CEM
Center for Empirical Macroeconomics

Working Paper No. 74

Currency Futures and Currency Crises

by

Andreas Röthig

University of Bielefeld
Department of Economics
Center for Empirical Macroeconomics
P.O. Box 100 131
33501 Bielefeld, Germany
(http://www.wiwi.uni-bielefeld.de/∼cem)

Currency Futures and Currency Crises*

Andreas Röthig**
Darmstadt University of Technology
June 2004

Abstract

Since financial derivatives are key instruments for risk taking as well as risk reduction, it is only straightforward to examine their role in currency crises. This paper addresses this issue by investigating the impact of currency futures trading on the underlying exchange rates. After a discussion of trading mechanisms and trader types, the linkage between futures trading activity and spot market turbulence is modelled using a VAR-GARCH approach for the exchange rates of Australia, Canada, Japan, Korea and Switzerland in terms of the US dollar. The empirical results indicate that there is a positive relationship between currency futures trading activity and spot volatility. Moreover, in the case of four out of the total of five currencies discussed in this paper, futures trading activity adds significantly to spot volatility.

JEL Classification: **C13, C32, F31, G15**

Keywords: Currency crises; Exchange rate volatility; Currency futures trading activity; VAR-GARCH estimation.

---

*I would like to thank Ingo Barens, Willi Semmler and Joachim Frohn for helpful discussions. All opinions and errors are my own.
**Darmstadt University of Technology, Department of Economics, Marktplatz 15 (Schloss), D-64283 Darmstadt, email: roethig@vwl.tu-darmstadt.de.

1 Introduction

The development of currency crisis theory from first to third generation models reflects the growing importance of financial markets and financial innovations such as derivatives. A sudden reversal of capital inflows together with speculative attacks against currencies are often seen as the main causes triggering financial crises, leading to declining economic activity and large output losses as discussed in Flaschel and Semmler (2003) and Acosta, Flaschel and Semmler (2004). Especially in emerging markets speculative attacks combined with self-fulfilling features such as herding, contagion and moral hazard can destabilize entire economic regions.

This paper deals with the role of currency futures in currency crises.[1] The underlying motivation for this topic stems from the key role of derivatives for risk taking and risk management as well as the growth of derivative markets in the 1990s which appears to dwarf other financial sectors. Exchange traded derivatives like currency futures represent only a fraction of derivative markets. Most derivative contracts are traded over-the-counter (OTC) like swaps and forwards. The main feature of standardized products is the fact that main variables (price data, trading volume) are recorded in the exchanges. Hence, time series data for empirical studies are available.

The exchange provides even more information. Variables such as 'futures daily trading volume' and 'futures open interest' allow a closer look at the behavior and preferences of traders since 'futures open interest' represents 'longer-than-intraday' positions while 'daily trading volume' is a measure for short-term (daily) trading. Hence, this kind of data which is generally not available for over-the-counter markets, might be a key element for a detailed analysis of a 'representative futures trader'. Understanding traders' behavior is very important with respect to self-fulfilling features such as moral hazard, herding and contagion.

The rest of the paper is organized as follows. Section 2 reviews institutional aspects of futures trading on organized exchanges as well as trading characteristics. Section 3 discusses different trader types and trading strategies. Section 4 presents an empirical analysis of the impact of futures trading activity on the underlying exchange rates for Australia, Canada, Japan, Switzerland and Korea in terms of the US dollar. First, futures trading activity is measured by the number of futures contracts traded. In addition, a new measure for futures trading activity is constructed: The trading volume of each currency future discussed in this investigation is standardized to its respective value in US dollars. Section 5 summarizes the empirical results and presents the conclusion as well as some possible areas for further research.

[1] Hence, this paper presents some insights into the 'capital flight' parameter α given in Acosta, Flaschel and Semmler (2004, p. 10) since α represents foreign exchange market pressures like speculative attacks.

2 Futures trading and market characteristics

2.1 Margin requirements

Currency futures are traded on organized exchanges. As the two parties to the futures contract usually do not know each other and thus have no reason to trust each other, the exchange provides a certain guarantee that the contract will be honored.[2]

When a trader enters into a contract he has to deposit a certain amount known as the initial margin. The margin account is adjusted at the end of every single trading day. This procedure known as 'marking to market' reflects the trader's gain or loss. When a futures position is generating a loss, the holder of the position must make the decision whether to deposit a certain amount to restore his margin account or to close out the position at a loss. These margin payments are made frequently and are usually small amounts relative to the total size of the futures position.

Clifton (1985) argues that the marking to market procedure increases the probability that an exchange rate move will lead to additional purchases or sales in the futures market, compared for example with the interbank market. When for instance a holder of a long futures position has to pay certain amounts each day in order to restore his margin account because the currency moves in the wrong direction, and if he loses confidence that the position will ever generate profits, he will surely close the position before things get even worse. The counterparty to the contract (which has a short position in this currency) will not close the position because it generates profits. Thus, if the currency weakens (e.g. in a currency crisis) and moves consistently in one direction, holders of long positions will tend to close their positions while other traders enter the market and take short positions in order to make profits betting against the currency. Following these arguments daily marking to market can increase herding tendencies and generate a liquidity problem if one side of the market shrinks while the other side booms. Furthermore, the rather small size of the initial margin relative to the total size of the futures position will not discourage the trader to close the position. Such a decision in spot markets would generate grave losses and thus is not made carelessly.

2.2 Technical analysis and order types

Technical analysis comprises a number of tools and prediction rules used for analyzing and forecasting developments in certain markets. This type of analysis is very popular in futures markets, "where high leverage, high liquidity, and low brokerage costs permit quick trading profits (and losses)."[3] Scientists have ignored technical analysis of charts for a long time because many of the rules are based on visual

[2]See Hull (2000), p. 23.
[3]Murphy (1986), p. 175.

interpretation and are influenced by psychological aspects and other subjective components.

One key tool of technical analysis are resistance and support levels where peaks are usually regarded as resistance levels and troughs are regarded as support levels. The fact that such levels are often placed on round numbers shows the importance of psychological aspects.[4] Clifton (1985) points out that there is usually a wide consensus among analysts about where the important levels are. If these levels are widely known, movements through these lines will probably cause further purchases or sales. Ludden (1999, p.17-19) discusses whether different trading rules have a destabilizing effect on exchange rates and comes to the result that trend-following techniques create positive feedback effects and thus reinforce the trend.

On organized exchanges, main features of currency futures contracts like the amount of currency deliverable and the time of delivery are clear to all parties to the contract. The only variable of the trade is the price (daily bids and offers), therefore price reservations play a key role. Orders to buy and to sell contracts at organized exchanges can be accompanied by various forms of price reservations. Two of them are discussed here: Stop-limit orders and stop-loss orders.

Stop-limit order:

> This sort of price reservation guarantees the trader that a purchase of a futures contract will be carried out at a specific price level or better.

Stop-loss order:

> A stop-loss order can be taken after a position in a contract is established. This price reservation preserves the trader from too high losses when futures prices start moving against the position. The order will be executed at the best available price "as soon as a bid or offer occurs at a price at least as unfavorable as the price reservation indicated on the order (above the stop price for a buy, below for a sell)."[5]

Stop-limit and stop-loss orders are often placed at levels where traders assume support or resistance lines, "or at levels that would otherwise cause a trader to be subject to a margin call."[6] If many traders expect support and resistance lines on the same level and place orders at these levels, the futures prices when crossing such a level will move even further because of the large number of traders buying or selling at the same level. Clifton (1985) concludes that these kinds of order types reinforce bandwagon effects, respectively herding.

[4]See Ludden (1999), p. 8.
[5]Duffie (1989), p. 38.
[6]Clifton (1985), p. 379.

3 Trader types

3.1 Speculators and market manipulators

Speculators are willing to take on risk and use the derivative market to speculate upon price movements. The main difference between speculators and investors lies in the short term character of speculation. In addition investors generally expect prices to rise while speculators bet on rising as well as falling prices.

The short-term character and their built-in leverage make derivatives powerful tools for speculation. These characteristics are the same among all derivative products, exchange traded and over-the-counter. The leveraging allows the speculator to take a large position with small amounts of money. Taking a futures position for instance only requires an initial margin, which is generally a small fraction of the cost of the underlying securities. The potential gain as well as the potential loss is very large.

The perception of speculation among authorities and market participants ranges from useful activities such as adding liquidity to markets, to destabilizing and ruthless market manipulation. Keyle (1984) introduces a model in which market manipulators with superior information make profits by creating 'corners' and 'squeezes'. In a 'corner' the speculator acquires large numbers of stocks to set up a temporary monopoly. By selling the stocks gradually, he keeps the prices high. In a 'squeeze', the speculator exploits the fact that not all stocks are available on favorable terms at the futures delivery date. The 'squeezer' makes his profits by threatening to take delivery when the short side to the contract has problems to deliver. Thereby the shorts are forced to deliver goods that are surely not the cheapest to deliver.[7] In Keyle's model the speculator makes profit and manipulation occurs in equilibrium.

Kumar and Seppi (1992) give a simple example how manipulators can achieve profits through cash settlement. A speculator, taking a long futures position, can push up prices by buying in the spot market. As long as the futures position is larger than the spot position, the expected gain is positive. This kind of trading is called 'punching the settlement price'.

Jarrow (1992) supports Keyle's findings that a profitable manipulation can occur in equilibrium and goes even further by showing that a large player can always profitably corner and squeeze the market. Jarrow (1994, p. 241) states that "the introduction of the derivative security generates market manipulation trading strategies that would otherwise not exist."

3.2 Destabilizing hedging activities

Traders using derivatives together with a spot position in order to reduce risks are called hedgers. Although hedging generally is said to be a productive and convenient activity for risk management and consequently a stabilizing tool, hedging can in

[7] For more details on 'corners' and 'squeezes', see Kyle (1984, p. 275-276).

some cases generate capital outflows and thus contribute to the downward pressure on currencies. This is in particular the case when investors begin to hedge their currency exposure anticipating the outbreak of a currency crisis. When currency and asset prices begin to fall, short hedge positions will lead to further pressure on prices. If a foreign investor hedges the full value of the invested principle, the positive effect of the spot capital inflow can potentially be neutralized by the hedging process in the futures market.[8]

3.3 Cross hedging and contagion

While the positive effect of spot capital inflows in the example above can in the worst case be neutralized through hedging, the situation is completely different when the hedge is a cross-currency position. The main idea of cross-currency positions is the hedging of currency exposure in a certain currency with a futures position in another currency.[9] This is a popular trading strategy for currencies where future contracts do not exist. In these cases other futures must be chosen to hedge the currency risk. The cross hedge is only successful in minimizing risk when the two currencies involved are highly correlated.[10]

The main point here is that positive effects from spot capital inflows in *country A* can lead to negative pressure on the currency in *country B* when the spot inflows are hedged with short futures positions in the currency of *country B*. If *country A* is at the brink of a currency crisis, traders will enter short futures positions in *currency B* in order to hedge their currency exposure and thus will threaten the stability of *currency B*. In this context cross-hedging can be a channel for contagion.[11]

Eaker and Grant (1987) point out that cross hedging is not limited to two different currencies[12], or to currencies at all. In fact, not only different currencies can be linked through cross-hedging but also different markets can be connected by multiple hedging. One example are commodity cross hedges. Eaker and Grant (1987) for instance investigate the role of gold futures in hedging currency risk.

