60	57.32	0.82	43.59	55.58	0.08	37.12	62.78	0.27	34.70	65.02	3.22	50.90	45.86
	15	2.06	40.60	57.32	0.82	43.60	55.57	0.09	37.16	62.74	0.27	34.70	65.02	3.30	50.97	45.72
	20	2.06	40.60	57.32	0.82	43.61	55.56	0.09	37.18	62.71	0.27	34.70	65.02	3.30	51.01	45.68

Note: The table reports the forecast error variance decompositions which indicate the amount of information each column variable contributes to the row variables. *IRD* is interest rate differential, *NP* is net positions, and *FX* is foreign exchange rate.

Table 2.5 VAR Granger Causality Tests P-Values

	D (IRD $^{US-GB}$)	**NP ^{GBP}**	**D (FX $^{GBP/USD}$)**
D (IRD $^{US-GB}$)	-	0.4417	0.1111
NP ^{GBP}	0.0190	-	0.0000
D (FX $^{GBP/USD}$)	0.2117	0.0032	-
	D (IRD $^{US-CA}$)	**NP ^{CAD}**	**D (FX $^{CAD/USD}$)**
D (IRD $^{US-CA}$)	-	0.9529	0.8711
NP ^{CAD}	0.4655	-	0.0000
D (FX $^{CAD/USD}$)	0.9568	0.0058	-
	IRD $^{US-(DE) EU}$	**NP $^{(DEM) EUR}$**	**D (FX $^{(DEM) EUR/USD}$)**
IRD $^{US-(DE) EU}$	-	0.9185	0.0589
NP $^{(DEM) EUR}$	0.0106	-	0.0000
D (FX $^{(DEM) EUR/USD}$)	0.7788	0.8648	-
	D (IRD $^{US-JP}$)	**NP ^{JPY}**	**D (FX $^{JPY/USD}$)**
D (IRD $^{US-JP}$)	-	0.6741	0.2300
NP ^{JPY}	0.7117	-	0.0000
D (FX $^{JPY/USD}$)	0.7069	0.1101	-
	D (IRD $^{US-CH}$)	**NP ^{CHF}**	**D (FX $^{CHF/USD}$)**
D (IRD $^{US-CH}$)	-	0.0813	0.0023
NP ^{CHF}	0.6790	-	0.0000
D (FX $^{CHF/USD}$)	0.5809	0.1340	-

Note: The table reports the p-values for Granger causality tests for interest rate differentials (IRD), net positions (NP), and exchange rates (FX). The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Table 2.6 Out-of-Sample Forecast Errors

	Horizon	RW		Hybrid	
		RMSE	**MAE**	**RMSE**	**MAE**
GBP	1- week	0.85	0.75	0.72	0.65
	3- weeks	0.87	0.74	0.77	0.66
	6- weeks	0.88	0.74	0.79	0.65
	9- weeks	0.87	0.72	0.80	0.64
	12- weeks	0.87	0.71	0.78	0.62
CAD	1- week	1.15	1.01	1.06	0.93
	3- weeks	1.26	1.03	1.17	0.95
	6- weeks	1.37	1.07	1.27	0.99
	9- weeks	1.36	1.05	1.25	0.98
	12- weeks	1.39	1.06	1.26	0.98
DEM-EUR	1- week	0.82	0.77	0.69	0.64
	3- weeks	0.84	0.76	0.73	0.64
	6- weeks	0.85	0.76	0.76	0.66
	9- weeks	0.86	0.77	0.77	0.66
	12- weeks	0.86	0.77	0.76	0.65
JPY	1- week	1.09	0.97	1.13	1.22
	3- weeks	1.19	1.00	1.12	1.03
	6- weeks	1.26	1.01	1.28	1.04
	9- weeks	1.27	0.99	1.30	1.04
	12- weeks	1.24	0.96	1.28	1.02
CHF	1- week	0.88	0.82	0.89	0.75
	3- weeks	0.90	0.81	0.96	0.76
	6- weeks	0.90	0.79	0.98	0.76
	9- weeks	0.89	0.77	0.99	0.76
	12- weeks	0.89	0.76	0.99	0.75

Note: RW stands for random walk and Hybrid refers to the model being investigated in this paper. Root mean squared errors (RMSE) and Mean Absolute Errors (MAE) are multiplied by 100.

Figure 2.1 Net Non-Commercial Positions of Traders in Major Currency Futures

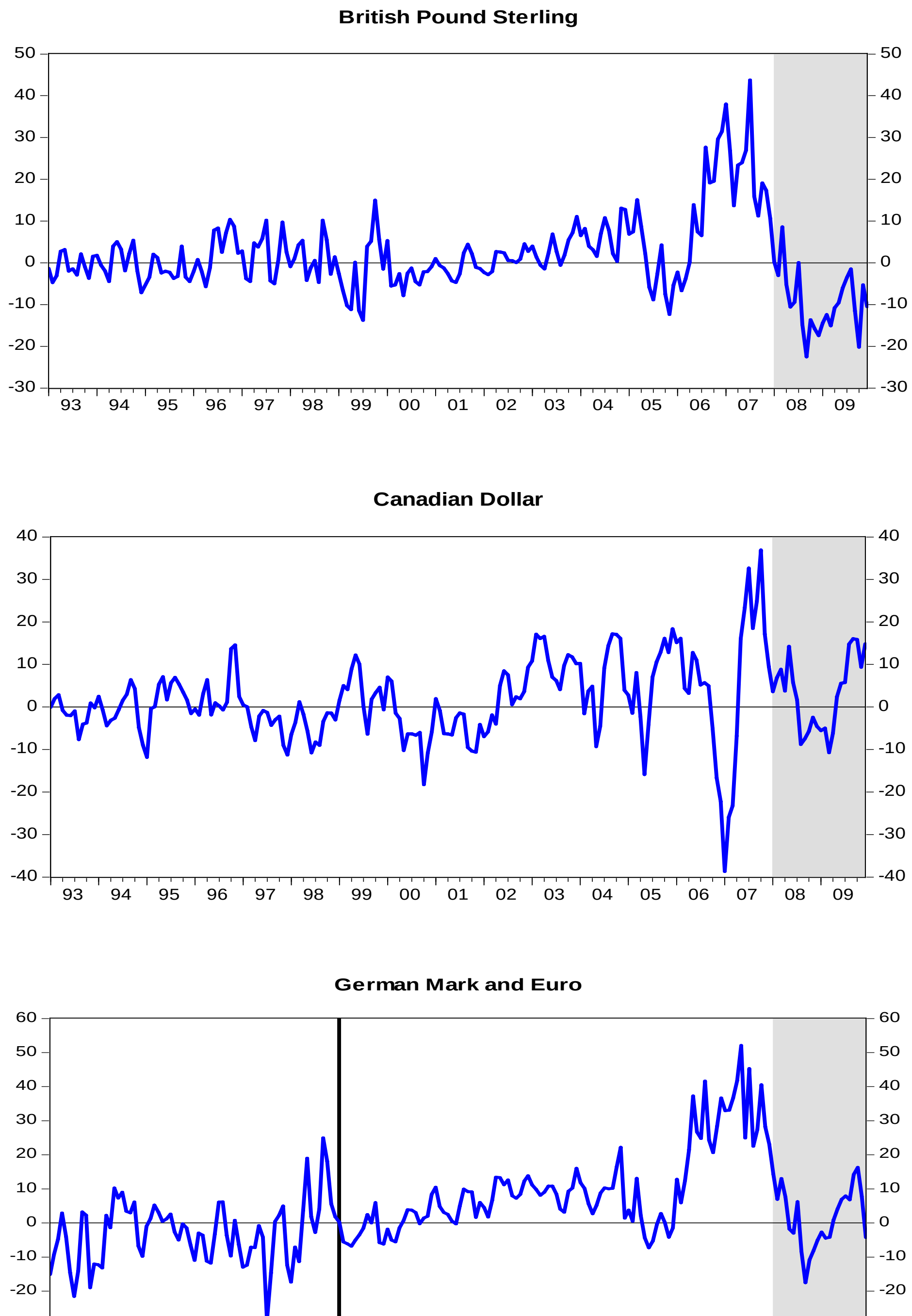
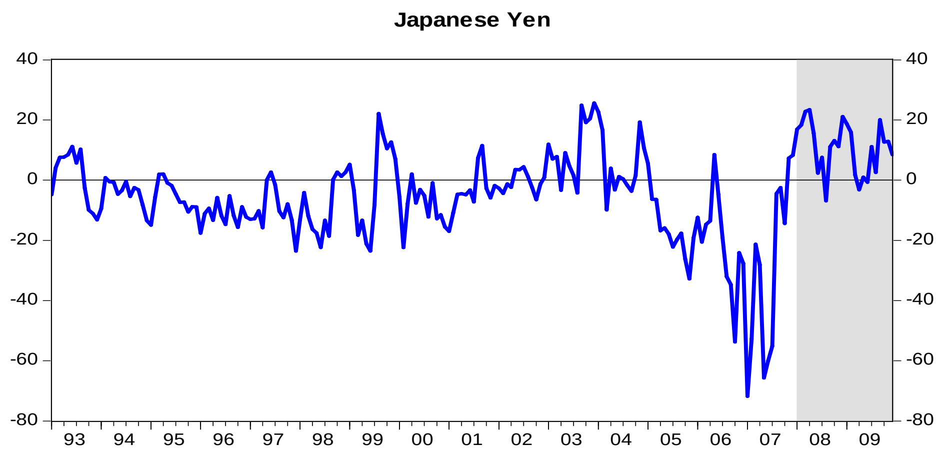
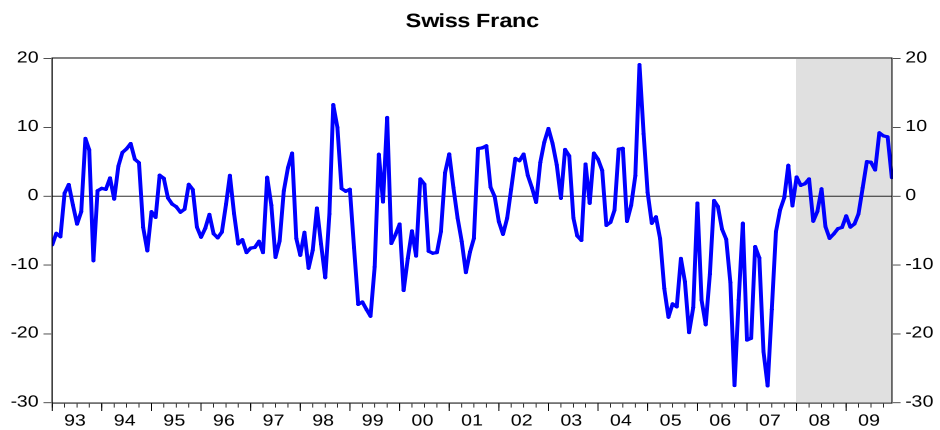


Figure 2.1 (Continued)





Source: Commitment of Traders Report. The shaded period corresponds to the recent global financial crisis and the vertical line in DEM-EUR grouping marks the launch of common currency in Europe.

