FUTURES TRADING ACTIVITY AND INDEX PRICE VOLATILITY: EVIDENCE FROM SET50 INDEX FUTURES

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ABSTRACT

This paper contributes empirical evidence on nature of relationship between SET50 index price variability and its related futures trading activity in a new perspective. The investigation is in the context of decomposed trading activity into moving average, expected and unexpected components according to Bessembinder and Seguin (1992). The daily data of SET50 index and SET50 index futures during April 28, 2006 to September 30, 2010 is observed from the Stock Exchange of Thailand. Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model is employed to explain volatility of SET50 index return. The results indicate significant relationship between contemporaneous futures volume and spot volatility. The discovery implies that a short-term enhancement in predicting SET50 index return can be achieved using variables from futures market. In particular, the finding suggests that market regulators should take the effect on spot market into account when launching new regulations related to futures market. Introducing trading supervision that favors higher trading volume in futures market may have destabilizing effect to spot market.

INTRODUCTION

Studies on volatility are always found in every field, especially in equity markets. Researchers try many different ways to explain nature of volatility. As a result, there are inconclusive explanations and many arguments are found due to product nature and its trading environment such as regulation and investor behaviors. Fundamentally, movements of asset's price generally fluctuate according to demand and supply which are consequence of new information that change expectation of investors. These unforeseeable volatility causes investors hard time deciding when to execute their trades. Then, investors try to find some other techniques to assist them making decision and technical analysis becomes popular.

The Thailand Futures Exchange Plc. has launched its first futures product, SET50 index futures, on April 28, 2006. This product is the first and the only security for two and a half year before individual stocks are allowed to trade. The intention is to bring up Thai capital market to international standard. Because of interesting derivative's characteristic, the market grows rapidly as expected. Moreover, it has a sign of maturity since its early years as shown in Norden (2010).

Equity securities are always in the center of attention so after new futures product launched, there are many investors who interested in the relationship of these futures on its underlying index. Although the believe that volume and open interest in futures market can be used to confirm trends for both futures and spot price is widely held, as studied by Floros (2007), there are no empirical research on this relation for Thai market. Then, there arises some question whether what investors rely on as a trading signal is actually related or not. This study, then, investigated the relationship between SET50 index price variability and its related futures trading activity.

It is obvious that people try to explain movements of spot market by futures market, and vice versa, since these two markets are linked by arbitrage opportunities. Moreover, derivative markets are formed to provide special features that cannot be found in spot markets such as increasing leverage, lowering transaction costs, and supporting hedging purpose in order to fulfill the need of investors. From these attributions, derivative markets, especially futures markets, become more liquid and efficient. As a result, the market attracts the attention of investors, and causes asymmetry of information which distorts spot price as documented in Hodgson, et al. (2006).

Until now, the research conducted on the trading activity of futures still considerably less than those in stock markets, especially in a small country liked Thailand. The contribution of this research is to further investigate whether futures trading activity, which include both volume and open interest, somehow relates to spot price volatility by testing the mixture of distribution hypothesis. In addition, this study separates trading activity into components, moving average, expected and unexpected parts, according to Bessembinder and Seguin (1992), to scrutinize such relation whether it is identical or not. The research is based on daily data from the Stock Exchange of Thailand covering the period from October 1, 2006 to September 30, 2010. Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model is employed in conducting this research.

The study provides supportive evidence that rises in futures trading of SET50 index is significantly related to the increasing volatility of the index. Thus, the results indicate destabilizing effect of futures market on the spot volatility. From the realization that these relationships exist, the study facilitates individual investors, both speculators and hedgers, develop a more efficient trading strategy. Furthermore, as futures market in Thailand is still emerging, related regulators and others stakeholders are concerning on the impact of this new market to the stability of the existing equity market. Prior to new regulation commencement, regulators need to scrutinize all related impact in order to mitigate all potential risks.

The remainder of this paper is organized as follows. Next section starts with a brief review of related academic literature. Then, testing methodology and data is clarified in section II and III, respectively. Before final conclusion is summarized in the last section, empirical results is presented and analyzed in section IV.

