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Behavior of Stock Market Index in the Stock Exchange of Thailand

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Abstract:

In this paper, the variance-ratio test and the ARMA-GARCH (1,1) are used to test whether the Stock Exchange of Thailand is an efficient market. Using monthly market index during January 1987 and December 2006, the variance-ratio test shows that the market index follows a random walk process, and this is confirmed by unit root tests. The GARCH process shows that the volatility of stock market return generated by the GARCH variance series exhibits an uneven pattern. The unpredictable stock index and uneven volatility of stock return imply that the Thai stock market is efficient according to weak-form efficient market hypothesis.

JEL Classification: G14; C 22

Keywords: Stock market index; Variance-Ratio; GARCH; Market efficiency

1. Introduction

Like other stock markets, the Stock Exchange of Thailand (SET) can be affected by macroeconomic variables, such as growth rate, inflation, money supply, exchange rate.¹ One focal point is the interactions between asset prices and monetary policy. There is a transmission of monetary policy through the influence of interest rates on stock prices since interest rates are the costs of borrowing for participants in the financial market. There have been several works testing the time-series properties of stock prices. These include empirical tests whether stock prices follow a random walk process. Lo and MacKinlay (1988), Malliaris and Urrutia (1990), Liu and He (1991), and Kim, Nelson, and Startz (1991) address the issue of a random walk process, among others. If stock prices follow a random walk process, future prices cannot be predictable using past prices. In this case, a stock market can be considered weak-form efficient and thus contradictory to technical analysis.

¹ See Chen, Roll, and Ross (1986) for earlier investigation, and Chung and Tai (1999) and Kim (2003) for more recent evidence on the impact of macro variables on the stock market. Kim (2003) finds that the S&P 500 stock price is positively related to the industrial production but negatively related to the real exchange rate, interest rate, and inflation.

Fluctuations of stock returns have prompted several researchers to investigate the pattern of volatility using variations of the generalized autoregressive conditional heteroskedasticity (GARCH) models. Empirical studies show different patterns of volatility and its impacts. For examples, French, et. al. (1987), and Campbell and Hentschel (1992) find that an increase in stock market volatility raises required rate of returns of investors and lowers stock prices. Glosten, et. al. (1993) indicates that the positive unanticipated returns can lead to lower conditional volatility and vice versa. Stock prices randomness and volatility are of importance to investors in the stock market. If the stock prices follow a random process, it is not helpful to forecast future stock prices. In other words, the more volatile stock prices the more unpredictable the stock market returns in terms of capital gain or loss. However, if there exists a mean reversion in stock prices, the predictable components can be useful to investors. It should be noted that the behavior of stock prices in emerging stock markets may not conform to that of well-developed market.

The main objectives of this paper are to assess the behavior of stock prices using the overall market index in the stock exchange of Thailand. The variance-ratio approach is employed to test whether stock prices follow a random walk process, while the GARCH process is employed to test the volatility of stock return measured in terms of capital gain or loss. The volatility of stock market return is caused by market expectations and speculations with new information. The generalized autoregressive conditional heteroskedasticity (GARCH) process can capture the volatility of stock return. The first technique is widely used in testing whether stock prices are pure random walks, while the latter technique can tell how volatile are stock prices which can cause volatile stock market returns. The results from this study can indicate whether efficiency exists in the Thai stock market. Section 2 analyzes the data and their properties. Section 3 explains the econometric methods used in the analysis. Section 4 highlights the empirical results. The last section concludes.

2. Properties of the Data

Monthly data are obtained from the Stock Exchange of Thailand (SET) and the Bank of Thailand (BOT) during 1987:01-2006:12. The data include SET index and consumer price index. The SET index is used as the overall market index. The series are transformed to the logarithm of the nominal and real stock market indexes. The real stock market index is constructed by deflating the nominal stock market index by the consumer price index, while the stock market return series are constructed using first differences of log of nominal and real stock market indexes. These returns may be defined as capital gain or loss.

2.1 Normality

The statistics of logs of nominal and real market indexes are shown in Table 1(a). The mean of nominal market index is slightly lower than that of real market index. In addition, the Jaque-Bera statistics reject the assumption of normal distribution in both nominal and real indexes. In Table 1(b), the same conclusion can be drawn, i.e., both

real and nominal stock market returns are not normally distributed.

