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Relationships between Stock Price Volatility and Futures Volume in Taiwan

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ABSTRACT

The purpose of this paper is to examine the relationship between stock price and futures volume. This paper contributes to previous studies of price-volume relationship and the determinants of futures volume by postulating three hypotheses and testing them with data for four stock index futures in Taiwan. The model developed in this article formalizes the price-volume relationship by stochastic calculus and *Itô* process. First, we find a long-run relationship between stock price and futures volume by cointegration test. If the cointegarted relationship exists, stock price and futures volume are non-stationary in level but stationary in the first differences. That is, stock price and futures volume follow a random-walk process. On the other hand, we extract the short-run and long-run impacts by vector error correction model. Furthermore, we consider three measures for stock price volatility to test the determinants of change and volatility of futures volume. Although the determinant of change and volatility of futures volume are sensitive to the volatility estimate used, we find that absolute stock price change is a more suitable measure for stock index price volatility.

Keywords: futures volume, stock price, volatility

I. INTRODUCTION

A futures contract is an agreement between two parties, a buyer and a seller, to exchange at a future date, particular goods or services at a pre-specified price. The price is determined through the bidding and offering process and subject to the rules of an organized exchange. The principle contributions of a futures market to the economy consist of three functions, namely hedging, speculating, and price discovery. Consequently, the sources of underlying market, future market and their interrelation are topics of enduring interest in financial market.

Karpoff (1987) suggests several reasons why the price-volume relationship is crucial in capital market by modeling the trade volume of heterogeneous investors who periodically and idiosyncratically revise their demand prices. He finds that larger volumes induce more competitive trade and lower the bid-ask spread. Therefore, the relationship between stock price and futures volume plays an

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important role in financial markets. For the relationship between volume and price volatility, previous studies such as Ying (1966), Crouch (1970), Clark (1973), Copeland (1976), Epps and Epps (1976), Westerfield (1977), Rogalski (1978), and Upton and Shannon (1979) have examined this issue extensively. Some studies such as Cornell (1981), Tauchen and Pitts (1983), Rutledge (1884) and Floros and Vougas (2007) have investigated the interrelation of price-volume with the data from futures markets. Floros and Vougas (2007) examine the relationship between trading volume and returns in Greek stock index futures market. They suggest that there is a significant relationship between lagged volume and absolute returns, while a positive contemporaneous relationship does not hold. That is, they found market participants use volume as an indication of prices.

On the other hand, Garcia, Leuthold and Zapata (1986) examine the lead-lag relationship between trading volume and price volatility for corn, wheat, soybeans, soybean oil and soybean meal futures contracts by causality tests. The relationship between stock prices and volume can be divided into short-run and long-run relationship. Therefore we postulate the first hypothesis to analyze short-run and long-run relationship between stock index price and futures volume by cointegration test and an error correction model. The methodology of cointegration test is Johansen’s (1988) maximum likelihood method, which is more elaborate than that of Garcia, Leuthold and Zapata (1986). Before testing cointegration, we have to test randomness and stationarity for the sample data in this paper by unit root test first. Consequently, if the first hypothesis is proved implying that stock index prices and futures volume follow a random-walk process (Kendall, 1953).

Then, we test the determinants of change and volatility of futures trading volume and open interest by three measures that are different from those used in previous works of Garcia, Leuthold and Zapata (1986), Chen, Cuny and Haugen (1995), Bhar and Malliaris (1998), Malliaris and Urrutia (1998), Wang and Yau (2000), Watanabe (2001), Pilar and Rafael (2002), Illueca and Lafuente (2003), Luu and Martens (2003), Holmes and Tomsett (2004) and Floros and Vougas (2007).

Chen, Cuny and Haugen (1995) examine how stock volatility affects the basis and open interest of stock index futures. They find that the basis, which is defined as the futures price minus the stock prices, decreases as the volatility of the S&P

500 Cash Index increases. The open interest of S&P 500 futures increases as the volatility of the S&P 500 Cash Index increases. Bhar and Malliaris (1998) find that price volatility is a determinant of the unexpected component of the changes in trading volume. They also find significant relationship between volatility of price and volatility of trading volume change for five foreign currency futures. Malliaris and Urrutia (1998) investigate the price-volume relationship and the determinants of trading volume with the use of agricultural commodity future contracts. They find that the volatility of trading volume as a function of price volatility. Furthermore, the price volatility impacts significantly volume's volatility.

Chang, Chou and Nelling (2000) examine the relation between stock market volatility and the demand for hedging in S&P 500 stock index futures contracts. They construct measures of daily price volatility by two estimators of time-varying price volatility, including extreme value estimator and an estimator using the GARCH process. Then, they decomposed volatility estimates into expected and unexpected components. They find only weak evidence of a positive relation between unexpected volatility and open interest. They conclude that the results are sensitive to the volatility estimate used.

Wang and Yau (2000) examine the relationship between trading volume and price volatility for futures markets by OLS (ordinary least squares) and GMM (generalized method of moments). The sample is based on two financial futures contracts (S&P 500 and DM) and two metal futures contracts (silver and gold), and covers the period 2 January 1990 to 29 April 1994. Their results show a positive relationship between trading volume and price volatility and a negative relationship between price volatility and lagged trading volume.

Watanabe (2001) examines the relation between price volatility and trading volume for the Nikkei 225 stock index futures from 24 August 1990 to 30 December 1997. He suggests that there is no relationship price volatility and volume following the method developed by Bessembinder and Seguin (1992).

Pilar and Rafael (2002) analyze the effect of futures on Spanish stock market volatility and trading volume by a GJR model. Their results show a decrease in the volatility and increase in trading volume. However, Illueca and Lafuente (2003) find no significant relationship between spot volatility and trading volume in the Spanish stock index futures market. Finally, Luu and Martens (2003) test the MDH using realized volatility. They find that the mixed evidence on MDH in the existing literature can in part be contributed to the use of poor realize volatility measures.

Holmes and Tomsett (2004) use the GMM approach to demonstrate that the link between futures volume volatility can be attributed to the flow of information. Floros and Vougas (2007) investigate the empirical relationship between price changes and trading volume for index futures contracts traded in the ADEX (Greece). They test how well GARCH effects are explained by trading volume and analyze the contemporaneous relationship between returns and volume using a system of simultaneous equations.

As a result, we construct three estimators for stock index price volatility in this paper. The first measure of stock price volatility is absolute change in price. Crouch (1970), Clark (1973), Westerfield (1973) have postulated that absolute value of price change is positively related to volume. Rogalski (1978) suggest additional empirical evidence to support that price change and volume are positively interrelated as suggested by Epps and Epps (1976). Numerous empirical studies have also examined the contemporaneous behavior of volume and absolute price changes, and have found a positive correction between the two as documented by Karpoff (1987). More recent empirical investigations such as Gerety and Mulherin (1989) also observe similar correlations.

The second measure is estimated by extreme value method. Parkison (1980) suggests that the extreme value, such as high and low prices, provides more information. Therefore, we adopt the extreme value estimator as the second measure of stock price volatility.

The third measure is estimated by GARCH model. Antoniou and Holmes (1995) examine the impact of trading in FTSE-100 Stock Index Futures on the volatility of the underlying spot market following the Generalized Autogressive Conditional Heteroscedastic (GARCH) family of statistical techniques. This is because volatility must be time varying and a natural way to capture varying nature of volatility is to model the conditional variance as a GARCH process (Engle, 1982; Bollerslev, 1986; Engle and Bollerslev, 1986). According to the aforementioned, we consider three measures of stock index price volatility that include absolute change in price, extreme value estimator and an estimator involving the GARCH process for the second and third hypotheses. Consequently, the second and third hypotheses are postulated to examine whether or not stock index price volatility is the significant determinant of change and volatility of futures volume.

The purpose of this paper is to investigate the relationship between stock price and futures volume for four stock index futures in Taiwan. This paper contributes to the literature in the following aspects. First, we investigate the short-run and long-run relationship between stock price and futures volume by cointegration test and vector error correction model (VECM). Further, we use stochastic calculus and Itô process to formalize the relationship between stock index price and futures volume. The model developed in this paper is different from that of previous studies such as Crouch (1970), Rogalski (1978), Martell and Wolf (1987), Karpoff (1986), Huffman (1987) and Pagano (1989).

Second, we consider three measures for stock price volatility, which is a more extensive discussion than previous studies. Third, we postulate three hypotheses and testing them more complete than previous studies. All these three hypotheses are tested using four stock index futures contracts in Taiwan covering the sample period of 1997-2004. We expect that the proposed model in this paper can provide a thorough investigation of the relationship between stock price and futures volume.

This paper is organized as follows. Section 1 provides the motivation. Section 2 develops the model to formalize the relationship between stock index price and futures volume. Then, we postulate three hypotheses. Section 3, we describe the methods used to test the three hypotheses. Section 4 describes the data used in this paper. Section 5 analyzes the main empirical results to verify the three hypotheses. Section 6 includes a discussion of our findings and conclusion.

II. MODEL SPECIFICATION

Following Crouch (1970), Rogalski (1978), Garcia et al. (1986) and Malliaris and Urrutia (1998) assume that futures volume is a function of futures price and time as

$$V(t) = L(t, F(t)) \tag{1}$$

where V(t) denotes futures volume. F(t) denotes futures price and t denotes time. In addition, the relationship between futures price and stock price is

$$F(t) = M(t, P(t)) \quad \textbf{(2)}$$

where P(t) denotes stock price. Equations (1) and (2) not only express a static model, but they also emphasize a change over time dynamically.