I. LITERATURE REVIEW

From the start of financial futures trade in 1970s, the concentration of academics and investors is shifted to the effect of financial derivatives trading on underlying markets. One of the greatest concerns is to investigate how futures impact spot market volatility. Previous studies document diverse evidence in various markets, but mostly related to the U.S. stock market. There are two main lines of arguments in academic research on the impact of futures trading on underlying spot markets. The first group found that futures trading and spot price volatility has positive relationship as supported by Harris (1989) and Schwert (1990) in the case of Standard & Poor's (S&P) 500 stock index. Harris (1989) explains the implication of this relationship as futures trading destabilize the underlying market since poorly informed investors are attracted by highly leverage. Then, noise in price discovery process is generated and lowers the content of prices.

On the other hand, there are some studies providing a negative relationship between futures volume and cash price volatility for S&P500. As opposed to previous explanation, the negative correlation is claimed to be a stabilizing effect caused by futures trading which enhances spot market efficiency and increases market depth. The argument is supported by Santoni (1987) and Bessembinder and Seguin (1992). Santoni (1987) explains that rises in futures trading volume lead to decreasing S&P 500 index volatility since negative relationship is found. Afterward, the study of Bessembinder and Seguin (1992) adopt an estimation procedure which iterating between a pair of mean and volatility regressions in order to scrutinize the relationship. The study includes exogenous variables, which are spot trading volume, aggregated futures trading volume and open interest, together with lagged endogenous variables in the augmented conditional return volatility equation. Furthermore, all exogenous variables are partition into three components (moving average trend, expected and unexpected parts). As expected futures trading volume is negatively related to the index's volatility, they conclude that the result supports destabilizing effect hypothesis. In particular, S&P500 index futures trading increases liquidity and depth of the underlying market.

There are several researches on non-U.S. markets which contributes mixed evidence on such relationship. Gulen and Mayhew (2000), Yu (2001), and Dong and Zhang (2010) had studied on the volatility of stock index returns following the introduction of index futures in major countries. Yu (2001) found that not all markets had a rising result of stock volatility after the listing of stock index futures since there were exceptions on the London and the Hong Kong stock markets. Gulen and Mayhew (2000) document that expected futures volume has a positive relation with spot volatility in Denmark, Germany and Hong Kong while they found the opposite for Austria and the U.K. and no effect for the other 18 countries. Thus, both papers concluded that the diverse results might be affected by macroeconomic factors, microstructure of the markets, and price stabilization mechanisms.

Dong and Zhang (2010) study the effect of the introduction of stock index futures in seven major Asian stock markets on the hypothesis that if a positive bubble exists in the stock market, arbitrage behavior from the introduction of futures market will eliminate the bubble. Thus, it causes price reversal and increase underlying market volatility. Though the most of the results are consistent to the hypothesis that introduction of futures trading is related to higher volatility in the spot market, the impact seems to exist as a short-term effect. In addition, they conclude that market performance, market development and the timing of the launch significantly affect the market response to the introduction of index futures trading. Following Bessembinder and Seguin (1992), there are numbers of empirical evidence applying similar nonparametric approach to study futures trading activity and underlying volatility relationship in non-U.S. markets. For example, Kyriacou and Sarno (1999) find that both contemporaneous and dynamic futures volume relates to the increased spot market volatility for the FTSE 100.

There is only a limited number of empirical evidence on the relationship between open interest and spot volatility, thus, the current empirical results are not definitive as well as the relationship for trading volume. Chen, Cuny, and Haugen (1995) found positive relationship between open interest and stock index volatility for S&P 500 index. In contrast, the study of Bessembinder and Seguin (1993) and Floros (2007) contributes to each other that negative relationship between open interest and volatility in futures market can be found. The results confirm that open interest, which is accounted for market dept, have an effect on volatility of index futures.