Table 1. a. Descriptive Statistics of Stock Market Index Series		
	Nominal SET Index	Real SET Index
Mean	672.291	813.319
Standard Deviation	339.127	463.652
Skewness	0.853	0.765
Kurtosis	2.913	2.528
Jarque-Bera Statistic	29.616	25.623
b. Descriptive Statistics of Stock Market Return Series		
	Nominal Market Return	Real Market Return
Mean	1.966	0.833
Standard Deviation	69.671	90.227
Skewness	0.344	0.179
Kurtosis	8.001	9.288
Jarque-Bera Statistic	253.719	394.975

2.2 Unit Root

The unit root tests are used to assess the time series properties of the data. In so doing, the augmented Dickey-Fuller test (ADF test) proposed by Dickey and Fuller (1979, 1981), the Phillips-Perron Tests (PP test) proposed by Phillips and Perron (1988) are used. If the null hypothesis of a unit root is rejected, a variable or a series being tested is a stationary series, but not a random walk process. The test statistics are to compare with MacKinnon critical values of rejecting the null hypothesis of unit roots in each series (MacKinnon, 1990). The unit root test results are reported in Table 2.

Table 2. Unit Root Tests				
	ADF Statistic without Trend	ADF Statistic with Trend	PP Statistic without Trend	PP Statistic with Trend
Log of Nominal SET Index	-2.225 [0] (0.187)	-2.395 [0] (0.381)	-2.274 [6] (0.181)	-2.399 [6] (0.379)
First Difference of Nominal SET Index	-14.871 [0] (0.000)	-14.903 [0] (0.000)	-14.860 [7] (0.000)	-14.894 [8] (0.000)
Log of Real SET Index	-1.558 [0] (0.503)	-2.286 [0] (0.439)	-1.611 [5] (0.476)	-2.305 [6] (0.429)
First Difference of Real SET Index	-14.745 [0] (0.000)	-14.761 [0] (0.000)	-14.731 [7] (0.000)	-14.746 [8] (0.000)

The number in brackets are optimal lags determined by SIC for ADF test, and optimal bandwidths for PP test. The probability to accept the null hypothesis of non-stationary is in parenthesis is provided by MacKinnon (1996). Results in Table 2 show that both nominal and real indexes of stock market are I(1) series, i.e., the series are non-stationary in level, but stationary in first difference.

3. Methodology

The methods used in this study are described as follows.

3.1 Variance-Ratio Tests

The variance-ratio test is believed to be a more powerful tool in the test for random walks hypothesis as employed in Lo and MacKinlay (1988, 1989), and Liu and He (1991). As specified by Liu and He (1991) if the variance of the increments in a random walk is linear in the sampling interval, i.e., a series follows a random walk process, the variance of its k-differences will be k times the variance of its first differences.

For a series P_t , if there are $kn+1$ observations, such as

$$P_0, P_1, P_2, \dots, P_{nk}$$

where k is an integer that is greater than one, and P_{it} is at equally spaced interval. Then the ratio of $1/k$ of the variance $P_t - P_{t-k}$ to the variance of $P_t - P_{t-1}$ will equal one.

Suppose the ex post real stock price follows a pure random walk process:

$$P_{t+1} = P_t + e_t \quad (1)$$

Such that $e_t \sim N(0, \sigma_e^2)$, where e_t is a random error which is serially uncorrelated. The variance of the first difference the series P_{t+1} is

$$E(P_{t+1} - P_t)^2 = \sigma_e^2 \quad (2)$$

Then the variance of the k^{th} difference when P_t is a random walk and grows linearly with the difference is

$$E(P_{t+k} - P_t)^2 = k\sigma_e^2 \quad (3)$$

The variance ratio statistic used to test the null hypothesis that the real stock price follows a random walk process is

$$VR(k) = \frac{1}{k} \left(\frac{k\sigma_e^2}{\sigma_e^2} \right) \quad (4)$$

The series that follows a random walk will give the $VR=1$, but if VR is less than one, the series is a stationary process.

3.2 Volatility

The autoregressive conditional heteroskedastic (ARCH) model proposed by Engel (1982) can be used to forecast variance of first differences of a non-stationary series over a period of time.² In case of stock market returns in terms of capital gain or loss, the return is computed from first differences of stock prices. This model assumes that the conditional variance depends on the lagged squared residuals of stock returns. The conditional variance is thus the volatility of stock price changes. Bollerslev (1986) extends the ARCH model by making conditional variance a function of its lagged value in addition to the lagged valued of squared residuals. The model is called generalized autoregressive conditional heteroskedasticity (GARCH) process. The GARCH process is more general and widely used to model financial time series since the accuracy of predicting conditional variance is superior to the ARCH process.

