“The volatility model of the ASEAN Stock Indexes”

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THE VOLATILITY MODEL OF THE ASEAN STOCK INDEXES

Abstract

This research study examines the characteristics of the Association of Southeast Asian Nations (ASEAN) volatility of stock indexes. The following models are used in this research: Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH), Fractionally Integrated Generalized Autoregressive Conditional Heteroscedasticity (FIGARCH), Glosten Jaganathan Runkle Generalized Autoregressive Conditional Heteroscedasticity (GJR-GARCH), and Multifractal Model of Asset Return (MMAR). The research also used the data from the ASEAN country members' (the Philippines, Indonesia, Malaysia, Singapore, and Thailand) stock indexes for the period from January 2002 until January 31, 2016 to determine the suitable model.

Meanwhile, the results of the MMAR parameter showed that the returns of the countries have a characteristic called long-term memory. The authors found that the scaling exponents are associated with the characteristics of the specific markets including the ASEAN member countries and can be used to differentiate markets in their stage of development.

Finally, the simulated data are compared with the original data by scaling function where most of the stock markets of the selected ASEAN countries have long-term memory with the scaling behavior of information asymmetry. Some of the countries such as the Philippines and Indonesia have their own alternative models using GARCH and EGARCH due to the possibility of leverage. Generally, MMAR is the best model for use in ASEAN market, because this model considered Hurst exponent as a parameter of long-term memory that indicates persistent behavior.

Keywords stock index, volatility, long-term memory, fractal market hypothesis, econometrics model

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INTRODUCTION

The Association of Southeast Asian Nations, also known as ASEAN, is one of the areas supporting competitive, diverse, and fast market growth. Gross Domestic Product is an indicator of economic growth of a country, particularly for the ASEAN member countries such as the Philippines, Indonesia, Malaysia, Singapore, and Thailand. These countries were selected based on the largest gross domestic income according to the International Monetary Fund (IMF) as shown in Table 1.

Investments can be made using various instruments, namely, stocks, mutual funds, commercial paper, bonds, futures contracts on securities, and so on[1]. In the research context, investment refers to the act of investing in a company through the buying of stocks. In the capital market, especially stocks, investors pay attention to the index joint

1 http://www.ojk.go.id/id/kanal/pasar-modal/regulasi/undang-undang/Documents/313.pdf

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Table 1. Gross Domestic Product of ASEAN member countries

Source: ASEANstats (2017).

Ranking	Country	Gross Domestic Product (in million USD)
1	Indonesia	940.953
2	Thailand	390.592
3	The Philippine	311.687
4	Malaysia	302.748
5	Singapore	296.642
6	Vietnam	205.860
7	Myanmar	68.277
8	Cambodia	19.476
9	Laos	13.761
10	Brunei Darussalam	10.458

stock price. The stock price index is an indicator reflecting the movement of stock prices; it serves as a guideline for investors to invest in capital markets, especially stocks[2].

Currently, stock investment has a high risk; the risk-return trade-off indicates that the expected rate of return will increase along with the level of risk. This is often called as high risk-high return. The risk in financial means refers to volatility that can cause a difference in the calculation of expected returns (Tsay, 2005).

There are various models of volatility estimators such as the Exponential Generalised Autoregressive Conditional Heteroscedasticity (EGARCH) developed by Nelson (1991), Fractionally Integrated Generalized Autoregressive Conditional Heteroscedasticity (FIGARCH) developed by Baillie et al. (1996), Generalized Autoregressive Conditional Heteroscedasticity (GARCH) developed by Bollerslev (1986), Glosten Jagannathan Runkle Generalized Autoregressive Conditional Heteroscedasticity (GJR-GARCH) popularized by Glosten et al. (1993) and Multifractal Model of Asset Return (MMAR) developed by Mandelbrot et al. (1997).

For large data, the GARCH model can be used, because it will give more accurate results. However, one drawback of GARCH is that it does not show the leverage effect that is observed in the EGARCH model. The FIGARCH model is an ARCH extension; the model includes EGARCH and permanent transitory components model in long-term memory. To complement the factors not observed in EGARCH, FIGARCH, GARCH, and GJR-GARCH models, the MMAR model is used (Kim et al., 2014).