In Thailand, futures market starts from commodity products in 1979, which Angkinanad (1997) found that introduction of futures market reduces volatility of spot prices; thus, stabilizing spot market. For Thai equity market, Chiradatesakunvong (2004) and Chatrirat (2006) investigate the trading volume and return relationship. They found that trading volume contains significant information that can explain both absolute return and volatility of stocks in the SET50 index. After index futures is introduced, Thammasiri (2009) reveals the relationship between trading volume and futures return volatility in SET50 index futures and confirms that the relationships are positive and significant. In addition, Thongthip (2010) conducts the latest study investigating the long-run relationship of SET50 index futures and cash market. The result confirms that those relationships exist in Thai market. Moreover, intraday relationship also exists as SET50 index futures return seem to lead cash return with 5-minute data set. These studies support that the spot and futures markets in Thailand also tied together and trading activity of futures should have significant relationship with volatility liked many others countries.

Using GARCH framework, this paper contributes empirical evidence on nature of relationship between futures trading activity and spot volatility. In particular, the study is in the context of decomposed trading activity into expected and unexpected components according to Bessembinder and Seguin (1992). The inclusion of both spot and futures trading activity as exogenous variables for explaining underlying index volatility has not been investigated in the case of SET50 index before. Thus, the study provides the first examination of the relationship for each component of index spot and futures trading activity.

II. METHODOLOGY

- Theoretical Framework

The price movements are widely known as consequences of information perception in the market. Arrival of new information and integration process of this information into the market prices are somehow related to price volatility progression.

Mixture of distribution hypothesis (MDH), brought in by Clark (1973), becomes a well-known hypothesis on the arrival of new information. The objective of this hypothesis is to explain the deviation from the central limit theorem of the distribution of price changes. This hypothesis successfully explains the GARCH effects in stock returns with a correlated mixture of variables by measuring the rate information arrives to the market. Bessembinder and Seguin (1993) suggests that those mixes include trading volume, number of transactions, bid-ask spread, or market liquidity per observation unit. As new information enters into the market, current prices together with investors' expectations adjust to new market prices. Especially in futures market where traders are allowed to take short positions (selling contracts) rather than only long position (holding contracts), it is more likely to have contradiction on expected prices from each trader's point of view and how they perceive that information. When public information spreads, investors' expectations usually move in one direction with relatively low volume because everyone perceive and response identically as usual. However, if there exist inside traders which give uncertain information flow in the market, large price changes with relatively high volume can easily occur due to investor suspicion. This ambiguous changes lead to different volume effects.

Following MDH, Epps and Epps (1976) then explain price changes in investor's reservation price perspective. They assume that as investors will always revise their carrying prices when they found disagreement between their prices and the adjusted market prices from the arrival of new information. This explains the association between investors' disagreement and increasing absolute price changes. Along with the disagreement, volume increase which results in relationship between price volatility and volume. As a result, both studies are complementing and reach to the same conclusion that positive relationship between absolute price change variability and trading volume can be expected.

According to MDH with extension by Tauchen and Pitts (1983), the model becomes more generalized. Ignoring what Epps and Epps (1976) assumes about positive relationship between absolute price change and volume but somewhat employs a variance components scheme in order to model the adjustments of investors' carrying price facilitate the derivation of their daily joint probability distribution. Moreover, they include number of traders as an endogenous variable so it can explain both market with fixed number of traders and growing markets. By adding random term for price changes, trading volume and the number of traders, the model becomes a trivariate normal mixture model. They also note that increasing number of traders can best explain the positive relationship between trading volume and price changes as the rise in trading volume is from the growing market.

In short, MDH suggests that the arrival of information causes contemporaneous changes in price and volume. The reason is that both daily price changes and volume movement contain the same mixing variables which assumed to be new information arrival. While the price adjustment process goes on, it accompanies by exceeding trading activity level. Return volatility and trading activity, therefore, should be positively correlated.