The time-varying volatility can be modeled as the GARCH(p,q) process which can be specified as

$$h_t = \alpha_0 + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \beta_j h_{t-j} \quad (5)$$

where $\alpha_0, \alpha_i, \beta_j$ are non-negative parameter to be estimated, while $p > 0$ and $q \geq 0$ are the order of the process.³ In equation (5), ε_{t-i}^2 are the arch terms, h_{t-j} are the GARCH terms, h_t is conditional variance which is a measure of volatility of stock returns. Stock return volatility is believed to be attributed to market expectations and market speculation due to news or information. News and events can cause a change in the volatility pattern of stock prices. The unexpected shocks influence the volatility over time. According to McKenzie (2002), negative shocks seem to produce a greater response in the market than that of positive shocks. This can also be applied to the case of stock price series.

In estimating volatility of stocks returns, high and persistent volatility is difficult to forecast changes in stock prices, and thus the stock market is not conformed to the weak-form efficiency while a decline in the level of volatility implies predictable changes in stock prices.⁴

² The ARCH model is used to estimate the variance of U.K. inflation which is first difference of price level.

³ The simplest form is the GARCH (1,1) process as suggested by Bollerslev (1986), which can be expressed as $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$.

⁴ One can use autoregression test in the form: $R_{t,t+k}^k = \alpha_k + \beta_k R_{t-k,t}^k + \varepsilon_{t,t+k}$, where β_k is the coefficient showing the first-order autocorrelation of k-period holding returns. The stock prices will have a random walk component if β_k takes the value of zero for all k. However, this test requires normality assumption.

4. Results

The estimated results of variance-ratio test are reported in Table 3. The indexes are not in logarithmic form according to Eq. (2) and Eq. (3).

VR(k)	Nominal SET Index	Real SET Index
VR(2)	1.05	1.09
VR(4)	1.13	1.18
VR(8)	0.94	0.93
VR(12)	1.04	1.01
Z-statistic for joint tests	0.664 (p-value=0.941)	0.821 (p-value=0.880)

By computing variances from Eq. (2) and Eq. (3) with k=2, 4, 8, and 12, the variance ratios seem to be close to one. This implies that both series of stock market index follow a random walk process.⁵ Using variance-ratio test can cause a crucial problem because stock market return does not follow a normal distribution. Cajueiro and Tabak (2006) employ an alternative to traditional variance-ratio test on stock market returns, i.e. bootstrapped variance-ratio test. However, the results are similar to those of traditional one. Furthermore, the data in their study show heteroskedasticity. Therefore, the GARCH process seems to be a better measure of stock return predictability.

The estimated equation of ARMA(2,2) with the constant variance for nominal stock market return is

$$R_t = 0.004 + 0.099*** R_{t-1} - 0.865*** R_{t-2} - 0.071*** \varepsilon_{t-1}^2 + 0.985*** \varepsilon_{t-2}^2 \quad (6)$$

(0.033) (0.032) (0.010) (0.007)

The number in parenthesis is standard error.

Log Likelihood = 213.390

Q(8) = 8.545 (p = 0.074) Q(12) = 16.678 (p = 0.034)

Q²(8) = 29.799 (p = 0.000) Q²(12) = 36.336 (p = 0.000)

Obs*R-squared = 3.769 (p = 0.052)

Equation (6) shows that there is no serial correlation, but the ARCH effect is present. Therefore, GARCH process should be used instead.

⁵ The ADF and PP tests reject the null hypothesis of stationarity in level of each series. The joint tests also show that both series exhibit random walks. This conforms to the results by Chaudhuri and Wu (2004). They indicate that most of the emerging market equity indexes do not have mean reversion. Unit root tests also indicate the non-stationarity of SET index during the period January 1985 to April 2002.

Volatility of overall stock return (first difference of nominal SET index) are obtained from ARMA-GARCH(1,1) type. The estimated result is

$$\begin{aligned}
 R_t &= 0.006 + 0.426^{***} R_{t-1} - 0.725^{***} R_{t-2} - 0.409^{***} \varepsilon_{t-1}^2 + 0.816^{***} \varepsilon_{t-2}^2 \\
 &\quad (0.173) \quad (0.135) \quad (0.142) \quad (0.106) \\
 \sigma_t^2 &= 0.001 + 0.135^{***} \varepsilon_{t-1}^2 + 0.803^{***} \sigma_{t-1}^2 \quad (7) \\
 &\quad (0.049) \quad (0.072)
 \end{aligned}$$

The number in parenthesis is standard error.