The advantages of MMAR model is its ability to model the most important stylized facts of the financial time series, such as fat tails, long memory, and trading time properties. According to Di Matteo et al. (2005), the most important advantage over the FIGARCH method is the scale consistency property, where the aggregation characteristics of the data (different sample numbers) can be used for testing and identifying the model.

Given the differences in these models, it is essential to determine the best model for estimating volatility in the ASEAN share index. By using a stable model, which better reflects the real data, the investors can analyze the volatility and the managers may decide whether to invest or not, besides that, the market can use Efficient Market Hypothesis (EMH) or Fractal Market Hypothesis (FMH) to analyze the market behaviors (Satchell & Knight, 2011). In the EMH, the market is said to be efficient when the price in the existing markets fully reflects information. Meanwhile, the FMH says that the market consists of various investors who have different investment zones and their own information analyses, resulting in asymmetric information. If the market follows the EMH, then the market cannot be predicted, because

2 http://www.idx.co.id/id-id/beranda/informasi/bagiinvestor/indeks.aspx

it will move randomly. If the market follows the FMH, then the market will be predictable in the long term, because the price movements are more volatile in the short run. The knowledge of this relationship can be an advantage for investors, especially those who want to invest money for the long term.

Based on the above explanation, it has become essential to determine the model (GARCH, EGARCH, FIGARCH, GJR-GARCH, and MMAR) best suitable for stock market conditions, particularly in the ASEAN countries. This research studied the behavior of the stock markets in ASEAN countries (Indonesia, Malaysia, Singapore, Thailand, and the Philippines). This study focused on the movement of stock indexes such as the Philippines Stock Exchange Index, Jakarta Stock Exchange Composite Index, FTSE Bursa Malaysia KLCI Index-Kuala Lumpur Composite Index, Straits Times Index (STI), and Thailand Stock Exchange Index by using the data from January 1, 2001 to January 31, 2016.

Therefore, this study has two objectives. The first aim was to determine the differences between the models GARCH, EGARCH, FIGARCH, GJR-GARCH, and MMAR that could reflect volatility in the Philippines, Indonesia, Malaysia, Singapore, and Thailand stock index. The second aim is to differentiate between MMAR model and other models such as GARCH, EGARCH, FIGARCH, and GJR-GARCH.

1. LITERATURE REVIEW

According to Day and Lewis (1992) and Thomas (2008), volatility can predict call prices on corporate underlying assets in the future. Volatility implies an unpredictable and rapid change; in finances to calculate such changes, Value at Risk (VaR), beta calculation in Capital Asset Pricing Model (CAPM), etc. are generally used. Volatility changes are found in the time series. In the financial series, it shows certain patterns that are crucial for model specifications, estimations and prediction. Fama (1990) used the efficient hypothesis theory to test the capital market capabilities in engaging and responding to information, i.e. three forms of information such as weak test form, semi-strong test, and strong test. In the EMH, the stock price change is a random walk. Therefore, the information available today is the current information and future information; due to the presence of these two kinds of information, the price is unpredictable.

In line with the development of time, there are several disagreements with the concept of EMH. In this case, the view is that the stock price behavior is the same as natural events such as floods, changes in air temperature, and so forth, indicating that there is a link between one event and the next.

These natural events can be analyzed by simple rules with the help of the fractal concept. Therefore, stock price behavior should be analyzed using fractal concept (Jamdee, 2005). The hypothesis emphasizes the impact of liquidity and investment areas on investor behavior. The purpose of this hypothesis is to provide a model of investor behavior and market price movements based on observations. The market exists to provide stability and liquidity environment of trade. The market will remain stable when many investors participate in different investment areas. As long as other investors have a long-investment territory than the investors experiencing a crisis, the market will stabilize on its own. Therefore, risks should be shared at the same level by investors. By sharing the risks, the market will explain why the distribution frequency of returns looks the same in that investment area. This FMH is proposed because of the statistical structure similar to the risks (Peters, 1994). According to Peters (1994), there are five points raised in the FMH: (1) stable market, when compiled from investors who closed the region, a lot of investment is mandatory for liquidity guarantee for traders; (2) the collection of information is related more to market sentiments and factor techniques in the short term rather than in the long term; (3) if something happens, then the validity of the basic information is questionable, so long-term investors should stop participating in the market or start trading on a collection basis for short-term information; (4) price combination of short-term trading techniques and long-term valuation basis may be more volatile than long-term transaction; and (5) if securities have no economic relationship, then there will be no trend in the long term. Due to this stability, the FMH will have a predictable pattern.