Furthermore, we assume that functions L(t) and M(t) are time continuously differentiable and P(t) follows an Itô process with drift $a(P, t)$ and volatility $\sigma(P, t)$ as[1]

$$dP(t) = a(P, t)dt + \sigma(P, t)dB(t) \quad \textbf{(3)}$$

where B(t) denotes a standardized Weiner process. Although Equation (1) and (2) are general model, the model described by Equation (3) is favorable, as Itô's processes describe better continuous random walks with a drift which lead to market efficiency. Another application of Itô lemma suggest Equations (1) and (2) as[2]

$$dV = L_t dt + L_F dF + \frac{1}{2} L_{FF} (dF)^2 \quad \textbf{(4)}$$

$$\begin{aligned} dF &= M_t dt + M_P dp + \frac{1}{2} M_{PP} (dp)^2 \\ &= M_t dt + M_P [adt + \sigma dB] + \frac{1}{2} M_{PP} \sigma^2 dt \\ &= [M_t + M_P a + \frac{1}{2} M_{PP} \sigma^2]dt + M_P \sigma dB \end{aligned} \quad \textbf{(5)}$$

where $L_t, L_F, L_{FF}, M_t, M_P, M_{PP}$ denote partial derivatives of functions L(t) and M(t). Then, substitution of Equation (5) into Equation (4) and rearrangement of terms gives

$$dV = L_t dt + L_F \left\{ \left[M_t + M_P a + \frac{1}{2} M_{PP} \sigma^2 \right] dt + M_P \sigma dB \right\} + \frac{1}{2} L_{FF} M_P^2 \sigma^2 dt$$

[1] The description of asset prices has been reviewed extensively in Merton (1982), who offers the use of Itô processes to characterize the behavior of an asset price.

[2] This expression has been expressed in Malliaris and Brock (1982).

$$= \left[L_t + L_F \left(M_t + M_P a + \frac{1}{2} M_{PP} \sigma^2 \right) + \frac{1}{2} L_{FF} M_P^2 \sigma^2 \right] dt + L_F M_P \sigma dB \quad \textbf{(6)}$$

Equations (1) and (6) describe trading volume theoretically and show whether it follows a random walk.

The model expressed by Equations (1)-(6) allows one to formulate the first hypothesis. Since both V(t) and P(t) are random variables with certain distribution functions, we say that V(t) and P(t) are non-stationary. If these distribution functions change over time, the stock price in Equation (3) is a Markov diffusion process. Furthermore, stock and futures markets may have interrelated relationship, including long-run and short-run relationships. As a result, we used cointegration and error correction methodology for the first hypothesis to express the relationship between stock price and futures volume, including both short-run and long-run relationships. If the first hypothesis is proved means that stock prices and future volumes all follow a random walk. Therefore tests of randomness and stationarity for stock price, futures trading volume and open interest suggest the validity for the first hypothesis first.

By taking expectations of equation (6), we derive the following expression:

$$E(dV) = \left[\left(L_t + L_F M_t \right) + L_F M_P a + \frac{1}{2} \left(L_F M_{PP} + L_{FF} M_P^2 \right) \sigma^2 \right] dt \quad \textbf{(7)}$$

Equation (7) suggest three determinants of the change in futures volume: (i) a trend factor; L_t and M_t; (ii) the drift coefficient of stock price, a; and (iii) the volatility of stock prices, σ^2. The second hypothesis is tested with Equation (7), which represents that the change in futures volume is a function of stock prices volatility.

Finally, we use stochastic calculus techniques to derive the volatility of futures volume is given by

$$Var(dV) = \left(L_F M_P \right)^2 \sigma^2 dt \quad \textbf{(8)}$$

From Equation (8), we find that stock prices volatility, σ^2, plays an important role in the volatility of futures volume. Bhar and Malliaris (1998) and Malliaris and Urrutia (1998) suggest that price volatility has a significant impact on volume volatility. Consequently, we postulate the second and third hypothesis to test whether or not stock price volatility is the significant determinant of change and volatility of futures volume.

III. METHODOLOGY

The first hypothesis in this paper is tested by cointegration with Johansen (1988), and the vector error correction methodology. The second and third hypotheses test whether or not stock index price volatility affects the change and volatility of futures volume. Then, we consider the volatility of stock index price via three measures, namely change in stock index price, extreme value of Parkison (1980) and generalized autogressive conditional heteroskedastically approach. We describe these methods used to test three hypotheses briefly.

1. Unit Root Test

First, we have to test the property of data by unit root test before testing cointegration. There are numerous unit root tests in the literature such as ADF test (augmented Dickey-Fuller) and Phillips-Perron test. Since most time series data with heavy-tailed distributions, Koenker and Xiao (2004) develop quantile autoregression model to infer unit root. Therefore, to test the existence of unit root in the time series of stock index price and futures volume, we adopt the ADF and quantile autoregression inference in this paper.

One of the most important extensions of the first order autoregression formulation of the unit root model is the ADF model[3]

$$y_t = \alpha_1 y_{t-1} + \sum_{j=1}^{q} \alpha_{j+1} \Delta y_{t-j} + u_t \tag{9}$$

[3] We calculate the lag numbers by the Akaike Information Criterion (AIC) that is computed as

$$AIC = -2\ell / T + 2k / T$$

where ℓ is the log likelihood. The log likelihood value is computed by assuming a multivariate normal (Gaussian) distribution as

$$\ell = -\frac{TM}{2}(1 + \log 2\pi) - \frac{T}{2}\log\left|\hat{\Omega}\right|$$

where $\hat{\Omega} = \det(\sum_i \hat{u}\hat{u}' / T)$ and M is the number of explators.

The AIC is often used in model selection for non-nested alternatives-smaller values of the AIC are preferred. We can choose the length of a lag distribution by choosing the specification with the lowest value of the AIC.

In this model, the autogressive coefficient α_1 plays an important role in measuring persistency in economic and financial time series. Under regularity conditions, if $\alpha_1 = 1$, y_t contains a unit root and is persistent; and if $|\alpha_1| < 1$, y_t is stationary. Denoting the σ-field generated by $\{u_s, s \le t\}$ by F_t, the τ-th conditional quantile of y_t, conditional on F_{t-1}, is given by

$$Q_{y_t}\left(\tau \middle| F_{t-1}\right) = Q_u(\tau) + \alpha_1 y_{t-1} + \sum_{j=1}^{q} \alpha_{j+1} \Delta y_{t-j} \quad \textbf{(10)}$$

Koenker and Xiao (2004) consider the t-ratio statistics like the ADF t-ratio test

$$t_n(\tau) = \frac{f(\hat{F}^{-1}(\tau))}{\sqrt{\tau(1-\tau)}} \left(Y_{-1}^T P_X Y_{-1}\right)^{1/2} \left(\hat{\alpha}_1(\tau) - 1\right) \quad \textbf{(11)}$$

where $f\left(\hat{F}^{-1}(\tau)\right)$ is a consistent estimator of $f\left(F^{-1}(\tau)\right)$, Y_{-1} is the vector of lagged dependent variables (y_{t-1}) and P_X is the projection matrix onto the space orthogonal to $X = (1, \Delta y_{t-1}, \cdots, \Delta y_{t-p})$.

In addition, Koenker and Xiao (2004) also use the coefficient-based statistic in the quantile autoregression model for unit root testing and define the following coefficient-based statistic

$$U_n(\tau) = n\left(\hat{\alpha}_1(\tau) - 1\right) \quad \textbf{(12)}$$

Furthermore, we calculate critical values by resampling method.

2. Cointegration Test

If the stock index price and futures volume are non-stationary, then their future time paths depend on past effects. Although the various variables are individually non-stationary, we expect them to be related to one another if a linear combination of them may be stationary. This means that these variables are cointegrated, if there exists a nonzero vector such that they are stationary. The nonzero vector is called cointegrated vector and can be interpreted for short-run and long-run equilibrium.

There are two main approaches for cointegration tests. The first approach is the Engle-Granger (1987) two-step methodology. Its disadvantage is that the result of the cointegration test may vary with the participant chosen for the purpose of normalizing the cointegrating vector and it is difficult to be applied to more than two cointegrating vectors.

The second approach is the Johansen's (1988) maximum likelihood methodology, which is used in this study. It does not have the disadvantages of the Engle-Granger approach. The estimation used the duality between the vector autoregression (VAR) representation and an ECM formulation provided by the Granger representation theorem (Engle and Granger, 1987). To test for cointegration, we express series X_t as a VAR process

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots + A_k X_{t-k} + \mu + \varepsilon_t \tag{13}$$

Then there exists an ECM

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{k-1} \pi_i \Delta X_{t-i} + \mu + \varepsilon_t \tag{14}$$

where $\pi = -I + \sum_{i=1}^{k} A_i,\ i = 1,2,\ldots k,\ \pi_i = -\sum_{j=i+1}^{k} A_j,\ j = i+1, i+2, \ldots, k$, and A is coefficients of the (n×n) matrix π. Johansen (1988) has suggested that the rank of matrix π in Equation (14) determines whether or not variables are cointegrated. If they are cointegrated, then the cointegration term is πX_{t-1}. It also determines the number of cointegrating vectors. Therefore, there are two test statistics provided by Johansen as

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{15}$$

$$\lambda_{max}(r, r+1) = -T \times \ln(1 - \hat{\lambda}_{r+1}) \tag{16}$$

where the n characteristic roots are ordered such that $\lambda_1 > \lambda_2 > \cdots > \lambda_n$ and T is the number of observations. The statistic λ_{trace} tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative is greater than r. On the other hand, the statistic λ_{max} tests the null hypothesis that the number of cointegrating vectors equal to r against the alternative is equal to r+1.