[8]See e.g. Dodd (2002), p. 10.

[9]For more technical details on cross hedging, see Anderson and Danthine (1981).

[10]Broll (1997, p. 476) gives some examples of correlated currencies (before the introduction of the common european currency Euro): The German mark and the Dutch guilder, the British pound and the Australian dollar, the U.S. and the Canadian dollar.

[11]This is in particular of interest in the case of regional contagion between neighbouring countries, because cross hedging only makes sense if there are strong economic relations between the countries involved (see Eaker and Grant (1987), p. 104).

[12]As an example for multiple hedging Eaker and Grant (1987) discuss the hedging of an exposure in Spanish peseta with a combination of future positions in the German mark and the British pound (before the introduction of the Euro).

3.4 Hedging currency risk in fixed exchange rate regimes?

There are many reasons for developing country governments to maintain fixed exchange rate regimes. The minimized exchange rate risk is like an invitation to foreign investors and thus encourages trade which leads to higher growth rates. Furthermore exporting goods and debt management become more calculable. The question is: What role do foreign exchange derivatives play in fixed exchange rate regimes? Does speculation make sense when there is no uncertainty because the government guarantees the peg? Does hedging make sense when there is no currency risk to hedge?

Dodd (2002, p. 15) gives a simple answer to these questions: The "exchange rate derivatives function as a speculative or hedging instrument against the success of the government's policy." A government failure, which would either mean devaluation of the pegged exchange rate or a complete abandonment of the peg, is the only risk a trader can either hedge against or bet on. The fact that government failure is equal to devaluation makes speculation against the peg a one way bet. There will be surely more speculators who want to be short rather than long. The one way bet together with the ability to leverage reinforces self-fulfilling speculation, leads to capital outflows and consequently makes it very difficult for the government to defend the peg. The future exchange rate determined in the derivative market seems to be less an economic value but rather "a political price or the price of a policy event."[13]

3.5 Nonsynchronous trading, negative basis and arbitrageurs

The cash market and the futures market are connected by arbitrageurs who operate in both markets. When there are large price differences between both markets, arbitrageurs buy in one market and sell in the other and thus keep the prices in the two markets moving together. The difference between futures and cash prices is called the basis:

$$b_t = f_t - s_t \tag{1}$$

where f_t is the futures price in t and s_t is the spot price in t.

As the key determinant of whether arbitrage opportunities exist, the basis spread is a measure of how integrated the markets are. Normally the basis has a slightly positive value due to transaction costs and other differences between the markets and types of transactions.[14]

Blume, MacKinlay and Terker (1989), Harris (1989) and Kleidon and Whaley (1992) investigate the 1987 NYSE crash and point to the negative basis during the crisis. Kleidon and Whaley (1992) argue that the negative basis is a clear sign of

[13]Dodd (2002), p. 15.

[14]See Kleidon and Whaley (1992), p. 851.

a breakdown of the usual linkages between the markets in the crisis. Harris (1989) points out that the disintegration of the markets and the resulting nonsynchronous trading were caused when traders were not able to execute sell orders in the cash market and trading in the futures contract[15] was stopped at the Chicago Mercantile Exchange (CME). Because of the regulatory disruptions in the trade processes, conducting arbitrage became impossible. Furthermore the regulatory disruptions lead to even more panic and sell orders in the futures markets which caused the negative basis before trading in the futures involved was stopped by the CME.

Authorities explained the crash and the negative basis with the so-called cascade theory, pointing their fingers at portfolio insurers and arbitrageurs. The main point is that linking two markets together through arbitrage activities can be dangerous when one of the two markets is experiencing a crisis. In fact, arbitrageurs guarantee that the prices in the two markets move together. Falling prices in the spot market will lead to falling futures prices resulting in even more pressure on the cash market. The result of this interaction is a "downward cascade" in prices which seems to be "mutually perpetuating."[16]

Furthermore Harris (1989) shows that the futures market leads the cash market and that the futures market is more efficient over short intervals and reacts faster than the cash market. This finding is indicative of a negative overshooting in futures prices, leading to a negative basis and thus increasing the pressure on the cash market dramatically.

4 The impact of futures trading activity on exchange rates

The impact of derivative trading activity on spot market volatility can be investigated empirically in two ways.

First, some researchers examine the reaction of the cash market to the introduction of specific derivative products by comparing the spot volatility before and after the introduction. An overview over this way of investigation is provided by Jochum and Kodres (1998, p. 7). These studies concentrate on exchange traded derivatives because of the absence of time series data for over-the-counter derivatives. Some researchers like Jochum and Kodres (1998) examine the introduction of futures markets, others like Shastri, Sultan and Tandon (1996) the impact of the listing of options in the foreign exchange market.

Second, researchers have directly investigated the impact of futures and options trading activity (mainly proxied by trading volume) on the behavior of the spot market. This section examines empirically the relationship between currency futures trading activity and the volatility in the underlying exchange rates and thus follows

[15]The futures contract meant here is the S&P 500 index future.

[16]Ghysels and Seon (2000), p. 7.

the second type of investigation described.[17] The study investigates this relationship for the Australian Dollar (AUD), Canadian Dollar (CAD), Japanese Yen (JPY), Korean Won (KRW) and Swiss Franc (CHF) in terms of the U.S. dollar.[18]

4.1 Econometric modelling

The relationship is estimated with a *Vector Autoregressive Generalized Autoregressive Conditional Heteroscedasticity (VAR-GARCH) Model*.[19] The VAR-GARCH estimation is carried out in two steps:

1. Estimation of conditional variance of exchange rates through a GARCH(p,q) model as proxy for cash market volatility. The continously compounded returns of the five currencies are obtained by the transformation:

$$R_t = 100 * ln \frac{S_t}{S_{t-1}} \tag{2}$$

with spot exchange rate S_t of the currencies.

To identify the lag length, the Akaike (AIC) and Schwartz Bayesian (SBC) information criteria were calculated for lags one to twelve. The results, given in Table 8 in the appendix, indicate that a lag length longer than one is not appropriate for all currencies. The GARCH(1,1) model is chosen for the investigation of the exchange rate variability of the five currencies:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \epsilon_t \tag{3}$$

$$\epsilon_t = z_t \sqrt{h_t} \tag{4}$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \gamma_1 h_{t-1} \tag{5}$$

with white-noise process z_t i.i.d., E(z_t)=0, Var(z_t)=1.[20]

[17]The relationship between futures trading activity and spot market variability is investigated also for other markets than the foreign exchange market. Bessembinder and Seguin (1992) examine the impact of futures trading activity on stock price volatility. Jacobs and Onochie (1998) investigate the relationship between futures trading volume and interest rate assets.

[18]The data were obtained by the Reuters 3000Xtra system. For more details on the data, see Table 1.

[19]For more details on VAR-GARCH modelling and applications, see e.g. Chatrath, Ramchander and Song (1996); Bauwens, Deprins and Vandeuren (1997).

[20]See e.g. Bollerslev, Chou, Kroner (1992), p. 6; Enders (1995), p. 142; Stier (2001), p. 350. For more technical details on properties of GARCH processes, see Gourieroux (1997), p. 29-39.

2. The investigation of the relationship between cash market volatility and futures trading activity is done by employing a vector autoregressive (VAR) system. To obtain a time series of daily futures data, nearby contracts are used.[21]

   As proxy for the futures trading activity VOI_t, the futures daily trading volume V_t is standardized by the futures open interest OI_t:

$$VOI_t = \frac{V_t}{OI_t} \tag{6}$$

   Chatrath, Ramchander and Song (1996) suggest that VOI_t reflects speculative activity. Open interest largely reflects hedging activity because of its 'longer-than-intraday' character. Daily trading volume represents speculation because of its short term character. By standardizing the volume by the open interest, an indicator of the relationship between speculative and hedging activity is constructed.

   After having obtained h_t through the GARCH estimation, the relationship between cash market volatility h_t and the futures trading activity VOI_t is investigated by employing the vector autoregressive (VAR) system:

$$h_t = a_1 + b_1 h_{t-1} + c_1 VOI_{t-1} + e_t \tag{7}$$

$$VOI_t = d_1 + f_1 VOI_{t-1} + g_1 h_{t-1} + u_t \tag{8}$$

   where b_1 and f_1 are the coefficients for the regressors of the dependent variable and c_1 and g_1 are the coefficients of the independent variable; e_t and u_t are random error terms.

   The lag length of one for the VAR system was found appropriate after calculating the likelihood ratio test (LR test) and multivariate versions of the information criteria (MAIC and MSBC). The LR test is conducted starting with a VAR(10) system and successively reducing the lag number by one at a time. The results presented in Table 9 point to a lag length between one and three for all currencies.

   As the LR test has some disadvantages[22], multivariate versions of the information criteria are estimated as an alternative approach. The results presented

[21] The majority of futures trading activity concentrates generally on nearby contracts. Contracts with longer maturities are often not traded. See the appendix for more detail on contract specifications.

[22] Brooks (2002, p. 334-336) compares the LR test to the MAIC/MSBC. He argues that using the LR test, comparison between different lag structures can only be made pairwise. A further argument against the LR test is the χ^2-statistic, which "will strictly be valid asymptotically only under the assumption that the errors from each equation are normally distributed." (Brooks (2002), p. 335).

in Table 10 point once to a lag length of three, three times to a lag length of two and six times to a lag length of one.[23]

4.2 Empirical results

Table 1 presents the summary statistics for the spot returns R_t and futures trading activity VOI_t. A first interesting result with regard to Table 1 is the large mean and standard error of the futures trading activity VOI_t of the Korean Won (KRW) compared to the other four currencies. While the means and standard errors of the AUD, CAD, JPY and CHF are on a comparable level, the mean of the KRW is about three times as large and the standard error about four times as large as the average of the other four futures trading activities. The Korean Won is exposed to much more speculation in the futures markets than the other currencies discussed in this study.