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In his research, Günay (2016) provided evidence of the stock market on stock indexes in Croatia, Poland, Turkey, and Greece. Fillol (2003) found that MMAR method is better than the GARCH or FIGARCH methods for replicating the main scaling features observed in the financial series of the stock market in France. The MMAR was popularized by Mandelbrot et al. (1997), but the model is based on Hurst's (1956) research on the problem of long-term storage in the market. Mandelbrot et al. (1997) combined the concept of long memory in GARCH method, which can keep the price of martingale property along with long memory in absolute return value. He also stated that the consistency of scale in GARCH literature, which gives the effect of aggregation characteristic of data with different number of samples that, can be used for testing and identifying the model (Toggins, 2008). Liu and Hung (2010) produced the most accurate volatility predictions followed by the model EGARCH where the data used are stock index S&P 100. The research also indicates the existence of asymmetric components, so it is worth considering the use of models from GJR-GARCH and EGARCH in the calculation of stock index volatility in ASEAN countries.

2. METHODOLOGY

The research includes quantitative data using an econometric model, where the GARCH, EGARCH, FIGARCH, GJR-GARCH, and MMAR models are used. This study uses data from stock index in five ASEAN countries (Indonesia, Malaysia, Singapore, the Philippines, and Thailand) during the period from January 1, 2002 to January 31, 2016 (Figure 1). The data have been obtained and calculated by log return equation:

$$r_t = \ln \frac{P_t}{P_{t-1}}, \tag{1}$$

where P_t is the price of the stock index at time t.

$$\varepsilon_t = \sigma_t \eta_t,$$
$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2, \; t \in Z. \tag{2}$$

The slope equation will be:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2. \tag{3}$$

The Hurst exponent will be:

$$\alpha > 1 \rightarrow H = \frac{\alpha - 1}{2}, \tag{4}$$

$$\alpha < 1 \rightarrow H = \frac{\alpha + 1}{2}. \tag{5}$$

Then the Aggregate Variance Method (AVM), using the equation:

$$X^{(m)}(k) = \frac{1}{m} \sum_{i=(k-1)m+1}^{km} Xi, \; k = 1, 2, 3, ..., [N/m], \tag{6}$$

$$VarX^{(m)} = \frac{1}{N/m} \left(X^{(m)}(k) - \bar{X} \right)^2. \tag{7}$$

So the slope of AVM will be caculated:

$$H = 1 - \frac{\beta}{2}. \tag{8}$$

The Multifractal Model of Asset Return will be represented:

$$\lambda = \frac{\alpha_0}{H}. \tag{9}$$

Finally, the Newton-Quasi Method will be represented on:

$$\nabla_x g\left(x^k\right) u^k = -g\left(x^k\right). \tag{10}$$

Furthermore, mono-fractal analysis is performed, where the analysis uses Hurst exponent, using two ways: the previously mentioned Detrended Fluctuation Analysis (DFA) and the Aggregate Variance Method (AVM). According to Kim et al. (2014), to calculate Hurst exponent using the DFA, the input log return to Jarque-Bera test and GARCH will result in a linear relationship between $\log F(n)$ and $\log n$. The slope is d which then uses the slope equation forgets which has been obtained will be counted Hurst exponent with the Hurst exponent. To calculate Hurst exponent with AVM, enter the log return to the Eqs. (5) and (6) so that the variance of the aggregate series can be plotted by m with log plots. The result is a straight line with slope b which has a relationship to calculate the Hurst exponent with Eq. (13) (Matos et al., 2008; Kim et al., 2014).

Source: Hurst (1956), Mandelbrot et al. (1997).