3. Error Correction Model (ECM)

It is possible to develop a model that can test the short-run and long-run relationships between stock index price and futures volume by integrating the concepts of cointegration and Granger causality. The model is known as the error correction model proposed by Engle and Granger (1987). First, we assume two time series X_t and Y_t. The long-run and short-run impact of Y_t on X_t can be expressed as

$$X_t - X_{t-1} = a_1\hat{Z}_{t-1} + \sum_{i=1}^{T} c_i\left(Y_{t-i} - Y_{t-i-1}\right) + \sum_{j=1}^{T} d_j\left(X_{t-j} - X_{t-j-1}\right) + \varepsilon_t \qquad \textbf{(17)}$$

where the cointegartion term, $a_1\hat{Z}_{t-1}$, is recalled from Equation (14). In particular, Equation (17) decomposes the dynamic adjustments of the change of dependent variable, X_t, into two components: (i) long-run component is given by the cointegration term, $a_1\hat{Z}_{t-1}$; and (ii) short-run component is given by the first summation term on the right-hand side of equation (17). Similarly, the short-run and long-run impact of X_t on Y_t can be expressed as follows:

$$Y_t - Y_{t-1} = b_1\hat{Z}_{t-1} + \sum_{i=1}^{T} \varphi_i\left(X_{t-i} - X_{t-i-1}\right) + \sum_{j=1}^{T} \theta_j\left(Y_{t-j} - Y_{t-j-1}\right) + \varepsilon_t \qquad \textbf{(18)}$$

According to Equation (17) and (18), if both a_1 and b_1 are significantly different from zero, then X_t and Y_t adjust to one another over the long run. If a_1 is significantly different from zero but b_1 is not, then X_t will adjust to Y_t in the long-run. The opposite occurs when b_1 is significantly different from zero but a_1 is not. On the other hand, coefficients c_i and φ_i represent the short-run relationship between X_t and Y_t. If both c_i and φ_i are significantly different from zero, it implies that X_t and Y_t will affect each other in the short-run. If c_i are not significantly different from zero but φ_i are, then Y_t will cause X_t in the short-run. The opposite occurs when not φ_i are significantly different from zero but c_i are.

4. Tests of Determinants of Change and Volatility of Futures Volume

This paper also examines whether or not stock index price volatility affects the change and volatility of futures volume, including futures trading volume and open interest as described by the third and fourth hypotheses of Equations (7) and (8), respectively. Consequently, the determinants of the change in futures trading volume and open interest can be tested with Equation (7) via running the following regression

$$\Delta V_t = \alpha_0 + \beta(\Delta P_t) + \gamma|\Delta P_t| + \varepsilon_t \qquad \textbf{(19)}$$

where ε_t denotes the residual term, $\Delta V_t = V_t - V_{t-1}$ denotes change in futures volume, $\Delta P_t = P_t - P_{t-1}$ denotes change in stock price, $|\Delta P_t|$ denotes absolute change in price as a proxy of stock index price volatility. On the other hand, the determinants of volatility of futures trading volume and open interest can be implemented by Equation (8) by running the following regressions

$$|\Delta V_t| = \alpha_2 + \delta|\Delta P_t| + \mu_t \qquad \textbf{(20)}$$

where μ_t denotes the residual term, $|\Delta V_t|$ denotes absolute change in futures trading volume or open interest that as a proxy of volatility of futures volume and others variables as in Equation (19).

According to Equations (19) and (20), the volatility of stock price is the determinant of change and volatility of futures volume. In particular, we consider three measures for stock index price volatility. The first is absolute change in stock index price, $|\Delta P_t|$, as described in Equations (19) and (20). The second is the extreme value estimator developed by Parkison (1980). The third is the Generalized Autoregressive Conditional Heteroskedastically (GARCH) process developed by Bollerslev (1986).

Several previous studies such as Edwards (1988a, 1988b), Damodaran (1990), Lee and Ohk (1992), and Kamara et al. (1992) examine the volatility by using closing prices, which is as unbiased estimator of volatility. Since there is more information provided by the extreme value (the high and low prices), Parkison

(1980) regards extreme the value as far superior estimation than those obtained by traditional estimated processes. The second estimator of volatility, the extreme value estimator, developed by Parkison (1980) is defined as follows

$$\sigma^2_{HL,t} = 0.3607 \times [\ln(H_t / L_t)]^2 \qquad \textbf{(21)}$$

where H_t and L_t are the highest and lowest stock index prices on day t, respectively.

The third estimator of stock index price volatility is developed from the GARCH model. In conventional econometric models, the innovation is assumed to be constant (homoskedasticity), which is inappropriate. Engle (1982) suggests that the variance of innovation is not constant, and assumes the conditional variance of the innovation as an AR(p) process, which is an autoregressive conditional heteroskedastic (ARCH) model. Bollerslev (1986) extends Engle's original work by developing a technique that allows the conditional variance of the innovation to be an ARMA process, which is called the generalized ARCH(p,q) model or GARCH(p,q) model. For this paper, we adopt the GARCH(1,1) model.[4] Consequently, there are three proxies of stock price volatility; they are absolute change in stock price, $|\Delta P_t|$, extreme value, $\sigma^2_{HL,t}$ and the conditional variance of GARCH(1,1), h_t. In summary, determinants of change in futures trading volume and open interest are examined using the following regressions that apply the above three measures to Equation (19)

$$\Delta Vol\_|\Delta P| \ : \ \Delta Vol_t = \alpha_{01} + \beta_{Vol1}(\Delta P_t) + \gamma_{Vol1}|\Delta P_t| + \varepsilon_{1t} \qquad \textbf{(22)}$$

$$\Delta Vol\_\sigma^2_{HL,t} \ : \ \Delta Vol_t = \alpha_{02} + \beta_{Vol2}(\Delta P_t) + \gamma_{Vol2}\sigma^2_{HL,t} + \varepsilon_{2t} \qquad \textbf{(23)}$$

$$\Delta Vol\_GARCH \ : \ \Delta Vol_t = \alpha_{03} + \beta_{Vol3}(\Delta P_t) + \gamma_{Vol3}h_t + \varepsilon_{3t} \qquad \textbf{(24)}$$

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[4] The GARCH(1,1) specification is frequently employed and supported in many studies such as Bollerslev, Chou and Kroner (1992). The simple GARCH (1,1) specification as

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 h_{t-1}$$

where h_t is the conditional volatility at time, t, α_0 is a constant, α_1 is a coefficient that relates the past value of the squared residuals, (ε^2_{t-1}), to current volatility, and β_1 is a coefficient that relates current volatility to the past period of volatility.

$$\Delta OI\_|\Delta P| \quad : \Delta OI_t = \alpha_{04} + \beta_{OI1}(\Delta P_t) + \gamma_{OI1}|\Delta P_t| + \varepsilon_{4t} \tag{25}$$

$$\Delta OI\_\sigma^2_{HL,t} \quad : \Delta OI_t = \alpha_{05} + \beta_{OI2}(\Delta P_t) + \gamma_{OI2}\sigma^2_{HL,t} + \varepsilon_{5t} \tag{26}$$

$$\Delta OI\_GARCH \quad : \Delta OI_t = \alpha_{06} + \beta_{OI3}(\Delta P_t) + \gamma_{OI3} h_t + \varepsilon_{6t} \tag{27}$$

where ΔVol and ΔOI denote change in futures trading volume and open interest, respectively. ΔP_t denotes change in stock index price and $|\Delta P_t|$ denotes absolute change in price as first measure of stock index price volatility. $\sigma^2_{HL,t}$ denotes the second measure from Parkinson (1980). Finally, h_t denotes the third measure from the GARCH model. Let the index i is within the range of 1 and 6. α_{0i} and α_{1i} denote intercepts and coefficients in every model, respectively. β and γ denote coefficients of every model and ε_{it} denotes the residual term.

In addition, determinants of volatility of futures trading volume and open interest by three measures are expressed by the following regressions:

$$|\Delta Vol|\_|\Delta P| \quad : \quad |\Delta Vol_t| = \alpha_{21} + \delta_{Vol1}|\Delta P_t| + \mu_{1t} \tag{28}$$

$$|\Delta Vol|\_\sigma^2_{HL,t} \quad : \quad |\Delta Vol_t| = \alpha_{22} + \delta_{Vol2}\sigma^2_{HL,t} + \mu_{2t} \tag{29}$$

$$|\Delta Vol|\_GARCH \quad : \quad |\Delta Vol_t| = \alpha_{23} + \delta_{Vol3} h_t + \mu_{3t} \tag{30}$$

$$|\Delta OI|\_|\Delta P| \quad : \quad |\Delta OI_t| = \alpha_{24} + \delta_{OI1}|\Delta P_t| + \mu_{4t} \tag{31}$$

$$|\Delta OI|\_\sigma^2_{HL,t} \quad : \quad |\Delta OI_t| = \alpha_{25} + \delta_{OI2}\sigma^2_{HL,t} + \mu_{5t} \tag{32}$$

$$|\Delta OI|\_GARCH \quad : \quad |\Delta OI_t| = \alpha_{26} + \delta_{OI3} h_t + \mu_{6t} \tag{33}$$

where $|\Delta Vol|$ and $|\Delta OI|$ denote volatility of futures trading volume and open interest, respectively. Let the index i is within the range of 1 and 6. α_{2i} and δ denote intercepts and coefficients for every model, respectively. μ_{it} denotes the residual term.

IV. DATA

The purpose of this paper is to examine the relationship between stock index price and futures volume for four stock index futures contracts in Taiwan, including FITX, FITF, FITE and MSCI. We describe the data used in this paper briefly. Taiwan stock index future contracts began trading on the FITX on July 21, 1998, and on the FITF and FITE on July 21, 1999. The FITX futures contract uses the Taiwan capitalization weighted index as the underlying index. That is, the FITX futures contract is a value-weighted index of all common stocks listed on the Taiwan Stock Exchange. The FITF and FITE futures contracts use the banking and insurance, and electronic capitalization weighted index as the underlying indexes, respectively. On the other hand, the FITF and FITE are value-weighted indexes of banking and insurance, and electronic common stocks listed on the Taiwan Stock Exchange.

In particular, another stock index futures is compiled by Morgan Stanley Capital International (MSCI), established by Singapore International Monetary Exchange (SIMEX). The Singapore government, looking for niches in financial services industry, established the Singapore International Monetary Exchange (SIMEX) as Asia's first financial futures market. As of 1998, there were a total of 12 futures contracts available on SIMEX. In January 1997, SIMEX launched the Taiwanese Stock Index futures according to the index compiled by Morgan Stanley Capital International (MSCI), which comprised 77 component stocks representing 67 percent of Taiwan stock market.