Table 1 also presents a test on stationarity of the spot returns and futures trading activity. The augmented Dickey Fuller (ADF) statistics are negative and significant at the 1% level; the null hypothesis of nonstationarity of the series is rejected for all currencies.

[23]In fact the results of the LR test and the MAIC/MSBC are pretty similar. The LR test just indicates a slightly larger lag structure. Only in one case (Japan), the LR test points to three lags. In all other cases the suggested lag length is one or two. In order to keep the VAR systems for all currencies homogeneous, the lag length of both equations and for all currencies is chosen to be one.

Table 1: Summary statistics: exchange rates and futures trading

	AUD		CAD		JPY		KRW		CHF	
Sample	02/22/01-04/08/03		03/30/01-05/20/03		02/22/01-05/20/03		02/26/01-04/01/03		02/22/01-04/08/03	
Variables	R_t	VOI_t	R_t	VOI_t	R_t	VOI_t	R_t	VOI_t	R_t	VOI_t
Observations	530	530	537	537	561	561	515	515	532	532
Sample mean	0.0211	0.1283	-0.0221	0.1836	0.0016	0.2000	0.0001	0.6016	-0.0354	0.2342
Standard error	0.1832	0.1085	0.1077	0.0939	0.1719	0.1138	0.1511	0.4482	0.1659	0.1218
Skewness	-0.7544	3.0360	-0.3146	1.6214	0.1790	1.7106	-0.4106	3.1980	0.0975	1.3582
Kurtosis	1.5622	12.3388	1.5337	4.2788	-0.0999	4.1684	1.2856	18.2274	1.1432	2.5688
Maximum	0.5547	0.8138	0.3366	0.6988	0.7173	0.7990	0.4399	4.5525	0.8377	0.8239
Minimum	-0.9156	0.0097	-0.4408	0.0086	-0.4761	0.0290	-0.6946	0.0500	-0.5953	0.0108
ADF(1)*	-5.1345	-10.5079	-3.8673	-12.1576	-4.8283	-11.8479	-4.3355	-10.6152	-5.3599	-12.6763
	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

*ADF represents the augmented Dickey Fuller Test. The test rejects the null hypothesis of nonstationarity if significant and negative. Significance Level is given in parentheses.

Table 2: Test for serial correlation in the residuals

Ljung-Box Q-Statistics	AUD	CAD	JPY	KRW	CHF
Q(5)	20.8070	8.1928	10.5865	33.8176	11.6973
	(0.0003)	(0.0847)	(0.0316)	(0.0000)	(0.0197)
Q(50)	87.3077	91.1525	67.0130	67.7040	55.9438
	(0.0006)	(0.0002)	(0.0445)	(0.0394)	(0.2304)
Q(100)	118.7271	157.5572	119.1827	110.2832	114.8409
	(0.0861)	(0.0001)	(0.0817)	(0.2060)	(0.1318)

To investigate whether a GARCH model is appropriate for modelling the variability of the exchange rates discussed, several tests are carried out. The residuals of the regression

$$R_t = \alpha_1 R_{t-1} + \epsilon_t \tag{9}$$

are checked for linear dependencies. The autocorrelation coefficients of the residuals as well as for the squared residuals are given in Table 7 in the appendix. Table 2 contains the results of the Ljung-Box Q-Statistic for lags five, fifty and one hundred. The long lags of fifty and one hundred are chosen according to Hsieh (1989, p. 307). The results presented in Table 2 are not unequivocal. Linear dependencies can not be rejected for all currencies at all lags. Nevertheless the GARCH(1,1) model shall be used for modelling the spot volatility. After the estimation, diagnostic checking will be conducted.

The next step in investigating whether a GARCH model is appropriate is to check the squared residuals for conditional heteroscedasticity. The autocorrelation coefficients of the squared residuals as well as the Ljung-Box Q-Statistics and the Lagrange Multiplier Test (LM) are indicative of strong conditional heteroscedasticity. Table 3 presents the results of the Ljung-Box Q-Statistics and the Lagrange Multiplier Test. These results indicate that the GARCH model is appropriate for modelling the exchange rates' volatility.

The identification procedure is supplemented after the estimation of the GARCH model with diagnostics on the standardized residuals z_t from equation (4)

$$z_t = \frac{\hat{\epsilon_t}}{\sqrt{\hat{h_t}}} \tag{10}$$

where $\hat{\epsilon_t}$ is the residual from equation (3) and $\hat{h_t}$ is the estimated variance from equation (5). The GARCH model is correctly specified if z_t has a zero mean and unit variance. Furthermore there should be no autocorrelation in the z_t series. Table 4 presents the results of the diagnostic checking. For all currencies the mean is close to zero and the variance close to one. Autocorrelation coefficients and Ljung-Box Q-Statistic indicate that there is no autocorrelation in the standardized residuals.

Table 3: Tests for ARCH errors in the squared residuals

	AUD	CAD	JPY	KRW	CHF
Ljung-Box Q-Statistics					
Q(4)	83.8043	56.4645	30.5064	94.8601	59.3009
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Q(8)	84.0327	65.6799	32.0121	95.1160	59.5787
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Q(12)	84.4451	66.4204	36.0810	95.5139	60.1016
	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)
Q(16)	84.4937	67.9704	37.6244	97.3823	60.2329
	(0.0000)	(0.0000)	(0.0010)	(0.0000)	(0.0000)
Lagrange Multiplier Test (LM)					
$\chi^2(1)$	82.8277	55.5243	29.8693	79.0837	58.4765
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\chi^2(4)$	102.2545	61.1028	33.6667	100.3291	66.4754
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\chi^2(8)$	102.5818	71.0175	34.2069	102.3469	66.1250
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\chi^2(12)$	102.1343	71.6834	36.6664	104.9859	65.8439
	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0000)

These results validate the decision to use a GARCH model for investigating the exchange rate volatility for all currencies discussed here.

After having obtained the measure for exchange rate volatility h_t through the GARCH model, h_t and the futures trading activity variable VOI_t are put in a VAR model to investigate the relationship between spot volatility and futures trading activity. The results of the VAR estimation are presented in Table 6.

The main question is whether both variables have an influence on each other. One way to investigate this question is to test for Granger causality. Tables 11 and 12 present the Granger causality test statistics. The results for h_t as the dependent variable (equation (7)) are given in Table 11 and the results for VOI_t as the dependent variable (equation (8)) are given in Table 12. The results in Table 11 strongly indicate that futures trading activity VOI_t Granger-causes the exchange rate volatility h_t for all currencies except the Korean Won. However, there is no indication in Table 12, that h_t Granger-causes VOI_t. The only exception is again the Korean Won with significant influence at 5 % level for small lags.

The results presented in Tables 11 and 12 show some structural difference between the industrialized countries Australia, Canada, Japan and Switzerland on the one side and the emerging market country Korea on the other side. This strengthens the assumption based on the summary statistics presented in Table 1 that Korea plays a special role in this investigation. One aspect all currencies have in common

Table 4: Diagnostics of the standardized residuals z_t

	AUD	CAD	JPY	KRW	CHF
Summary Statistics					
Mean	-0.0017	-0.0022	-0.0000	-0.0272	0.0306
Variance	1.0019	1.0018	1.0018	1.0012	1.0009
Autocorrelation coefficients					
1	-0.0253	-0.0127	-0.0447	-0.0488	0.0083
2	-0.0369	0.0092	0.0119	0.0561	0.0005
3	0.0454	0.0593	0.0529	0.0136	0.0462
4	0.0701	0.0332	0.0023	0.0495	0.0868
5	0.0033	0.0528	0.0608	-0.0106	0.0070
Ljung-Box Q-Statistics					
Q(4)	4.7374	2.5969	2.7529	4.1712	5.1586
	(0.1920)	(0.4580)	(0.4313)	(0.2435)	(0.1605)
Q(8)	14.3948	11.3119	5.6075	6.1037	6.5394
	(0.0445)	(0.1255)	(0.5862)	(0.5276)	(0.4783)
Q(12)	15.0397	12.5142	7.6530	13.6890	10.0322
	(0.1806)	(0.3262)	(0.7440)	(0.2506)	(0.5274)

is that there seems to be no 'bi-directional causality' or 'bi-directional feedback'.[24]

However, the results indicate that there seems to be a link between futures trading activity and exchange rate volatility. In order to investigate this linkage more deeply, impulse response functions and variance decompositions are estimated. Figure 1 shows the responses of the spot volatilities h_t of the five currencies to one standard deviation shocks in VOI_t, and Figure 2 shows the responses of the trading activities of the five currency futures to one standard deviation shocks in the underlying exchange rates' volatilities.

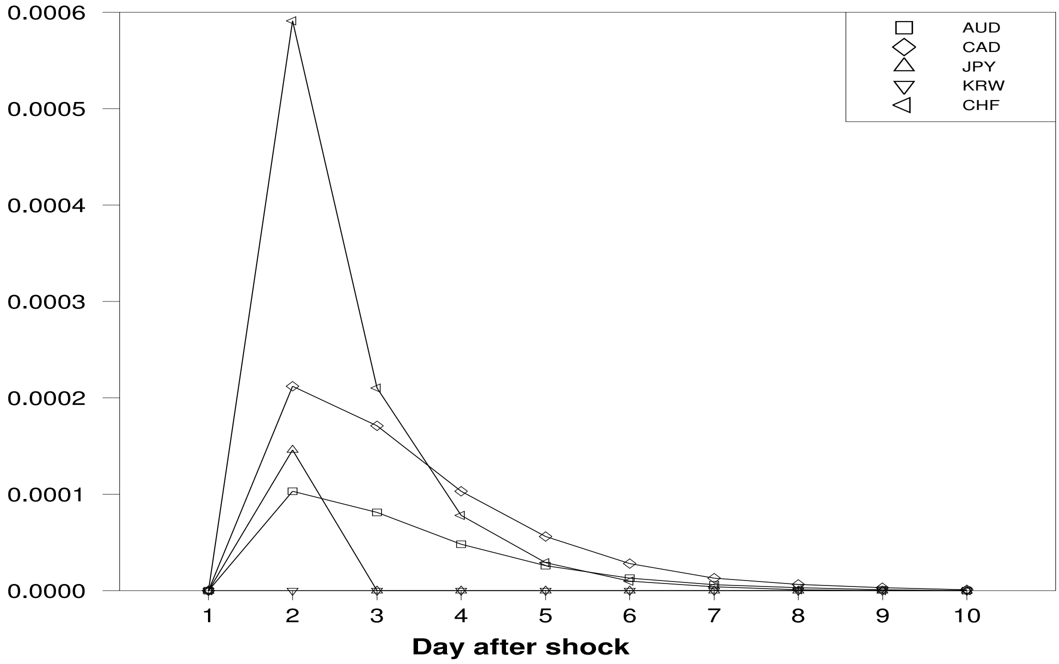
The impulse responses presented in Figure 1 are positive reactions of the spot volatility h_t to shocks in futures trading activity VOI_t. The only exception is the Korean Won. The Korean spot volatility does not react at all to a shock in futures trading activity.