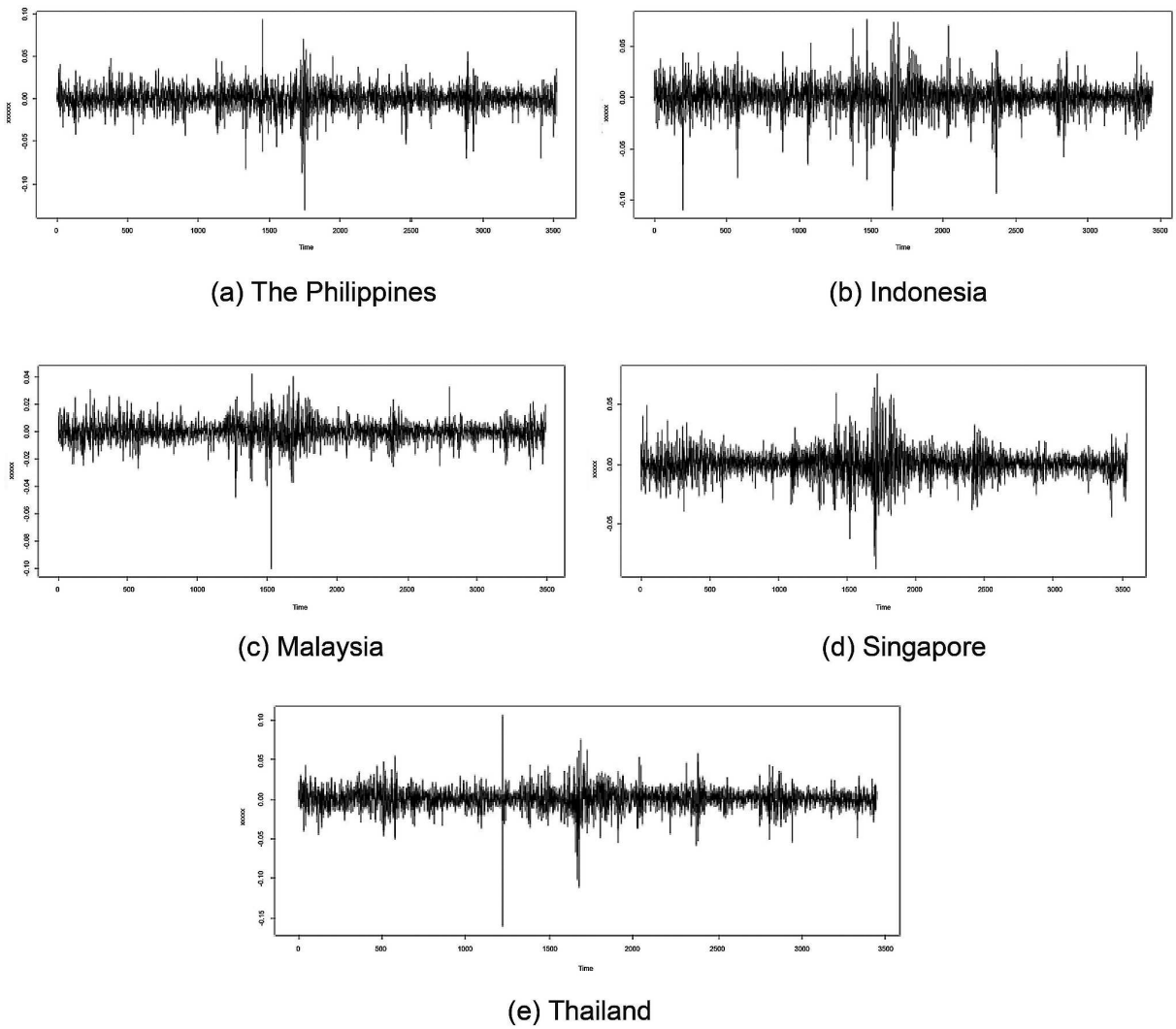

Figure 1. The return index of (a) the Philippines, (b) Indonesia, (c) Malaysia, (d) Singapore, and (e) Thailand (January 1, 2002 – January 31, 2016)