The data corresponding to daily settlement prices and volume for the four stock index futures contracts: FITX, FITF, FITE and MSCI from January 19, 1997 to September 30, 2004 are employed to test the validity of the four hypotheses. In addition, the futures volumes include futures trading volume and open interest in this paper. The data, including close price, open price, trading volume, volume of open interest, highest price and lowest price are provided by InfoWinner 2000 of InfoTimes Corporation.

V. EMPIRICAL RESULTS

1. Descriptive Statistics

Table 1 reports the descriptive statistics of stock index price and stock index futures contracts in Taiwan. Table 2 shows the descriptive statistics of futures trading volume and open interest. In addition, the stock index price, futures trading volume and open interest are taken logarithm for testing three hypotheses in this paper. Visual inspections of Table 1 and 2, we find that all series in this paper are not normality from the value of Jarque-Bera.

Table 1. Descriptive statistics of stock indexes and futures in Taiwan

	FITX		***FITF***		***FITE***		***MSCI***	
	Stock index	***Future***	***Stock index***	***Future***	***Stock index***	***Future***	***Stock index***	***Future***
Sample period	1998/7/21 ~2004/9/30		1999/7/21 ~2004/9/30		1999/7/21 ~2004/9/30		1997/1/9 ~2004/9/30	
observations	1587		1318		1318		1960	
Mean(%)	-0.019	-0.020	-0.010	-0.010	-0.038	-0.038	-0.013	-0.012
Standard Derivation(%)	1.757	2.004	1.985	2.225	2.104	2.483	1.846	2.293
Skewness	0.029	-0.047	0.121	-0.020	0.101	0.051	0.052	-0.111
Excess Kurtosis	4.117	4.875	3.826	4.414	3.690	4.061	4.026	6.496
Jarque-Bera	82.763 (0.00)**	232.945 (0.00)**	40.677 (0.00)**	109.954 (0.00)**	28.393 (0.00)**	62.377 (0.00)**	86.934 (0.00)**	1000.891 (0.00)**

Note: 1. p-value of Jarque-Bera are reported in paretheses.
2.(*) and (**) are denoted significant at 5% and 1% level, respectively.

Table 2. Descriptive statistics of futures volume

	Futures trading volume	Open interest
Panel (2A) FITX		
Mean(%)	0. 307	0.336
Median(%)	-3.111	0.010
Standard Derivation	0.448	0.3576
Skewness	0.832	2.509959
Excess Kurtosis	8.824	15.2221
Jarque-Bera	2425.733 (0.00)**	11544.12 (0.00)**
Panel (2B) FITF		
Mean(%)	0.301	0.392
Median(%)	-2.133	0.000
Standard Derivation	0.494	0.309
Skewness	0.989	2.234
Excess Kurtosis	14.033	15.980
Jarque-Bera	6899.851 (0.00)**	10349.07 (0.00)**
Panel (2C) FITE		
Mean(%)	0.187	0.298
Median(%)	-3.860	0.000
Standard Derivation	0.491	0.287
Skewness	0.852	2.299
Excess Kurtosis	13.619	14.944
Jarque-Bera	6351.951 (0.00)**	8995.302 (0.00)**
Panel (2D) MSCI		
Mean(%)	0.335	0.202
Median(%)	1.446	0.000
Standard Derivation	0.439	0.195
Skewness	-0.070	0.412
Excess Kurtosis	5.987	82.962
Jarque-Bera	730.227 (0.00)**	522224.2 (0.00)**

Note: 1. p-value of Jarque-Bera are reported in parentheses.
2.(*) and (**) are denoted significant at 5% and 1% level, respectively.

2. Unit Root Test

Before we present the empirical result, it is informative to check the time series properties of all stock indexes and stock index futures in this paper. Figure 1 suggests the time series for the sample period from January 1997 to September 2004 of observations of the stock indexes and stock index futures. We find that there are comovements in the time series of stock indexes and stock index futures and all series seem to follow a random walk process will be discussed in the following.

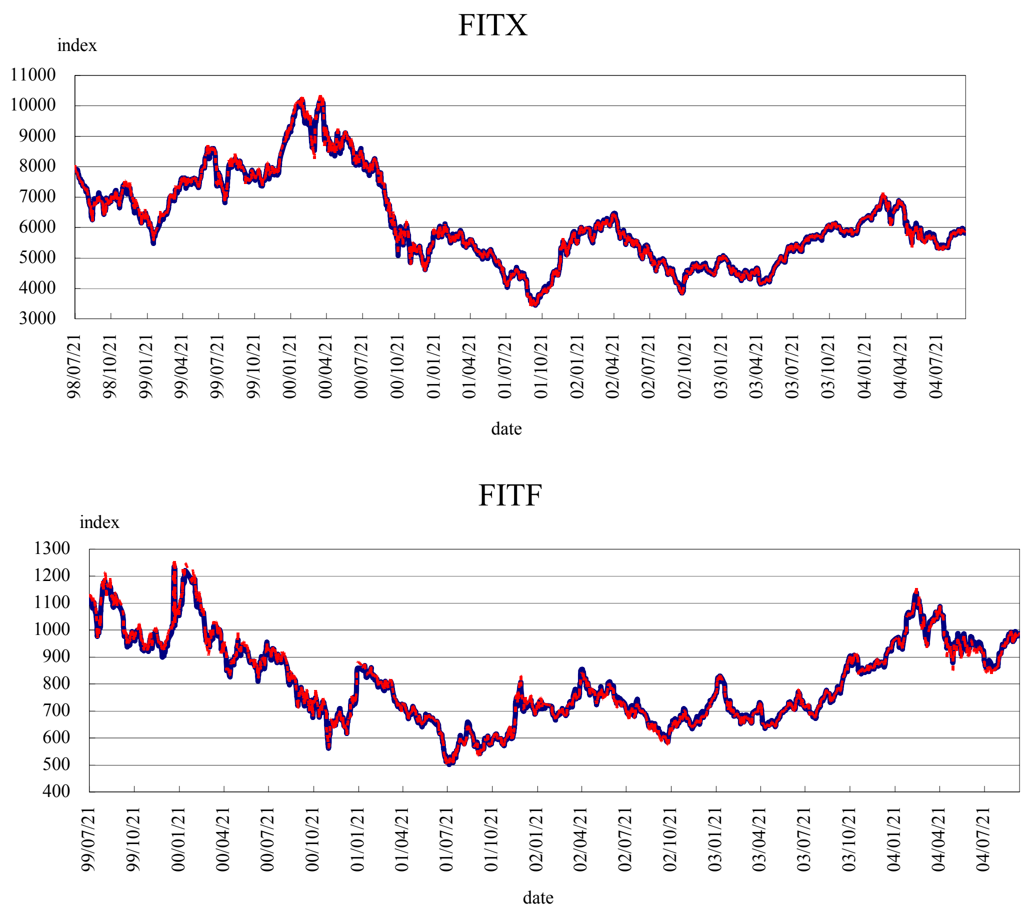

Figure 1. Time series of four stock indexes and futures

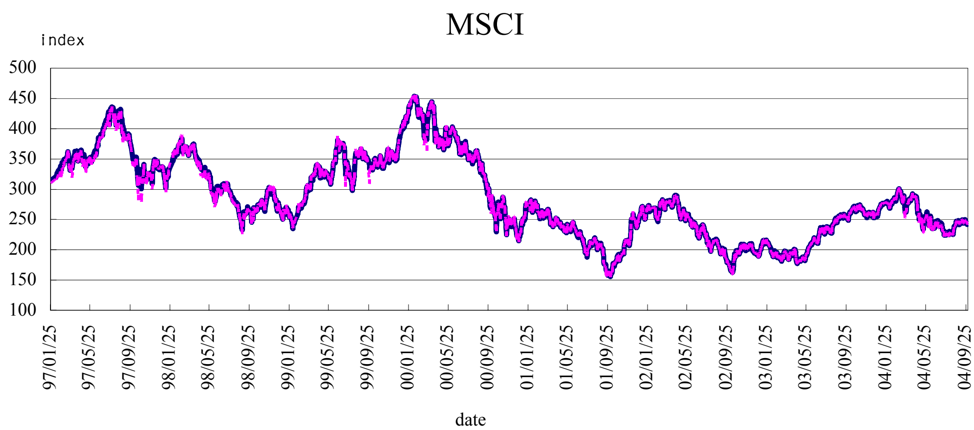

Figure 1. Time series of four stock indexes and futures (continue)

To avoid spurious regression results, we test unit root for stock index price, futures trading volume and open interest. Table 3 presents the results of ADF tests. An implication of Table 3 is that all the data series are I(1) in the level for all series by ADF unit root test in this paper. There is strong evidence that four series are not constant unit root process. For example, the null hypothesis of unit root is rejected for future trading volume and open interest in case 3. We conjecture that the test equation with trend and intercept is not proper for future trading volume and open interest. On the other hand, the time series data with heavy-tailed distribution may have influence on the ADF test.

Table 3. Unit root test by ADF (level)

	Case 1	*Case 2*	*Case 3*
Panel (3A) Stock index price			
FITX	-0.436 (0.526)	-1.817 (0.339)	-1.930 (0.638)
FITF	-0.181 (0.621)	-2.170 (0.218)	-2.019 (0.590)
FITE	-0.651 (0.435)	-1.423 (0.572)	-2.107 (0.541)
MSCI	-0.403 (0.539)	-1.856 (0.354)	-2.466 (0.345)
Panel (3B) Futures trading volume			
FITX	1.574 (0.972)	-2.967 (0.038)*	-4.502 (0.002)**
FITF	0.415 (0.803)	-2.396 (0.143)	-4.488 (0.002)**
FITE	0.486 (0.820)	-1.682 (0.441)	-3.606 (0.030)*
MSCI	1.409 (0.961)	-3.302 (0.015)*	-4.519 (0.001)**
Panel (3C) Open interest			
FITX	1.529 (0.969)	-2.466 (0.124)	-3.583 (0.032)*
FITF	1.205 (0.942)	-1.880 (0.341)	-3.572 (0.033)*
FITE	1.049 (0.924)	-1.118 (0.711)	-4.044 (0.008)**
MSCI	1.681 (0.978)	-2.194 (0.209)	-4.370 (0.002)**

Note: 1.The critical values follow Hamilton (1994), "Time Series Analysis".
2.p-value of Jarque-Bera are reported in parentheses.
3.The optimal lag length is following Akaike information criterion (AIC).
4.(*) and (**) are denoted significant at 5% and 1% level, respectively.
5.There are three test equations, including none (case 1), intercept (case 2) and trend and intercept (case 3).