Figure 2.2 Interest Rates and Foreign Exchange Rates

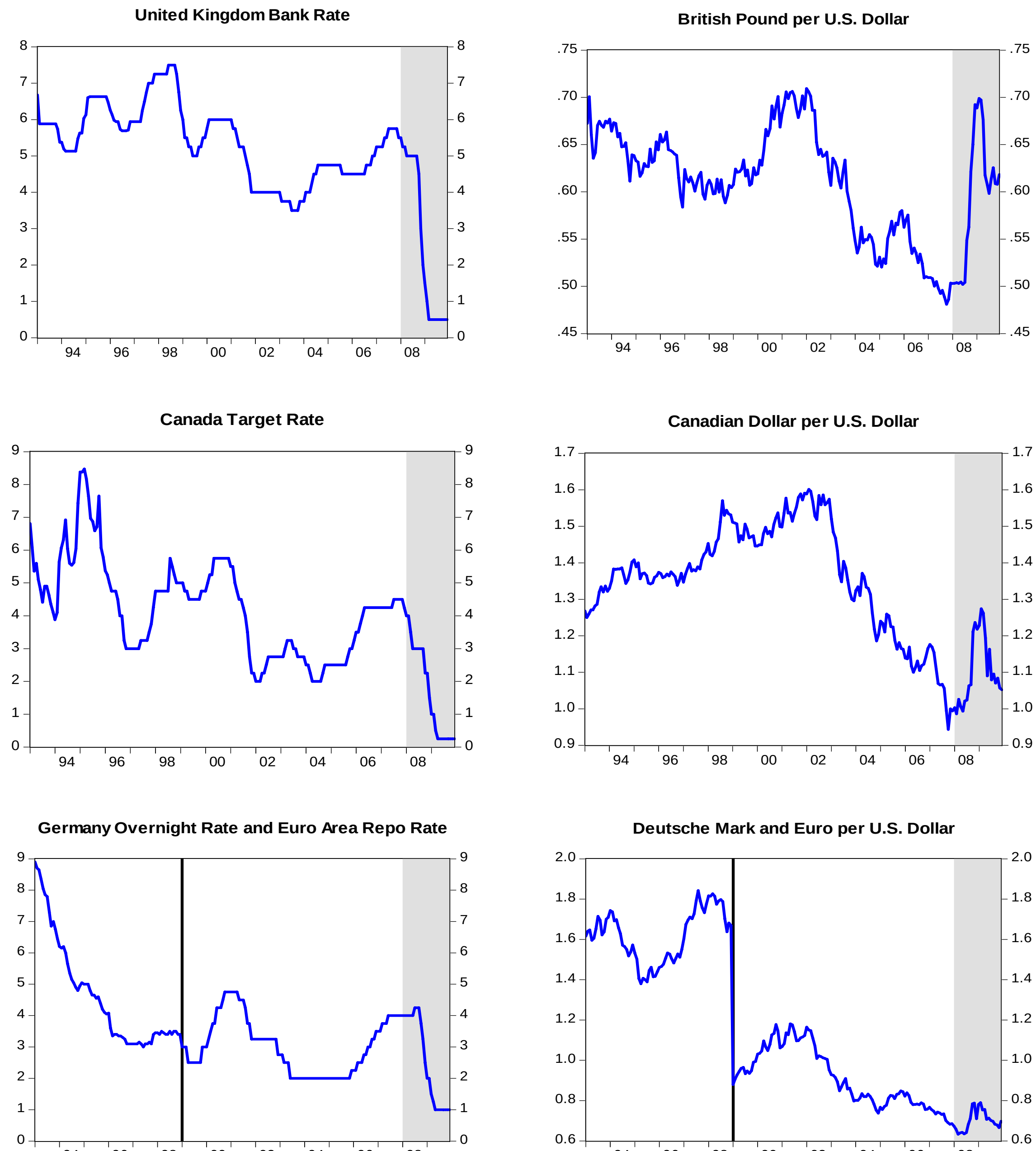
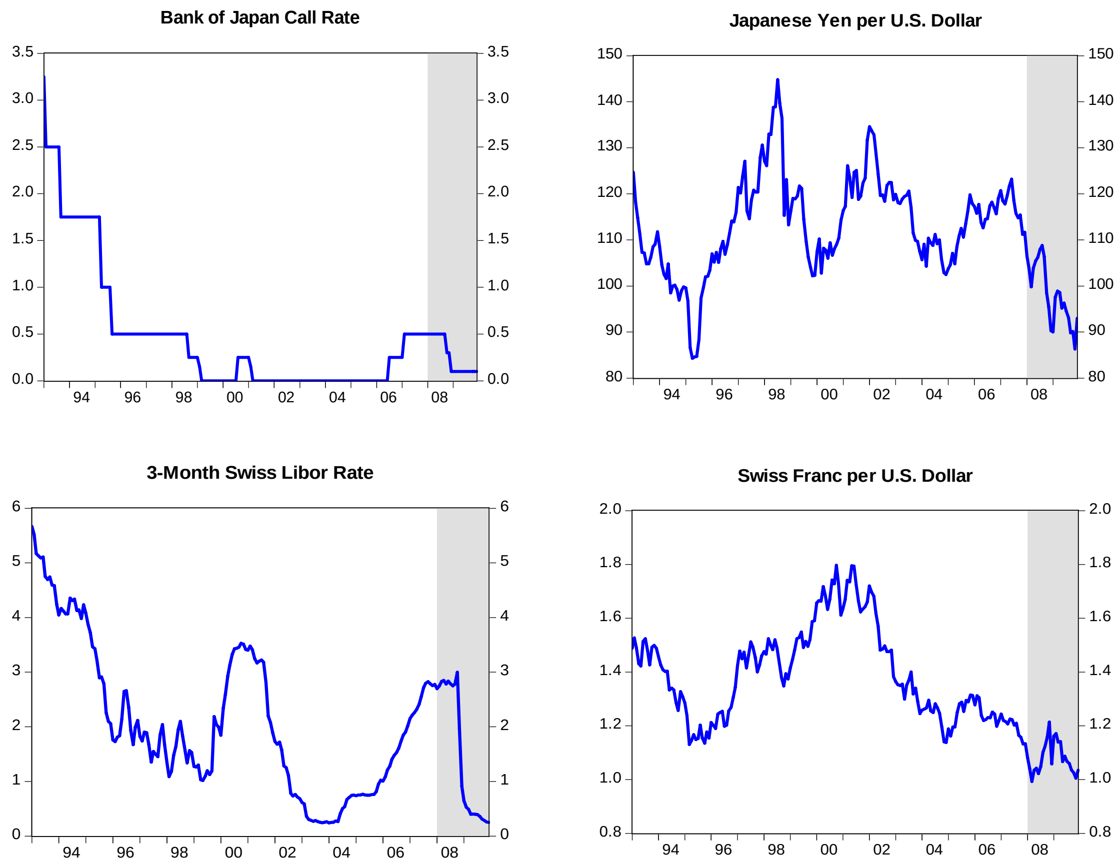
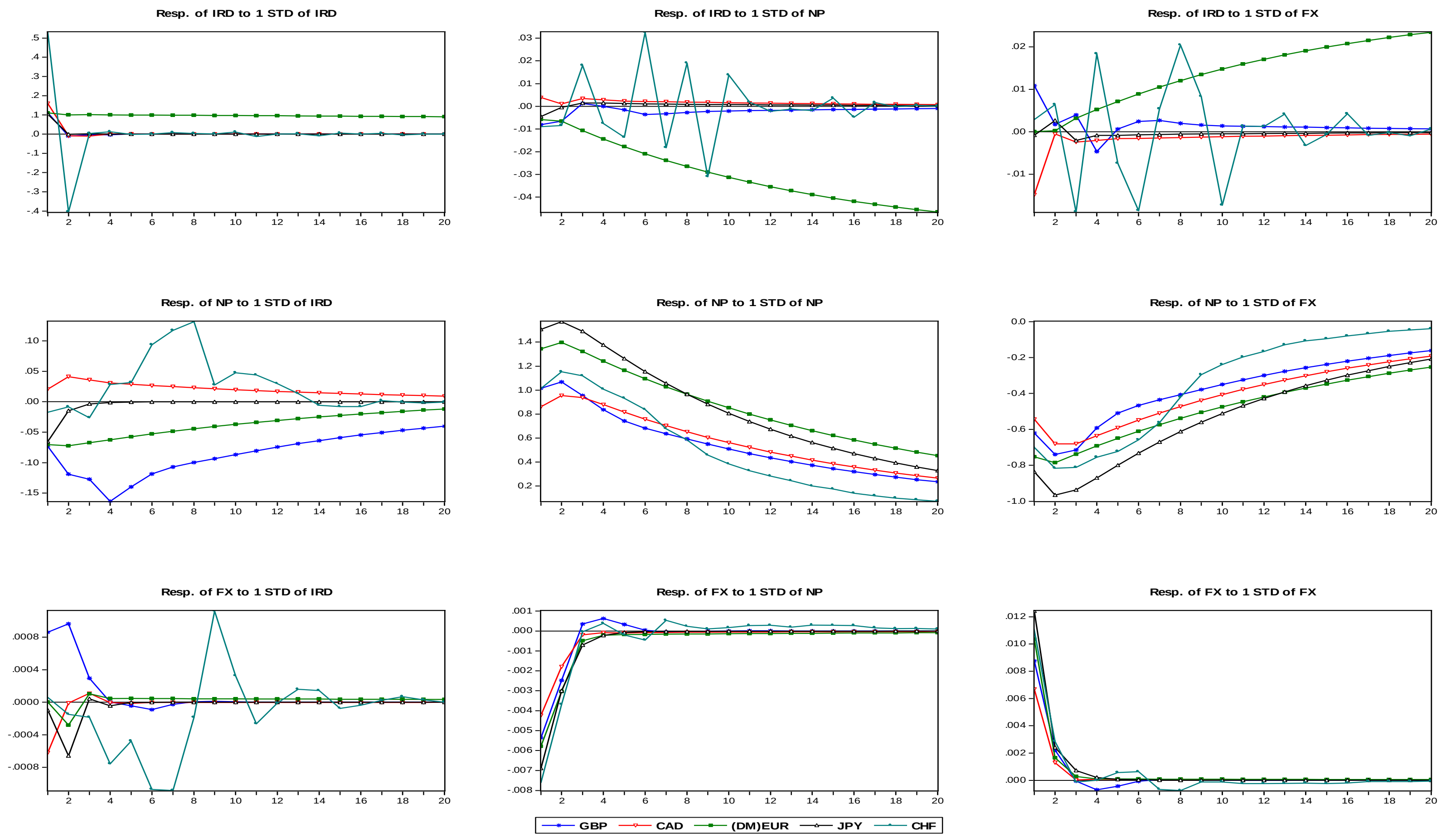


Figure 2.2 (Continued)



Source: Bloomberg and Federal Reserve Bank of New York. The shaded period corresponds to the recent global financial crisis and the vertical line in DEM-EUR grouping marks the launch of common currency in Europe.