Another point in analyzing Figure 1 is the sign of overreaction of some currencies; in particular the Swiss Franc. The AUD, CAD, JPY and CHF reach their maximum on the second day after the shock, and drop back to zero pretty fast.

Figure 2 presents the impulse response function of futures trading activity VOI_t to shocks in the underlying's volatility h_t. Again there are differences between the reactions in the industrialized countries Australia, Canada, Japan and Switzerland and the emerging markets country Korea.

[24]In fact, the only currency that shows slight 'bi-directional causalities' is the Canadian Dollar. The results of the variance decomposition presented in Table 13 indicate this point.

Figure 1: Impulse response function of h_t to shock in VOI_t



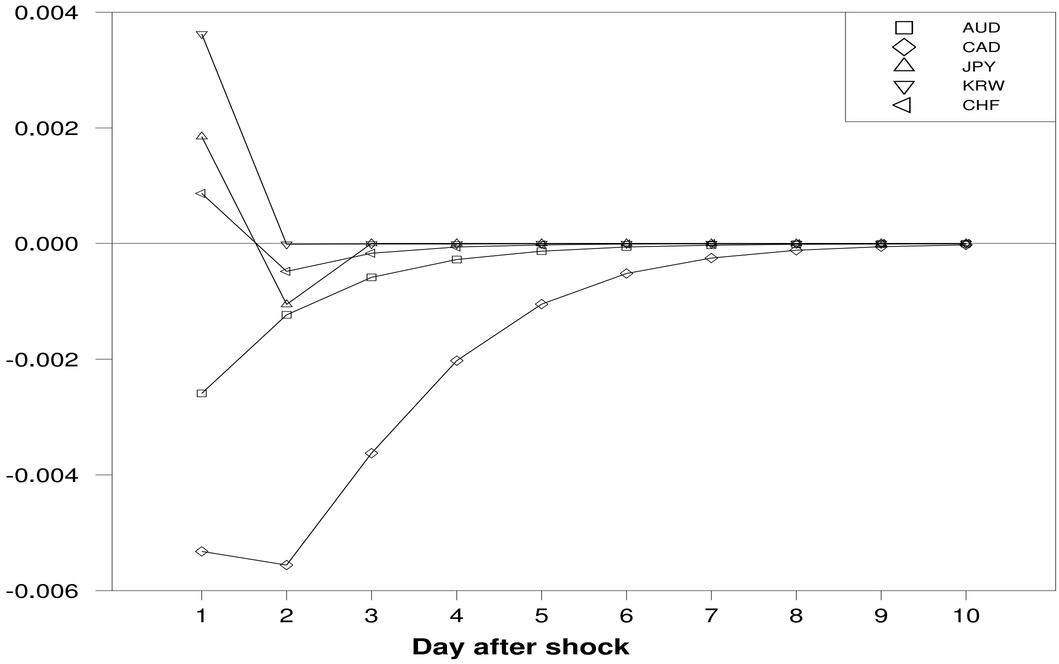
The reactions in the developed countries are consistent with the findings of Chatrath, Ramchander and Song (1996) who analysed the British Pound, Deutsche Mark, Swiss Franc, Canadian Dollar and Japanese Yen in terms of the US Dollar. The reaction of the KRW-futures trading activity on a shock in h_t is large, positive and drops back to zero on the second day after the shock. On the first trading day after the shock there are also smaller positive reactions in futures trading in the Japanese Yen and Swiss Franc. But these reactions become negative on the second trading day.

The comparable strong positive reaction of the trading activity in KRW-futures after a shock in KRW spot volatility might indicate that signs of instability in the Korean Won lead traders to take positions in derivative markets. If the variable VOI_t represents speculation, this might be a sign that traders bet against the currency. If VOI_t also includes other traders than speculators, hedgers who fear the spot markets to become more and more volatile may open positions in futures markets in order to minimize currency risk. Whether speculators betting against the currency or hedgers minimizing risks, the traders do not seem to have much confidence in the stability of the Korean Won.

4.3 A new measure for futures trading activity

In the previous investigation futures trading activity was represented by the daily trading volume standardized by open interest:

Figure 2: Impulse response function of VOI_t to shock in h_t



$$VOI_t = \frac{V_t}{OI_t} \tag{11}$$

This measure is based on the number of contracts traded. The units of trading of the future contracts are all denoted in different currencies.[25] Thus the question arises whether the results for the different countries are comparable.

In order to examine the robustness of the results above a new measure for futures trading activity is constructed. To make the results for the five countries more comparable the trading activity is standardized to its value in US dollars. This is done by the following transformation:

1. For Australia, Canada, Japan and Switzerland:[26]

$$VID_t = V_t * UoT[domestic\ currency] * e[\frac{US\ dollar}{domestic\ currency}]_t \tag{12}$$

2. For Korea:[27]

[25] For more details on futures contract specifications, see the appendix.

[26] The units of trading for these countries are denoted in the domestic currencies. To obtain the value of the contracts in US dollars at time t, the unit of trading is multiplied with the exchange rate in t.

[27] The units of trading for the Korean Won futures contracts are already denoted in US dollars. Thus, a transformation of the currency is not necessary.

$$VID_t = V_t * UoT[US\ \ dollar] \tag{13}$$

where:
V_t: daily trading volume[28],
UoT: unit of trading,
$e[\frac{US\ \ dollar}{domestic\ \ currency}]_t$: exchange rate.

Table 5: Summary statistics for VID series

	AUD	CAD	JPY	KRW	CHF
Observations	530	537	561	515	532
Unit of trading	100,000 AUD	100,000 CAD	12,500,000 JPY	50,000 USD	125,000 CHF
Sample Mean	585,771,004	684,203,490	1,592,878,047	248,187,378	799,493,031
Standard error	385,688,983	317,906,979	838,492,406	94,830,914	419,053,404
Skewness	1.9909	0.9262	1.4030	0.1809	1.1906
Kurtosis	5.6345	1.5310	2.8514	0.2164	1.7447
Maximum	2,935,036,713	2,162,645,859	6,225,104,174	538,400,000	2,573,903,869
Minimum	10,743,199	8,944,375	149,462,388	19,550,000	22,102,229
ADF(1)	-12.4585	-12.7138	-12.8191	-11.8344	-12.5946
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

The summary statistics, units of trading and the augmented Dickey Fuller (ADF) statistics are presented in Table 5. The KRW futures market appears to be comparable small while the JPY futures market is the largest of the markets presented here.

As there are no changes in the GARCH estimation of the exchange rate volatility, the VAR system can be constructed as follows:

$$h_t = a_1 + b_1 h_{t-1} + c_1 VID_{t-1} + w_t \tag{14}$$

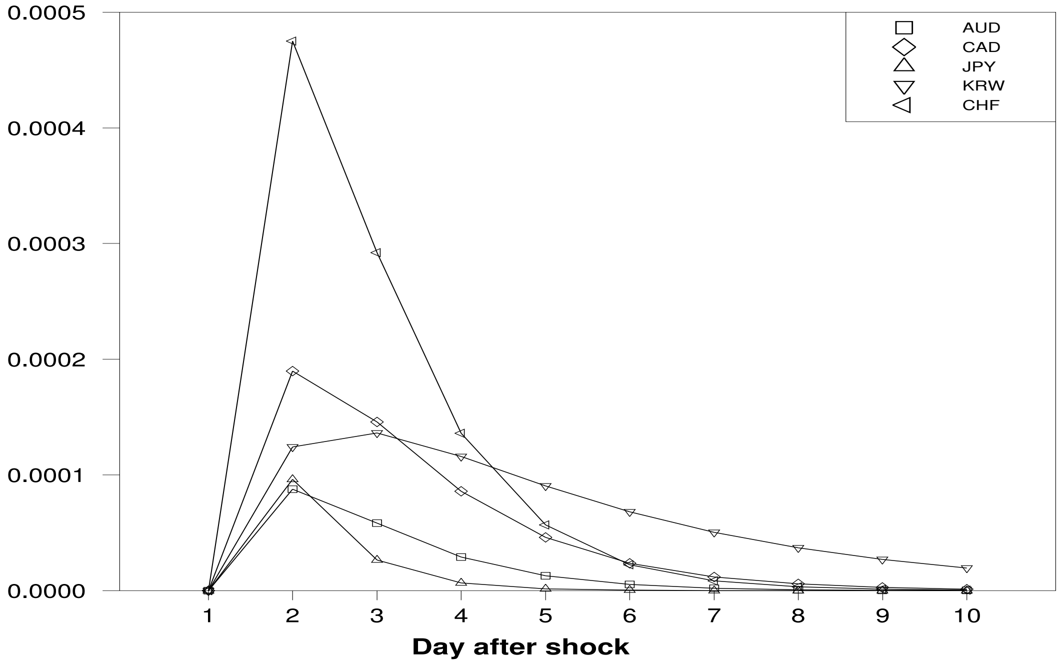
$$VID_t = d_1 + f_1 VID_{t-1} + g_1 h_{t-1} + u_t \tag{15}$$

The VAR-estimation results as well as the results of the Granger Causality tests and the variance decomposition are presented in Tables 14, 15, 16 and 17 in the appendix. The impulse response functions are shown in Figures 3 and 4.

The impulse responses of h_t to shocks in VID_t shown in Figure 3 appear to be similar to the previous results presented in Figure 1. The volatilities of all exchange rates react positive to shocks in futures trading activity. In contrast to the previous investigation the volatility of the Korean Won reacts positive with a long lasting

[28]In this investigation, V_t is not standardized by OI_T, because V_T represents a clearer measure for speculative activity.