As a result, we take a closer look on the four series dynamics by examining the unit root behavior at various quantiles in Table 4. The second column in Table 4 reports the estimates of the largest autoregressive roots at each decile. The evidence based on these point estimates of the largest autoregressive root at each quantile suggests that these series are not constant unit root processes. From all these series we can see that there is asymmetry in the persistency. The largest autoregressive coefficient $\hat{\alpha}_1(\tau)$ has different values over different quantiles. The autoregressive coefficient values at the lower quantiles are smaller than those at higher quantiles.

Table 4. Unit root test by the quantile autoregressive model (continue)

Quantiles	$\hat{\alpha}_1(\tau)$	$U_n(\tau)$	Critical Values for $U_n(\tau)$			
			2.5%	5%	95%	97.5%
Panel 5A. FITX						
Panel (5A-1) ***Stock index price***						
0.1	0.970	-47.781*	-8.348	-8.349	8.357	8.358
0.2	0.993	-10.420*	-8.569	-8.569	8.573	8.573
0.3	0.994	-10.239*	-8.637	-8.637	8.640	8.641
0.4	0.999	-1.351	-8.870	-8.878	8.940	8.948
0.5	1.002	3.831	-8.777	-8.785	8.847	8.855
0.6	1.003	4.190	-8.671	-8.679	8.741	8.748
0.7	1.005	8.286	-8.464	-8.465	8.470	8.470
0.8	1.006	9.970#	-9.096	-9.097	9.103	9.104
0.9	1.009	14.189#	-8.684	-8.685	8.687	8.688
Panel (5A-2) ***Futures trading volume***						
0.1	0.978	-35.011*	-6.875	-6.881	6.957	6.963
0.2	0.997	-5.047	-9.411	-9.421	9.488	9.495
0.3	0.997	-5.017	-7.702	-7.710	7.766	7.771
0.4	0.998	-3.826	-8.997	-9.007	9.072	9.078
0.5	0.998	-3.347	-9.685	-9.694	9.763	9.771
0.6	0.999	-0.901	-8.080	-8.088	8.146	8.152
0.7	1.000	-0.441	-10.002	-10.012	10.084	10.091
0.8	1.002	3.842	-8.495	-8.504	8.565	8.571
0.9	1.003	4.821	-10.544	-10.546	10.566	10.568
Panel (5A-3) ***Open interest***						
0.1	0.984	-24.913*	-7.290	-7.295	7.373	7.378
0.2	0.993	-10.479*	-9.963	-9.973	10.045	10.053
0.3	0.998	-2.815	-8.367	-8.376	8.435	8.442
0.4	1.000	-0.100	-10.490	-10.491	10.507	10.508
0.5	1.001	1.293	-9.202	-9.211	9.277	9.284
0.6	1.002	2.839	-8.075	-8.083	8.141	8.147
0.7	1.002	3.449	-9.483	-9.492	9.560	9.567
0.8	1.004	6.215	-8.625	-8.634	8.695	8.702
0.9	1.005	7.873	-8.916	-8.925	8.989	8.996
Panel 5B. FITF						
Panel (5B-1) ***Stock index price***						
0.1	0.972	-36.646*	-5.142	-5.148	5.190	5.193
0.2	0.995	-7.050*	-5.275	-5.280	5.323	5.325
0.3	0.998	-2.491	-5.444	-5.449	5.493	5.494
0.4	1.001	0.801	-5.502	-5.507	5.552	5.553
0.5	1.001	1.286	-5.364	-5.369	5.413	5.414
0.6	1.001	1.752	-5.563	-5.569	5.614	5.615
0.7	1.003	3.806	-5.690	-5.695	5.742	5.745
0.8	1.003	4.257	-5.906	-5.911	5.960	5.963
0.9	1.011	14.756#	-6.108	-6.115	6.167	6.170

Table 4.　Unit root test by the quantile autoregressive model (continue)

Panel (5B-2) ***Futures trading volume***						
0.1	0.677	-425.523*	-5.932	-5.939	6.010	6.015
0.2	0.993	-8.634*	-6.773	-6.780	6.838	6.841
0.3	0.996	-5.783	-7.732	-7.740	7.803	7.807
0.4	0.996	-5.779	-8.130	-8.139	8.205	8.208
0.5	0.999	-1.758	-7.163	-7.170	7.230	7.234
0.6	1.000	-0.550	-7.469	-7.477	7.538	7.541
0.7	1.000	-0.077	-7.935	-7.942	8.007	8.010
0.8	1.001	1.876	-8.323	-8.331	8.399	8.403
0.9	1.004	5.764	-8.719	-8.729	8.807	8.814
Panel (5B-3) ***Open interest***						
0.1	0.946	-71.360*	-6.396	-6.403	6.469	6.475
0.2	0.994	-7.621*	-6.462	-6.479	6.667	6.681
0.3	1.000	-0.445	-7.785	-7.793	7.856	7.860
0.4	1.000	0.337	-8.604	-8.613	8.685	8.688
0.5	1.001	1.713	-8.018	-8.025	8.091	8.093
0.6	1.001	1.966	-7.515	-7.522	7.584	7.587
0.7	1.003	4.168	-7.262	-7.269	7.328	7.332
0.8	1.007	9.511#	-8.239	-8.247	8.315	8.318
0.9	1.010	13.707#	-9.184	-9.187	9.215	9.217
Panel 5C. FITE						
Panel (5C-1) ***Stock index price***						
0.1	0.964	-0.443	-6.864	-6.865	6.872	6.872
0.2	0.994	-0.403	-6.474	-6.483	6.535	6.538
0.3	0. 998	-0.161	-6.767	-6.773	6.829	6.833
0.4	0.999	-0.142	-6.605	-6.606	6.616	6.617
0.5	0.999	-0.142	-6.526	-6.527	6.534	6.535
0.6	0. 100	-0.011	-6.555	-6.555	6.564	6.565
0.7	1.008	0.117	-6.447	-6.448	6.460	6.461
0.8	1.025	0.337	-6.846	-6.855	6.910	6.915
0.9	1.047	0.627	-6.674	-6.684	6.740	6.743
Panel (5C-2) ***Futures trading volume***						
0.1	0.878	-161.419*	-4.691	-4.698	4.776	4.784
0.2	0.993	-9.516*	-5.805	-5.811	5.861	5.865
0.3	0.997	-3.680	-6.266	-6.272	6.325	6.328
0.4	0.998	-2.528	-7.041	-7.049	7.109	7.111
0.5	0.998	-2.276	-6.648	-6.655	6.712	6.714
0.6	0.998	-2.026	-7.443	-7.451	7.514	7.517
0.7	1.000	-0.103	-7.864	-7.873	7.939	7.943
0.8	1.001	1.079	-8.339	-8.347	8.418	8.422
0.9	1.014	18.598#	-9.143	-9.148	9.188	9.191

Table 4. Unit root test by the quantile autoregressive model (continue)

Panel (5C-3) ***Open interest***						
0.1	0.969	-41.040*	-5.482	-5.489	5.553	5.559
0.2	0.996	-5.479	-8.877	-8.879	8.897	8.898
0.3	0.998	-3.021	-6.416	-6.422	6.478	6.481
0.4	1.000	0.207	-7.377	-7.387	7.446	7.451
0.5	1.001	0.898	-6.850	-6.857	6.914	6.917
0.6	1.001	0.944	-7.130	-7.137	7.196	7.199
0.7	1.003	3.470	-7.687	-7.697	7.761	7.765
0.8	1.004	4.989	-8.161	-8.169	8.239	8.243
0.9	1.007	8.958	-9.458	-9.461	9.485	9.488
Panel 5D. MSCI						
Panel (5D-1) ***Stock index price***						
0.1	0.971	-55.929*	-5.195	-5.200	5.235	5.237
0.2	0.994	-12.734*	-5.445	-5.449	5.486	5.489
0.3	0.998	-3.555	-5.559	-5.564	5.601	5.605
0.4	0.999	-1.290	-5.796	-5.786	5.790	5.772
0.5	1.000	0.066	-5.503	-5.508	5.545	5.549
0.6	1.001	1.774	-5.660	-5.664	5.703	5.705
0.7	1.002	2.971	-5.831	-5.836	5.875	5.879
0.8	1.004	8.673#	-5.999	-5.999	6.004	6.005
0.9	1.005	9.882#	-5.340	-5.345	5.381	5.383
Panel (5D-2) ***Futures trading volume***						
0.1	1.000	-0.580	-9.452	-9.461	9.528	9.532
0.2	1.000	-0.555	-8.714	-8.724	8.788	8.792
0.3	1.000	-0.537	-9.578	-9.587	9.660	9.665
0.4	1.000	-0.127	-9.830	-9.836	9.872	9.874
0.5	1.000	0.451	-8.296	-8.304	8.372	8.376
0.6	1.001	2.379	-9.286	-9.291	9.361	9.365
0.7	1.002	2.987	-8.836	-8.845	8.918	8.924
0.8	1.002	3.779	-9.117	-9.127	9.193	9.198
0.9	1.006	12.487*	-7.111	-7.124	7.223	7.231
Panel (5D-3) ***Open interest***						
0.1	0.953	-91.526*	-8.540	-8.550	8.620	8.625
0.2	0.993	-14.277*	-10.430	-10.439	10.510	10.515
0.3	0.995	-10.196*	-9.677	-9.685	9.750	9.755
0.4	0.995	-9.022	-10.612	-10.621	10.692	10.699
0.5	0.996	-7.162	-9.331	-9.339	9.401	9.405
0.6	1.001	2.319	-9.831	-9.840	9.906	9.912
0.7	1.004	7.326	-10.133	-10.142	10.210	10.215
0.8	1.008	16.199#	-11.222	-11.223	11.236	11.238
0.9	1.015	30.000#	-10.824	-10.834	10.906	10.912

Note: The values of $U_n(\tau)$ denoted by an (*) are significant the 5% level when the alternative is $H_{1A}:\alpha_1<1$. Similarly, the values denoted by (#) are significant the 5% level when the alternative is $H_{1B}:\alpha_1>1$.