In addition to volume, a unique feature of futures market is that the existing number of contracts traded during the day, so called open interest, is determined and reported daily. The open interest, then, provides additional measure of trading activity. Chen, et al. (1995) point out the positive relation between changes in open interest and stock index volatility. This coincidence is the consequence of how market participants respond to market risk. As the market volatility increases, investors usually reduce their risk by selling stocks and futures, thus, this increased risk is shared in a wider range of market participants. New participants are attracted to the market during this period since benefits outweigh the entry costs. As a result, the new equilibrium is characterized by higher open interest and a lower futures price comparing to the fair value. In contrast, when market volatility decreases, existing investors, especially those who carry higher value, remain in the market. The market is not attractive enough to new investors to enter. Thus, the new equilibrium is characterized by lower open interest and a higher futures price.

- **Estimation Method**

Autoregressive Conditional Heteroskedasticity (ARCH) has been recognized as ordinary occurrence in financial data. Thus, Generalized ARCH (GARCH) model is capable of imitating observed statistical characteristics of many time series of return on financial assets. Comparing to the original ARCH model, GARCH model reduces number of lags to catch the nature of the volatility. The model incorporates much more information comparing to the same lag length in ARCH model.

When ARCH effects in daily return are explained by a mixture of distributions, where the rate of daily information arrival is the stochastic mixing variable, Lamoureux and Lastapes (1990) employs GARCH model to show significant relationship between volume and volatility, and the reduction of ARCH effect when including trading activity as an explanatory variable in the variance equation according to MDH. This study also uses GARCH model with the extension of decomposed trading activity as introduced by Bessembinder and Seguin (1992).

The research starts with unit roots test for all variables by using the Augmented Dickey-Fuller (ADF) test. Following Gulen and Mayhew (2000) and Engle and Ng (1993), the time-series return of SET50 index is formed using a univariate GARCH model in order to apprehend most of the main features of the data. Mean and variance equations are shown in equation (1) and (2), accordingly. Thus, equation (1) presents conditional expected return while equation (2) is conditional variance of the index.

$$R_t = \mu + \sum_{j=1}^{n} \gamma_j R_{t-j} + \varepsilon_t \quad (1)$$

$$\sigma_t^2 = \alpha + \sum_{j=1}^{n} \beta_j \sigma_{t-1}^2 + \sum_{j=1}^{n} \omega_j \varepsilon_{t-1}^2 \quad (2)$$

where $\varepsilon_t | R_{t-1} \sim N(0, \sigma_t^2)$

with mean μ and lagged return coefficients γ_j. Daily rate of return (R_t) is derived from $R_t = 100 \cdot ln\,(P_t/P_{t-1})$, where P_t represent SET50 index price at time t, so that R_t becomes continuously compounded return. ε_t is the error term from mean equation at time t which is conditional on lagged return and is assumed to be an independent identically distributed random variable. σ_t^2 represents variance of SET50 index return at time t. In addition, the variance equation consists of mean α, lagged variance coefficients β_j and lagged residual coefficients ω_j.

Before adding trading activity into consideration, following Bessembinder and Seguin (1992), spot and futures volume are detrended by deducting the 100-day moving average, representing slower adjusting changes in the variables, from the observed series so that the series contain less effect on the volume growth. Subsequently, they are decomposed into two components using an Autoregressive Moving Average (ARMA) specification in order to reduce spurious problem by include only its own lag term to predict itself. Optimal lag length for each variable is determined by the lowest Bayesian Information Criterion (BIC). Specifically, The ARMA(p, q) process of autoregressive order p and moving average order q can be described as shown in equation (3).

$$X_t = c + \epsilon_t + \sum_{i=1}^{p} \varphi_i X_{t-i} + \sum_{j=1}^{q} \theta_j \epsilon_{t-j} \qquad (3)$$

with mean c, autoregressive coefficients φ_i and moving average coefficients θ_j. X_t represents a trading activity at time t. Process of autoregressive order m and moving average order n After the process, the unexpected component (ϵ_t) is decomposed from the detrended series in order to represent a daily activity shocks while the expected part is interpreted as regular fluctuation in volume across days. Therefore, summing up the three components will results in original activity series.