Figure 2.3 Generalized Impulse Responses of Interest Rate Differentials, Net Positions, and Exchange Rates to a Shock



Note: The figure plots the time path of the impulse response functions of interest rate differentials (IRD), net positions (NP), and exchange rates (FX) to a one standard deviation shock of themselves and each other for the British pound (GBP), Canadian dollar (CAD), German mark-euro (DEM) EUR, Japanese yen (JPY), and Swiss franc (CHF).

CHAPTER 3

THE EFFECT OF NET POSITIONS IN FOREIGN CURRENCY FUTURES ON PRICE VOLATILITY OF SPOT EXCHANGE RATES

3.1. Introduction

The relationship between futures trading activity and exchange rate volatility has been studied extensively. Clifton (1985) finds that volume of trading activity in the currency futures market is significantly correlated with exchange rate fluctuations in the interbank foreign exchange market. Grammatikos and Saunders (1986) indicate a bi-causal relationship between futures trading volume and futures currency prices. Adrangi and Chatrath (1998) employ data compiled from the Commodity Futures Trading Commission's (CFTC) Commitment of Traders (COT) report which provides a periodic breakdown of the net positions of commercial, non-commercial, and small traders and demonstrate that surges in the participation of large speculators and small traders destabilize the markets. More recently, Wang (2002) investigating the effect of net positions on return volatility of currency futures markets shows that volatility is positively associated with shocks in net positions of speculators and small traders, and negatively related to shocks in net positions of hedgers.

This paper also makes use of the CFTC's COT report but to investigate the dynamic relationship between the net position of traders in foreign currency futures and price volatility of spot exchange rates in a Vector Autoregression (VAR) framework. Thus, the proxy for trading activity is the net position of traders in currency futures. Most research on futures trading activity and exchange rate volatility has concentrated on the contemporaneous volatility-volume relation, with few studies examining the dynamic lagged relationships between trading activity and volatility. In fact, to the best of the author's knowledge, there has been no work examining the lagged relationship between the net position of traders in currency futures market and volatility of spot exchange rates. However, the use of VAR methodology in this study is inspired by two recent articles. On the one hand, Bhargava and Malhotra (2007) use the VAR system to determine the relationship between volatility and volume and use Granger tests to determine whether there is any causality. However, authors do not use the net position of traders in currency futures markets. Instead, they use the aggregate open interest position of commercial and non-commercial traders. On the other hand, Nguyen and Daigler (2007) use the volume data of commercial and non-commercial traders to investigate the dynamic relation among return, volume, and volatility for futures markets by employing a VAR model as well. While this particular methodology used in previous studies examine the relation between trading activity, measured by either volume or open interest, and volatility in the futures market by type of trader, the current study employs the VAR methodology to investigate the relationship between the net position of traders in foreign currency futures and volatility in the corresponding spot exchange rates. A net position is defined as the long open interest less the short open interest based on the CFTC's COT report. Notice that our choice of methodology is different from the earlier studies examining the effect of net positions by type of trader on volatility. However, we follow the convention of distinguishing between commercial, non-commercial, and small traders to explain how each affects price variability. Furthermore, we use three different ways to measure volatility: (i) the historical standard deviation, which gives volatility for investors with a long investment horizon; (ii) weekly range (the extreme value estimator), which measures the volatility of speculators and day traders; and finally (iii) conditional variance based on generalized autoregressive conditional heteroskedasticity (GARCH).

This chapter proceeds as follows. Section 3.2 reviews the previous literature. Section 3.3 discusses the paper's data and methodology. Section 3.4 explains the empirical results, and Section 3.5 presents the conclusions.

3.2. Literature Review

Previous studies on the relationship between trading in futures and the underlying price volatility provide mixed evidence. Eldridge (1984) investigates the impact of the futures positions taken by European traders at the end of their business day on the volatility of currency futures traded on the International Monetary Market and find that the price volatility in German mark futures contracts temporarily rises at the close of the European business day. Grammatikos and Saunders (1986) also find a strong positive correlation between futures trading volume and futures currency prices. McCarthy and Najand (1993) find that trading in German mark futures has a stabilizing impact on volatility and that Canadian dollar futures have a destabilizing impact. Bessembinder and Seguin (1993) find that futures return volatility is positively associated with trading volume, but negatively related to open interest. Chang et al. (1997) find a positive relation between speculative trading volume and price volatility in the S&P 500 index, Treasury bonds, gold, corn, and soybean futures markets. Chang et al. (2000) report a positive relation between price volatility and (long/short) hedging positions, but a negative relation between volatility and (long/short) speculative positions in the S&P 500 index futures market. Wang (2002) investigate the effect of net positions by type of trader on return volatility in currency futures markets by decomposing net positions into expected and unexpected components. The author finds that while an unexpected change in net positions of speculators and small traders is positively associated with volatility, there is a negative connection between an unexpected change in net positions of hedgers and volatility. Bhargava and Malhotra (2007) examine the relationship between trading activity in currency futures and exchange rate volatility, using both volume and open interest to distinguish between speculators and hedgers. They find that speculators destabilize the market for futures while the role of the hedgers on volatility is inconclusive.

A few researchers explicitly study the relationship between currency futures trading and exchange rate volatility. For instance, Clifton (1985) shows that the volume of trading activity in the currency futures market is significantly correlated with exchange rate fluctuations in the interbank foreign exchange market during the early 1980s. However, the author does not find causality except in the case of Canadian dollar. Chatrath, Ramchander and Song (1996) provide stronger evidence on the causality between futures trading volume and exchange rate volatility. Adrangi and Chatrath (1998) group trader like hedgers, speculators, and small traders separately and find that large speculators and small traders destabilize markets.

3.3. Data and Methodology

3.1. Data

Figure 3.1 presents the movements of net non-commercial, commercial and non-reportable traders in major currency futures markets. The net positions are in units of 10,000 contracts. Notice that the movements of non-commercials and commercials are the opposite of each other. That is because when we sum the entire outstanding long and short futures market positions, the number of contracts bought must always equal to the number of contracts sold. Thus, the total must always equal to zero. In other words, the net non-commercial positions are always taken against the net commercial positions and vice versa. For instance, an increase in the net non-commercial positions must be met by an equivalent decrease in the net commercial positions.

Net position of non-commercial accounts
+
Net position of commercial accounts = 0

However, this definition ignores the role of non-reportable or small traders. One must add the net positions of small traders either on to the net position of non-commercial or commercial traders in order to reach the required sum of zero. Therefore, the positions of small traders should not be disregarded in futures markets. The data for futures positions are obtained from the COT report which is calculated from Wednesday to Tuesday and released to the public the following Friday by the CFTC. The six currencies studied in this study for which futures contracts are traded on the CME are: the British pound (GBP), the Canadian Dollar (CAD), the euro (EUR), the German mark (DEM), the Japanese yen (JPY), and the Swiss franc (CHF). These foreign currency futures contracts are selected because they represent the most active currency futures markets in terms of overall trading volume. The period under investigation is from January 5, 1993 to December 31, 2007. The spot exchange rate data is gathered from the Federal Reserve Bank of New York. Since net positions represent the outcome of weekly adjustments of trading strategies by traders, the daily volatility estimates are averaged over the Wednesday-Tuesday interval to match the COT data.

3.2. Methodology

We use the VAR methodology given by Sims (1972) to determine the relationship between spot market volatility and net trader's positions in foreign currency futures market. The model is expressed as follows:

$$Vol_t = \alpha_{10} + \sum_{j=1}^{k} a_{1j} Vol_{t-j} + \sum_{j=1}^{k} b_{1j} TA_{t-j} + \varepsilon_{1t}$$
$$TA_t = \alpha_{20} + \sum_{j=1}^{k} a_{2j} TA_{t-j} + \sum_{j=1}^{k} b_{2j} Vol_{t-j} + \varepsilon_{2t}$$

where *Vol* refers to volatility and *TA* is trading activity. We use three different measures for volatility, namely, historical standard deviation, extreme value estimator, and conditional variance based on generalized autoregressive conditional heteroskedasticity (GARCH). Bhargava and Malhotra (2007) use the same three measures of volatility and the same methodology to study the relationship between open interest as well as volume in currency futures market on the volatility of currency futures prices. Here, trading activity is measured by the net position of non-commercial, commercial and non-reportable traders. Since the net positions represent the outcome of weekly adjustments of trading strategies by traders, the daily volatility estimates are averaged over the Wednesday-Tuesday interval to match the COT data. The lag order selection is based on Log Likelihood, Final Prediction Error, Akaike, Schwarz and Hannan-Quinn information criteria and a lag structure that is selected by at least three out of the five criteria is chosen for each model. Augmented Dickey-Fuller and Phillips-Perron tests are conducted to test for stationarity for all the series. The results are presented at Table 3.1.

Our first measure for exchange rate variability is the historical standard deviation which is defined by the following equation:

$$HSD = \sqrt{\sum \frac{\left(R_t - \overline{R}\right)^2}{T-1}}$$

where $R_t = \ln\left(\frac{S_t}{S_{t-1}}\right)$ and $\overline{R} = \sum_{t=1}^{T} \frac{R_t}{T}$

S is equal to the spot exchange rates of currencies under investigation. Volatility is also measured using the weekly high and low levels of exchange rates by the following equation:

$$WR = \frac{\left(H_t - L_t\right)}{\left(H_t + L_t\right)/2}$$

where H_t and L_t are the weekly high and low levels of currencies in the spot market, respectively. Finally, we use conditional variance from the GARCH (1, 1) model on the returns R_t of the five currencies. It has been shown that GARCH (1, 1) is the most common and appropriate model used to determine conditional variance of exchange rates. GARCH (1, 1) model can be written as:

$$R_t = \mu_{t-1} + \varepsilon_t$$
$$\varepsilon_t \left| I_{t-1} \sim N\left(0, h_t\right)\right.$$
$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1}$$

where μ_{t-1} is the mean R_t conditional on past information and h_t is the measure of volatility.