$$\begin{aligned}
 \text{Log Likelihood} &= 223.321 \\
 Q(8) &= 3.018 \quad (p = 0.555) \quad Q(12) = 7.975 \quad (p = 0.436) \\
 Q^2(8) &= 2.259 \quad (p = 0.688) \quad Q^2(12) = 3.183 \quad (p = 0.874)
 \end{aligned}$$

*** indicates that the estimated coefficients are significant at the 1% level.

The estimated equation of ARMA process with the constant variance for real stock market return is

$$\begin{aligned}
 R_t &= 0.001 + 0.105^{***} R_{t-1} - 0.864^{***} R_{t-2} - 0.072^{***} \varepsilon_{t-1}^2 + 0.986^{***} \varepsilon_{t-2}^2 \quad (8) \\
 &\quad (0.034) \quad (0.033) \quad (0.009) \quad (0.007)
 \end{aligned}$$

The number in parenthesis is standard error.

$$\begin{aligned}
 \text{Log Likelihood} &= 222.151 \\
 Q(8) &= 8.701 \quad (p = 0.069) \quad Q(12) = 17.459 \quad (p = 0.026) \\
 Q^2(8) &= 31.356 \quad (p = 0.000) \quad Q^2(12) = 39.040 \quad (p = 0.000) \\
 \text{Obs*R-squared} &= 3.889 \quad (p = 0.049)
 \end{aligned}$$

Equation (8) shows that there is no serial correlation, but the ARCH effect is present. Therefore, GARCH process should be used instead.

Volatility of overall real stock return are obtained from ARMA-GARCH(1,1) type. The estimated result is

$$\begin{aligned}
 R_t &= 0.003 + 0.447^{***} R_{t-1} - 0.726^{***} R_{t-2} - 0.424^{***} \varepsilon_{t-1}^2 + 0.820^{***} \varepsilon_{t-2}^2 \\
 &\quad (0.165) \quad (0.131) \quad (0.136) \quad (0.101) \\
 \sigma_t^2 &= 0.001 + 0.134^{***} \varepsilon_{t-1}^2 + 0.804^{***} \sigma_{t-1}^2 \quad (9) \\
 &\quad (0.047) \quad (0.070)
 \end{aligned}$$

The number in parenthesis is standard error.

$$\begin{aligned}
 \text{Log Likelihood} &= 222.468 \\
 Q(8) &= 3.114 \quad (p = 0.539) \quad Q(12) = 8.632 \quad (p = 0.374) \\
 Q^2(8) &= 2.309 \quad (p = 0.679) \quad Q^2(12) = 4.221 \quad (p = 0.837)
 \end{aligned}$$

*** indicates that the estimated coefficients are significant at the 1% level.

The estimated results in equations (6) and (7) are satisfactory since the Ljung-Box Q-tests on the residuals indicates that there are no serial correlations in the error terms. Also, the Q^2 statistics indicate that the absence of residual ARCH. In addition, both ARCH and GARCH terms have highly significant coefficients. The similar results are shown in equations (8) and (9). This indicate that there is a similarity using nominal and real returns.

The GARCH variance series generated from the estimated models in equation (6) and (7) are shown in Figure 1 and 2 respectively.