The third columns in Table 4 report the calculated coefficient statistics $U_n(\tau)$. Coulmns 5 to 7 report critical values of 2.5%, 5%, 95% and 97.5% quantiles using the resampling procedure.

Table 5. Unit root test (first difference)

	Case 1	*Case 2*	*Case 3*
Panel (A) Stock index price			
FITX	-19.262 (0.000)**	-19.261 (0.000)**	-19.263 (0.000)**
FITF	-18.171 (0.000)**	-18.165 (0.000)**	-18.210 (0.000)**
FITE	-33.197 (0.000)**	-33.194 (0.000)**	-33.181 (0.000)**
MSCI	-22.184 (0.000)**	-22.182 (0.000)**	-22.176 (0.000)**
Panel (B) Futures trading volume			
FITX	-18.514 (0.000)**	-18.630 (0.000)**	-18.705 (0.000)**
FITF	-17.876 (0.000)**	-17.894 (0.000)**	-17.894 (0.000)**
FITE	-14.808 (0.000)**	-14.819 (0.000)**	-14.813 (0.000)**
MSCI	-16.819 (0.000)**	-16.913 (0.000)**	-16.897 (0.000)**
Panel (C) Open interest			
FITX	-18.416 (0.000)**	-18.512 (0.000)**	-18.548 (0.000)**
FITF	-12.896 (0.000)**	-12.897 (0.000)**	-12.999 (0.000)**
FITE	-15.564 (0.000)**	-15.609 (0.000)**	-15.603 (0.000)**
MSCI	-10.516 (0.000)**	-10.681 (0.000)**	-10.720 (0.000)**

Note: 1.The critical values follow Hamilton (1994), "Time Series Analysis".
2. p-value of Jarque-Bera are reported in parentheses.
3.The optimal lag length is following Akaike information criterion (AIC).
4.(*) and (**) are denoted significant at 5% and 1% level, respectively.
5.There are three test equations, including none (case 1), intercept (case 2) and trend and intercept (case 3).

We can see that only at quantiles that are around median can the unit root hypothesis not be rejected. At low quantiles and high quantiles the unit root hypothesis is rejected (Koenker and Xiao, 2004). However, most quantiles cannot reject the null hypothesis of unit root. Therefore we conclude that these time series are I(1) in the level. We believe that the quantile regression based inference procedures have some advantages over the last squared based tests in analyzing dynamics and persistency in time series with heavy-tailed distributions.

3. Cointegration Test and Error Correction Model

Table 6. Cointegration test

	λ_{trace}		λ_{max}	
	$H_0 : r \le 0$	$H_0 : r \le 1$	$H_0 : r = 0$	$H_0 : r = 1$
Panel (A) Stock index price and futures trading volume				
FITX	66.156 (0.000)**	3.698 (0.785)	62.458 (0.000)**	3.698 (0.785)
FITF	31.362 (0.009)**	5.454 (0.533)	25.908 (0.005)**	5.454 (0.533)
FITE	24.095 (0.002)**	1.691 (0.194)	22.404 (0.002)**	1.691 (0.194)
MSCI	61.774 (0.000)**	5.997 (0.461)	55.776 (0.000)**	5.997 (0.461)
Panel (B) Stock index price and open interest				
FITX	73.009 (0.000)**	3.699 (0.785)	69.310 (0.000)**	3.699 (0.000)
FITF	61.405 (0.000)**	5.828 (0.482)	55.577 (0.000)**	5.828 (0.482)
FITE	25.886 (0.001)**	1.875 (0.171)	25.011 (0.001)**	1.875 (0.171)
MSCI	59.252 (0.000)**	5.606 (0.512)	53.646 (0.000)**	5.606 (0.512)

Note: 1.Critical values are sourced from Johansen (1995).
2.(*) and (**) are denoted significant at 5% and 1% level, respectively.
3. The values in parentheses are p-value.

From Table 6, it is concluded that stock index price, futures trading volume and open interest follow a non-stationary random process and are integrated of order one, I(1), which is a condition for cointegration tests. The results of cointegration test are presented in Table 6, which reveal the existence of a long-run relationship between stock index price and futures volume. From Table 6, the Johansen's likelihood ratio test rejects the null hypothesis of no cointegration between stock index price and futures trading volume. The results for stock index price and open interest are similar.

Table 7. VECM for testing short-run and long-run relationship between stock

index price and futures trading volume

	FITX	FITF	FITE	MSCI
Panel (7-A) $X_t - X_{t-1} = a_1\hat{Z}_{t-1} + \sum_{i=1}^{3} c_i (Y_{t-i} - Y_{t-i-1}) + \sum_{j=1}^{3} d_j (X_{t-j} - X_{t-j-1}) + \varepsilon_t$ **(Equation (17))**				
a_1	-0.0034 (-0.2980)	-0.0013 (-0.7727)	-0.0013 (-0.7727)	0.0112 (1.2479)
c_1	0.0033 (0.3984)	-0.0048 (-0.4917)	-0.0048 (-0.4917)	-0.0108 (-1.2761)
c_2	0.0025 (0.3271)	-0.0049 (-0.5535)	-0.0049 (-0.5535)	-0.0091 (-1.1760)
c_3	0.0011 (0.1555)	-0.0041 (-0.5353)	-0.0041 (-0.5353)	-0.0073 (-1.0762)
c_4	0.000728 (0.1193)	-0.0040 (-0.6094)	-0.0040 (-0.6093)	-0.0053 (-0.9212)
c_5	0.0011 (0.2118)	-0.0016 (-0.2937)	-0.0016 (-0.2937)	-0.0020 (-0.4309)
c_6	0.0016 (0.3812)	0.0010 (0.2330)	0.0009 (0.2330)	-0.0015 (-0.4438)
c_7	0.0015 (0.4880)	0.0021 (0.7706)	0.0021 (0.7706)	0.0001 (0.0568)
c_8	0.0013 (0.6107)	0.0020 (1.3996)	0.0020 (1.3996)	0.0003 (0.2810)
c_9	8.12E-05 (0.0686)	--	3.56E-05 (0.0581)	--
d_1	-0.8300 (-29.4788)**	-0.8038 (-28.6234)**	-0.8038 (-18.5261)**	-0.8357 (-36.9377)**
d_2	-0.7087 (-20.3585)**	-0.6579 (-18.5261)**	-0.6579 (-18.5261)**	-0.7068 (-24.2690)**
d_3	-0.5568 (-14.5081)**	-0.5117 (-13.0337)**	-0.5117 (-13.0337)**	-0.5676 (-17.4519)**
d_4	-0.5112 (-12.8893)**	-0.4519 (-11.1533)**	-0.4519 (-11.1533)**	-0.5193 (-15.4343)**
d_5	-0.4208 (-10.4998)**	-0.3683 (-9.0962)**	-0.3683 (-9.0963)**	-0.4253 (-12.6495)**
d_6	-0.3422 (-8.7478)**	-0.2845 (-7.2447)**	-0.2845 (-7.2447)**	-0.3075 (-9.4487)**
d_7	-0.2780 (-7.4504)**	-0.2174 (-6.1186)**	-0.2174 (-6.1186)**	-0.2215 (-7.5915)**
d_8	-0.1795 (-5.4178)**	-0.0898 (-3.1980)**	-0.0898 (-3.1980)**	-0.1025 (-4.5197)**
d_9	-0.0951 (-3.7048)**	--	--	--

Note-1.(*) and (**) are denoted significant at 5% and 1% level, respectively.

2.The values in parentheses are t-statistics.

3. Dependent variable (X) is index price and independent variable (Y) is volume.

4. The lag number is determined by AIC.

Table 7. VECM for testing short-run and long-run relationship between stock index price and futures trading volume (continue)

	FITX	FITF	FITE	MSCI
Panel (7-B) $Y_t - Y_{t-1} = b_1\hat{Z}_{t-1} + \sum_{i=1}^{3}\varphi_i(X_{t-i} - X_{t-i-1}) + \sum_{j=1}^{3}\theta_j(Y_{t-j} - Y_{t-j-1}) + \varepsilon_t$ **(Equation (18))**				
b_1	-4.5200 (-18.9962)**	0.5565 (17.5194)**	0.5565 (17.5194)**	-3.7327 (0.1682)
φ_1	2.1484 (3.6185)**	-1.1955 (-2.2199)*	-1.1955 (-2.2199)*	-0.6327 (-1.4964)
φ_2	2.1892 (2.9820)**	-0.6519 (-0.9572)	-0.6519 (-0.9572)	-1.1108 (-2.0407)*
φ_3	1.4931 (1.8448)*	-0.8422 (-1.1187)	-0.8423 (-1.1187)	-1.6687 (-2.7453)**
φ_4	2.0425 (2.4419)**	-0.2491 (-0.3206)	-0.2491 (-0.3206)	-0.6916 (-1.0999)
φ_5	1.7917 (2.1202)*	-0.3467 (-0.4466)	-0.3467 (-0.4465)	-0.6149 (-0.9787)
φ_6	1.2274 (1.4877)	-0.5633 (-0.7482)	-0.5634 (-0.7482)	-1.1631 (-1.9124)*
φ_7	-0.3976 (-0.5054)	-0.9992 (-1.4662)	-0.9992 (0.6815)	-1.4619 (-2.6804)**
φ_8	-0.9894 (-1.4157)	-0.7317 (-1.3592)	-0.7317 (-1.3592)	-0.5538 (-1.3073)
φ_9	-0.1359 (-0.2510)	--	--	--
θ_1	2.0779 (11.6586)**	1.8905 (10.1975)**	1.8905 (10.1975)**	2.0825 (13.1292)**
θ_2	1.6410 (9.9981)**	1.4416 (8.5457)**	1.4416 (8.5457)**	1.5677 (10.8399)**
θ_3	1.2769 (8.6688)**	1.0406 (7.0053)**	1.0406 (7.0053)**	1.1640 (9.1333)**
θ_4	0.9406 (7.3132)**	0.7334 (5.8247)**	0.7334 (5.8247)**	0.7832 (7.2776)**
θ_5	0.6946 (6.3988)**	0.4936 (4.8493)**	0.4936 (4.8493)**	0.4948 (5.7335)**
θ_6	0.4715 (5.3926)**	0.3057 (0.0766)	0.3057 (3.9917)**	0.3182 (4.9129)**
θ_7	0.2947 (4.4508)**	0.1798 (3.4558)**	0.1798 (3.4558)**	0.1775 (4.1135)**
θ_8	0.1566 (3.4591)**	0.0556 (1.9943)*	0.0556 (1.9943)*	0.0577 (2.5692)**
θ_9	0.0629 (2.5185)**	--	--	--

Note: 1.(*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are t-statistics.
3. Dependent variable (Y) is volume and independent variable (X) is index price.
4. The lag number is determined by AIC.