Nguyen and Daigler (2007) employ three types of structural analyses to examine the relation between volume and volatility using data from various futures markets in a VAR model. We conduct the same three analyses. They are: (1) Granger causality analysis, (2) impulse response functions, and (3) forecast variance decompositions. Granger causality statistics determine whether lagged values of the variables help to “Granger cause” the relevant dependent variable. Descriptions of the other analysis are provided with the results.

3.4. Empirical Results

4.1. Granger Causality Tests

Tables 3.2 through 3.4 provide the p-values for testing whether the coefficients for the lagged values of a given variable are jointly equal to zero. Table 3.2 presents the Granger causality test results between the net position of traders in currency futures market and GARCH (1, 1) estimate of volatility of the corresponding currencies in the spot market. We observe a causal direction from commercial traders to volatility for all the contracts except the Euro. The strongest causality from commercial traders in futures market to spot volatility is present in the Canadian dollar while the weakest is in the Swiss franc. Furthermore, we observe causality running from non-commercial traders to volatility for Canadian dollar and Swiss franc. Similarly, there is causality from small traders in British pound and German mark futures to spot volatility in British pound and German mark. Note that there is bi-directional causality in the case of non-commercial traders in the Canadian dollars. While there is no causality from non-commercial traders in Euro futures to volatility of Euro spot exchange rate, there is, however, reverse causality. That is, we observe causality running from volatility to non-commercial positions in Euro futures.

On the other hand, when we look at Table 3.3 which displays the causality test results for the net position of traders and historical standard deviation estimate of volatility, we see a somewhat different picture. Now, we observe a causal direction from non-commercial traders to volatility, as opposed to commercial traders to volatility, for all the contracts except German mark. The strongest causality is from non-commercial traders in Euro futures market to spot volatility of Euro exchange rate. Nevertheless, we still do detect Ganger causality from commercial traders in futures market to volatility in corresponding exchange rates in the spot market for British pound, Canadian dollar, Japanese yen, and Swiss franc. Small traders in the Canadian dollar and Japanese yen futures also cause volatility in the cash market for Canadian and Japanese exchange rates. All the observed causalities from the net position of traders to volatility are unidirectional.

Lastly, we look at Table 3.4 to study Granger causality results for the net position of traders and weekly estimate of volatility in the spot market. We see that non-commercial, commercial and small traders in Canadian futures market still Granger cause spot exchange rate volatility in the Canadian dollar. Furthermore, we observe that non-commercial traders and commercial traders in the Euro futures significantly Granger cause volatility in the spot Euro exchange rate.

4.2. Impulse Response Functions

The impulse response function traces out the dynamic response time path of current and future values of a variable to a one standard deviation shock in the current value of a variable. Figure 3.2 through Figure 3.7 display the impulse responses functions. We observe in the impulse response functions of the Canadian dollar, German mark, Japanese yen, and Swiss franc, the same outcome. That is, when a positive shock is introduced by the speculators and small traders, the volatility in the spot market increases whereas a positive shock by hedgers in currency futures markets decreases the volatility in the spot exchange rate markets. This outcome is observed for all three estimates of volatility used in this study. The magnitude of the response of volatility to its own shock is similar across all the measures of volatility. However, note that while GARCH estimate of volatility displays an immediate jump and a slow decline, the historical standard deviation and weekly range estimates of volatility display an immediate jump but also an immediate decline to their own shocks. Furthermore, note that the response of net positions by type of trader to a shock in different estimates of volatility is also similar across all contracts. While speculators and small traders respond positively to shocks in different measures of volatility, hedgers respond negatively. This indicates that while hedgers reduce their positions in the futures market in response to increases in volatility in the spot market, speculators and small traders increase their positions.

4.3. Variance Decompositions

Forecast error decomposition provides the percentage of the forecast error variance of each variable that is due to innovations (shocks) of its own and other variables in the system. Tables 3.5 to 3.7 show the results of the variance decomposition analysis. The proportion of the variance of GARCH estimate of volatility, historical standard deviation, and weekly range estimate of volatility due to their own lagged effects are significantly high. The same is true for speculators, hedgers, and small traders in different currency futures. Therefore, each variable's variance is explained mostly by its own past values, although other variables often explain a small amount of the dependent variable's variability. For instance, we observe that the contribution of the net position of speculators and hedgers in the Canadian dollar futures to GARCH (1, 1) estimate of volatility ranges from 0.89 percent to 11.40 percent and 0.54 percent to 10.56 percent, respectively. Furthermore, we see that the net position of speculators and hedgers in

Swiss franc futures explain 1.11 percent to 3.56 percent and 1.07 percent to 2.85 percent of volatility, respectively. Additionally, the net positions of speculators in the Euro futures explain a range of 0.43 percent to 4.35 percent of volatility measured by GARCH. When we look at Table 3.6, we see that the contributions of the net position of speculators and hedgers in the Canadian dollar to historical standard deviation estimate of volatility ranges from 1.33 percent to 6.94 percent and 1.26 percent to 7.36 percent, respectively. Speculators in the Euro currency futures market explain 1.49 percent to 6.68 percent of volatility in the spot market. Table 3.7 revels that speculators and hedgers in the Canadian dollar currency futures still explain a relatively large portion of the weekly range estimate of volatility in the spot market. Specifically, the forecasting contribution of speculators in the Canadian dollar currency futures range from 2.79 percent to 7.25 percent and hedgers range from 3.18 to 7.50 percent over 20 periods. Speculators in the Euro futures also keep explaining 1.79 to 5.34 percent of weekly variation in the spot market of Euro. Similarly, hedgers contribute to the weekly variation in the Euro cash market as well. Hedger’s positions explain 1.34 percent to 4.00 percent of weekly volatility.

3.5. Conclusion

While previous studies in the literature examine the contemporaneous association between the net position of traders in foreign currency futures and price volatility, this paper investigates the lagged relationship between the variables in question. In this paper I examine the dynamic relationship between the net positions of foreign currency futures by type of trader and spot exchange rate volatility. I employ high-low (weekly range), historical standard deviation, and GARCH (1, 1) measures of volatility to investigate the relationship between the net positions of foreign currency futures by type of trader and spot exchange rate volatility using three VAR structural analysis procedures: Granger causality, impulse response functions, and variance decomposition. The main finds are as follows; when we measure volatility by the GARCH (1, 1) model, we observe that hedgers are the primary traders causing volatility in the market. However, when volatility is measured by historical standard deviation, we see that not only hedgers but also speculators are the key players causing volatility. While the causality relationship between the net position of traders, particularly speculators and hedgers, and weekly range measure of volatility is significant for the Canadian dollar and Euro, the same inference cannot be made for the rest of the markets. The impulse response functions reveal to us that while shocks to the net position of speculators and small traders increase volatility in the market, shocks to the position of hedgers reduce volatility, regardless of the type of volatility measure used. However, we observe the opposite outcome in the case of the British pound and the Euro. We find out that shocks to the net position of hedgers increase volatility while shocks to the positions of speculators and small traders decrease volatility. The variance decomposition analyses tell us that the largest contribution of speculators and hedgers to volatility is present in the Canadian dollar and Euro markets over a 20-week period. The contribution of net positions to volatility in other markets seems to be negligible.

Table 3.1 Unit Root Tests

	Augmented Dickey-Fuller		Phillips-Perron	
Variables	**Level**	**First Difference**	**Level**	**First Difference**
Net Hedgers ^{GBP}	-6.05***	-25.77***	-5.42***	-29.05***
Net Speculators ^{GBP}	-5.42***	-26.70***	-5.25***	-30.54***
Net Small Traders ^{GBP}	-6.63***	-28.92***	-6.72***	-35.47***
Net Hedgers ^{CAD}	-5.00***	-24.49***	-4.62***	-24.32***
Net Speculators ^{CAD}	-4.94***	-24.66***	-4.30***	-24.52***
Net Small Traders ^{CAD}	-4.44***	-20.06***	-5.51***	-35.53***
Net Hedgers ^{EURO}	-3.61***	-16.17***	-3.17**	-19.72***
Net Speculators ^{EURO}	-3.16**	-16.76***	-2.75*	-22.57***
Net Small Traders ^{EURO}	-4.18***	-23.04***	-4.13***	-24.97***
Net Hedgers ^{DM}	-4.65***	-16.64***	-4.65***	16.73***
Net Speculators ^{DM}	-4.80***	-16.78***	-4.80***	-17.02***
Net Small Traders ^{DM}	-4.70***	-17.40***	-4.83***	-17.88***
Net Hedgers ^{JPY}	-5.99***	-25.54***	-5.46***	-27.25***
Net Speculators ^{JPY}	-4.89***	-26.65***	-5.11***	-27.89***
Net Small Traders ^{JPY}	-6.12***	-26.59***	-5.67***	-36.95***
Net Hedgers ^{CHF}	-7.04***	-23.25***	-6.49***	-23.91***
Net Speculators ^{CHF}	-6.77***	-24.83***	-6.47***	-25.98***
Net Small Traders ^{CHF}	-6.83***	-25.05***	-6.51***	-27.22***
GARCH ^{GBP}	-19.33***	-16.86***	-18.59***	-17.70***
GARCH ^{CAD}	3.78***	-22.52***	-3.16**	-22.51***
GARCH ^{EURO}	-2.46	-16.10***	-2.34	-16.10***
GARCH ^{DM}	-3.72***	-13.18***	-3.23**	-12.92***
GARCH ^{JPY}	-6.46***	-18.67***	-5.85***	-24.60***
GARCH ^{CHF}	-4.47***	-18.26***	-4.11***	-20.22***
HSD ^{GBP}	-8.95***	-17.02***	-27.93***	-146.64***
HSD ^{CAD}	-4.95***	-19.69***	-24.43***	-136.23***
HSD ^{EURO}	-7.62***	-15.18***	-19.23***	-153.29***
HSD ^{DM}	-7.88***	-14.37***	-14.86***	-80.35***
HSD ^{JPY}	-7.91***	-15.65***	-23.69***	-246.58***
HSD ^{CHF}	-9.33***	-16.46***	-26.77***	-401.07***
WR ^{GBP}	-10.35***	-18.52***	-28.92***	-277.18***
WR ^{CAD}	-6.19***	-20.75***	-27.30***	-146.90***
WR ^{EURO}	-11.87***	-12.42***	-20.22***	-154.07***
WR ^{DM}	-10.15***	-15.08***	-17.40***	-232.86***
WR ^{JPY}	-6.69***	-22.60***	-26.31***	-105.95***
WR ^{CHF}	-7.75***	-17.88***	-28.27***	-151.13***

Note: ***H_o of a unit root is rejected at the 1%, **5%, and *10% level.