For open interest, we take into account outstanding contract at the end of each trading days as another trading activity. Bessembinder and Seguin (1993) claim that open interest is correlated with number of active informed traders. In addition, it represents willingness and ability of traders which related to market depth. The addition of the open interest variable also needs to replicate the detrended and decomposed process as what done in trading volume. From the procedures, the result gives a separation of expected and unexpected open interest.

As all trading activity is ready, A_k, which represent m trading activity variables, is included into equation (2). In addition, day of the week dummy variables (d_i) which show effects from differing mean from each day of the week (French (1980), Chotigeat and Lee (1993), and Sutheebanjard and Premchaiswadi (2010)) are included to conditional variance equation. Then, variance equation turns out to be as shown in equation (4). The intercept, α, can then be interpreted as the unconditional return variance.

$$\sigma_t^2 = \alpha + \sum_{j=1}^{n} \beta_j \sigma_{t-1}^2 + \sum_{j=1}^{n} \omega_j \varepsilon_{t-1}^2 + \sum_{i=1}^{4} \rho_i d_i + \sum_{k=1}^{m} \delta_k A_k \qquad (4)$$

with additional variable which includes daily dummy coefficients ρ_i and each trading variable coefficients δ_k. The null hypothesis is that coefficient of each trading variable (δ_k) equals to zero or trading activity is not related to spot volatility. In order to support the MDH, coefficients of both spot and futures volume should be significantly deviated from zero. In particular, they should have positive value for all components. Similarly for futures open interest, coefficients should be positive according to Chen, et al (1995).

III. DATA

This research is conducting on daily data of SET50 index futures and SET50 index spot over the period between April 2006 and September 2010. However, the actual data used begins in October 2006, with total 977 observations, since the beginning period is a base to calculate moving average of the series. These data are extracted from the Stock Exchange of Thailand and Bloomberg. In order to obtain aggregated futures volume and open interest, trading activities are summed across contracts with various delivery dates. Spot volume is shown in hundred million units while futures volume and open interest are scaled to thousands.

The reason for conducting this research on only SET50 index futures is because SET50 index is a good representative of stocks traded in the market from their high market capital with more liquidity. Moreover, SET50 index futures is the first futures and has the longest period of trading. Thus, this asset contains enough information, and is more mature than other futures securities. The SET50 index is appropriate to detect the relationship between these two markets.

IV. EMPIRICAL RESULT

Descriptive statistics of all variables are presented in Table I and Table II. Both spot and futures volume have positive skewness, or distributions are skew to the right, while SET50 index return and open interest have negative skewness. The distributions of all series, except open interest, are leptokurtic, or peak when comparing to normal distribution. Moreover, all trading activities are significantly correlated with their first lags.

[Table I and II is here]

Subsequently, the results of Augmented Dickey-Fuller (ADF) tests, the stationary tests, are presented in Table III (A and B). The result shows that the null hypothesis of unit root is rejected at all significant level. The outcome indicates that all variables are trend stationary. The series are also stationary after detrended as shown in Table III (B). The existence of unit root for all variables is an important preliminary step in decomposing the series into predictable and unpredictable components.

[Table III is here]

Testing ARCH effect of trading activities and SET50 return using Engle's LM test statistics is performed and presented in table IV. The result shows significant ARCH effect for all of the variables. As the series have significant ARCH effect, it is appropriate that they are regressed using autoregressive model. Afterward, each trading variable is estimated using

ARMA model and the results are presented in table V. The lowest Bayesian Information Criteria (BIC) value is employed to determine the appropriate ARMA(p, q) specification. In order to decompose each trading activity series, ARMA(2,1) is employed for spot and futures volume while open interest is modeled by AR(1).

[Table IV and V is here]

Table VI presents Pearson correlation coefficients among all variables after the decomposed process. The table emphasizes high correlation level among variables in the study. Especially for all moving average parts of trading activities, they are significantly related as these parts share the same nature that represent adjustment according to time.