Table 8. VECM for testing short-run and long-run relationship between stock index price and open interest

	FITX	FITF	FITE	MSCI
Panel (8-A) $X_t - X_{t-1} = a_1\hat{Z}_{t-1} + \sum_{i=1}^{3} c_i(Y_{t-i} - Y_{t-i-1}) + \sum_{j=1}^{3} d_j(X_{t-j} - X_{t-j-1}) + \varepsilon_t$ **(Equation (17))**				
a_1	-0.0106 (-1.3274)	0.0005 (0.0376)	-0.0112 (-1.1369)	0.0026 (0.5101)
c_1	0.0087 (1.1589)	-0.0015 (-0.1276)	0.0094 (1.0426)	0.0111 (0.8081)
c_2	0.0065 (0.9469)	-0.0027 (-0.2573)	0.0067 (0.8336)	0.0117 (0.9341)
c_3	0.0047 (0.7495)	0.0003 (0.0369)	0.0082 (1.1743)	0.0155 (1.4032)
c_4	0.0031 (0.5724)	0.0013 (0.1509)	0.0074 (1.2498)	0.0135 (1.4177)
c_5	0.0012 (0.2462)	0.0020 (0.2834)	0.0063 (1.3328)	0.0159 (2.0159)*
c_6	0.0017 (0.4224)	0.0014 (0.2292)	0.0038 (1.0862)	0.0133 (2.1585)*
c_7	-2.19E-05 (-0.0071)	-5.27E-05 (-0.0111)	0.0012 (0.5192)	0.0101 (2.2892)*
c_8	-0.0016 (-0.7075)	-0.0005 (-0.1504)	--	0.0051 (2.0285)*
c_9	-0.0014 (-1.0250)	-0.0023 (-1.0186)	--	--
d_1	-0.8273 (-32.5107)**	-0.8019 (-28.7413)**	-0.7787 (-28.1383)**	-0.8393 (-36.3769)**
d_2	-0.7139 (-21.9463)**	-0.6772 (-19.1044)**	-0.6366 (-18.3897)**	-0.7129 (-24.3349)**
d_3	-0.5628 (-15.3868)**	-0.5353 (-13.5706)**	-0.4792 (-12.5899)**	-0.5701 (-17.5048)**
d_4	-0.5143 (-13.4194)**	-0.4845 (-11.7562)**	-0.4122 (-10.6605)**	-0.5238 (-15.6033)**
d_5	-0.4200 (-10.7519)**	-0.4000 (-9.5383)**	-0.3109 (-8.1629)**	-0.4285 (-12.7659)**
d_6	-0.3416 (-8.9120)**	-0.3222 (-7.8201)**	-0.2155 (-6.2185)**	-0.3114 (-9.6017)**
d_7	-0.2800 (-7.6474)**	-0.2731 (-6.9261)**	-0.1391 (-5.0417)**	-0.2237 (-7.6940)**
d_8	-0.1867 (-5.7339)**	-0.1642 (-4.6389)**	--	-0.1033 (-4.5795)**
d_9	-0.1016 (-4.0210)**	-0.0946 (-3.4004)**	--	--

Note: 1. (*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are t-statistics.
3. Dependent variable (X) is index price and independent variable (Y) is volume.
4. The lag number is determined by AIC.

Table 8. VECM for testing short-run and long-run relationship between stock index price and open interest (continue)

	FITX	FITF	FITE	MSCI
Panel (8-B) $Y_t - Y_{t-1} = b_1\hat{Z}_{t-1} + \sum_{i=1}^{3}\varphi_i(X_{t-i} - X_{t-i-1}) + \sum_{j=1}^{3}\theta_j(Y_{t-j} - Y_{t-j-1}) + \varepsilon_t$ **(Equation (18))**				
b_1	-2.6773 (-18.3219)**	-2.4804 (-16.4783)**	-2.1908 (-18.1062)**	0.9961 (21.2348)**
φ_1	1.3634 (2.9382)**	-0.6487 (-1.8852)*	0.7121 (2.0932)*	-0.5607 (-2.6682)**
φ_2	2.3964 (4.0398)**	0.5628 (1.2871)	1.8050 (0.4255)	-0.7036 (-2.6368)**
φ_3	1.7035 (2.5540)**	0.2310 (0.4747)	1.3691 (2.9257)**	-0.6712 (-2.2625)**
φ_4	1.8891 (2.7029)**	0.4052 (0.7972)	1.4339 (3.0171)**	-0.3357 (-1.0980)
φ_5	1.3600 (1.9092)*	-0.0322 (-0.0623)	0.8412 (1.7968)*	-0.1403 (-0.4588)
φ_6	1.2966 (1.8548)*	0.1020 (0.2006)	0.8608 (2.0208)**	0.0151 (0.0511)
φ_7	0.6544 (0.9801)	-0.3165 (-0.6508)	0.3491 (1.0292)	-0.0937 (-0.3537)
φ_8	-0.0416 (-0.0701)	-0.6361 (-1.4571)	--	0.0338 (0.1642)
φ_9	0.3353 (0.7278)	0.09479 (0.2763)	--	--
θ_1	1.3886 (10.1363)**	1.2626 (8.9672)**	0.9804 (8.8597)**	1.3998 (11.1530)**
θ_2	1.1366 (9.0188)**	1.0294 (7.9428)**	0.7573 (7.6456)**	1.0940 (9.6105)**
θ_3	0.9148 (8.0509)**	0.8092 (6.9181)**	0.5524 (6.4072)**	0.8547 (0.1007)
θ_4	0.7120 (7.1063)**	0.6283 (6.0786)**	0.3868 (5.3509)**	0.6346 (7.3283)**
θ_5	0.5336 (6.2038)**	0.4842 (5.4371)**	0.2637 (4.5709)**	0.4460 (6.2169)**
θ_6	0.3815 (5.3498)**	0.3483 (4.6989)**	0.1519 (3.5350)**	0.2741 (4.8661)**
θ_7	0.2514 (4.4600)**	0.2203 (3.7467)**	0.0566 (2.0569)*	0.1412 (3.5271)**
θ_8	0.1488 (3.6208)**	0.1350 (3.1055)**	--	0.0468 (2.0578)*
θ_9	0.0636 (2.5197)**	0.0624 (2.2486)**	--	--

Note: 1.(*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are t-statistics.
3. Dependent variable (Y) is volume and independent variable (X) is index price.
4. The lag number is determined by AIC.

Furthermore, we can specify that the system contains information on both the short-run and long-run impacts by vector error correction model (VECM) and show these results in Tables 7 and 8. Table 7 is VECM for testing relationship between stock index price and future trading volume. From Panel A in Table 7, we find that a_1 and c_i are not significant means that four stock index futures contracts have no long-run and short-run relationships from volume to price. From Panel B in Table 7, we find that most b_1 and φ_i are significant different zero means that there are strong short-run and long-run relationships. The similar results are also found in Table 8, which is testing relationship between stock index price and open interest. Therefore, we conclude that Y_t will adjust to X_t in the long-run and Y_t will cause X_t in the short-run. These findings are consistent with model specification as Equations (1) and (2).

4. Tests of Determinants of Change and Volatility of Futures Volume

The second hypothesis postulates that the determinants of change in futures trading volume and open interest. Table 9 presents the results of the third hypothesis suggested in Equation (22)-(24) for futures trading volume by three stock index price volatility measures, including $|\Delta P_t|$, $\sigma_{HL,t}$, and h_t. The similar tests for open interest suggested in Equation (25)-(27) are reported in Table 10. That is, whether or not futures trading volume and open interest as a function of stock price volatility is tested. According to Table 9, there is a significant relationship between change of futures trading volume and stock price volatility as indicated by absolute stock price change, $|\Delta P_t|$. For the measures of volatility are $\sigma_{HL,t}$ and h_t, the coefficients γ are not all significant different from zero means that we cannot find a certain relation between change of futures trading volume and stock price volatility by two measures. Therefore, we conclude that $|\Delta P_t|$ is the better proxy for stock index volatility measure.

From Table 10, stock price volatility affect change of open interest significantly whereas the volatility measures is $|\Delta P_t|$. On the other hand, the volatility measures of $\sigma_{HL,t}$ and h_t all have no significant effects at 1% level for change of open interest as seen in Table 10. Consequently, the absolute stock price change, $|\Delta P_t|$, would be proper to measure stock index price volatility. That is, the absolute stock price change, $|\Delta P_t|$, is more suitable for capturing the relation between change of futures volume and stock price volatility.

