Identifying the Signs of Currency Speculation in Hong Kong's Linked exchange Rate

Li, Kui-Wai

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JEL classification: C25, C32, E44, F31, N15, O53.

Keywords: Currency speculation, linked exchange rate, Hong Kong

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* Corresponding Author: Kui-Wai Li, Department of Economics and Finance and APEC Study Center, City University of Hong Kong, Tel: 852 3442 8805; Fax: 852 3442 0195; E-mail: efkwli@cityu.edu.hk.

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I. Introduction

Financial crises involving massive outflows of capital usually lead to currency speculation. While weak economic fundamentals have been emphasized in the "first generation" financial crisis models, the "second generation" models have examined the economic consequences of currency speculation through two transmission mechanisms of trade with subsequent exchange rate changes, and macroeconomic similarities with subsequent competitive devaluation (Krugman 1979, Agenor *et al*. 1992, Eichengreen *et al*. 1994, 1996, 1998; Obstfield 1996; Jeanne 1997; Morris and Shin 1998; Rangvid 2001). The fundamental-based hypothesis and financial panic hypothesis are the two schools that attempted to explain the causes of the 1997 Asia financial crisis (AFC) (Kaminsky *et al*. 1998; Kaminsky 1999; Krugman 1998a, 1998b, Radelet and Sachs 1998a, 1998b). Other explanations on the causes of financial crisis included activities in the capital market, such as financial inter-dependence, herb behavior, market over-reaction and hedge funds (Glick and Ross 1999; Fratzher 2003; Chari and Kehoe 2003; Calvo 1998; Rigobon 1998; Bekaert and Harvey 1999; Azman-Saini 2006).

The linkage between the stock, derivative and exchange rate markets at the time of currency speculations has been studied. Hau and Rey (2006), for example, developed a theoretical model to examine the correlation between exchange rates, stock prices and capital flows, though their results are based only on constant correlations. Other studies have provided different definitions of speculative currency attacks. Frankel and Rose (1996) defined currency crisis in developing countries as a devaluation by at least 25 percent, or by at least 10 percent over the previous year. Eichengreen *et al*. (1996) proposed that currency speculation were said to have occurred when the speculative pressure index, which consisted of the weighted average in the changes of exchange rate, foreign reserve and interest rate, exceeded 25 percent. Kumar *et al*. (2003) defined a crisis by a large interest-rate-differential-adjusted movement in the financial market.

Hong Kong has long been regarded as a regional financial center (City of London 2007; Schenk 2002; Leung and Unteroberdoerster 2008). The fall in economic and business confidence in 1984 at the peak of Hong Kong's political uncertainty over the 1997 sovereignty reversion to Mainland China has led the then British Hong Kong government to adopt the linked exchange rate (LER) at US$1 to HK$7.8 (HKMA 2002; Latter 2007a). Under the LER, note issuing banks have to submit US dollars to the exchange fund account of the Hong Kong Monetary Authority in exchange for the Certificates of Indebtedness. The Hong Kong currency notes are fully backed by and convertible into the US dollar held by the exchange fund (Greenwood 2008). Hong Kong has effectively adopted a currency board system with the full backing of the currency base by the reserve currency (Latter 2007b). The currency board system requires a rule-based monetary authority that issued base money solely for the exchange of foreign currency. Williamson (1995) pointed out the advantages of the currency board included assured convertibility, discipline over fiscal policy, certainty of a balance of payment adjustment mechanism and public confidence. On the contrary, the problems of the currency board included the inability of the monetary policy, the absence of a lender of last resort and the needed adjustment resulting from the emergence of sudden shocks.

The HKMA proposed in 1992 the "first line of defense" by fixing the exchange rate at US$1:HK$7.75, and introduced a liquidity adjustment facility that served as a discount window. After currency attack in 1997/98, the HKMA converted the Hong Kong dollar gradually back to the rule-based currency board system. The prolonged usage of the "first line of defense" was thought to have lengthened the deviation, making the currency a subject of currency speculation and attack. Nonetheless, the currency board has experienced changes since its adoption in 1983 (Greenwood 2008). Hong Kong has experienced three episodes of currency speculations in 1988 when there was a prolonged weakness in the US currency, in 1998 at the peak of the AFC when speculators used the stock, derivative and foreign exchange markets to attack the Hong Kong currency, and in 2007 when there was pressure on the appreciation of the Renminbi.

Under the linked exchange rate system, the Hong Kong Monetary Authority (HKMA) exercises a currency board refinement mechanism that involves currency intervention once the exchange rate has reached the strong-side or weak-side Convertibility Undertaking rate. As such and despite the ability of the exchange fund in managing the flow of funds, the spot exchange rate in Hong Kong can no longer reflect the actual fluctuation in the market. The movements of forward exchange rate can be considered as an alternative as that can give the best unbiased forecast of future spot rate (Cornell 1977; Bilson 1979). In this study, currency speculation is defined by a movement greater than 1 in the standard deviation in the value of the daily exchange rate difference between the 3-month forward rate and the spot rate.

Hong Kong's capital flow movements during the three crisis periods will be studied in order to identify the features in the period prior to and during the currency speculation. The dynamic conditional correlation model in Engle (2002) and Tse and Tsui (2002) will be used to examine the time varying correlation structure between the Hang Seng Index (HSI) returns, the HSI futures returns and the exchange rate forwards premium. Section II summarizes the key events in the three episodes. Section III presents the methodology and Section IV shows the empirical findings. The last section concludes the paper.

II. Features of the Three Episodes

The data on the daily closing price of the HSI, HSI futures and the three-month Hong Kong to United State dollar exchange rate forward contacts for the period January 1986 to September 2008 are obtained from DataStream. The HSI is a capitalization-weighted market index. As of June 2008, there are 43 HSI constituent stocks, composing the most representative companies in Hong Kong and Mainland China.[1] However, since the HSI futures data are not available until late 1989, only the last two episodes of currency attack in 1997-1998 and 2007-2008 are analyzed empirically. All the estimated results are obtained from the program G@RCH 5.0.

The first episode occurred in the period from January 1986 to end of 1990 with the prolonged weak US currency. The US recession that began in the mid-1980s has resulted in a period of prolonged weakness in the US exchange rate. Subsequently, the Federal Reserve adopted a low interest rate policy in order to stimulate the US economy. Under the linked exchange rate system, Hong Kong had to follow the US and pursued a low interest rate policy. On the other hand, the Hong Kong economy recovered quickly after the successful conclusion of the Sino-British negotiation in late 1984. It was rumored that the linked exchange rate system would be abandoned, though the then British Hong Kong government emphasized otherwise. Hong Kong experienced a massive inflow of hot money that challenged the linked exchange rate system. The currency speculators were eventually driven off upon the announcement of a negative interest rate on December 22, 1987, by the Hong Kong Association of Banks.

The AFC began in Thailand on July 2, 1997, with the exhaustion of the foreign

[1] Events in various periods are obtained from the website of the Hong Kong Monetary Authority, and daily news from *South China Morning Post* and *Ming Pao Daily*.

exchange and the abandonment of the fixed exchange rate system. International speculators mobilized hedge funds and their block trade caused high fluctuations in the stock and currency markets (Asman-Saini 2006). The second episode covered the four years in the AFC period from January 1996 to end of 2000. Between early July 1997 and October 1997, the Hong Kong HSI dropped by 30 percent from the peak of 16,820 points. The inter-bank interest rate jumped to 300 percent. Speculation on the Hong Kong currency was made as there were block trade of short selling of Hong Kong exchange rate forward contracts. The real attack came in August 1998 when speculators shorted a total of HK$49 billions, though the HKMA used the foreign exchange reserve to prevent the currency from depreciating. It was in August 1998 when eventually the Hong Kong SAR Government (HKSAR) used HK$50 billions from the Exchange Fund to purchase portfolio of stocks that eventually defeated the currency speculators.