Table 3.2 Granger Causality Tests

Net Positions and GARCH (1, 1) Estimate of Volatility

Non-Commercial Traders in British Pound

	Net Positions	GARCH(1, 1)
Net Positions	-	0.2025
GARCH(1, 1)	0.4873	-

Commercial Traders in British Pound

	Net Positions	GARCH(1, 1)
Net Positions		0.0541
GARCH(1, 1)	0.3176	

Small Traders in British Pound

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0020
GARCH(1, 1)	0.1991	-

Non-Commercial Traders in Canadian Dollar

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0018
GARCH(1, 1)	0.0628	-

Commercial Traders in Canadian Dollar

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0084
GARCH(1, 1)	0.8216	-

Small Traders in Canadian Dollar

	Net Positions	GARCH(1, 1)
Net Positions	-	0.1050
GARCH(1, 1)	0.8907	-

Non-Commercial Traders in Euro

	Net Positions	GARCH(1, 1)
Net Positions	-	0.2490
GARCH(1, 1)	0.0682	-

Commercial Traders in Euro

	Net Positions	GARCH(1, 1)
Net Positions	-	0.4971
GARCH(1, 1)	0.1546	-

Small Traders in Euro

	Net Positions	GARCH(1, 1)
Net Positions	-	0.8530
GARCH(1, 1)	0.9169	-

Non-Commercial Traders in German Mark

	Net Positions	GARCH(1, 1)
Net Positions	-	0.1414
GARCH(1, 1)	0.4478	-

Commercial Traders in German Mark

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0734
GARCH(1, 1)	0.4733	-

Small Traders in German Mark

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0328
GARCH(1, 1)	0.6092	-

Non-Commercial Traders in Japanese Yen

	Net Positions	GARCH(1, 1)
Net Positions	-	0.2947
GARCH(1, 1)	0.9977	-

Commercial Traders in Japanese Yen

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0359
GARCH(1, 1)	0.7682	-

Small Traders in Japanese Yen

	Net Positions	GARCH(1, 1)
Net Positions	-	0.2608
GARCH(1, 1)	0.6543	-

Non-Commercial Traders in Swiss Franc

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0712
GARCH(1, 1)	0.5561	-

Commercial Traders in Swiss Franc

	Net Positions	GARCH(1, 1)
Net Positions	-	0.0810
GARCH(1, 1)	0.6703	-

Small Traders in Swiss Franc

	Net Positions	GARCH(1, 1)
Net Positions	-	0.2128
GARCH(1, 1)	0.4405	-

Note: The table reports the p-values for Granger causality tests for GARCH (1, 1) estimate of volatility and net positions by type of traders in various currency futures contracts. The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Table 3.3 Granger Causality Tests

Net Positions and Historical Standard Deviation Estimate of Volatility

Non-Commercial Traders in British Pound

	Net Positions	HSD
Net Positions	-	0.0140
HSD	0.8478	-

Commercial Traders in British Pound

	Net Positions	HSD
Net Positions	-	0.0304
HSD	0.7352	-

Small Traders in British Pound

	Net Positions	HSD
Net Positions	-	0.2019
HSD	0.4897	-

Non-Commercial Traders in Canadian Dollar

	Net Positions	HSD
Net Positions	-	0.0143
HSD	0.6078	-

Commercial Traders in Canadian Dollar

	Net Positions	HSD
Net Positions	-	0.0085
HSD	0.5197	-

Small Traders in Canadian Dollar

	Net Positions	HSD
Net Positions	-	0.0074
HSD	0.2303	-

Non-Commercial Traders in Euro

	Net Positions	HSD
Net Positions	-	0.0012
HSD	0.1351	-

Commercial Traders in Euro

	Net Positions	HSD
Net Positions	-	0.5217
HSD	0.0366	-

Small Traders in Euro

	Net Positions	HSD
Net Positions	-	0.5477
HSD	0.4544	-

Non-Commercial Traders in German Mark

	Net Positions	HSD
Net Positions	-	0.6051
HSD	0.2233	-

Commercial Traders in German Mark

	Net Positions	HSD
Net Positions	-	0.5643
HSD	0.1815	-

Small Traders in German Mark

	Net Positions	HSD
Net Positions	-	0.4796
HSD	0.2405	-

Non-Commercial Traders in Japanese Yen

	Net Positions	HSD
Net Positions	-	0.0512
HSD	0.9095	-

Commercial Traders in Japanese Yen

	Net Positions	HSD
Net Positions	-	0.0422
HSD	0.8655	-

Small Traders in Japanese Yen

	Net Positions	HSD
Net Positions	-	0.0983
HSD	0.1335	-

Non-Commercial Traders in Swiss Franc

	Net Positions	HSD
Net Positions	-	0.0026
HSD	0.5016	-

Commercial Traders in Swiss Franc

	Net Positions	HSD
Net Positions	-	0.0545
HSD	0.6902	-

Small Traders in Swiss Franc

	Net Positions	HSD
Net Positions	-	0.1057
HSD	0.7182	-

Note: The table reports the p-values for Granger causality tests for historical standard deviation estimate of volatility and net positions by type of traders in various currency futures contracts. The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Table 3.4 Granger Causality Tests

Net Positions and Extreme Value Estimate of Volatility

Non-Commercial Traders in British Pound

	Net Positions	H-L
Net Positions	-	0.4332
H-L	0.6101	-

Commercial Traders in British Pound

	Net Positions	H-L
Net Positions	-	0.5480
H-L	0.9019	-

Small Traders in British Pound

	Net Positions	H-L
Net Positions	-	0.3448
H-L	0.6271	-

Non-Commercial Traders in Canadian Dollar

	Net Positions	H-L
Net Positions	-	0.0019
H-L	0.4887	-

Commercial Traders in Canadian Dollar

	Net Positions	H-L
Net Positions	-	0.0005
H-L	0.4457	-

Small Traders in Canadian Dollar

	Net Positions	H-L
Net Positions	-	0.0215
H-L	0.6630	-

Non-Commercial Traders in Euro

	Net Positions	H-L
Net Positions	-	0.0000
H-L	0.8870	-

Commercial Traders in Euro

	Net Positions	H-L
Net Positions	-	0.0007
H-L	0.9851	-

Small Traders in Euro

	Net Positions	H-L
Net Positions	-	0.5141
H-L	0.7399	-

Non-Commercial Traders in German Mark

	Net Positions	H-L
Net Positions	-	0.8705
H-L	0.2966	-

Commercial Traders in German Mark

	Net Positions	H-L
Net Positions	-	0.7837
H-L	0.2230	-

Small Traders in German Mark

	Net Positions	H-L
Net Positions	-	0.6417
H-L	0.1934	-

Non-Commercial Traders in Japanese Yen

	Net Positions	H-L
Net Positions	-	0.1256
H-L	0.9129	-

Commercial Traders in Japanese Yen

	Net Positions	H-L
Net Positions	-	0.1507
H-L	0.8036	-

Small Traders in Japanese Yen

	Net Positions	H-L
Net Positions	-	0.5431
H-L	0.1488	-

Non-Commercial Traders in Swiss Franc

	Net Positions	H-L
Net Positions	-	0.0109
H-L	0.3835	-

Commercial Traders in Swiss Franc

	Net Positions	H-L
Net Positions	-	0.4554
H-L	0.4674	-

Small Traders in Swiss Franc

	Net Positions	H-L
Net Positions	-	0.8282
H-L	0.6904	-

Note: The table reports the p-values for Granger causality tests for weekly high-low estimate of volatility and net positions by type of traders in various currency futures contracts. The format is such that the rows reflect the Granger-causal impact of the row-variable on the column-variable.

Table 3.5 Variance Decompositions

Net Positions and GARCH Estimate of Volatility

	Speculators				Hedgers				Small Traders			
GBP	Var. Decom. of GARCH		Var. Decom. of Spec.		Var. Decom. of GARCH		Var. Decom. of Hed.		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	0.08	99.91	100.00	0.00	0.05	99.94	100.00	0.00	0.03	99.96
6	99.57	0.42	0.40	99.59	99.51	0.48	0.49	99.50	99.60	0.39	0.61	99.38
12	99.55	0.44	0.54	99.45	99.53	0.46	0.67	99.32	98.27	1.72	0.78	99.21
20	99.55	0.44	0.60	99.39	99.42	0.57	0.74	99.25	96.93	3.06	0.85	99.14
CAD	Var. Decom. of GARCH		Var. Decom. of Spec		Var. Decom. of GARCH		Var. Decom. of Hed		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	0.01	99.98	100.00	0.00	0.00	99.99	100.00	0.00	0.01	99.98
6	99.10	0.89	0.26	99.73	99.45	0.54	0.19	99.80	99.91	0.08	0.08	99.91
12	95.75	4.25	0.22	99.77	95.78	4.21	0.48	99.51	98.80	1.20	0.26	99.73
20	88.60	11.40	1.21	98.78	89.44	10.56	0.93	99.06	95.81	4.18	0.58	99.41
DEM	Var. Decom. of GARCH		Var. Decom. of Spec		Var. Decom. of GARCH		Var. Decom. of Hed		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	0.00	0.04	99.96
6	99.08	0.91	0.76	99.23	98.51	1.48	0.76	99.23	97.64	2.36	0.75	99.25
12	99.23	0.76	0.90	99.10	98.59	1.40	0.88	99.11	97.16	2.83	0.82	99.17
20	99.30	0.70	0.92	99.08	98.67	1.33	0.89	99.10	97.01	2.98	0.82	99.17
EUR	Var. Decom. of GARCH		Var. Decom. of Spec		Var. Decom. of GARCH		Var. Decom. of Hed		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	0.36	99.64	100.00	0.00	0.36	99.64	100.00	0.00	0.14	99.86
6	99.57	0.43	1.29	98.71	99.73	0.26	0.77	99.22	99.98	0.02	0.05	99.94
12	98.00	1.99	4.16	95.84	98.92	1.07	2.57	97.43	99.98	0.02	0.06	99.93
20	95.65	4.35	8.79	91.21	97.72	2.28	5.77	94.23	99.95	0.04	0.10	99.90
JPY	Var. Decom. of GARCH		Var. Decom. of Spec		Var. Decom. of GARCH		Var. Decom. of Hed		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	1.04	98.97	100.00	0.00	0.87	99.13	100.00	0.00	0.63	99.37
6	98.54	1.46	1.00	98.99	98.96	1.04	0.96	99.04	99.08	0.92	1.50	98.50
12	97.56	2.44	0.89	99.11	98.69	1.31	0.77	99.23	98.87	1.13	1.30	98.70
20	97.77	2.23	1.00	99.00	98.57	1.43	0.72	99.28	98.59	1.40	1.58	98.42
CHF	Var. Decom. of GARCH		Var. Decom. of Spec		Var. Decom. of GARCH		Var. Decom. of Hed		Var. Decom. of GARCH		Var. Decom. of ST	
Period	GARCH	Spec	GARCH	Spec	GARCH	Hed	GARCH	Hed	GARCH	ST	GARCH	ST
1	100.00	0.00	0.85	99.15	100.00	0.00	0.66	99.33	100.00	0.00	0.25	99.75
6	98.88	1.11	1.87	98.13	98.92	1.07	1.40	98.60	99.44	0.56	0.59	99.41
12	97.58	2.42	2.34	97.66	97.92	2.07	1.55	98.45	99.10	0.90	0.51	99.49
20	96.44	3.56	2.63	97.37	97.14	2.85	1.59	98.41	98.85	1.15	0.67	99.33

Note: The table reports the forecast error variance decompositions which provide the percentage of the forecast error variances of each variable that is due to innovations of its own and other variables in the system. *Spec* stands for speculators, *Hed* stands for Hedgers, and *ST* is small traders.