Figure 3: Impulse response function of h_t to shock in VID_t

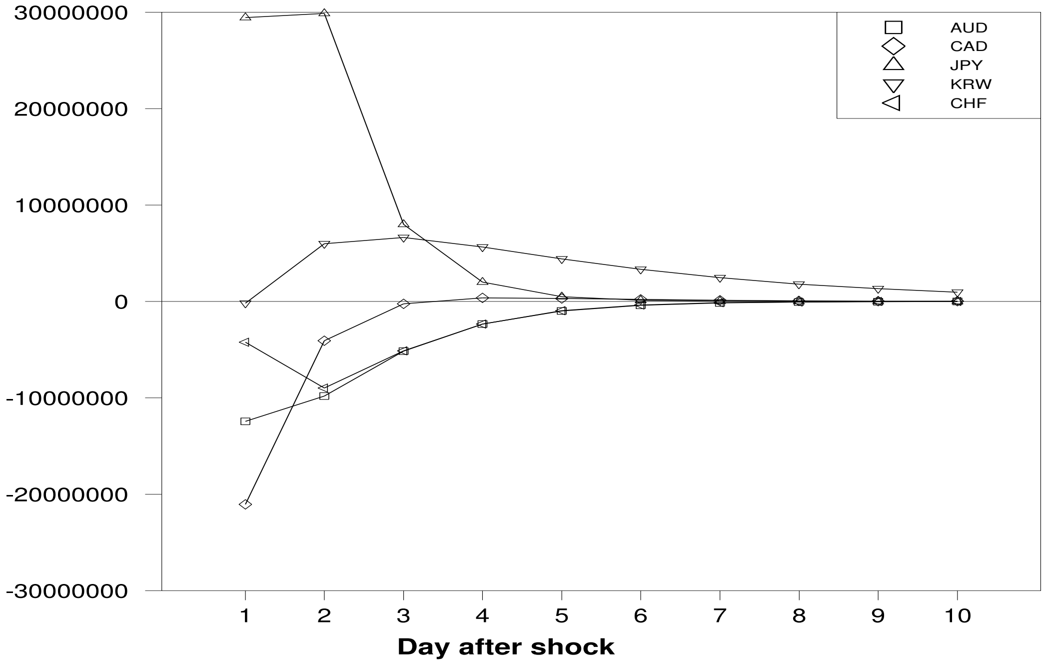


impact of the shock. Hence, these findings confirm the previous results that a shock in futures trading activity whether measured by the number of contracts traded or the total amount in US dollars, adds to the instability of the underlying exchange rate. The results are therefore consistent.

Figure 4 shows the impulse responses of VID_t to shocks in h_t. The results of the Granger Causality test presented in Table 16 indicate only for the Korean Won a significant impact of the spot volatility on futures trading activity. Figure 4 shows that this impact is positive. Again this confirms the previous results although comparing Figures 2 and 4 the courses of the reactions of the KRW futures trading activity are different. While Figure 2 shows a strong, overshooting positive reaction with very short duration, the reaction presented in Figure 4 looks more like a flat, positive and long lasting curve.

The results for the other four currencies presented in Figure 4 are mixed. The reaction for Canada, Australia and Switzerland appear to be similar to the results presented in Figure 2. The curves are mainly in the negative sphere and reach the zero line between the sixth and seventh day after the shock. The curve for Japan shows a strong positive reaction of futures trading activity to a shock in spot volatility before it reaches zero on the sixth day after the shock.

Figure 4: Impulse response function of VID_t to shock in h_t



5 Summary and conclusion

This paper examines the linkage between currency futures trading and currency crises. The sections on market characteristics and derivative traders present some potential linkages between futures market activities and spot market turbulence. The last section investigates this linkage empirically. A VAR-GARCH model is implemented to investigate the relationship between futures trading activity measured by number of contracts and total amount in US dollars and the spot volatility of five exchange rates in terms of the US dollar: the Australian Dollar, the Canadian Dollar, the Japanese Yen, the Korean Won and the Swiss Franc. The main results of the empirical investigation are:

- The summary statistics presented in Table 1 show a very large mean and standard deviation of the VOI_t ratio for the Korean Won futures. This may indicate that the Korean Won is exposed to more speculative activity in futures markets than the other four currencies discussed in this investigation, although the Korean Won futures market is the smallest of the markets discussed here (see Table 5).

- The GARCH model is appropriate to model the spot volatility of the exchange rates. This finding is consistent with the results of Chatrath, Ramchander and Song (1996) and Hsieh (1989).

- The results of the VAR systems indicate some structural differences between the industrialized countries Australia, Canada, Japan and Switzerland and the emerging market country Korea:

  1. Granger Causality tests and variance decomposition indicate a small but significant impact of futures trading activity on spot volatility in the industrialized countries and a significant impact of spot volatility on futures trading activity for the Korean Won.
  2. The impulse responses of spot volatility to shocks in futures trading activity presented in Figures 1 and 3 show for almost all countries a positive, overshooting reaction that generally drops back to zero during the first ten days after the shock. Hence, for both measures of futures trading activity a shock in futures trading activity seems to have a destabilizing effect on the underlying exchange rates.
  3. The impulse responses of futures trading activity to shocks in spot volatility are mixed among the different countries. However, following the results of the Granger Causality statistics, only for Korea there is a significant impact of spot volatility on futures trading. This impact appears to be positive although the responses shown in Figures 2 and 4 differ in size, duration and course of the curves. This positive reaction might indicate that traders react very sensitive to changes in the Korean Won. Whether the traders who open positions in futures markets as reaction to a higher volatility are hedgers or speculators, the traders do not seem to be very confident in the stability of the Korean Won.

While the empirical results appear reasonably clear, the absence of a wider range of data for a larger number of countries implies that a general conclusion about the role of currency futures in currency crises cannot be drawn. Moreover, because of the lack of futures data for emerging markets, only one emerging market country is presented in this study. Regarding the fact that especially developing countries may be vulnerable to self-fulfilling speculative attacks and adverse developments in international financial markets, the significance of this investigation about the potential role of futures trading in developing countries' exchange rate stability is limited. Additional research is needed to obtain further insights into this issue, as soon as more data are available. However, for the five countries' exchange rates examined in this study, the evidence indicates a positive relationship between currency futures trading activity and spot exchange rate volatility.

A Empirical results

Table 6: VAR results: VOI_t and h_t

Country	Dependent Series	Variables	Coefficients	Standard Error	T-Stat.	Signif.
Australia	h_t	h_{t-1}	0.3119	0.0412	7.5590	0.0000
		VOI_{t-1}	0.0009	0.0015	0.5992	0.5492
		Constant	0.0051	0.0004	12.4078	0.0000
	VOI_t	h_{t-1}	-0.0929	0.9903	-0.0939	0.9252
		VOI_{t-1}	0.4748	0.0383	12.3750	0.0000
		Constant	0.0681	0.0099	6.8413	0.0000
Canada	h_t	h_{t-1}	0.4836	0.0377	12.8220	0.0000
		VOI_{t-1}	0.0021	0.0007	2.8144	0.0050
		Constant	0.0007	0.0001	4.0899	0.0000
	VOI_t	h_{t-1}	-2.5906	2.0680	-1.2526	0.2108
		VOI_{t-1}	0.3225	0.0409	7.8713	0.0000
		Constant	0.1300	0.0096	13.4205	0.0000
Japan	h_t	h_{t-1}	0.0339	0.0417	0.8126	0.4167
		VOI_{t-1}	0.0008	0.0005	1.4830	0.1386
		Constant	0.0052	0.0002	20.0882	0.0000
	VOI_t	h_{t-1}	0.4562	3.0843	0.1479	0.8824
		VOI_{t-1}	0.2771	0.0407	6.8001	0.0000
		Constant	0.1421	0.0194	7.3232	0.0000
Korea	h_t	h_{t-1}	0.7241	0.0305	23.6673	0.0000
		VOI_{t-1}	-0.0001	0.0003	-0.5465	0.5849
		Constant	0.0015	0.0003	5.0181	0.0000
	VOI_t	h_{t-1}	7.6051	3.3422	2.2754	0.0232
		VOI_{t-1}	0.4483	0.0392	11.4117	0.0000
		Constant	0.2944	0.0329	8.9362	0.0000
Switzerland	h_t	h_{t-1}	0.3716	0.0401	9.2674	0.0000
		VOI_{t-1}	0.0041	0.0017	2.3300	0.0201
		Constant	0.0032	0.0005	6.0910	0.0000
	VOI_t	h_{t-1}	-0.5380	0.9537	-0.5641	0.5729
		VOI_{t-1}	0.2227	0.0424	5.2490	0.0000
		Constant	0.1856	0.0128	14.4698	0.0000

Table 7: Autocorrelations (ρ_i) of residuals (ϵ_t) and squared residuals (ϵ_t^2)

	AUD		CAD		JPY		KRW		CHF	
Autocorrelation coefficients	ϵ_t	ϵ_t^2	ϵ_t	ϵ_t^2	ϵ_t	ϵ_t^2	ϵ_t	ϵ_t^2	ϵ_t	ϵ_t^2
ρ_1	-0.1567	0.3960	-0.0996	0.3220	-0.0917	0.2310	-0.2233	0.3925	-0.1102	0.3321
ρ_2	0.0029	-0.0044	-0.0035	0.0096	0.0371	-0.0180	0.0810	0.0452	0.0232	-0.0047
ρ_3	0.0725	-0.0033	0.0602	-0.0146	0.0620	0.0032	0.0771	0.1229	0.0505	-0.0211
ρ_4	0.0957	0.0252	0.0230	-0.0272	0.0133	-0.0210	0.0414	0.1097	0.0789	-0.0160
ρ_5	0.0045	-0.0151	0.0326	0.0016	0.0701	-0.0246	0.0353	-0.0162	0.0189	-0.0101
ρ_6	0.1343	0.0065	0.1355	0.1229	0.0319	-0.0083	0.0361	-0.0070	-0.0030	0.0040
ρ_7	0.0060	0.0118	-0.0148	0.0301	-0.0213	-0.0231	0.0482	-0.0055	0.0526	-0.0083
ρ_8	-0.0397	-0.0037	0.0000	-0.0299	0.0323	-0.0378	0.0547	-0.0120	-0.0093	-0.0180
ρ_9	0.0156	-0.0191	0.0011	-0.0242	-0.0279	-0.0413	0.0311	-0.0045	-0.0399	-0.0141
ρ_{10}	0.0081	-0.0137	0.0609	-0.0169	0.0439	-0.0475	-0.0084	-0.0123	-0.0388	-0.0247