China's trade surplus has expanded after the Renminbi devaluated by 30 percent in January 1994, its growing reserve has added pressure on the revaluation of the Renminbi, which is still not a fully convertible currency. In April 2006, Beijing signaled that qualified domestic institutions investors (QDII) would soon be allowed to invest in fixed income and money market products in Hong Kong, and the scheme expanded to include investment in stocks in May 2007. This had led to the speculation that the Renminbi may become fully convertible. The stock market in Hong Kong turned bullish and climbed continuously for a few months until a contrary announcement was made in November 2007 that the decision to allow QDII investment to Hong Kong needed further investigation. By October 2007, attention has been drawn to the potential impact on the Hong Kong dollar by possible change in China's exchange rate system. The Hong Kong dollar reached the strong-side convertibility region within a week. There was a significant interest rate premium for the HK dollar over the US dollar. The HKMA brought about HK$775 million worth of US dollars to maintain monetary stability.

Figure 1 shows the HK dollar to US dollar spot exchange rate against the 1-month, 3-month and 6-month forward rate. When compared with the spot rate, the forward exchange rate contained additional expectation, including the presence of premium (discount) when the forward rate is lower (higher) than the spot rate. The large difference in the two rates can be seen during the various currency speculation periods.

The daily HSI returns (HSI returns) and HSI futures returns (HSIF returns) are defined by the formula $y_t = \ln (P_t \ / P_{t-1})$, where P_t is the daily closing price. The HSI and HSI futures are shown in Figures 2(a) and 2(b), while their daily returns are shown in Figures 2(c) and 2(d), respectively. The HSI and HSI futures are not stationary processes since the means are not the same in different periods. A spurious problem would appear if a non-stationary series was used. It can be seen from Figures 2(c) and 2(d) that the first-order differenced series would become stationary because the means generally would trend to their mean value. Hong Kong has experienced a sharp decline in both the HSI and HSIF in late 2007 as a result of the announcement in shelving the QDII and the subprime mortgage crisis in United States.

Table 1 shows the HSI returns, HSIF returns and the 30-days exponential moving average of the daily difference between 3-month forward exchange rate and spot rate (3MEMA30). The Skewness and Excess Kurtosis estimates are used to indicate the extent of speculation in the stock market. The results indicate a high level of speculation in the Hong Kong stock market. The Excess Kurtosis of all three series is larger than 3, and the Chi-square tests for normality are statistically significant at 1 percent level. The null hypothesis of normality can be rejected. All series contain the property of thick tail and non-normal distribution.

III. Methodology

Statistical tests are first conducted on the time series data in order to avoid the spurious problem or model misspecification. The dynamic conditional correlation GARCH (DCC-GARCH) model is employed to study the time varying structure between the stock and foreign exchange markets. Finally, such additional variables as the open interest contracts, together with the estimated conditional correlations, are used to examine the probability of currency speculation in the logistic (logit) regression model.

Due to fluctuations in the exchange rate forward contracts, disturbance can affect the accuracy of the financial signal. The exponential moving average (EMA) method is adopted to smooth the exchange rate difference series by applying the exponentially decreasing weighting factors. The 30-days data are weighted exponentially, and the degree of weighting α can be expressed as $\alpha = \frac{2}{N+1}$, where N denotes the number of time periods. The conventional EMA formula is:

$$EMA = \frac{\sum_{t=1}^{T} (1-\alpha)^{t-1} P_t}{\sum_{t=1}^{T} (1-\alpha)^{t-1}}, \tag{1}$$

where P_t represents the daily data of the variable. The weighting factor on each data point can ensure that the influence of the previous data decreases exponentially.

To estimate the DCC-GARCH model, each of the data series is first fitted into the univariate GARCH models to obtain the estimated standard residuals. The intercept parameters of conditional correlation are then estimated. Finally, the coefficients governing the dynamics of correlation are estimated using the intercept parameters of conditional correlation.

The ARCH model in Engle (1982) could allow the conditional means and variance to change over time, namely:

$$y_t \mid \Omega_{t-1} \sim (x_t\beta, h_t) \quad , \qquad h_t = w_0 + \alpha u_{t-1}^2 \quad . \tag{2}$$

It is assumed that $x_t \beta$ is the mean of y_t, which is a linear combination of lagged variables included in the information set (Ω_{t-1}) with a vector (β) of unknown parameters. Based on past forecast errors, the underlying forecast variance (h_t) may change over time, keeping the unconditional variance constant.

The GARCH model in Bollerslev (1986) incorporated the problem of parsimony and allowed a longer memory and a more flexible structure. The variance equation of the GARCH (p, q) process can be defined as:

$$h_t = w_0 + \sum_{i=1}^{q} \alpha_i u_{t-1}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}, \tag{3}$$

where $w_0 > 0$, $\alpha_i \geq 0$ and $\beta_i \geq 0$ ($\forall i$). The GARCH (p,q) process permits an autoregressive moving average component in the heteroscedastic variance.

Studies have shown that a negative shock to a financial time series is likely to cause higher volatility than a positive shock of the same magnitude (Black 1976; Christie 1982; French *et al*. 1987; Nelson 1990; Schwert 1990; Engle and Ng 1993). In order to catch the asymmetric response, Glosten *et al*. (1993) introduced the following model for conditional variance:

$$h_t = w_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2 I_{t-1}, \tag{4}$$

where $I_{t-1} = 1$ if $u_{t-1} > 0$ and $I_{t-1} = 0$ otherwise. The existence of the asymmetry effect would be found if γ_1 is greater than zero, and α_1 must be non-negative. Equation (4) is a modified GARCH model with the addition of a dummy variable, I_{t-1}.

The dynamic conditional correlation (DCC) model is applied to examine the dynamic correlation of the exchange rates difference, HSI returns and HSIF returns (Engle 2002; Tse and Tsui 2002). Engle (2002) formulated the conditional correlation as a weighted sum of past correlations. Assume that the multivariate GARCH model with *k x 1* vector of assets returns y_t exhibits a conditional normal distribution of zero mean and covariance matrix H_t, we then have

$$y_t \mid \Omega_{t-1} \sim N(0, H_t), \tag{5}$$

where Ω_{t-1} is the information set at time t-1. Under the DCC-GARCH framework, the covariance matrix is defined as:

$$H_t \equiv D_t R_t D_t, \tag{6}$$

where $D_t = diag\left\{\sqrt{h_{it}}\right\}$ is a k x k diagonal matrix of time varying standard deviations from univariate GARCH models with $\sqrt{h_{it}}$ on the *i*th diagonal, and $R_t \equiv \left\{\rho_{ij}\right\}_t$ is the time varying correlation matrix containing conditional correlation coefficients. The univariate GARCH (*p, q*) is given as:

$$h_{it} = w_i + \sum_{p=1}^{P_i} \alpha_{ip} \varepsilon_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it-q} \tag{7}$$

The estimation of the DCC-GARCH model is obtained by:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}, \tag{8}$$

where

$$Q_t = (1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n) \bar{Q} + \sum_{m=1}^{M} \alpha_m (\xi_{t-m} \xi_{t-m}^{'}) + \sum_{n=1}^{N} \beta_n Q_{t-n}. \tag{9}$$

$\xi_t = \dfrac{\varepsilon_{it}}{\sqrt{h_{it}}}$ is a vector that included the standard residuals and $\varepsilon_t \sim N(0, R_t)$. $\bar{Q}$ is the unconditional covariance of standard residual obtained from Equation (8), and $Q_t \equiv \{q_{ij}\}_t$ is regarded as a conditional variance-covariance matrix. Q_t^* is a *k x k* diagonal matrix containing the square root of the diagonal elements of Q_t :

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11}} & 0 & \cdots & 0 \\ 0 & \sqrt{q_{22}} & \cdots & 0 \\ \vdots & \cdots & \ddots & 0 \\ 0 & 0 & \cdots & \sqrt{q_{kk}} \end{bmatrix}. \tag{10}$$

The time varying conditional correlation is expressed as $\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,i,t} q_{j,j,t}}}$, which is included in R_t. The DCC-GARCH model is estimated computationally by the maximum likelihood method in which the log-likelihood is given as:

$$L = \frac{1}{2} \sum_{t=1}^{T} (n \log(2\pi) + 2 \log |D_t| + \log |R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t) . \tag{11}$$

The general restriction of non-negativity and stationarity of variances is assumed.