Table 3.6 Variance Decompositions

Net Positions and Historical Standard Deviation (HSD) Estimate of Volatility

	Speculators				Hedgers				Small Traders			
GBP	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	0.10	99.90	100.00	0.00	0.17	99.83	100.00	0.00	0.24	99.76
6	99.48	0.52	1.14	98.86	99.56	0.44	1.86	98.14	99.47	0.53	1.18	98.82
12	97.90	2.10	1.50	98.50	98.21	1.79	2.45	97.55	98.78	1.22	2.27	97.73
20	97.90	2.10	1.82	98.18	98.21	1.79	2.63	97.37	98.27	1.73	2.83	97.17
CAD	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	0.10	99.90	100.00	0.00	0.10	99.90	100.00	0.00	0.07	99.93
6	98.67	1.33	0.31	99.69	98.74	1.26	0.38	99.62	98.78	1.22	0.16	99.84
12	96.27	3.73	0.60	99.40	96.19	3.81	0.75	99.25	97.75	2.25	0.47	99.53
20	93.06	6.94	0.88	99.12	92.64	7.36	1.12	98.88	95.69	4.31	0.52	99.48
DEM	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	0.55	99.44	100.00	0.00	1.00	99.00	100.00	0.00	1.95	98.05
6	99.68	0.32	1.21	98.79	99.56	0.44	1.57	98.42	99.31	0.68	2.26	97.74
12	99.68	0.32	1.69	98.31	99.55	0.45	2.11	97.89	99.15	0.84	2.73	97.27
20	99.68	0.32	1.75	98.25	99.55	0.45	2.18	97.82	99.13	0.87	2.80	97.20
EUR	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	0.73	99.27	100.00	0.00	0.78	99.22	100.00	0.00	0.41	99.59
6	98.51	1.49	2.98	97.02	98.93	1.07	1.92	98.08	98.90	1.10	0.58	99.42
12	95.68	4.32	4.69	95.30	98.41	1.59	5.30	94.70	98.90	1.10	0.84	99.16
20	93.31	6.68	5.50	94.50	97.52	2.48	9.18	90.82	99.00	1.00	1.25	98.74
JPY	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	1.29	98.71	100.00	0.00	1.32	98.68	100.00	0.00	0.80	99.20
6	98.72	1.28	1.81	98.19	98.72	1.28	1.90	98.10	98.67	1.33	1.82	98.18
12	98.53	1.47	1.82	98.18	98.62	1.38	1.76	98.24	98.68	1.32	1.62	98.38
20	98.45	1.55	1.82	98.18	98.59	1.41	1.69	98.31	98.52	1.48	1.90	98.10
CHF	Var. Decom. of HSD		Var. Decom. of Spec.		Var. Decom. of HSD		Var. Decom. of Hed.		Var. Decom. of HSD		Var. Decom. of ST	
Period	HSD	Spec	HSD	Spec	HSD	Hed	HSD	Hed	HSD	ST	HSD	ST
1	100.00	0.00	0.86	99.14	100.00	0.00	0.81	99.18	100.00	0.00	0.38	99.62
6	98.23	1.77	2.12	97.88	99.03	0.97	1.62	98.38	99.01	0.99	0.92	99.08
12	97.33	2.67	2.41	97.59	97.70	2.31	2.18	97.82	98.10	1.90	0.80	99.20
20	97.11	2.89	2.47	97.53	97.08	2.92	2.36	97.64	97.95	2.05	1.00	99.00

Note: The table reports the forecast error variance decompositions which provide the percentage of the forecast error variances of each variable that is due to innovations of its own and other variables in the system. *Spec* stands for speculators, *Hed* stands for Hedgers, and *ST* is small traders.

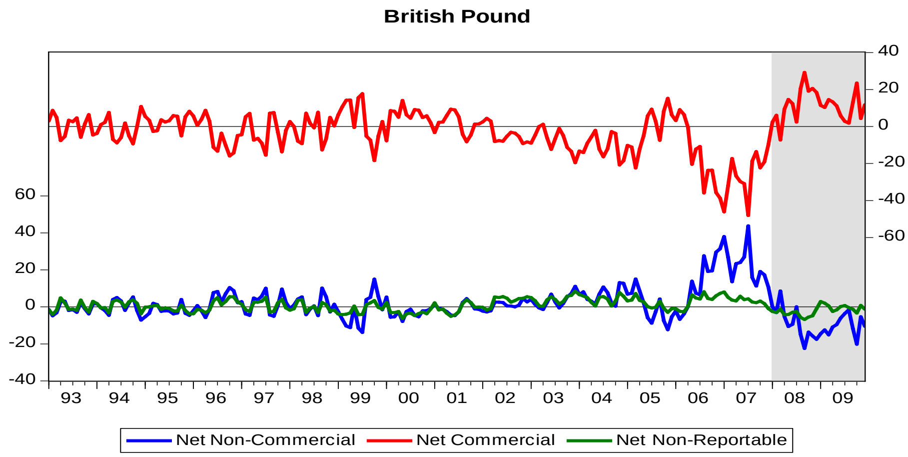
Table 3.7 Variance Decompositions

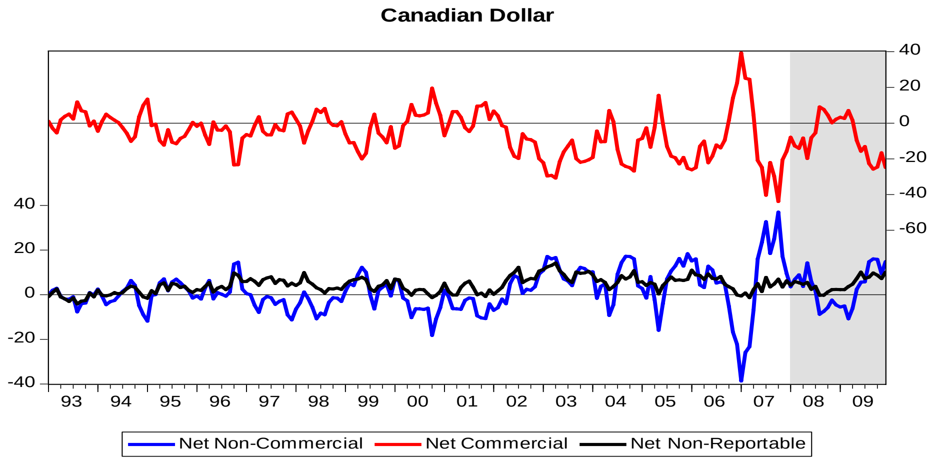
Net Positions and Weekly Range (WR) Estimate of Volatility

	Speculators				Hedgers				Small Traders			
GBP	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	0.19	99.81	100.00	0.00	0.28	99.72	100.00	0.00	0.18	99.82
6	99.29	0.71	0.44	99.56	99.50	0.50	1.08	98.92	99.46	0.54	1.20	99.80
12	98.83	1.17	1.11	98.89	99.50	0.50	1.87	98.13	99.15	0.85	1.90	98.10
20	98.83	1.17	1.93	98.07	99.48	0.52	2.26	97.73	99.00	0.99	2.17	97.83
CAD	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00	0.00	0.01	99.99
6	97.21	2.79	0.24	99.76	96.82	3.18	0.25	99.75	97.99	2.01	0.18	99.82
12	94.71	5.29	0.83	99.17	94.44	5.56	0.95	99.05	97.08	2.92	0.54	99.46
20	92.75	7.25	1.53	98.47	92.50	7.50	1.77	98.22	96.08	3.92	0.97	99.03
DEM	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	0.97	99.03	100.00	0.00	1.63	98.37	100.00	0.00	2.81	97.19
6	99.30	0.70	4.04	95.96	99.07	0.93	4.86	95.14	98.74	1.26	5.70	94.30
12	99.27	0.73	3.86	96.14	99.07	0.93	5.58	95.42	98.72	1.28	5.26	94.74
20	99.24	0.76	3.93	96.07	99.05	0.95	4.65	95.35	98.72	1.28	5.27	94.73
EUR	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	1.00	99.00	100.00	0.00	1.16	98.84	100.00	0.00	0.27	99.73
6	98.21	1.79	1.60	98.40	98.66	1.34	1.36	98.64	99.79	0.21	0.13	99.87
12	96.08	3.92	1.74	98.26	97.00	3.00	1.40	98.60	99.73	0.27	0.09	99.91
20	94.66	5.34	1.79	98.21	96.00	4.00	1.41	98.58	99.70	0.30	0.08	99.92
JPY	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	1.30	98.70	100.00	0.00	1.15	98.85	100.00	0.00	0.56	99.44
6	98.71	1.29	2.48	97.52	98.78	1.22	2.37	97.63	99.47	0.53	1.63	98.37
12	98.40	1.60	2.28	97.72	98.73	1.27	2.07	97.92	99.47	0.53	1.37	98.63
20	98.38	1.62	2.05	97.95	98.73	1.27	1.95	98.05	99.37	0.63	1.64	98.36
CHF	Var. Decom. of WR		Var. Decom. of Spec.		Var. Decom. of WR		Var. Decom. of Hed.		Var. Decom. of WR		Var. Decom. of ST	
Period	WR	Spec	WR	Spec	WR	Hed	WR	Hed	WR	ST	WR	ST
1	100.00	0.00	0.85	99.15	100.00	0.00	0.93	99.07	100.00	0.00	0.48	99.52
6	98.94	1.06	2.15	97.85	99.73	0.27	3.15	96.85	99.83	0.17	1.62	98.38
12	98.51	1.49	2.45	97.55	99.08	0.92	4.35	96.65	99.65	0.35	1.55	98.45
20	98.41	1.59	2.50	97.50	98.69	1.31	4.68	95.32	99.49	0.51	1.54	98.46

Note: The table reports the forecast error variance decompositions which provide the percentage of the forecast error variances of each variable that is due to innovations of its own and other variables in the system. *Spec* stands for speculators, *Hed* stands for Hedgers, and *ST* is small traders.