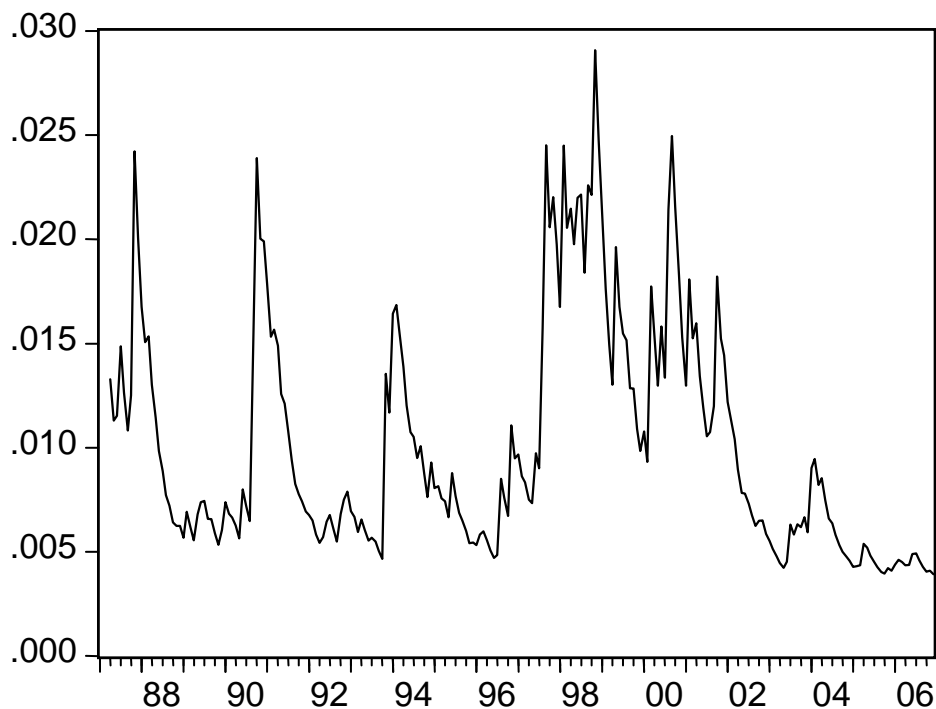


Figure 1. Volatility of Nominal Stock Market Return

In Figure 1, the volatility of nominal stock market return seems to fluctuate from time to time. The low level of volatility at the end of 2004 is not lower than other lower limits in other years.

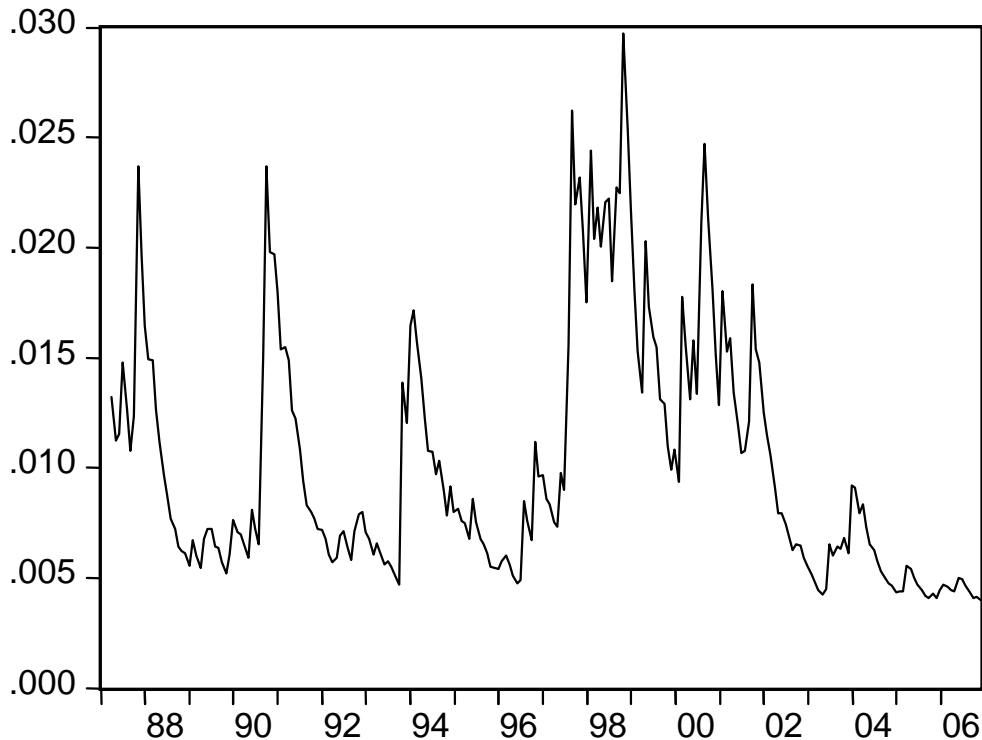


Figure 2. Volatility of Real Stock Market Return

In Figure 2, the pattern of volatility of real stock market return is similar to that of nominal stock market return. Therefore, one can use either nominal or real stock prices to calculate market return in term of capital gain or loss.

The instability of the GARCH variance series implies that stock return in the Stock Exchange of Thailand cannot be predictable due to market expectations and market responses to news or information.

5. Conclusion

This paper examines the behavior of stock prices using stock market index in the Stock Exchange of Thailand. The random walk hypothesis is tested using the variance-ratio test on the stock index (SET index), and the results show that the SET index follow a random walk. This is true using either nominal or real index. The results from the variance-ratio test conform to the non-stationarity of the index from the results of unit root tests. Therefore the stock prices in the market are unpredictable. The results of the variance-ratio test support the weak-form efficiency. The ARMA(2,2)-GARCH(1,1) type generates the residual variance series that show the high and persistent volatility of stock market return. Thus the stock market return cannot be predictable.

The evidence of both tests shows that the Stock Exchange of Thailand is somewhat efficient during the period of investigation. This might be due to rational expectations of investors in the market and their quick response to new information.

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