The logit regression is a widely used multivariate statistical parametric model for estimating the probability of occurrence for a certain event, such as the probability of currency speculation using a series of explanatory variables. The general form of the logit function is:

$$P(x) = \frac{1}{1 + e^{-Z_t}} . \tag{12}$$

z_t includes the total contribution of all independent variables used in the model and can be defined as:

$$z_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \beta_i X_{it} + \varepsilon_t . \tag{13}$$

This becomes a multiple regression with *i*th independent variables in *X*. Assume Y_t is the

3-month exchange rate difference, and its value is transformed to 1 if $(Y_t > \bar{Y} \pm \sigma)$, and to 0 otherwise, along with the continuous explanatory variables X_{it}. Let $P(x)$ represents the probability of being attacked when the random variable Y_t is equal to 1. The logarithm of odds is, therefore, a linear function of explanatory variables of X_{it}.. The logarithm of odds of the logit model can be expressed as:

$$P = E(Y_t = 1 \,|\, x_{it}) = \frac{1}{(1 + e^{-(\beta_0 + \beta x_{it})})}, \quad L\,[p_t(x_{it})] = \ln\left[\frac{p_t}{(1 - p_t)}\right] = x_t^{'}\beta \,. \tag{14}$$

The logit model possesses significant properties of the linear regression model, including linear parameters. By extending $x_t^{'}\beta$ to a set of p variables, the logit model then becomes:

$$L\,[p_t(x_{it})] = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \beta_i X_{it} + \varepsilon_t \,. \tag{15}$$

The ith coefficient, β_i, represents the influences of a certain unitary variation of X_{it} on the odds, other explanatory variables being constant.

IV. Empirical Results

Table 2 shows the statistic results of the Augmented Dickey-Fuller (ADF) test and the Lagrange Multiplier (LM) test for the ARCH effect. The calculated t-ADF values of the three series are much smaller than the 1 percent critical value. Since the t-ADF values are all statistically significant with a critical value of 1 percent, we can statistically reject the null of unit root in the series. The LM test for the ARCH effect strongly rejected the null that all the coefficients of the squared residual are equal to zero. In short, the ARCH effect existed in all series. Variances are not equal in different time domains, implying the existence of the heteroskedasticity property.

The unconditional correlation between HSI returns, HSIF returns and the exponential moving average of the exchange rate difference is reported in Table 3. The HSI returns and HSIF returns are highly correlated, while the correlation of exchange rate difference with HSI returns and with HSIF returns are weak. The changes in the HSI returns and HSIF returns do not generate any movement to the forward exchange rate in a normal situation. We test for constant correlation among the series with the null hypothesis of constant correlation against the alternative hypothesis of time varying correlation (Engle and Sheppard 2001). The null of constant correlation is rejected.

The dynamic conditional correlation estimation process consisted of fitting the univariate GARCH specifications to each data series, as shown in Table 4. All the coefficient of parameters is statistically significant at 5 percent level. The three parameters w, α and β are the GARCH parameters from Equation (3), while γ shows the asymmetry parameter in Equation (4). The asymmetric effect is a common feature in financial markets. Table 4 shows that both γ_H and γ_F are significant. In the HSI returns, bad news could generate a higher level of fluctuation than good news. The coefficient of asymmetry of the exchange rate difference (3MEMA30) is statistically insignificant. Both good news and bad news generated symmetric effect in the 3-month exchange rate forward premium. Figure 3(a) plots the volatility news impact curves of the HSI and HSI futures. The curves highlight the asymmetry response to news of HSI and HSI futures. It is clear that the HSI news impact curve has a higher magnitude than the HSI futures news impact curve. Figure 3(b) shows the 3-month exchange rate difference, and that both good news and bad news generated the same impact.

Given the low unconditional correlation between the exchange rate difference and both HSI and HSI futures, the possibility of a high correlation in the currency speculation attack period is considered. The Engle and Sheppard (2001) test for constant conditional correlation is applied prior to the estimation of the Engle (2002) DCC-model and Tse & Tsui (2002) DCC-model. The Engle and Sheppard (2001) test shows the presence of a time varying conditional correlation structure in the series.

In Table 5, the coefficients of the Engle DCC-model parameters are all statistically significant, suggesting that the conditional correlation is not constant over time. The estimated value of α_D in the Tse & Tsui DCC-model is not significant under the Gaussian distribution, but becomes significant under the Student distribution. The estimated value of the degree of freedom (df) of Student distribution is 9.0768, which is statistically significant at 1 percent level. The result matches with the finding of normality Chi-square test shown previously. Table 6 compares the two DCC-models using four different criteria. A better conditional correlation structure can be obtained if the model is correctly specified. The various comparison criteria provided consistent results, but the results from the Engle GJR-Student-DCC (1, 1) model are preferred.

The correlation structure between HSI and HSI futures, as shown in Figure 4, demonstrates that there is a high degree of positive correlation between the two series. It is clear that changes in the correlation structure have occurred, due possibly to changes in the expectation of market participants. An unfavorable announcement by government or about the constituent stocks would generate a sharp decline in the HSI futures. Because of the 15 minutes lag in the closing time between stock market and futures market in Hong Kong, it is feasible to have a sharp deviation between HSI and HSI futures.

Figure 5 shows the two correlation structures of the exchange rate difference to HSI and to HSI futures. Normally, the two correlation structures should have the same pattern. But divergence is possible due to the expectation of market participants. One can note from Figure 5 that the conditional correlation drops to -0.1 in the three currency speculation periods of October 1997, July 1998 and October 2007. The fact that a massive capital outflow in late 1997 and mid-1998 has yielded a sharp discount in the 3-month forward rate that resulted in a decline in both HSI and HSI futures. On the contrary, the capital inflow of October 2007 that caused the rise in the 3-month forward rate premium, HSI and HSI futures has generated a decline in the correlation structure. A low correlation between exchange rate difference and HSI, and between exchange rate difference and HSI futures could serve as the early signs of a currency speculation in Hong Kong.

The DCC estimation shows that the declining correlation trend is caused by a massive capital movement and relatively low correlation in the currency attack periods. The large difference between forward and spot exchange rates serves as another signal for an imminent currency speculation. Figure 6 summarizes the difference between the smoothed 3-month and 1-month exchange rate difference. The smoothened 1-month exchange rate difference is used for comparison as it is the closest series to the spot exchange rate. Under normal circumstances, the exchange rate difference curves swing along the zero line, which is the equality between forward rate and spot rate, without exhibiting any steady trend. However, a significant deviation can clearly be seen before each episode of currency speculation in Figure 6. For example, the exchange rate forward premium was particularly high in late 1987, when the currency speculation was for the Hong Kong dollar to delink and appreciate (Figure 6(a)). On the contrary in Figure 6(c), there is a sharp discount in late 1997 and 1998, when the currency speculation was for the Hong Kong dollar to delink and depreciate. In addition, one could also note that the non-zero duration generally has lasted either for a few months or longer than the period of the currency crisis, but certainly has emerged before the crisis started. Indeed, it has lasted longer than a year between 1987 and 1988 and between 2006 and 2007. It is noted that a deviation period of approximately 8 months has appeared before the first speculation in October 1997.

The conventional logit model is used to study the interrelationship between stock market, futures market and exchange rate market, and predict the probability of the occurrence of currency speculation. To determine the importance of the parameters in different markets, a total of four models are used in the estimation of Equation (15), as shown in Table 7. Model A consists only of the foreign exchange market variable. The parameter FDP is the difference between 3-month and 1-month forward rate multiplied by the probability of the occurrence, which is indicated by the number of day dispersal. The probability follows the exponential distribution with the function of $P(x) = 1 - e^{x/\vartheta}$, where $x > 0$ and θ is the mean of the number of days of dispersal.

The coefficient of FDP is statistically significant at 1 percent level, suggesting that FDP is positively related to the currency crisis. This matched with the finding that a large and prolonged difference between forward and spot rate would increase the probability of currency speculation. In general, the 1-month and 3-month forward exchange rates should have the same movement over time, but a sharp difference could lead to market uncertainty in a longer time period and provide valuable information about the future expectation of market participants at the current situation.