Figure 3.1 Net Positions of Traders in Currency Futures





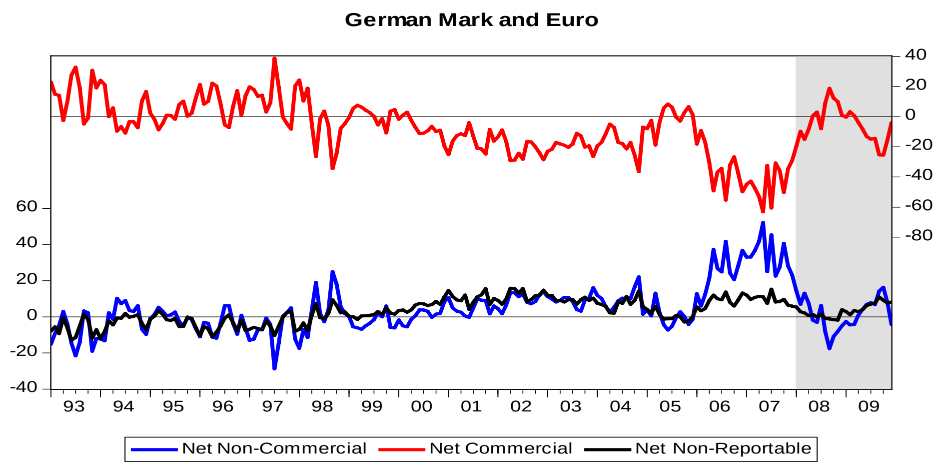
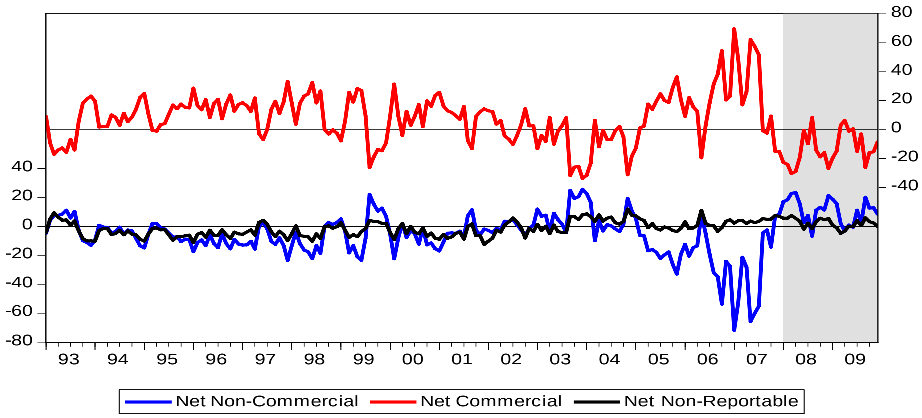
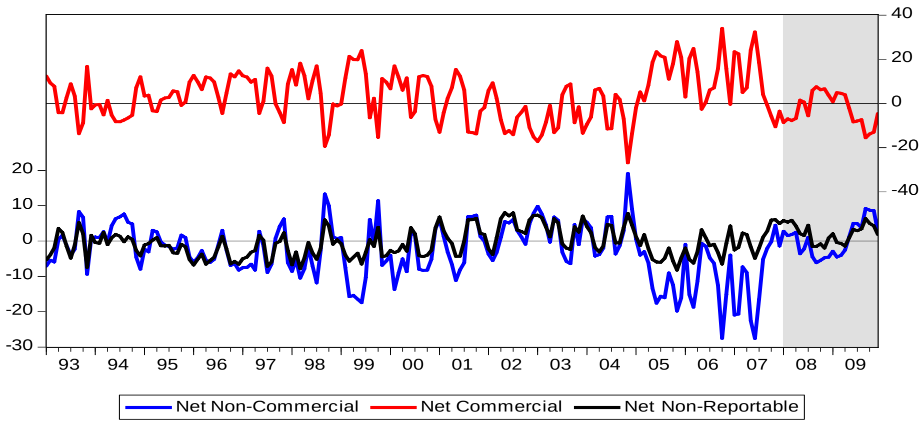


Figure 3.1 (Continued)

Japanese Yen

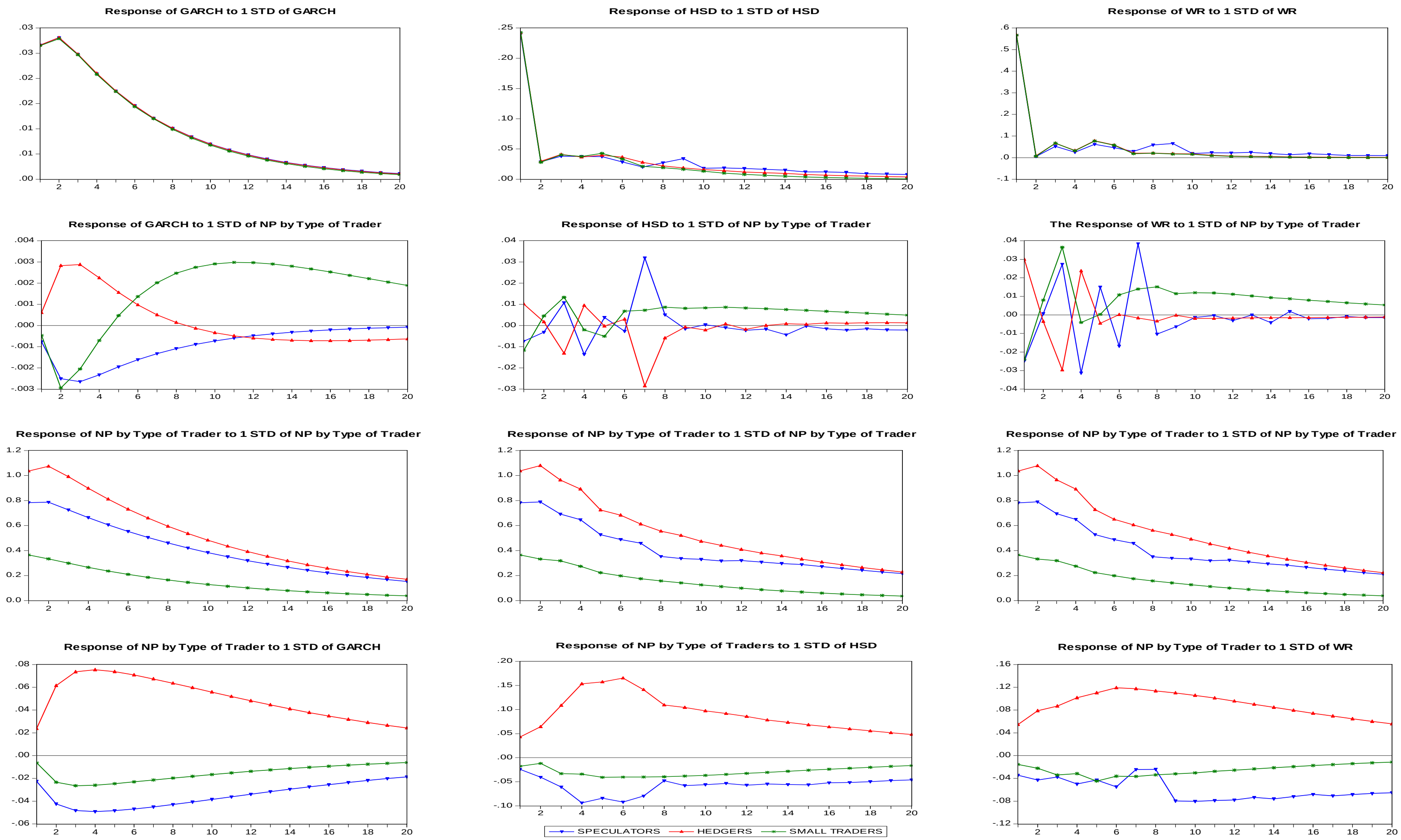


Swiss Franc



Source: Commitment of Traders Report. The shaded period corresponds to the latest global financial crisis.

Figure 3.2 Generalized Impulse Responses of British Pound Volatility and Net Positions by Type of Trader to a Shock