[Table VI is here]

Estimation results for equations (1) and (4) are presented as model A in Table VII. The difference between two models is that model B excludes open interest from conditional variance equation in order to scrutinize volume effects to the variance of return. Both models agree that daily dummies help explaining variance of SET50 returns as supporting by the study of Sutheebanjard and Premchaiswadi (2010). Estimated coefficients for moving average parts of volumes are significantly different from zero at 1% which point to the fact that long term variations in trading activity are relevant for explaining volatility. Consistent with Mixture of Distribution Hypothesis, the coefficients estimate for unexpected futures volume is positive and significant. The results assure that information shocks move prices and generate trading. As the market grows, futures volume increases according to the rising number of participants. Investors of futures market usually invest in both spot and futures market in order to speculate and hedge their portfolios. Thus, spot volatility increases along the way as Thai market becomes less efficient from new participants who bring noise to the market. As a result, information shocks in futures market does not only affect futures market volatility but also significantly related to changes in spot market return.

Unlike the all-positive results of futures trading volume, coefficient estimates for spot volume and futures open interest contain both negative and positive values. The expected and moving average components for spot trading volume are negative, but only moving average part is significant. Besides, coefficient estimates for futures open interest are negative for expected open interest and positive for the unexpected and moving average parts, but none of them is statistically different from zero. This unrelated open interest can be explained by the study of Ferris, et al. (2002) which open interest rises in response to a pricing error shock. Thus, open interest is rather a proxy for capital flows into or out of the markets in response to price change, unlike trading volume that moves contemporaneously with price as a result of information flows.

[Table VII is here]

It is necessary to consider Pearson correlations between the variables, especially the moving average components of all trading variables which are highly correlated with correlations exceed 0.60. As a result, although multicollinearity does not give a bias result, the estimated coefficients are recognized as partial effects, given the levels of other activity variables. Contingent on levels of spot trading activity, the positive estimation of futures volume coefficient provides supportive evidence to large number of previous researches (eg. Clark 1973; Harris 1989) that the relationship between trading volume and volatility is positive and significant.

Furthermore, the result of estimated moving average coefficient indicates that futures markets provide a destabilizing speculative instrument which attracts more uninformed traders to equity markets. In general, the more outstanding stocks, the more liquid and more stable the market should be. Thus, volatility should decrease as there are more futures trading in the market. (Figlewski 1981) Nevertheless, the result of positive relationship between futures trading volume and spot volatility is in contrast to ordinary situation. The rises in futures trading generate higher spot volatility together with liquidity to cash market. Newbery (1987) gives the two causes of destabilization that it can occur in the market that all agents are not equally well informed and do not hold rational expectations. Another cause is that there are some agents who have market power, thus, speculators can manipulate or mislead the market prices. The situation in Thai stock market falls into both conditions that investors in Thai stock market are not equally well informed. Moreover, there are some groups, such as institution investors, who can manipulate the market prices. Then, destabilizing effect can be expected in Thailand.

V. Conclusion

The objective of this study is to determine the nature of relationship between SET50 index return volatility and trading activity in both spot and futures market during October 2006 to September 2010. The study is conducted based in the GARCH framework. Moreover, decomposed series of trading activity are used to identify the exact nature of those variables.

The results from GARCH estimations indicate positive relationship between futures trading volume and index volatility. Moreover, the relationship is consistent for all components of futures trading volume which supports the Mixture of Distribution Hypothesis. Though significant relation between spot volume and return is found, the significance of estimated coefficient is not as significant as found in futures volume. Expected part of spot volume is not significant at all. The results confirm that information flows from futures market is crucial to changes in volatility of SET50 index return as well as from spot market itself. It is not unanticipated that futures market usually has greater speed of absorption of new information due to their inherently high leverage and low transaction costs.

Furthermore, the positive relation in predictable and long-run futures volume also support destabilizing hypothesis which stated that more uninformed traders are attracted to equity markets after futures market is operated. Thus, the information content in prices becomes lower and more noise is generated in price discovery process. As a result, higher spot volatility is expected. (Figlewski 1981) This same relation is also found in Malaysian stock market which Dong and Zhang (2010) conclude that effects of futures market introduction may vary according to market performance, market development, and timing of the launch. The introduction of futures market when investors are generally positive towards the market prospect, together with the less developed structure of the market and less experienced investors, attracts more noise traders which results in higher prices and volatility.