Models B and C include the variable CHED, which is the first difference of conditional correlation between HSI and exchange rate difference. The use of the first difference served as the transformation needed to avoid the potential problem of multicollinearity. The conditional correlation of exchange rate difference to HSI return is significant with a negative sign (-60.730), suggesting that the probability of currency speculation occurrence is negatively related to the change in conditional correlation. This provided a robust result that the decrease in the correlation would increase the possibility of currency speculation. In Model C, the coefficient of CHFE (-44.964), which is the conditional correlation between HSI futures and exchange rate difference, is statistically significant, suggesting that the conditional correlation between exchange rate difference and HSI futures is negatively related to currency speculation.

The HSI premium (HSIP) is the difference between HSI and HSI futures, noting also that the positive (negative) excess return of HSI futures could be considered as a premium (discount). The daily changes in the HSI premium virtually reflected the expectation on the HSI futures. Figure 7 illustrates the HSI premium, and the presence of sharp volatility appeared in different periods. For example, the Mexican currency crisis occurred in 1994. The HSI premium had also shown large fluctuations in the AFC period. Note that a sharp decline in the HSI premium can be seen in August 1998 when the government tackled the currency speculation. In addition, a significant volatility can also be found in late 2007.

The open interest of HSI futures is the number of opened contracts that has not expired. Theoretically, futures contract is an instrument for investors to manage portfolio risk. In general, the open interest of futures contracts should not show any trend. However, an obvious and positive trend that started from March 1998 can be found in Figure 8, when speculators quickly accumulated a block of open interest contracts over a few months. By August 1998, speculators closed those futures contracts and exchange rate forward contracts simultaneously, causing a sharp collapse in open interest, HSI, HSI futures and exchange rate. The estimates of Model D in Table 7 show that the HSI premium and open interest of futures are related to the currency attacks as their coefficient are statistically significant. The negative sign of the coefficient of open interest (-0.587) provided further information that when speculators closed their long position of the open interest contracts in turn can cause a serious decline in the HSI, HSI futures and exchange rate.

The log likelihood and Akaike information criteria (AIC) are further used to measure the efficiency of the models. Both criteria showed that Model D in Table 7 is the best model that could provide reliable prediction for currency speculation. Figure 9 shows the estimated probabilities of Model D in the different currency speculation periods. The calculated mean and standard deviation of the estimated probability in Model D is 0.1588 and 0.2703, respectively. The data on exchange rate difference shows that over 85 percent of the daily probability is lower than the mean. Indeed, it makes sense that currency speculation is not a familiar and long lasting phenomenon to any economy. Prior attention could thus be given when the estimated probability is higher than the mean. Currency speculation could thus be imminent when the estimated probability of currency speculation is greater than the mean (15.88%) plus 1 standard deviation (27.03%), which is equivalent to a probability of or higher than 43 percent.

V. Conclusion

This study has shown that the relationship between HSI return, HSI futures returns and exchange rate difference is significant during the three episodes of currency speculation in Hong Kong. An unusual movement of exchange rate difference and strategic disposition by the speculators can be identified. The speculators took advantage of the record high level in the HSI in all three episodes, especially when retail investors looked for large returns by selling their over valued stocks. The estimations from the DCC models showed that information could generate impacts on conditional volatility and conditional correlation. This is in line with Chari and Patrick (2003) whom pointed out that information can heighten the uncertainty of individuals and the volatility of the markets.

There are four major factors that can provide information or signals to potential currency speculation. Firstly, Figure 5 shows that the conditional correlation between HSI and exchange rate difference produced a large drop either prior to or during the period of currency speculation. Secondly, Figure 6 shows that there is a prolonged non-zero deviation between the 3-month and 1-month exchange rate forward premium or exchange rate forward discount prior to the currency speculation. The two cases when premium occurred are shown in the first episode and the third episode, while the case of discount can be seen clearly in the second episode. A potential currency speulation could be imminent when there is a prolonged period, say three quarters, of non-zero deviation in the 3-month and 1-month forward exchange rates.

Thirdly, the fluctuation in the HSI premium is high when currency speculation is imminent (Figure 7), as in the case of the Mexican crisis in 1994, the AFC in mid-1998 (second episode) and in late 2007 (third episode). Negative news in the market might have led to a downward revision in market expectation, and the subsequent loss in market confidence could result in capital outflow. The fourth signal appeared when a rapid accumulation of open interest of HSI futures was faced with equally rapid closure within a short time, as in 1998 (Figure 8). The monetary authority could counteract the accumulation by raising the deposit of futures contracts, as that would raise the cost of speculation.

The results of the logit model show that the prediction criterion for currency speculation is the mean of probability plus 1 standard deviation. Notable signs could be identified prior to currency speculation and closer observations with timely and appropriate actions could deter speculators in attacking the Hong Kong currency. One other lesson from the empirical study is that despite Hong Kong's high ranking as an international financial center (Cheung and Yeung 2007), capital funds coming to Hong Kong are mainly short term with the intention to make speculative gains through activities in the stock market, derivatives market and foreign exchange market.

The situation in late 2008 was worsened by the closure of Lehman Brothers on September 15, 2008 in New York. The credit and liquidity of banks have become the major concern. Following an unfound rumor about the financial stability of the Bank of East Asia on September 24, 2008, the government has decided to provide a stronger support to the banking sector by declaring on October 14, 2008, the provision of a fully bank deposit guarantee until 2010, from the previous level of 10 percent only. Inflow of capital shown by the large demand for Hong Kong dollar took place after the announcement in October 2008 as the spot exchange rate frequently reached the strong-side of Convertibility Undertaking rate. In order to maintain liquidity in the banking system, the HKMA had injected in various occasions large capital to maintain the Hong Kong dollar balance. Though the HIBOR rate was lowered, one concern was that the exchange rate was still strong even after the injection. The situation in the financial economy could still be difficult as unexpected shocks that were to impose financial burden on banks in Hong Kong would impose pressure on the foreign exchange reserve, thereby reduced the ability to defend any speculation on the Hong Kong dollar.