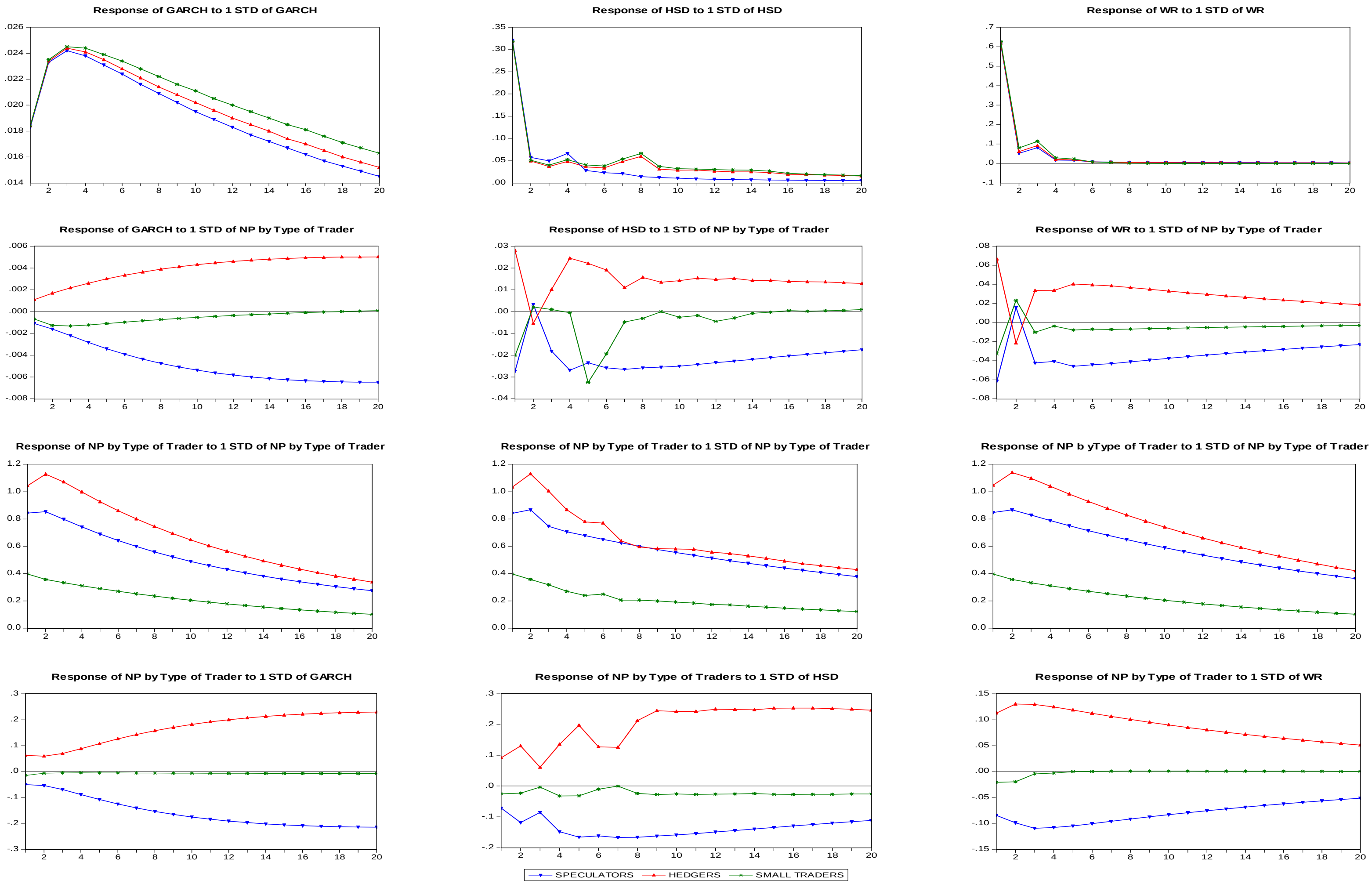


Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in British pound currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

Figure 3.3 Generalized Impulse Responses of Canadian Dollar Volatility and Net Positions by Type of Trader to a Shock

Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in Canadian dollar currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

Figure 3.4 Generalized Impulse Responses of Euro Volatility and Net Positions by Type of Trader to a Shock

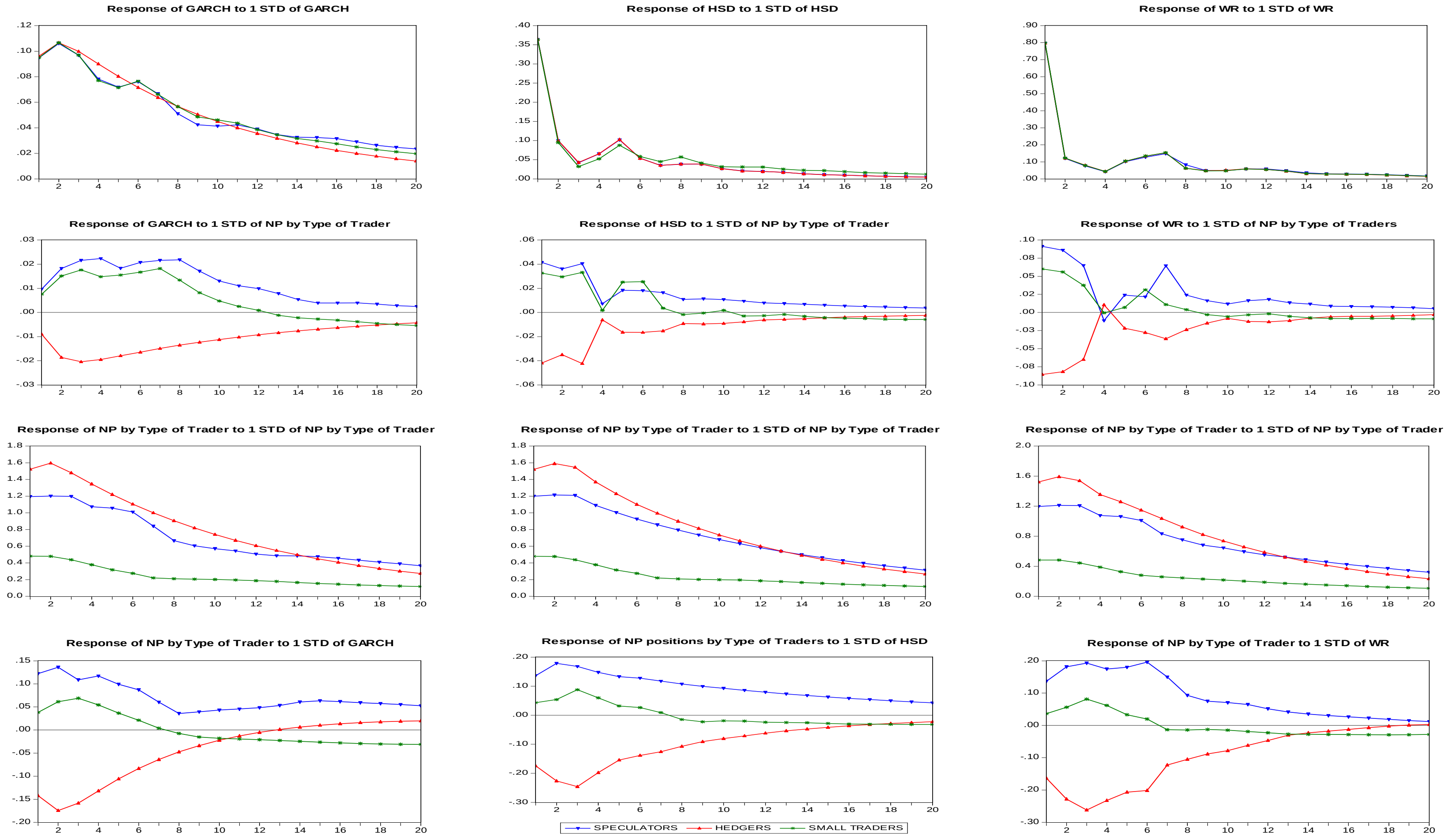


Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in Euro currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

Figure 3.5 Generalized Impulse Responses of German Mark Volatility and Net Positions by Type of Trader to a Shock

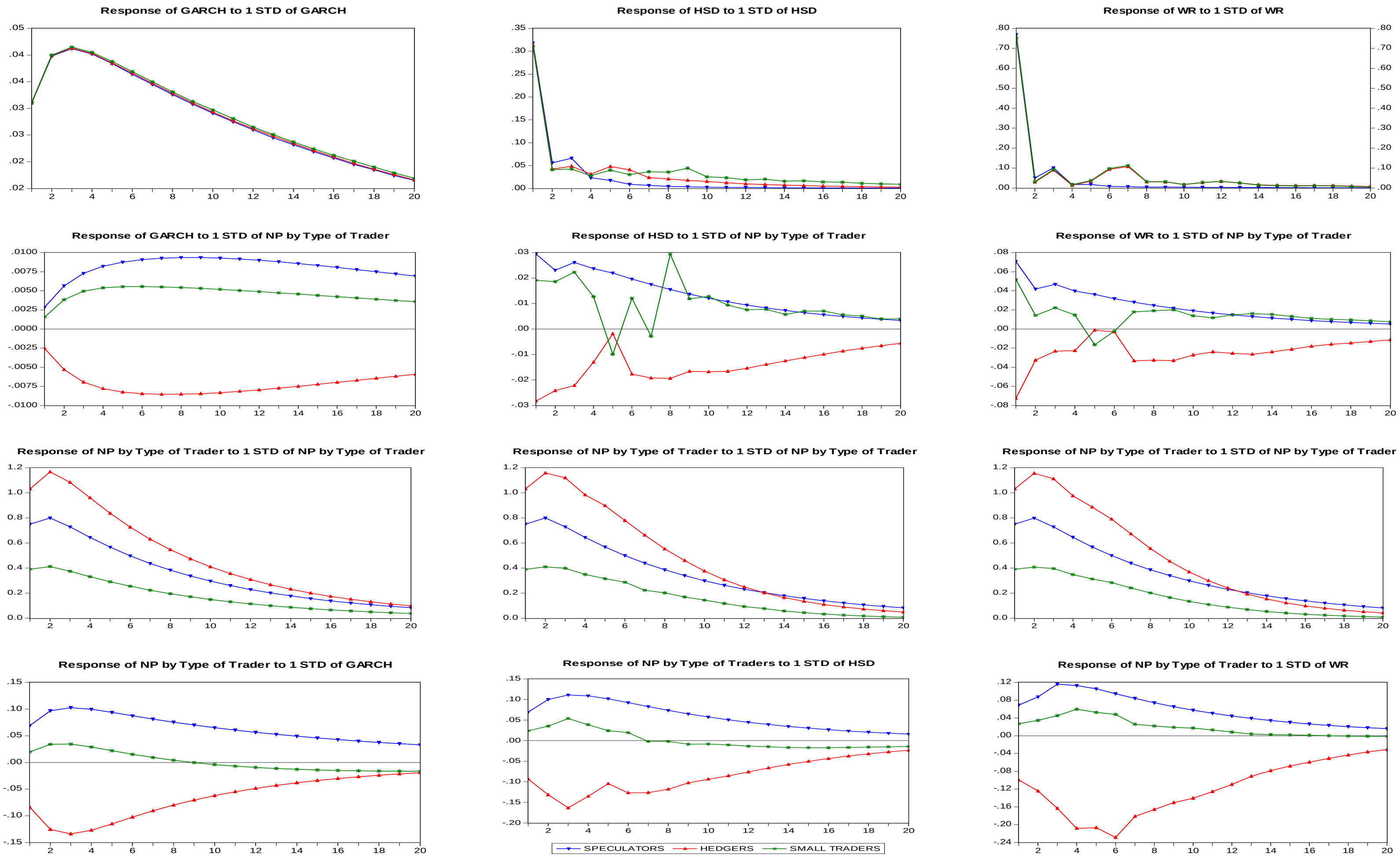
Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in German mark currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

Figure 3.6 Generalized Impulse Responses of Japanese Yen Volatility and Net Positions by Type of Trader to a Shock



Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in Japanese yen currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

Figure 3.7 Generalized Impulse Responses of Swiss Franc Volatility and Net Positions by Type of Trader to a Shock



Note: The figure plots the time path of the impulse response functions of GARCH (1, 1), historical standard deviation (HSD), weekly high-low (WR) estimate of volatility, and net positions (NP) by type of trader in Swiss franc currency futures contracts to a one standard deviation (STD) shock of themselves and each other.

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