Table 8: Lag length selection of GARCH model with information criteria

	AUD		CAD		JPY		KRW		CHF	
	AIC	SBC	AIC	SBC	AIC	SBC	AIC	SBC	AIC	SBC
ARCH(1)	775.7513	792.7743	72.6029	89.6793	661.8732	679.1274	520.4689	537.3750	686.9298	703.9681
ARCH(2)	777.7513	799.0300	74.6029	95.9483	663.8732	685.4409	522.4689	543.6016	688.9298	710.2277
ARCH(3)	779.7513	805.2858	76.6029	102.2174	665.8732	691.7545	524.4689	549.8281	690.9298	716.4872
ARCH(4)	781.7513	811.5415	78.6029	108.4865	667.8732	698.0680	526.4689	556.0546	692.9298	722.7468
ARCH(5)	783.7513	817.7973	80.6029	114.7556	669.8732	704.3816	528.4689	562.2812	694.9298	729.0064
ARCH(6)	785.7513	824.0530	82.6029	121.0247	671.8732	710.6951	530.4689	568.5077	696.9298	735.2660
ARCH(7)	787.7513	830.3088	84.6029	127.2938	673.8732	717.0087	532.4689	574.7342	698.9298	741.5256
ARCH(8)	789.7513	836.5645	86.6029	133.5629	675.8732	723.3222	534.4689	580.9608	700.9298	747.7851
ARCH(9)	790.2777	841.3236	88.4805	139.6869	676.6886	728.4295	535.4561	586.1508	701.6316	752.7236
ARCH(10)	790.8041	846.0788	90.3582	145.8071	677.5041	733.5330	536.4433	591.3368	702.3335	757.6582
ARCH(11)	791.3305	850.8301	92.2358	151.9234	678.3195	738.6329	537.4305	596.5188	703.0353	762.5889
ARCH(12)	791.8568	855.5775	94.1135	158.0358	679.1350	743.7291	538.4177	601.6967	703.7372	767.5157
GARCH(1,1)	761.2801	786.8146	70.6283	96.2428	660.3205	686.2018	491.7874	517.1466	683.4576	709.0151

Table 9: Lag length selection of VAR system using the likelihood ratio test

	AUD		CAD		JPY		KRW		CHF	
High TO Low	χ^2	Signif. Level	χ^2	Signif. Level	χ^2	Signif. Level	χ^2	Signif. Level	χ^2	Signif. Level
10 TO 9	11.7735	0.9999	-0.9827	NA	3.3556	1.0000	4.6095	1.0000	2.2154	1.0000
9 TO 8	21.2455	0.9567	2.4329	1.0000	27.8975	0.7603	0.5401	1.0000	2.0656	1.0000
8 TO 7	22.9524	0.8172	-0.9798	NA	26.6734	0.6403	0.7015	1.0000	1.7243	1.0000
7 TO 6	1.2635	1.0000	3.5037	0.9999	13.4272	0.9798	1.7360	1.0000	5.7940	0.9999
6 TO 5	1.7983	1.0000	3.3814	0.9999	17.1081	0.7573	2.7629	0.9999	5.7141	0.9998
5 TO 4	25.7016	0.1067	10.1668	0.9263	11.1214	0.8891	2.2338	0.9999	1.1352	0.9999
4 TO 3	5.3426	0.9804	4.4694	0.9919	14.4705	0.4152	1.7726	0.9999	10.2295	0.7452
3 TO 2	5.8145	0.8305	2.0009	0.9963	35.2593	0.0001	11.9828	0.2862	5.5721	0.8498
2 TO 1	11.9660	0.0627	25.7483	0.0002	66.4382	0.0000	29.6621	0.0000	19.8501	0.0029

Table 10: Lag length selection of VAR model with multivariate versions of the information criteria

	AUD		CAD		JPY		KRW		CHF	
	MAIC	MSBC	MAIC	MSBC	MAIC	MSBC	MAIC	MSBC	MAIC	MSBC
VAR(1)	-8320.6442	-8295.0183	-9475.5079	-9449.8031	-9764.9805	-9739.0129	-6713.5658	-6688.1125	-7879.6358	-7853.9872
VAR(2)	-8309.0895	-8266.3986	-9476.0461	-9433.2234	-9807.1701	-9763.9086	-6722.7330	-6680.3302	-7877.0059	-7834.2771
VAR(3)	-8291.2880	-8231.5472	-9452.3513	-9392.4257	-9817.7569	-9757.2159	-6713.9089	-6654.5724	-7859.8295	-7800.0357
VAR(4)	-8273.0338	-8196.2584	-9431.2235	-9354.2101	-9807.0660	-9729.2598	-6694.5785	-6618.3238	-7847.5093	-7770.6655
VAR(5)	-8276.0629	-8182.2682	-9416.0668	-9321.9806	-9792.9741	-9697.9172	-6675.7416	-6582.5846	-7825.7631	-7731.8847
VAR(6)	-8254.1074	-8143.3086	-9393.8402	-9282.6964	-9785.2307	-9672.9375	-6657.4774	-6547.4337	-7808.8413	-7697.9434
VAR(7)	-8231.5965	-8103.8090	-9371.7654	-9243.5791	-9773.7019	-9644.1870	-6638.1407	-6511.2262	-7792.0419	-7664.1399
VAR(8)	-8232.2941	-8087.5334	-9344.9225	-9199.7089	-9776.3724	-9629.6503	-6617.7074	-6473.9380	-7770.9296	-7626.0389
VAR(9)	-8231.3103	-8069.5918	-9321.7503	-9159.5246	-9780.5306	-9616.6158	-6597.1045	-6436.4961	-7750.1973	-7588.3332
VAR(10)	-8220.1734	-8041.5126	-9294.8837	-9115.6613	-9758.3072	-9577.2143	-6580.9443	-6403.5129	-7729.6426	-7550.8205

Table 11: Granger causality test for dependent variable h_t (Equation (7))

	AUD		CAD		JPY		KRW		CHF	
lag	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t
1	57.1391	0.3591	164.4061	7.9209	0.6604	2.1994	560.1416	0.2987	85.8861	5.4293
	(0.0000)	(0.5492)	(0.0000)	(0.0050)	(0.4167)	(0.1386)	(0.0000)	(0.5849)	(0.0000)	(0.0201)
2	30.0909	0.2499	94.7962	6.4284	15.6813	4.7871	302.9200	0.2619	48.8445	5.3455
	(0.0000)	(0.7790)	(0.0000)	(0.0017)	(0.0000)	(0.0086)	(0.0000)	(0.7696)	(0.0000)	(0.0050)
3	20.5368	0.4688	62.8925	4.1426	11.5178	4.0204	208.0807	0.5336	33.2234	4.2470
	(0.0000)	(0.7041)	(0.0000)	(0.0064)	(0.0000)	(0.0075)	(0.0000)	(0.6594)	(0.0000)	(0.0055)
4	15.3565	0.8042	46.9384	3.2017	8.2610	3.1586	155.3546	0.3675	25.2426	4.1159
	(0.0000)	(0.5228)	(0.0000)	(0.0129)	(0.0000)	(0.0139)	(0.0000)	(0.8317)	(0.0000)	(0.0027)
5	13.4014	5.7906	38.0433	3.0732	5.2987	2.4769	123.3014	0.2742	19.9578	3.3215
	(0.0000)	(0.0000)	(0.0000)	(0.0095)	(0.0000)	(0.0311)	(0.0000)	(0.9272)	(0.0000)	(0.0058)
6	10.2597	4.7746	32.2167	2.2989	3.6649	2.2435	102.3599	0.2973	16.4496	3.3454
	(0.0000)	(0.0000)	(0.0000)	(0.0336)	(0.0014)	(0.0378)	(0.0000)	(0.9381)	(0.0000)	(0.0030)
7	8.5339	4.1415	27.9778	2.0299	2.5758	1.7440	87.1507	0.2391	13.5171	3.1759
	(0.0000)	(0.0001)	(0.0000)	(0.0496)	(0.0128)	(0.0964)	(0.0000)	(0.9754)	(0.0000)	(0.0026)
8	7.4919	5.9102	24.1488	1.7908	2.3360	2.9567	75.6605	0.2195	11.4734	2.8998
	(0.0000)	(0.0000)	(0.0000)	(0.0764)	(0.0179)	(0.0030)	(0.0000)	(0.9874)	(0.0000)	(0.0036)
9	5.2444	7.6237	21.4385	1.9365	2.7288	2.5411	66.6749	0.2181	10.1922	2.7049
	(0.0000)	(0.0000)	(0.0000)	(0.0448)	(0.0040)	(0.0073)	(0.0000)	(0.9918)	(0.0000)	(0.0043)
10	5.4987	8.1035	19.1341	1.7392	2.2762	2.3451	60.2669	0.7098	9.1297	2.6954
	(0.0000)	(0.0000)	(0.0000)	(0.0693)	(0.0129)	(0.0103)	(0.0000)	(0.7155)	(0.0000)	(0.0031)

Table 12: Granger causality test for dependent variable VOI_t (Equation (8))

	AUD		CAD		JPY		KRW		CHF	
lag	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t
1	0.0088	153.1418	1.5692	61.9574	0.0219	46.2425	5.1777	130.2272	0.3182	27.5521
	(0.9252)	(0.0000)	(0.2108)	(0.0000)	(0.8824)	(0.000)	(0.0232)	(0.0000)	(0.5729)	(0.0000)
2	0.4094	80.3036	1.3967	34.2471	0.1033	32.8193	3.5729	65.9986	0.3916	17.9339
	(0.6642)	(0.0000)	(0.2493)	(0.0000)	(0.9018)	(0.0000)	(0.0287)	(0.0000)	(0.6761)	(0.0000)
3	0.3323	54.0733	0.8731	23.0791	1.5154	26.5261	2.5702	43.0065	1.0707	12.5712
	(0.8019)	(0.0000)	(0.4547)	(0.0000)	(0.2094)	(0.0000)	(0.0535)	(0.0000)	(0.3610)	(0.0000)
4	0.4105	40.9422	1.2998	17.9770	1.2768	20.0287	1.8986	32.3442	1.5903	10.3129
	(0.8011)	(0.0000)	(0.2690)	(0.0000)	(0.2779)	(0.0000)	(0.1094)	(0.0000)	(0.1754)	(0.0000)
5	0.3290	32.8004	1.8411	15.6765	0.9315	16.2998	1.6380	26.3700	1.2098	8.4550
	(0.8955)	(0.0000)	(0.1031)	(0.0000)	(0.4599)	(0.0000)	(0.1482)	(0.0000)	(0.3031)	(0.0000)
6	0.3392	27.1802	1.5367	13.0342	0.8159	14.4225	1.7152	21.7464	1.1297	7.1241
	(0.9160)	(0.0000)	(0.1639)	(0.0000)	(0.5577)	(0.0000)	(0.1154)	(0.0000)	(0.3436)	(0.0000)
7	0.2601	23.1165	1.3831	11.1396	0.7427	12.7490	1.8011	18.9919	1.3859	6.1952
	(0.9688)	(0.0000)	(0.2100)	(0.0000)	(0.6358)	(0.0000)	(0.0849)	(0.0000)	(0.2088)	(0.0000)
8	0.2103	20.7379	1.1909	9.7024	0.8333	10.9405	1.4944	14.8705	1.2979	5.5519
	(0.9890)	(0.0000)	(0.3022)	(0.0000)	(0.5734)	(0.0000)	(0.1469)	(0.0000)	(0.2420)	(0.0000)
9	0.3667	18.5434	1.1365	8.6037	1.0647	10.1294	1.4944	14.8705	1.2345	5.1045
	(0.9505)	(0.0000)	(0.3347)	(0.0000)	(0.3872)	(0.0000)	(0.1469)	(0.0000)	(0.2712)	(0.0000)
10	0.3054	16.7291	1.0308	7.6593	1.1611	9.0413	1.3957	13.4926	1.0710	4.6400
	(0.9797)	(0.0000)	(0.4158)	(0.0000)	(0.3147)	(0.0000)	(0.1788)	(0.0000)	(0.3828)	(0.0000)

Table 13: Decomposition of variance for series h_t and VOI_t

	For series h_t [1]										For series VOI_t									
	AUD		CAD		JPY		KRW		CHF		AUD		CAD		JPY		KRW		CHF	
	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t	VOI_t	h_t
1	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	99	1	100	0
2	100	0	99	1	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
3	100	0	98	2	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
4	100	0	98	2	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
5	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
6	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
7	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
8	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
9	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0
10	100	0	97	3	99	1	100	0	99	1	100	0	99	1	100	0	99	1	100	0

[1]Numbers are in percentages and may not add up to 100 percent due to rounding errors.