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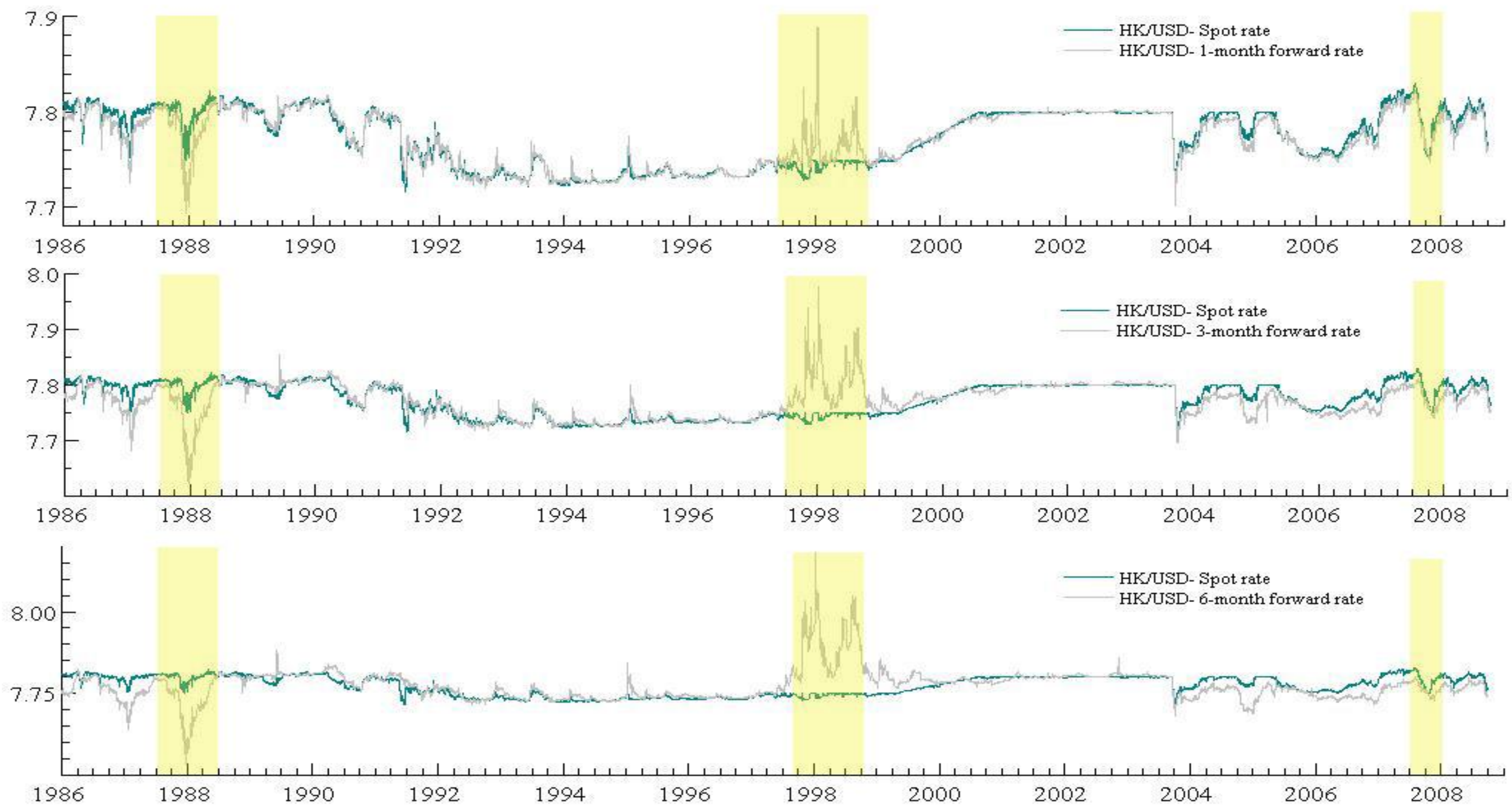


Figure 1 The Spot Exchange Rate and 1-, 3-, and 6-month Exchange Rate Forwards.

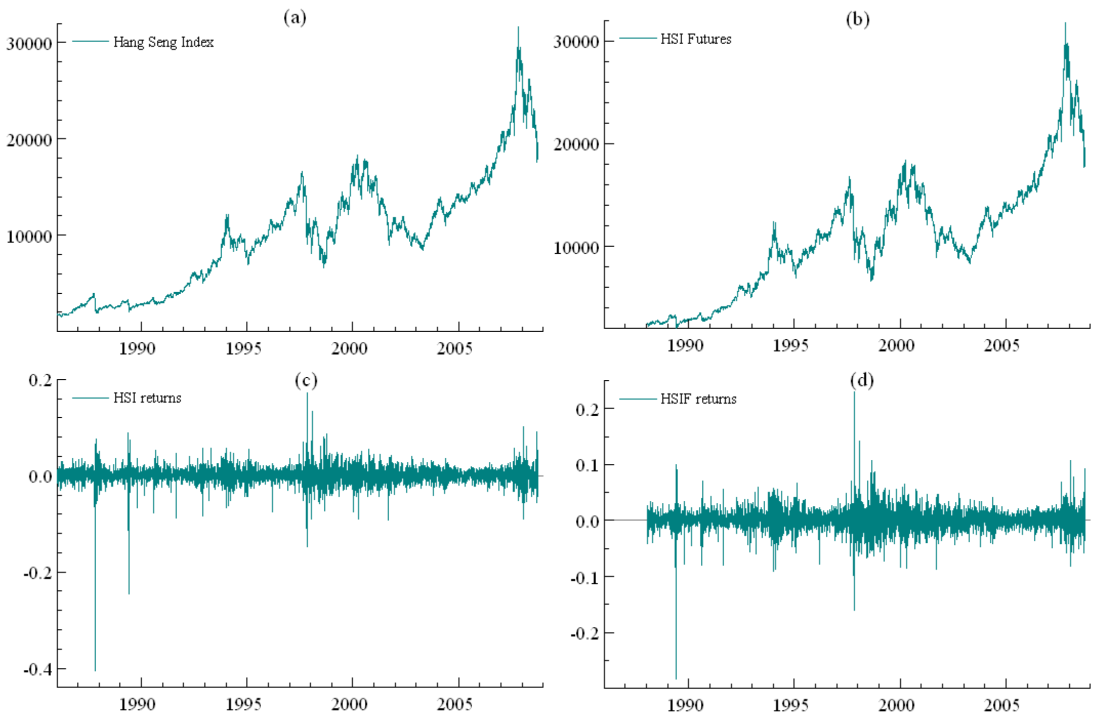


Figure 2 The Hang Seng Index and Hang Seng Index Futures

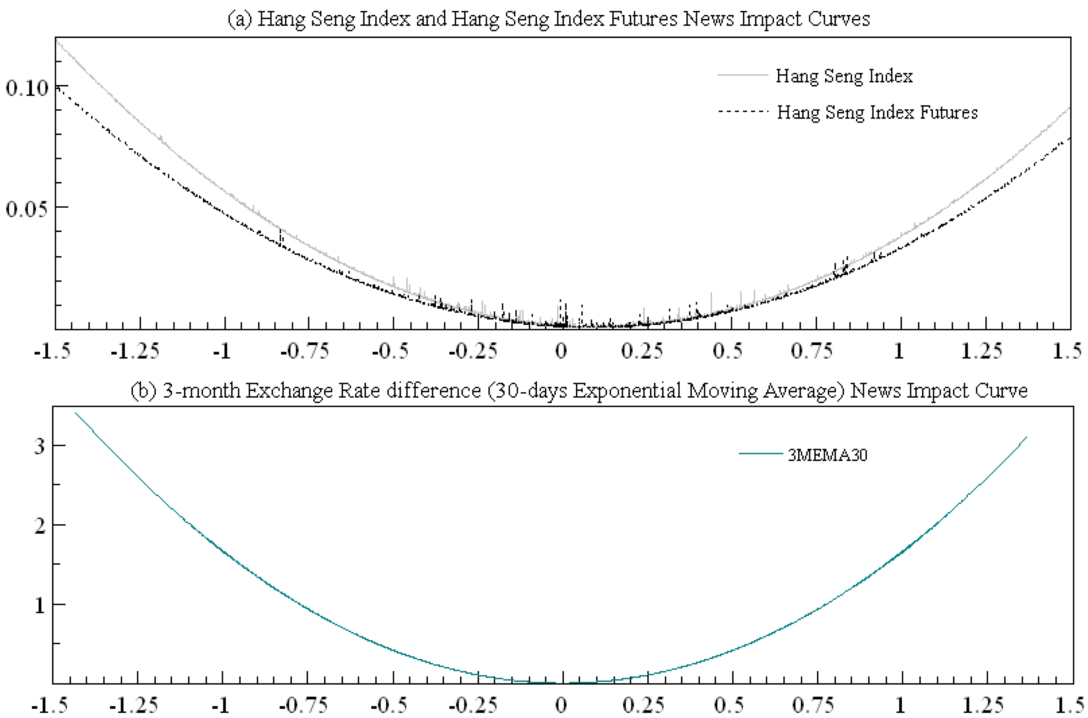


Figure 3 The News Impact Curves for HSI, HSI futures, and Exchange Rate Difference.