In contrast to futures volume, open interest is not significantly related to SET50 index return volatility, rather, the index return Granger causes open interest movement. The finding can be explained by the study of Ferris, et al. (2002) which open interest rises in response to a pricing error shock. The increasing volatility and open interest moves together as a reaction to pricing error which last only a few days. They suggested that open interest is a proxy for examining capital flows into or out of the markets, giving pricing errors information shocks. Thus, the change in open interest is a result of the change in stock return not a simultaneous change.

The discovery of relationship between contemporaneous futures volume and spot volatility in Thai stock market implies that a short-term enhancement in predicting SET50 index return can be achieved using trading variables from futures market. This improvement of predictability should also lead to the construction of better investment strategies. The finding could be useful to market regulators to take into account the effect to spot market before launching new regulations. Introducing trading supervision that favors higher trading volume in futures market may have destabilizing effect to spot market. Finally, the findings of this study are important to policymakers and researchers alike.

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Table I

Descriptive Statistics

No. of Observation: 977

Period: October 2006 to September 2010

Variable	Mean	Standard Deviation	Skewness	Kurtosis
SET50 Return	0.035	1.914	-0.996	15.042
SET50 Volume[a]	7.207	5.823	1.694	6.092
SET50 Futures Volume[b]	7.972	4.560	0.823	4.453
SET50 Futures Open Interest[b]	20.093	7.762	-0.116	2.428

[a] shown in hundred million units
[b] shown in thousand units

Table II

Partial autocorrelation

	Partial autocorrelation at lag				
Variable	1	2	3	4	5
SET50 Return	-0.021	0.075*	0.016	-0.022	-0.039
SET50 Volume	0.537***	0.060	0.086**	0.080*	-0.007
SET50 Futures Volume	0.527***	0.071*	0.021	0.060**	0.085
SET50 Futures Open Interest	0.712***	0.019	-0.11**	0.045	0.040

***, **, * denote significant at 1%, 5% and 10%, respectively

Table III

Unit root tests
(ADF test statistic)

This table shows the results of the Augmented Dickey-Fuller (ADF) unit root test for SET50 index return and trading activity series. The Augmented Dickey-Fuller (ADF) test involves incorporating lagged values of the dependent variable (original series) into the following equation $\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \gamma T + \delta_1 \Delta Y_{t-1} + \delta_n \Delta Y_{t-n} + u_t$, with the number of lags being determined by BIC. The results rejected null hypothesis of unit root which implies that all series are trend stationary.

Table III (A)

	ADF test statistic			
Lag order	**SET50 return**	**SET50 volume**	**SET50 futures volume**	**SET50 futures open interest**
0	-31.871	-12.091	-13.016	-2.904
1	-20.732	-9.779	-10.590	-2.969
2	-17.016	-8.209	-9.304	-3.106
3	-15.245	-7.458	-8.111	-2.822
4	-14.229	-7.486	-7.403	-2.712
5	-14.040	-6.529	-6.696	-2.825

Critical value:	1% level	-3.960
	5% level	-3.410
	10% level	-3.120

The following result of ADF test shown in Table III (B) involves incorporating lagged values of the detrended trading variable into the following equation $\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \delta_1 \Delta Y_{t-1} + \delta_n \Delta Y_{t-n} + u_t$. The different from above result is that data is extracted from series after deducting moving average trend. Thus, there will be no trend included in the regression equation. The results confirm that the series are trend stationary.

Table III (B)

	ADF test statistic		
Lag order	**SET50 volume**	**SET50 futures volume**	**SET50 futures open interest**
0	-12.561	-13.116	-4.257
1	-10.198	-10.690	-4.393
2	-8.590	-9.410	-4.648
3	-7.820	-8.200	-4.200
4	-7.888	-7.486	-4.061
5	-6.909	-6.781	-4.279

Critical value:	1% level	-3.430
	5% level	-2.860
	10% level	-2.570

Table IV

Engle's LM test statistics

This table shows LM test result for autoregressive conditional heteroskedasticity (ARCH). The null hypothesis is that the series has no ARCH effect.