Table 14: VAR results: VID_t and h_t

Country	Dependent Series	Variables	Coefficients	Standard Error	T-Stat.	Signif.
Australia	h_t	h_{t-1}	0.6970	0.0312	22.3303	0.0000
		VID_{t-1}	1.48e-13	0.0000	0.0000	0.0000
		Constant	0.0017	3.27e-04	5.3120	0.0000
	VID_t	h_{t-1}	-1.57e+09	3.40e+09	-0.4619	0.6442
		VID_{t-1}	0.3519	0.0408	8.6197	0.0000
		Constant	389498217.9353	35754278.1594	10.8937	0.0000
Canada	h_t	h_{t-1}	0.4819	0.0377	12.7613	0.0000
		VID_{t-1}	5.52e-13	0.0000	0.000	0.0000
		Constant	7.35e-04	1.88e-04	3.9104	0.0001
	VID_t	h_{t-1}	3.52e+08	7.09e+09	0.0496	0.9604
		VID_{t-1}	0.2875	0.0418	6.8650	0.0000
		Constant	4.87e+08	35365481.6088	13.7794	0.0000
Japan	h_t	h_{t-1}	0.0339	0.0417	0.8118	0.4172
		VID_{t-1}	1.09e-13	0.0000	0.0000	0.0000
		Constant	0.0052	2.66e-04	19.7901	0.0000
	VID_t	h_{t-1}	3.64e+09	2.29e+10	0.1588	0.8738
		VID_{t-1}	0.2415	0.0411	5.8719	0.0000
		Constant	1.18e+09	1.46e+08	8.1244	0.0000
Korea	h_t	h_{t-1}	0.7209	0.0306	23.5236	0.0000
		VID_{t-1}	1.10e-12	1.70e-12	0.6515	0.5149
		Constant	0.0011	4.64e-04	2.4502	0.0146
	VID_t	h_{t-1}	1.50e+09	7.32e+08	2.0597	0.0000
		VID_{t-1}	0.3859	0.0407	9.4826	0.0000
		Constant	1.44e+08	11089539.9054	13.0660	0.0000
Switzerland	h_t	h_{t-1}	0.3733	0.0401	9.3021	0.0000
		VID_{t-1}	1.07e-12	0.0000	0.0000	0.0000
		Constant	0.0033	5.41e-04	6.2556	0.0000
	VID_t	h_{t-1}	-2.20e+09	3.26e+09	-0.6756	0.4995
		VID_{t-1}	0.2460	0.0422	5.8340	0.0000
		Constant	617601683.3202	43978146.2556	14.0433	0.0000

Table 15: Granger causality test for dependent variable h_t (Equation (14))

	AUD		CAD		JPY		KRW		CHF	
lag	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t
1	57.2818	0.2925	162.8527	6.1440	0.6592	2.1404	553.3615	0.4245	86.5308	4.3258
	(0.0000)	(0.5887)	(0.0000)	(0.0134)	(0.4171)	(0.1440)	(0.0000)	(0.5149)	(0.0000)	(0.0380)
2	30.0843	0.1382	92.9293	4.5580	15.9970	6.9253	299.9684	0.6345	49.4630	5.4985
	(0.0000)	(0.8709)	(0.0000)	(0.0108)	(0.0000)	(0.0010)	(0.0000)	(0.5305)	(0.0000)	(0.0043)
3	20.4838	0.3567	62.0078	2.9272	11.9669	5.2815	205.7829	0.3153	32.7443	3.6676
	(0.0000)	(0.7842)	(0.0000)	(0.0332)	(0.0000)	(0.0013)	(0.0000)	(0.8143)	(0.0000)	(0.0122)
4	15.4511	1.3108	46.3597	2.8712	8.4725	3.9005	154.1913	0.2081	24.4597	3.6140
	(0.0000)	(0.2647)	(0.0000)	(0.0225)	(0.0000)	(0.0039)	(0.0000)	(0.9339)	(0.0000)	(0.0064)
5	12.3321	1.4772	37.6587	2.6463	5.4958	3.0174	123.0227	0.2834	19.3388	2.9259
	(0.0000)	(0.1955)	(0.0000)	(0.0224)	(0.0000)	(0.0106)	(0.0000)	(0.9221)	(0.0000)	(0.0128)
6	10.1012	1.1956	32.2253	2.0281	3.7949	2.8037	102.1371	0.2559	15.9322	2.9981
	(0.0000)	(0.3070)	(0.0000)	(0.0603)	(0.0010)	(0.0107)	(0.0000)	(0.9568)	(0.0000)	(0.0068)
7	8.3751	1.0288	27.9908	2.0895	2.7056	2.1620	87.0269	0.2157	12.9918	3.1758
	(0.0000)	(0.4097)	(0.0000)	(0.0430)	(0.0091)	(0.0360)	(0.0000)	(0.9817)	(0.0000)	(0.0026)
8	7.2384	1.7375	24.0080	1.8421	2.2777	2.1993	75.5230	0.2103	10.7406	3.3673
	(0.0000)	(0.0873)	(0.0000)	(0.0671)	(0.0210)	(0.0261)	(0.0000)	(0.9890)	(0.0000)	(0.0008)
9	5.5051	4.4327	21.4118	1.9970	2.7731	2.2542	66.7245	0.3203	9.4292	3.0004
	(0.0000)	(0.0000)	(0.0000)	(0.0377)	(0.0035)	(0.0176)	(0.0000)	(0.9682)	(0.0000)	(0.0016)
10	5.4832	4.4961	19.1226	1.7978	2.3259	2.0363	59.8461	0.4158	8.4886	2.7908
	(0.0000)	(0.0000)	(0.0000)	(0.0583)	(0.0109)	(0.0280)	(0.0000)	(0.9391)	(0.0000)	(0.0022)

Table 16: Granger causality test for dependent variable VID_t (Equation (15))

	AUD		CAD		JPY		KRW		CHF	
lag	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t
1	0.1333	74.5144	0.0024	47.1282	0.0252	34.4794	4.2427	89.9205	0.4564	34.0366
	(0.7150)	(0.0000)	(0.9604)	(0.0000)	(0.8738)	(0.000)	(0.0399)	(0.0000)	(0.4995)	(0.0000)
2	0.2732	37.4106	0.6771	24.9740	0.3923	21.6418	2.9010	44.1876	0.4366	20.5833
	(0.7610)	(0.0000)	(0.5085)	(0.0000)	(0.6756)	(0.0000)	(0.0558)	(0.0000)	(0.6464)	(0.0000)
3	0.2642	24.8290	0.4933	16.5203	1.1649	14.6654	2.6962	31.0799	0.9305	14.1962
	(0.8511)	(0.0000)	(0.6870)	(0.0000)	(0.3224)	(0.0000)	(0.0453)	(0.0000)	(0.4256)	(0.0000)
4	0.4423	19.2929	1.0523	12.7713	0.9972	11.0449	2.3844	25.0817	1.1049	12.7234
	(0.7779)	(0.0000)	(0.3795)	(0.0000)	(0.4084)	(0.0000)	(0.0504)	(0.0000)	(0.3533)	(0.0000)
5	0.4298	15.3498	1.3554	11.7688	0.6375	9.2364	2.0491	20.6661	0.8429	10.1340
	(0.8278)	(0.0000)	(0.2396)	(0.0000)	(0.6711)	(0.0000)	(0.0705)	(0.0000)	(0.5196)	(0.0000)
6	0.4064	12.6738	1.1389	9.8830	0.6297	7.8279	1.7570	17.5377	0.8472	8.6134
	(0.8748)	(0.0000)	(0.3382)	(0.0000)	(0.7064)	(0.0000)	(0.1060)	(0.0000)	(0.5337)	(0.0000)
7	0.3276	11.1370	1.1694	8.4583	0.5246	6.7268	2.1491	15.7291	0.9662	7.3677
	(0.9414)	(0.0000)	(0.3186)	(0.0000)	(0.8161)	(0.0000)	(0.0373)	(0.0000)	(0.4551)	(0.0000)
8	0.2495	10.3025	1.0557	7.3500	0.5941	6.5005	1.9569	13.6120	0.9310	6.5510
	(0.9808)	(0.0000)	(0.3930)	(0.0000)	(0.7830)	(0.0000)	(0.0500)	(0.0000)	(0.4902)	(0.0000)
9	0.4434	9.3542	0.9410	6.8597	0.7171	5.7942	1.8528	13.6558	0.8984	5.9195
	(0.9112)	(0.0000)	(0.4887)	(0.0000)	(0.6934)	(0.0000)	(0.0568)	(0.0000)	(0.5263)	(0.0000)
10	0.3456	8.3667	0.9249	6.4132	0.6799	5.1722	1.7026	12.5115	0.8113	5.4474
	(0.9680)	(0.0000)	(0.5097)	(0.0000)	(0.7434)	(0.0000)	(0.0772)	(0.0000)	(0.6178)	(0.0000)

Table 17: Decomposition of variance for series h_t and VID_t

	For series h_t [1]										For series VID_t									
	AUD		CAD		JPY		KRW		CHF		AUD		CAD		JPY		KRW		CHF	
	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t	VID_t	h_t
1	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0
2	100	0	99	1	100	0	100	0	99	1	100	0	100	0	100	0	100	0	100	0
3	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
4	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
5	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
6	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
7	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
8	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
9	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0
10	100	0	98	2	100	0	100	0	99	1	100	0	100	0	100	0	99	1	100	0

[1] Numbers are in percentages.