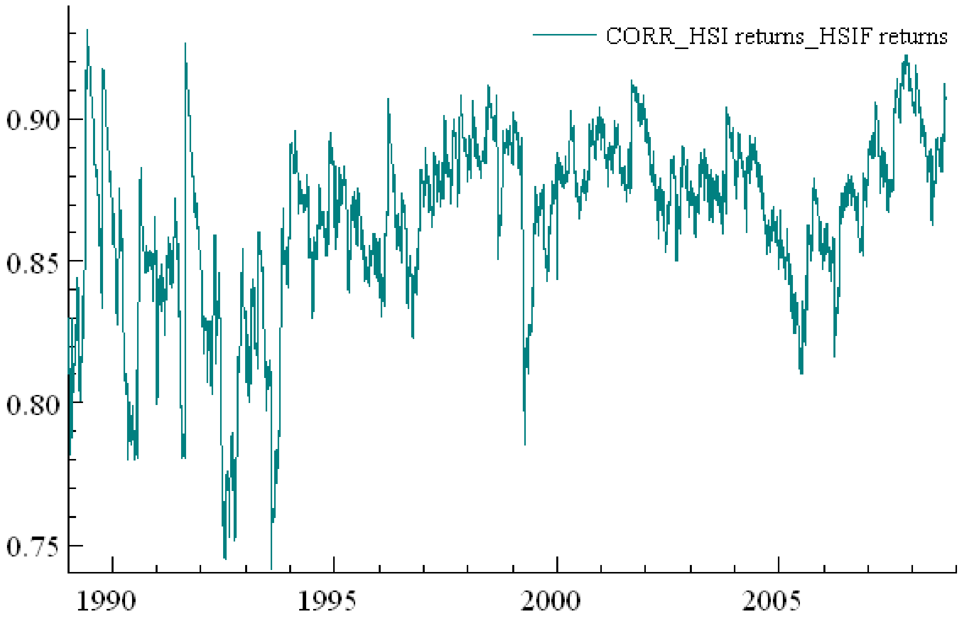


Figure 4 The Estimated Conditional Correlation of HSI Returns and HSIF Returns.

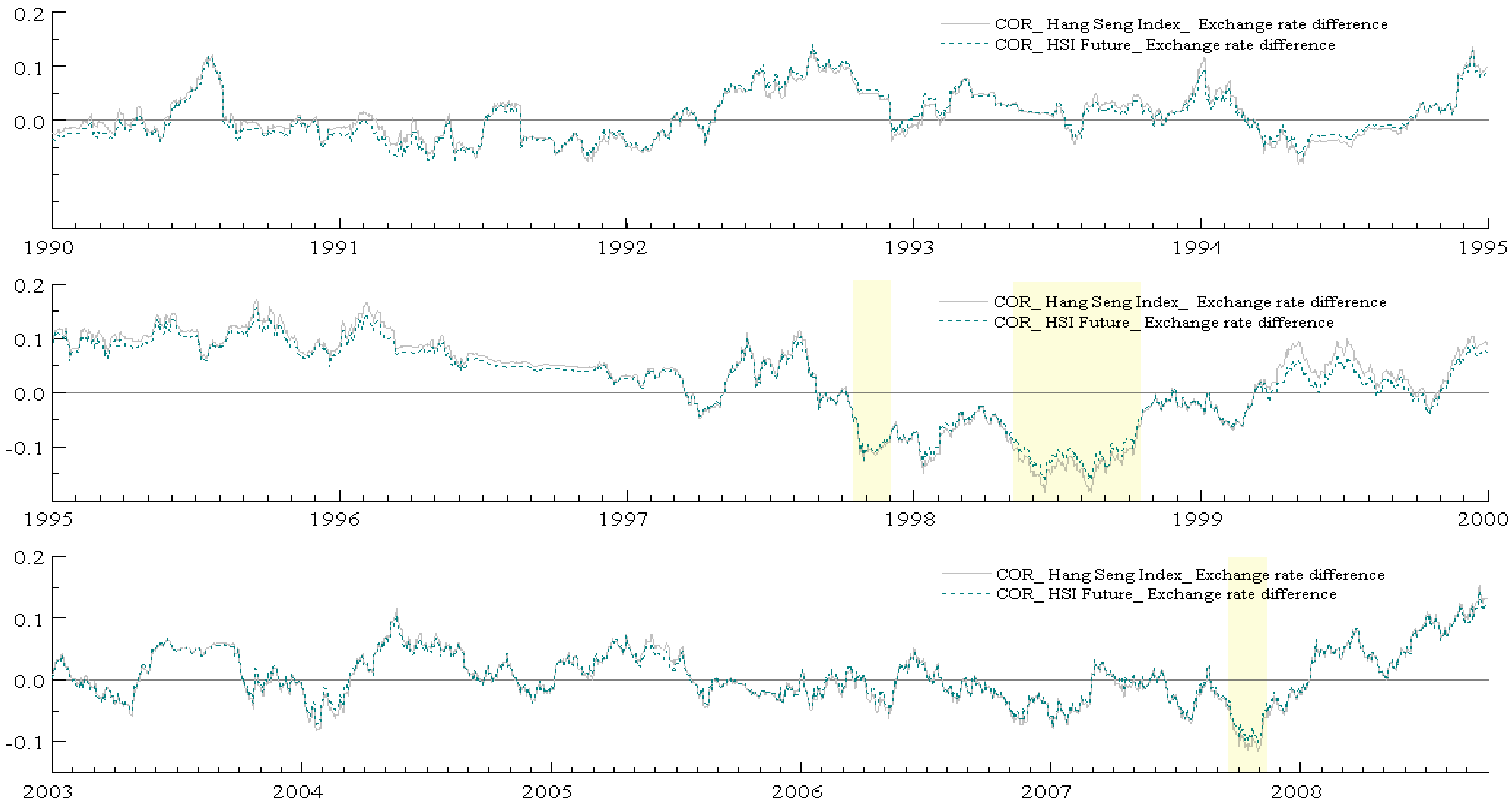


Figure 5 The Estimated Conditional Correlation of Exchange Rate Difference to HSI Returns and HSIF Returns.

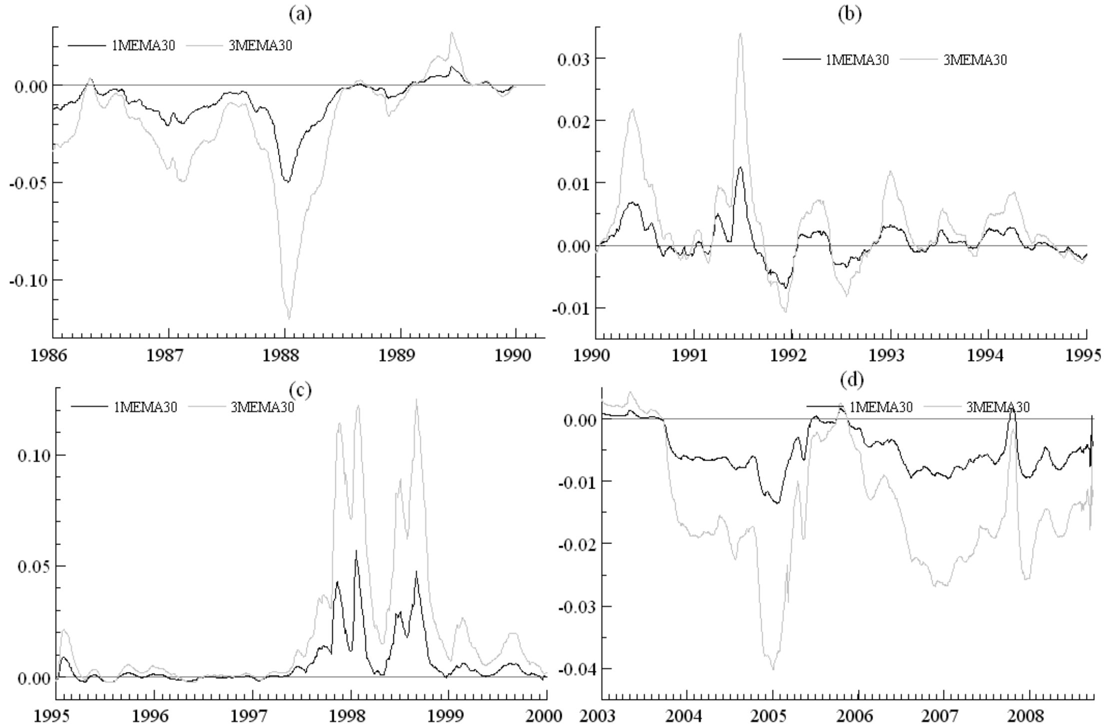


Figure 6 The Exponential Moving Average of 1- and 3-month Exchange Rate Difference.