The next step estimates the parameters GARCH, FIGARCH, and GJR-GARCH for the Philippines, Indonesia, Malaysia, Singapore, and Thailand. In estimating these parameters, the Quasi-Newton method of Broyden Fletcher Goldfarb Shanno (BFGS) is used to optimize its parameters (Byrd et al., 1987). The results of estimation obtained will generate t_q for order q from –5 to 5, which becomes scaling function and by searching $t_q = 0$ will get the corresponding q with Eq. (2.4) so that Hurst exponent can be searched for $H = 1q$. Then, the multifractal spectrum can be calculated based on the calculated D_q result, where D_q is selected when D_q equals one. Therefore, with the same D_q with 1 then obtained h_q or can be said α_0. After getting both parameters, according to Jamdee et al. (2005), the average and variance can be calculated along with the standard deviation by using Eqs. (9) and (10).

In the analysis process, the Hurst exponent obtained in the second step and the results of parameters that have been calculated in the third step starting from statistics descriptive to MMAR are analyzed (Matos et al., 2008). The results of these parameters can explain the characteristics of stock indexes in the Philippines, Indonesia, Malaysia, Singapore and Thailand that indirectly can describe the movement of stocks in those countries.

After the analysis, the next stage is to create a simulation, where the simulation results are calculated with Monte Carlo method based on pa-

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rameters that have been calculated using the existing MFE toolbox created by Sheppard to calculate the return ranges from GARCH, EGARCH, FIGARCH, and GJR-GARCH. As for the MMAR model, the FFGN toolbox derived from Wengert[3] is used with parameter results that have been calculated before.

Finally, the models used are compared with respect to the scaling function of simulation results and the scaling function of the return sequence original. The model showing the closest scaling function is considered the best model. It is not only to compare by numbers, but also to calculate standard deviation of the intermediate results scaling function of original return sequence by scaling function series returns the simulation results at each point q where the standard deviation is the most small and is the best model for each country.

3. RESULTS AND DISCUSSION

The results obtained for descriptive statistics are shown in Table 2.

The mean value of the calculation shows that it is approaching zero. Based on the standard deviation, it appears that Indonesia has the largest volatility, followed by Thailand, the Philippines, Singapore, and Malaysia. The result implied that it crates higher uncertainty and risk. But it also creates a higher chance of abnormal returns (Kim, 2014). The results showed a change in the different volatility patterns for different types of stocks. The impact of rumors on each share is different and rumors do not always increase the grouping of stock price volatility. Changes in the pattern of stock price volatility due to rumors not always move the stock price trend up (down). As a result, the implementation of the strategy "buys on rumors, sell on news "will be different for each share and need to be adjusted to the pattern volatility (asymmetrical or symmetrical)". If viewed on the basis of skewness, the whole state has negative skewness; in other words, the return sequence is leaning to the left (Fama, 1990), so the left tail is longer than the right tail. In the world of investment, the curve has a negative skewness will result in losses for investors. If the data in the study are a return data, meaning that the distribution curve is skewed negative returns, the return value of negative median and mode in which it indicates that the returns are mostly negative returns/decrease (Fama, 1990; Day, 1992).

Kurtosis has a value greater than three such that the distribution is not normal where Kurtosis with a value of > 3 indicated that the distribution curve has a more pointed peak compared to the normal curve, and this curve tends to be positive and is called leptokurtic. Leptokurtic distribution is the distribution that usually describes the distribution of asset returns. This distribution is due to the volatility grouping (Campbell, 1992). Kirchler (2007) suggested that information heterogeneity is the main actor in trading activities, volatility and the appearance of fat-tails. Thus from the result showed that there are volatility clustering, the result also found that Malaysia has the largest kurtosis among the five countries. The Jarque-Bera test was used to see whether the data are normally distributed or not (Toggins, 2008). If it is not normally distributed, the data contained elements of time varying volatility. Based on Table 2, all return ranges are located far from normal distribution.

Table 2. The model return series estimation results

Source: Jamdee (2005), Kim (2014).