B Contract details

Table 18: Contract details, trading hours for CME Australian dollar

Chain RIC	-	$< 0\#AD :>$ - Large Lot Chain RIC: $< 0\#LA :>$
Unit Of Trading	-	100,000 AUD
Large Lot	-	400 contracts basis
Contract Months	-	RTH: Mar(H), Jun(M), Sep(U), Dec(Z). GLOBEX2: First Six quarterly months.
Minimum Price Limit	-	\$0.0001 per AUD or \$10 per contract.
Position Limits	-	6000 contracts net long or net short in all contract months combined.
Last Trading Day	-	Second business day immediately preceding the third Wednesday of the contract month.
Delivery	-	Third Wednesday of the contract month.
Trading Hours	-	RTH: $< 0\#2AD :>$ Monday to Friday: 7:20am to 2:00pm
	-	Globex2: $< 0\#ADSS :>$ Monday to Thursday: 4:30pm to 4:00pm Sundays & Holidays: 5:30pm to 2:00pm (Chicago Time)

Table 19: Contract details, trading hours for CME Canadian dollar

Chain RIC	-	$< 0\#CD :>$ - Large Lot Chain RIC: $< 0\#LK :>$
Unit Of Trading	-	100,000 CAD
Contract Months	-	RTH: Mar(H), Jun(M), Sep(U), Dec(Z).
		GLOBEX2: First six March quarterly months.
Minimum Price Limit	-	$0.0001 per CAD or $10 per contract.
Position Limits	-	If owning or controlling more than 6,000 contracts net long or net short in all contract months combined. Upon request, the exchange will provide information regarding the nature of the position, trading strategy, and hedging if applicable.
Last Trading Day	-	The business day preceding the third Wednesday of the contract month.
Delivery Day	-	First business day following the last trading day.
Trading Hours	-	RTH: $< 0\#2CD :>$ Monday to Friday: 7:20am to 2:00pm
	-	Globex2: $< 0\#CDSS :>$ Monday to Thursday: 4:30pm to 4:00pm
		Sundays & Holidays: 5:30pm to 2:00pm
		(Chicago Time)

Table 20: Contract details, trading hours for CME Japanese Yen

Chain RIC	-	$< 0\#JY :>$ - Large Lot Chain RIC: $< 0\#LJ :>$
Unit Of Trading	-	12,500,000 JPY
Position Limits	-	Persons owning or controlling more than 10,000 contracts, net long or short in all contract months combined will provide, in timely fashion, upon request by CME, regarding the nature of the position, trading strategy and hedging info., if applicable.
Contract Months	-	RTH: Mar(H), Jun(M), Sep(U), Dec(Z).
		GLOBEX2: First six March Quarterly cycle.
Minimum Price Limit	-	$.000001 or $12.50 per contract.
Last Trading Day	-	Futures trading will terminate at 9:16am on the 2nd business day immediately preceding the 3rd Wednesday of the contract month.
Delivery Day	-	Physical delivery on 3rd Wednesday of contract month.
Trading Hours	-	RTH: $< 0\#2JY :>$ Monday to Friday: 7:20am - 2:00pm
	-	Globex2: $< 0\#JYSS :>$ Monday to Thursday: 4:30pm - 4:00pm
		Sundays & Holidays: 5:30pm - 2:00pm
		(Chicago Time)

Table 21: Contract details, trading hours for CME Swiss Franc

Chain RIC	-	$< 0\#SF :>$ - Large Lot Chain RIC: $< 0\#LS :>$
Unit Of Trading	-	125,000 CHF
Contract Months	-	RTH: Mar(H), Jun(M), Sep(U), Dec(Z). GLOBEX2: First six March quarterly months.
Minimum Price Limit	-	$.0001 or $12.50 per contract.
Position Limits	-	If owning or controlling more than 6,000 contracts net long or net short in all contract months combined. Upon request, the exchange will provide information regarding the nature of the position, trading strategy, and hedging if applicable.
Last Trading Day	-	9:16am on the 2nd business day preceding the third Wednesday of the contract month.
Delivery Day	-	Third Wednesday of the contract month.
Trading Hours	-	RTH: $< 0\#2SF :>$ Monday to Friday: 7:20am - 2:00pm
	-	Globex2: $< 0\#SFSS :>$ Monday to Thursday: 4:30pm - 4:00pm Sundays & Holidays: 5:30pm - 2:00pm (Chicago Time)

Table 22: Contract details, trading hours for the USD/KRW currency futures

Chain RIC	-	$< 0\#KRW :>$
Unit Of Trading	-	USD 50,000
Delivery Month	-	Six Delivery Months The latest three months plus three other months from March, June, September, December
Trading Months	-	All months
Last Trading Day	-	The second business day just before the settlement day
	-	(Normally third Monday of settlement month)
Settlement Date	-	The third Wednesday of settlement month
Quotation	-	USD/KRW Exchange Rate
Min. Price Move	-	.20 Won
Trading Hours	-	Weekdays: 0930 - 1630 (Local Time)
	-	The last trading day: 0930 - 1130 (Local Time)

References

Acosta, C.P., P. Flaschel and W. Semmler (2004). *Currency and Financial Crises in Emerging Market Economies*. Working Paper No. 73, Center for Empirical Macroeconomics, University of Bielefeld.

Anderson, R.W. and J.P. Danthine (1981). *Cross Hedging*. Journal of Political Economy, Vol. 89, No. 6, 1182-1196.

Bauwens, L., D. Deprins and J.P. Vandeuren (1997). *Modelling Interest Rates with a Cointegrated VAR-GARCH Model*. Core Discussion Paper 9780, Center for Operations Research & Econometrics, Universite Catholique de Louvain, Belgium.

Bessembinder, H. and P.J. Seguin (1992). *Futures-Trading Activity and Stock Price Volatility*. The Journal of Finance, Vol. XLVII, No. 5, December, 2015-2034.

Blume, M.E., A.C. MacKinlay and B. Terker (1989). *Order Imbalances and Stock Price Movements on October 19 and 20, 1987*. The Journal of Finance, Vol. XLIV, No. 4, September, 827-848.

Bollerslev, T., R.Y. Chou and K.F. Kroner (1992). *ARCH modeling in finance: A review of the theory and empirical evidence*. Journal of Econometrics 52, 5-59.

Broll, U. (1997). *Cross Hedging in Currency Forward Markets: A Note*. The Journal of Futures Markets, Vol. 17, No. 4, 475-482.

Brooks, C. (2002). *Introductory Econometrics for Finance*. Cambridge University Press.

Chatrath, A., S. Ramchander and F. Song (1996). *The Role of Futures Trading Activity in Exchange Rate Volatility*. The Journal of Futures Markets, Vol. 16, No. 5, 561-584.

Clifton, E.V. (1985). *The Currency Futures Market and Interbank Foreign Exchange Trading*. The Journal of Futures Markets, Vol. 5, No. 3, 375-384.

Dodd, R. (2002). *Derivatives, the Shape of International Capital Flows and the Virtues of Prudential Regulation*. Discussion Paper No. 2002/93, United Nations University, World Institute for Development Economic Research, Helsinki, Finland, October.

Duffie, D. (1989). *Futures markets*. Prentice Hall, Englewood Cliffs.

Eaker, M.R. and D.M. Grant (1987). *Cross-Hedging Foreign Currency Risk*. Journal of International Money and Finance, 6, 85-105.

Enders, W. (1995). *Applied Econometric Time Series*. John Wiley & Sons, Inc.

Flaschel, P. and W. Semmler (2003). *Currency crisis, financial crisis, and large output loss.* Working Paper No. 52, Center for Empirical Macroeconomics, University of Bielefeld.

Ghysels, E. and J. Seon (2000). *The Asian Financial Crisis: The Role of Derivative Securities Trading and Foreign Investors.* Série Scientifique, CIRANO, Montréal, Mars.

Gouriéroux, C. (1997). *ARCH Models and Financial Applications.* Springer, New York.

Harris, L. (1989). *The October 1987 S&P 500 Stock-Futures Basis.* The Journal of Finance, Vol. XLIV, No. 1, March, 77-99.

Hsieh, D.A. (1989). *Modelling Heteroscedasticity in Daily Foreign-Exchange Rates.* Journal of Business & Economic Statistics, Vol. 7, No. 3, July, 307-317.

Hull, J.C. (2000). *Options, futures, and other derivatives.* 4th ed., Prentice Hall, Upper Saddle River.

Jacobs, M.Jr. and J. Onochie (1998). *A Bivariate Generalized Autoregressive Conditional Heteroscedasticity-In-Mean Study of the Relationship between Return Variability and Trading Volume in International Futures Markets.* The Journal of Futures Markets, Vol. 18, No. 4, 379-397.

Jarrow, R.A. (1992). *Market Manipulation, Bubbles, Corners, and Short Squeezes.* Journal of Financial and Quantitative Analysis, Vol. 27, No. 3, September, 311-336.

Jarrow, R.A. (1994). *Derivative Security Markets, Market Manipulation, and Option Pricing Theory.* Journal of Financial and Quantitative Analysis, Vol. 29, No. 2, June, 241-261.

Jochum, C. and L. Kodres (1998). *Does the Introduction of Futures on Emerging Market Currencies Destabilize the Underlying Currencies?* IMF Working Paper WP/98/13, International Monetary Fund, Washington, February.

Kleidon, A.W. and R.E. Whaley (1992). *One Market? Stocks, Futures, and Options During October 1987.* The Journal of Finance, Vol. XLVII, No. 3, July, 851-877.

Kumar, P. and D.J. Seppi (1992). *Futures Manipulation with Cash Settlement.* The Journal of Finance, Vol. XLVII, No. 4, September, 1485-1501.

Kyle, A. (1984). *A Theory of Futures Market Manipulation.* in Weller, P. (editor), "The Theory of Futures Markets", Blackwell Publishers, First published 1992, Oxford, Cambridge, 272-303.

Ludden, U. (1999). *Technical Analysis on Foreign Exchange Markets.* LIT Verlag, Münster.

Murphy, J.A. (1986). *Futures Fund Performance: A Test of the Effectiveness of Technical Analysis.* The Journal of Futures Markets, Vol. 6, No. 2, 175-185.

Shastri, K., J. Sultan and K. Tandon (1996). *The impact of the listing of options in the foreign exchange market.* Journal of International Money and Finance, Vol. 15, No. 1, 37-64.

Stier, W. (2001). *Methoden der Zeitreihenanalyse.* Springer, Berlin.