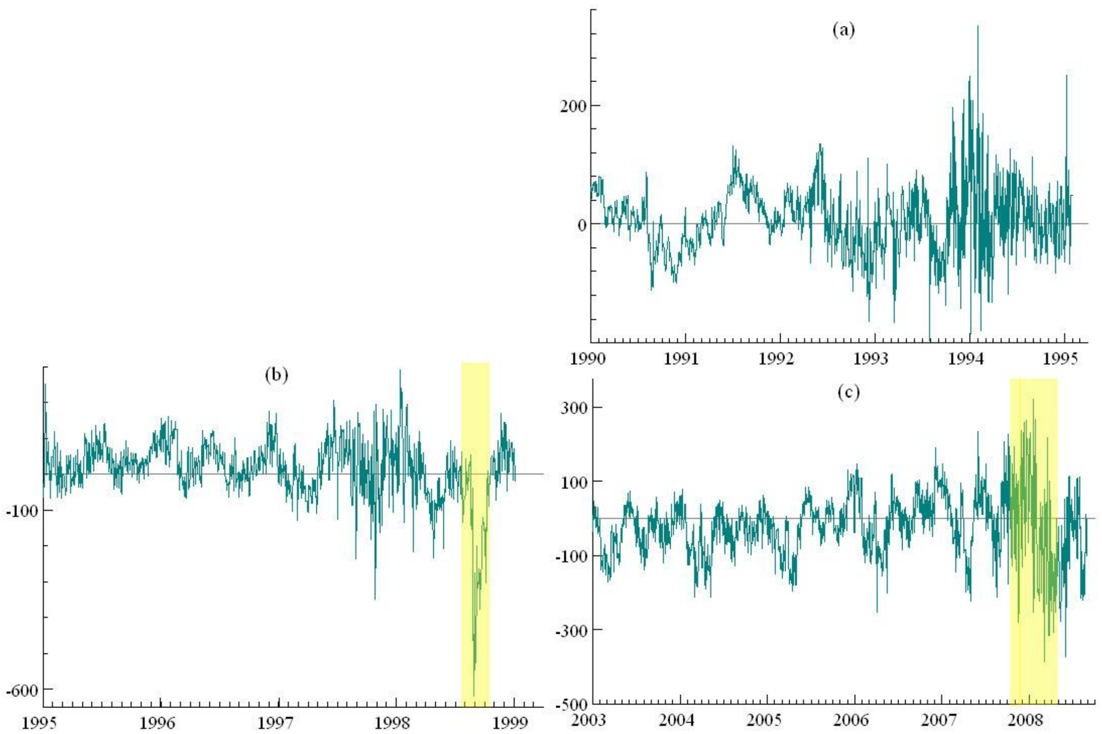


Figure 7 The Hang Seng Index Premium.

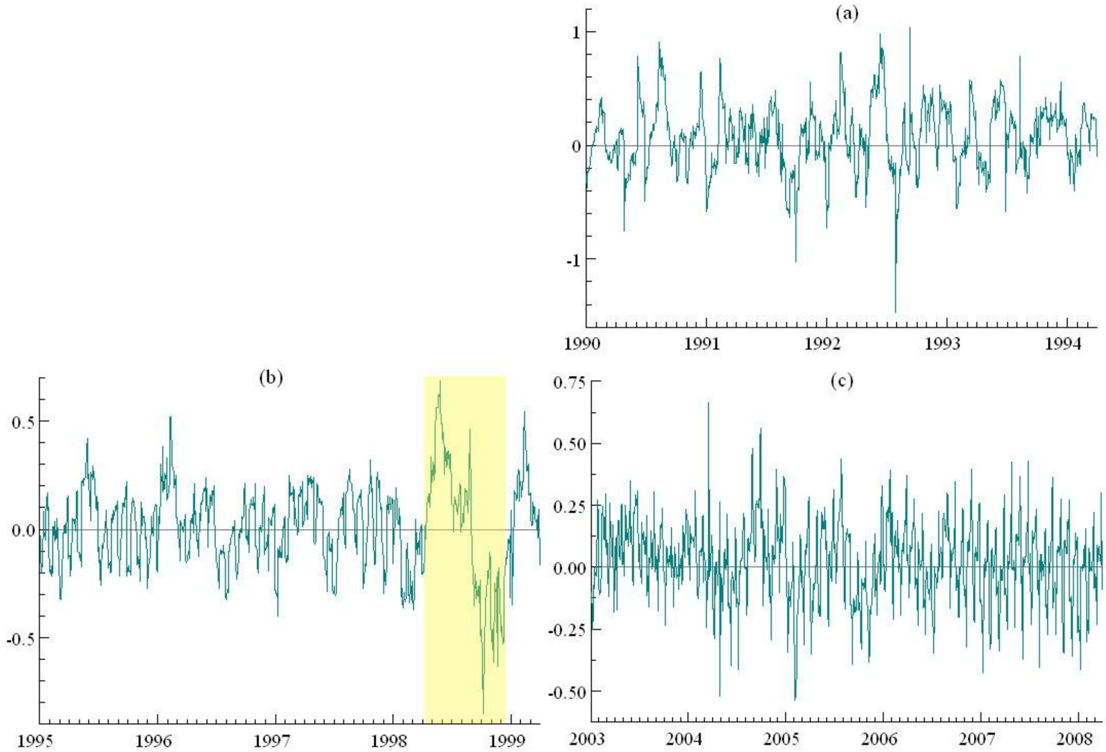
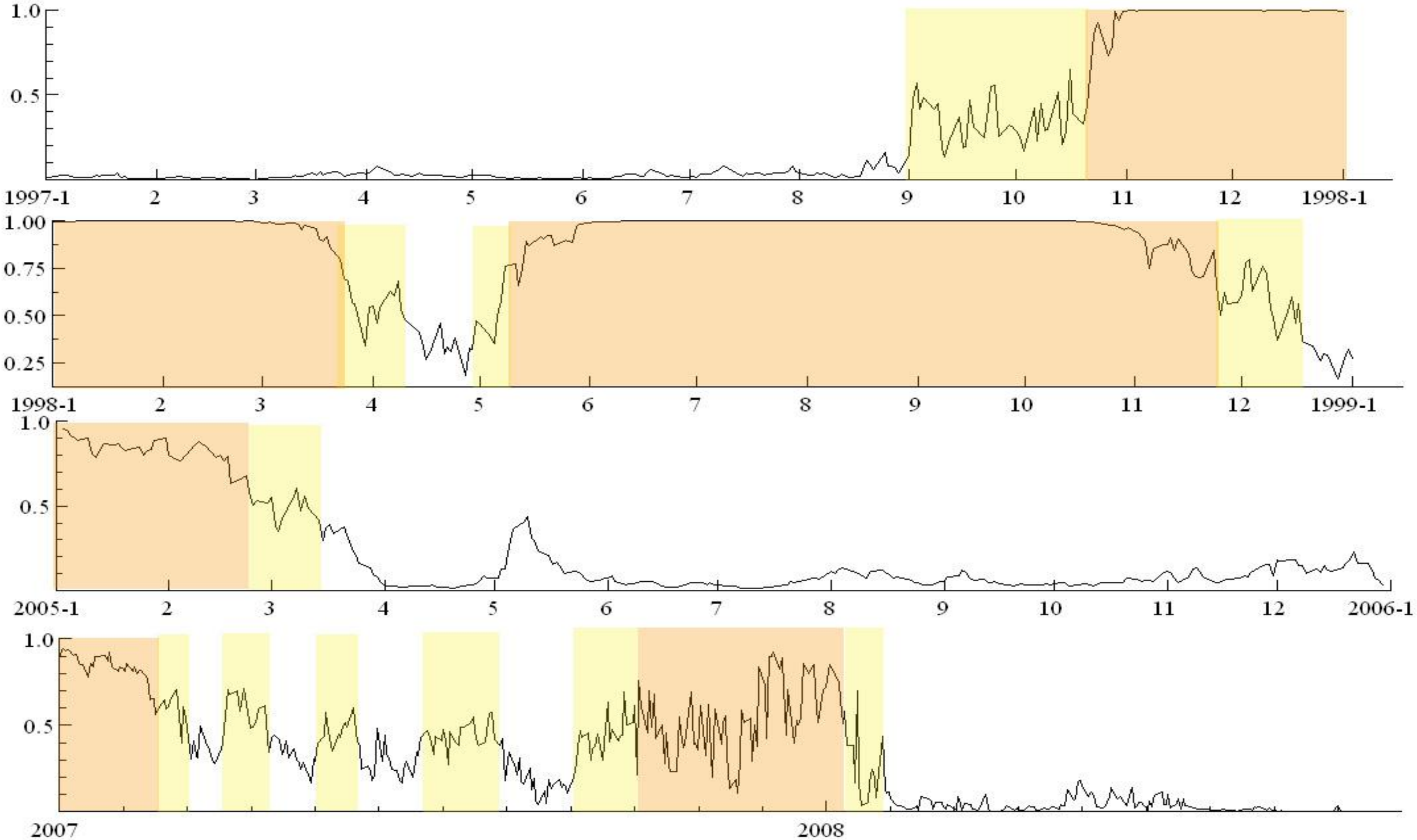