Variable	chi2	df	Prob > chi2
Original series			
SET50 Return	112.346	1	0.0000
SET50 Volume	309.011	1	0.0000
SET50 Futures Volume	212.456	1	0.0000
SET50 Futures Open Interest	945.639	1	0.0000
Series after deducted moving average			
SET50 Volume	231.695	1	0.0000
SET50 Futures Volume	153.216	1	0.0000
SET50 Futures Open Interest	814.119	1	0.0000

Table V

The results from ARMA model

This table shows the result from estimated ARMA models. Spot and futures volume is modeled by using ARMA(2,1) while open interest is modeled by AR(1). Model selection is based on Bayesian Information Criterion (BIC). These models are used to decompose the series into expected and unexpected components. Prediction of variables by fitted coefficient in equation (3) is considered expected components. On the other hand, residuals from the prediction are unexpected components of each variable.

	Spot volume	Futures volume	Open interest
c	64.7099	0.5414	1.2483
φ_1	1.4095***	1.4385***	0.9629***
φ_2	-0.4377***	-0.4563***	
θ_1	-0.8108***	-0.8655***	

***, **, * denote significant at 1%, 5% and 10%, respectively

Table VI

Pearson correlation coefficients

		Spot Volumes			Futures Volumes			Open Interest	
	SET50 Return	**Moving Avg.**	**Expected**	**Unexpected**	**Moving Avg.**	**Expected**	**Unexpected**	**Moving Avg.**	**Expected**
Spot Volumes									
Moving Avg.	0.055								
Expected	0.051	0.052							
Unexpected	0.070*	-0.027	0.002						
Futures Volumes									
Moving Avg.	0.017	0.760***	0.018	-0.003					
Expected	-0.003	-0.139***	0.211***	-0.104**	-0.207***				
Unexpected	-0.087**	-0.026	0.060	0.314***	-0.065*	0.002			
Open Interest									
Moving Avg.	0.025	0.644***	0.148***	0.029	0.916***	-0.132***	-0.019		
Expected	-0.004	-0.406***	-0.223***	-0.057	-0.249***	0.027	0.014	-0.341***	
Unexpected	-0.032	-0.046	-0.011	-0.017	-0.038	-0.062	0.147***	-0.069*	0.003

***, **, * denote significant at 1%, 5% and 10%, respectively

Table VII

The result from GARCH model

Coefficients estimated from GARCH model are presented in the table for both mean and variance equations. All trading variables in the model are already detrended by deducting 100-day moving average before separating into expected and unexpected parts. Statistical significant for individual coefficients are determined by t-statistics which test whether the coefficient is zero.
Model A is regressed according to equation (1) and (4) while model B excludes open interest from conditional variance equation to consider only volume effects to volatility. Appropriate lag length for both models is indentified by the lowest BIC. Model A is regressed by GARCH(1,1) while model B uses GARCH(2,1).

	Mean equation	
	Model A	**Model B**
Intercept	0.0969**	0.0962**

	Variance equation	
	Model A	**Model B**
Intercept	0.0979	0.0156
Daily dummies		
Tuesday	-0.5107**	-0.5362**
Wednesday	-0.6141***	-0.6381***
Thursday	-0.5632**	-0.5373**
Friday	-0.6605***	-0.6811***
Trading activity		
Spot volumes		
Expected	-0.0002	-0.0001
Unexpected	0.0012***	0.0011***
Moving average	-0.1719***	-0.1768***
Futures volumes		
Expected	0.2420***	0.2225***
Unexpected	0.2386***	0.2590***
Moving average	0.2157***	0.2640***
Futures open interest		
Expected	-0.0054	
Unexpected	0.0711	
Moving average	0.0181	
Lagged unexpected return (sum)	0.0645**	0.1310*
Lagged volatility estimates	0.0084	0.0077
Log Likelihood	-1706.05	-1704.66

***, **, * denote significant at 1%, 5% and 10%, respectively