Table 9. The determinants of change of futures trading volume

	α	β	γ
Panel (7-A) $\Delta Vol_t = \alpha + \beta(\Delta P_t) + \gamma\|\Delta P_t\| + \varepsilon_t$ **(Equation (22))**			
FITX	-0.0819 (0.0000)**	1.9489 (0.0020)**	6.4856 (0.0000)**
FITF	-0.1272 (0.0000)**	4.9438 (0.0000)**	8.7298 (0.0000)**
FITE	-0.0671 (0.0009)**	2.4441 (0.0001)**	4.4249 (0.0000)**
MSCI	-0.0916 (0.0000)**	0.2619 (0.6199)	6.8478 (0.0000)**
Panel (7-B) $\Delta Vol_t = \alpha + \beta(\Delta P_t) + \gamma\sigma^2_{HL,t} + \varepsilon_t$ **(Equation (23))**			
FITX	-0.0799 (0.0000)**	2.4508 (0.0001)**	480.1935 (0.0000)
FITF	-0.1278 (0.0000)**	5.2572 (0.0000)**	493.2896 (0.0000)**
FITE	-0.0826 (0.0000)**	2.3857 (0.0001)**	349.9507 (0.0000)**
MSCI	-0.0598 (0.0000)**	0.5203 (0.3269)	283.3820 (0.0000)**
Panel (7-C) $\Delta Vol_t = \alpha + \beta(\Delta P_t) + \gamma h_t + \varepsilon_t$ **(Equation (24))**			
FITX	0.0255 (0.2810)	2.0879 (0.0011)**	-70.4453 (0.2823)
FITF	0.0769 (0.0403)*	5.3483 (0.0000)**	-191.9377 (0.0380)*
FITE	0.0135 (0.6480)	2.5677 (0.0001)**	-23.2678 (0.6899)
MSCI	0.0487 (0.0343)*	0.4344 (0.4174)	-136.6190 (0.0259)*

Note: 1.(*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are p-value.

Table 10. The determinants of change of open interest

	α	β	γ
Panel (8-A) $\Delta OI_t = \alpha + \beta(\Delta P_t) + \gamma\lvert\Delta P_t\rvert + \varepsilon_t$ **(Equation (25))**			
FITX	0.0447 (0.0009)**	-0.1966 (0.6922)	-3.1486 (0.0000)**
FITF	0.0230 (0.0763)	1.2871 (0.0027)**	-1.2657 (0.0530)
FITE	0.0330 (0.0058)**	0.1892 (0.6138)	-1.8953 (0.0009)**
MSCI	-0.0027 (0.6820)	0.1310 (0.5835)	0.3442 (0.3420)
Panel (8-B) $\Delta OI_t = \alpha + \beta(\Delta P_t) + \gamma\sigma^2_{HL,t} + \varepsilon_t$ **(Equation (26))**			
FITX	0.0184 (0.1082)	-0.3155 (0.5377)	-89.0899 (0.0344)*
FITF	0.0128 (0.2637)	1.2368 (0.0039)**	-33.0157 (0.2538)
FITE	0.0103 (0.3198)	0.1532 (0.6840)	-29.7053 (0.2759)
MSCI	0.0039 (0.5064)	0.1363 (0.5683)	-8.4876 (0.6311)
Panel (8-C) $\Delta OI_t = \alpha + \beta(\Delta P_t) + \gamma h_t + \varepsilon_t$ **(Equation (27))**			
FITX	-0.0057 (0.7635)	-0.2428 (0.6353)	26.9908 (0.6068)
FITF	-0.0128 (0.5952)	1.2289 (0.0042)**	43.6801 (0.4606)
FITE	-0.0069 (0.6891)	0.1415 (0.7069)	21.3961 (0.5323)
MSCI	0.0077 (0.4518)	0.1419 (0.5532)	-17.2325 (0.5323)

Note: 1.(*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are p-value.

The third hypothesis examines the determinants of volatility of futures trading volume and open interest. Table 11 presents the test results of the third hypothesis with Equation (28)-(30) for futures trading volume. Similar results for open interest test with Equation (31)-(33) are reported in Table 12.

For the first measure, $\lvert\Delta P_t\rvert$, it has significant influence on FITF and FITE of futures trading volume and FITX, FITF and FITE of open interest. The second measure, $\sigma_{HL,t}$, has significant influence only on FITF either futures trading volume or open interest. Finally, the third measure, h_t, affects FITX, FITE and MSCI of futures trading volume, and FITX and FITF of open interest significantly. Although, we find that the change and volatility of futures volume are sensitive to the volatility estimate used (Chang, Chou and Nelling, 2000). However, the coefficients δ estimated by first measure, $|\Delta P_t|$, are more significant. Accordingly, we conclude that $|\Delta P_t|$ is more suitable to investigate the relation between volatility of futures volume and stock index price volatility.

Table 11. The determinants of volatility of futures trading volume

	α_2	δ
Panel (9-A) $\lvert\Delta Vol_t\rvert = \alpha_2 + \delta\lvert\Delta P_t\rvert + \varepsilon_t$ **(Equation (28))**		
FITX	0.3022 (0.00)**	0.6562 (0.35)
FITF	0.3186 (0.00)**	2.8180 (0.00)**
FITE	0.2925 (0.00)**	2.4585 (0.00)**
MSCI	0.3310 (0.00)**	-0.2929 (0.59)
Panel (9-B) $\lvert\Delta Vol_t\rvert = \alpha_2 + \delta\sigma^2_{HL,t} + \varepsilon_t$ **(Equation (29))**		
FITX	0.2994 (0.00)**	66.9954 (0.08)
FITF	0.3256 (0.00)**	132.1007 (0.00)**
FITE	0.3254 (0.00)**	24.1103 (0.48)
MSCI	0.3341 (0.00)**	-32.5412 (0.22)
Panel (9-C) $\lvert\Delta Vol_t\rvert = \alpha_2 + \delta h_t + \varepsilon_t$ **(Equation (30))**		
FITX	0.2790 (0.00)**	99.6416 (0.03)*
FITF	0.3384 (0.00)**	57.9206 (0.37)
FITE	0.2744 (0.00)**	126.3935 (0.00)**
MSCI	0.3968 (0.00)**	-209.9298 (0.00)**

Note: 1. (*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are p-value.

Table 12. The determinants of volatility of open interest

	α_2	δ
Panel (10-A) $\left\|\Delta OI_t\right\| = \alpha_2 + \delta\left\|\Delta P_t\right\| + \varepsilon_t$ **(Equation (31))**		
FITX	0.144 (0.00)**	1.520 (0.03)*
FITF	0.128 (0.00)**	1.635 (0.00)**
FITE	0.122 (0.00)**	1.308 (0.01)*
MSCI	0.076 (0.00)**	-0.044 (0.89)
Panel (10-B) $\left\|\Delta OI_t\right\| = \alpha_2 + \delta\sigma^2_{HL,t} + \varepsilon_t$ **(Equation (32))**		
FITX	0.153 (0.00)**	65.306 (0.08)
FITF	0.127 (0.00)**	94.128 (0.00)**
FITE	0.133 (0.00)**	39.328 (0.09)
MSCI	0.075 (0.00)**	-0.269 (0.99)
Panel (10-C) $\left\|\Delta OI_t\right\| = \alpha_2 + \delta h_t + \varepsilon_t$ **(Equation (33))**		
FITX	0.128 (0.00)**	111.853 (0.02)*
FITF	0.109 (0.00)**	112.585 (0.03)*
FITE	0.132 (0.00)**	23.265 (0.43)
MSCI	0.082 (0.00)**	-20.611 (0.42)

Note: 1.(*) and (**) are denoted significant at 5% and 1% level, respectively.
2.The values in parentheses are p-value.

VI. CONCLUSIONS

This paper postulates three hypotheses concerning the relationship between stock index price and futures volume, including randomness and stationarity, short-run and long-run relationships, and the determinants of change and volatility of futures volume according to three measures of stock index price volatility. All these three hypotheses are tested using three stock index futures contracts in Taiwan covering the sample period of 1997-2004.

The model developed via stochastic calculus and Itô process analyzes the relationship between stock index price and futures volume. Then, we postulate four hypotheses and test their validity. Therefore this paper serves as one of the first studies that postulate four hypotheses to investigate the relationship between stock price and futures volume, which is discussed more complete than previous studies of price-volume relationship.

For the empirical result, first, we employ cointegration test and VECM to analyze the short-run and long-run relationship between stock index price and futures volume. The result shows the significant long-run relationship of stock index price and futures volume. Furthermore, the first hypothesis also imply that price and volume series of four stock indexes and futures are non-stationary in the level but stationary in the first differences.

Then, we examine the determinants of change and volatility of futures volume. In particular, we employ three volatility measures of stock price, including absolute change in price, extreme value estimator and an estimator using GARCH process that is a more extensive discussion than previous studies. Although, the determinant of change and volatility of futures volume are sensitive to the volatility estimated used, the absolute stock price can capture the relationship accurately. Consequently, we conclude that absolute stock price change, $|\Delta P_t|$, is a more suitable measure for stock index price volatility.

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台灣股市波動性與期貨市場交易之關聯性

王毓敏・呂素蓮・楊嘉銘 *

摘要

本文採用隨機微積分與 Itô 過程研究期貨市場價量與股票價格間的動態關係，並且建構三個假說以驗證股票市場波動性對於期貨市場交易活動之影響。本文以台股指數期貨市場爲探討對象，選取台股指數期貨、金融類股指數期貨、電子類股指數期貨與摩根台股指數期貨進行實證分析。實證結果顯示，股票價格與期貨市場交易活動皆服從隨機漫步，兩者經過一階差分後爲定態序列，並且存在共整合關係，亦即股票價格與期貨市場交易活動間存在長期關係，因此，本文進一步以誤差修正模型萃取出兩者間的長期與短期關係。另外，本文採用三個代理變數衡量股票價格的波動性，並藉此探討股市價格波動性如何影響期貨市場交易活動的波動性，實證結果發現期貨市場交易活動的波動性對於所採用之代理變數頗爲敏感，然而，三個代理變數中股價變動之絕對值仍爲較佳之代理變數。

關鍵字:期貨市場交易量，股票價格，波動性

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