Figure 8 The Open Interest Contract of HSI Futures.



Note: Lighter (darker) shades are the estimated probability of speculative attacks lie between 1 and 2 (greater than 2) standard deviations.

Figure 9 The Estimated Probabilities of Currency Attacks Occurrence by Logit Model.

Table 1 Descriptive Statistics of HSI Returns, HSIF Returns and 3MEMA30

Statistics	HSI returns	HSIF returns	3MEMA30 [a]
Mean	0.0004	0.0004	0.0003
Standard Deviation	0.016	0.018	0.0227
Skewness	-0.7542	-0.5586	1.6268
Excess Kurtosis	19.422	21.65	9.8659
Minimum	-0.2452	-0.2822	-0.1185
Maximum	0.1725	0.2298	0.1248
Normality test χ^2	10340**	12553**	1456.3**

Notes: [a] = 30-days exponential averaged value. ** = significance level at 1%.

Table 2 The ADF Test and LM ARCH Effect Test

Statistics	HSI returns	HSIF returns	3MEMA30
ADF Statistics	-28.612**	-29.157**	-5.956**
Critical value	-2.566		
LM ARCH effect test	618.650	16.874	63.284
	(0.000)	(0.000)	(0.000)

Notes: The p-values of 1 to 5 lags in the ARCH effect test are shown in the parenthesis.
** represents 1% level of significance.

Table 3 The Unconditional Correlation Matrix

	HSI returns	HSIF returns	3MEMA30
HSI returns	1	0.944	0.007
HSIF returns		1	0.006
3MEMA30			1

Table 4 The Univariate GARCH Models

	w_H	α_H	β_H	γ_H	w_F	α_F	β_F	γ_F	w_E	α_E	β_E	γ_E
GARCH (1,1) with Gaussian Distribution												
Coefficients	0.0008	0.1005	0.8837	—	0.0009	0.0835	0.9030	—	0.0005	1.6629	-0.6625	—
Std. Error	(0.0002)	(0.0151)	(0.0160)	—	(0.0002)	(0.0138)	(0.0148)	—	(0.0000)	(0.0407)	(0.0408)	—
GJR (1,1) with Gaussian Distribution												
Coefficients	0.0006	0.0462	0.8782	0.1007	0.0006	0.0393	0.8963	0.0895	0.0005	1.6650	-0.6624	-0.0034#
Std. Error	(0.0002)	(0.0095)	(0.0154)	(0.0243)	(0.0002)	(0.0085)	(0.0142)	(0.0242)	(0.0000)	(0.0413)	(0.0408)	(0.0045)
GJR (1,1) with Student Distribution												
Coefficients	0.0006	0.0462	0.8782	0.1007	0.0006	0.0393	0.8963	0.0895	0.0005	1.6650	-0.6624	-0.0034#
Std. Error	(0.0002)	(0.0095)	(0.0154)	(0.0243)	(0.0002)	(0.0085)	(0.0142)	(0.0242)	(0.0000)	(0.0413)	(0.0408)	(0.0045)
GARCH (1,1) with Student Distribution												
Coefficients	0.0008	0.1005	0.8837	—	0.0009	0.0835	0.9030	—	0.0005	1.6629	-0.6625	—
Std. Error	(0.0002)	(0.0151)	(0.0160)	—	(0.0002)	(0.0138)	(0.0148)	—	(0.0000)	(0.0407)	(0.0408)	—

Notes: The subscripts of H, F, and E represent the estimates for HSI returns, HSI futures returns and exchange rate difference, respectively. Figures in parenthesis give the standard error of the coefficients. # represents 5% insignificance level.

Table 5 The DCC-GARCH Models

	Engle DCC-model			Tse &Tsui DCC-model		
Models/Parameters	α_D	β_D	df	α_D	β_D	df
DCC (1,1)	0.0097	0.9880	—	0.0049 #	0.9859	—
	(0.0025)	(0.0040)	—	(0.0050)	(0.0156)	—
GJR-DCC (1,1)	0.0091	0.9907	—	0.0042 #	0.9882	—
	(0.0023)	(0.0030)	—	(0.0029)	(0.0086)	—
GJR-Student-DCC (1,1)	0.0078	0.9904	9.5979	0.0041	0.9899	9.1391
	(0.0015)	(0.0020)	(0.5529)	(0.0010)	(0.0025)	(0.5015)
Student-DCC (1,1)	0.0076	0.9904	9.4287	0.0043	0.9893	9.0768
	(0.0014)	(0.0021)	(0.5283)	(0.0010)	(0.0025)	(0.4921)

Notes: DCC = Dynamic conditional correlation; GJR = Glosten *et al*. (1993); Student = Student t distribution. df is the degree of freedom. # represents statistical insignificant at 5% level.

Table 6 The DCC Models Compared

Models/ Criteria	Log-likelihood value	Schwarz value	Hannan-Quinn value	Akaike Information value
<u>Engle DC- model</u>				
DCC (1,1)	55976.53	-20.72	-20.73	-20.73
GJR-DCC (1,1)	56007.29	-20.74	-20.74	-20.74
GJR-Student-DCC (1,1)	[56358.32]	[-20.86]	[-20.87]	[-20.87]
Student-DCC (1,1)	56336.15	[-20.86]	-20.86	-20.86
<u>Tse &Tsui DCC-model</u>				
DCC (1,1)	55903.81	-20.70	-20.70	-20.70
GJR-DCC (1,1)	55913.26	-20.70	-20.71	-20.71
GJR-Student-DCC (1,1)	56315.72	-20.85	-20.85	-20.86
Student-DCC (1,1)	56305.68	-20.84	-20.85	-20.85

Note: Figures in brackets denote the best result in each criterion.

Table 7 The Estimates of the Logistic Models

Parameters	Model A	Model B	Model C	Model D
Constant	-3.231	-3.327	-2.921	-2.756
	(0.000)	(0.000)	(0.000)	(0.000)
FDP	74.443	69.616	67.969	66.264
	(0.000)	(0.000)	(0.000)	(0.000)
CHED		-60.730	-35.891#	-47.180
		(0.004)	(0.104)	(0.043)
CHFE			-44.964	-53.202
			(0.000)	(0.000)
HSIP				0.007
				(0.000)
Open Interest (HSIF)				-0.587
				(0.048)
AIC	0.534	0.488	0.426	[0.419]
log-likelihood	-1581.848	-1314.321	-1147.126	[-1034.602]

Notes: FDP gives the difference between 3-month and 1-month forward rates multiplied by probability of the occurrence of number of day dispersal; CHED is the first difference of conditional correlation between HSI and exchange rate difference; CHFE is the conditional correlation between HSI futures and exchange rate difference; HSIP is the Hang Seng Index premium; Open Interest (HSIF) is the 30-days differenced open interest contracts of index futures. ( ) and [ ] denote, respectively, the p-value of the coefficients and the best result in each criterion. # represents insignificance level of 5%.