Statistics	The Philippines	Indonesia	Malaysia	Singapore	Thailand
Mean	0.00049599	0.00072280	0.000255952	0.00013614	0.00042064
Standard deviation	0.01269318	0.01407791	0.00755126	0.01121124	0.01326632
Skewness	–0.6176678	–0.7048186	–0.8517144	–0.1641052	–0.8027332
Kurtosis	7.5534	6.9364	11.8632	5.8887	11.7689
Jarque-Bera	8586.9*	7185.2*	20881*	5117.6*	20263

Note: *p < 2.2e–16.

3 https://www.mathworks.com/matlabcentral/fileexchange/29686-multifractal-model-of-assetreturns–mmar-?requestedDomain=www.mathworks.com

Table 3. Mono-fractal *H* for origin series

Source: Günay (2016).

Method	The Philippines	Indonesia	Malaysia	Singapore	Thailand
Detrended fluctuation analysis	0.461132	0.528436	0.534969	0.525505	0.547426
Aggregated variance	0.549803	0.531409	0.556035	0.570178	0.520577

Next is mono-fractal analysis to see if there is memory on a refund series (Peters, 1994). This is done in two ways: DFA and AVM. The Hurst exponent lies in the range $0 < H < 1$. If the Hurst exponent is 0.5, then the process is said to follow a random walk. When the Hurst exponent is greater than 0.5, it suggests positive long-range autocorrelation in the return series or persistence in the stock price series.

The calculated results are presented in Table 3. Based on the results, its value is around 0.5 and the closest is Singapore using the DFA and Thailand using the AVM method. So if in Table 3 Hurst exponent values obtained about 0.5 indicating a persistent value for the time series against the trend and have the effect of long-term memory (Kim, 2014), where the value of the shares currently affected by the previous values in the long term. Thus a prediction can be made on the stock index because the value is not completely random. But in the DFA method, it appears that the Philippines does not have long-term memory so that there is a possibility that the estimator model is the GARCH model, because it is a fairly common model in finance due to its simplicity.

Based on the estimation of GARCH model in Table 4, the coefficient is used to calculate the reaction of the volatility at any given time against the market; so, volatility is sensitive to market events (Alexander, 2001). According to Dedi (2016), the ARCH parameter of α usually ranges from 0.05 (for a relatively stable market) and around 0.1 (for an anxious market). In other words, α measures the extent of the shock on the feedback generated volatility today following period, and $\alpha + \beta$ measures the rate at which these effects die over time. Table 4 shows that only Singapore has stable market. Meanwhile, Indonesia, the Philippines and Malaysia tended to jump.

The beta coefficient indicates that the shocks to special variance take a long time to die out so that volatility follows before or is said to be persistent (Alexander, 2001). Persistence in volatility indicates a long memory on return variance (Engle & Bollerslev, 1986). The sum of alpha α and beta β is less from one for all countries, and this shows that the process of return is stationary (Alexander, 2008). According to Dedi (2016), long term (cumulative) effect of past shocks on returns is measured by the GARCH parameter β, which usually ranges between 0.85 and 0.98. Thus, Table 4 shows that Singapore has the highest persistence and Thailand is the lowest.

According to Dedi (2016), to see the size of the volatility persistence, the sum of the ARCH and GARCH coefficient values must be used. If that number is closer to one that means the shock effect fades very slowly. The lower the GARCH and ARCH effect value, the faster the effect fades.

The EGARCH model in Table 5 showed asymmetrical effects that are produced based on past shocks in volatility. Therefore, changes occur in volatility to good and bad information incorporated in the model (Alexander, 2008); these asymmetrical effects are shown by parameter

Table 4. Return series estimation results using GARCH model

Source: Engle and Bollerslev (1986), Alexander (2001), Alexander (2008), Dedi (2016).

Country	ω (ρ-value)	α (ρ-value)	β (ρ-value)	$\alpha + \beta$ (ρ-value)
The Philippines	0.00000629 (0.0051)	0.126668 (0.0000)	0.837050 (0.0000)	0.963718 (0.0000)
Indonesia	0.00000543 (0.0044)	0.127432 (0.0000)	0.849257 (0.0000)	0.976689 (0.0000)
Malaysia	0.00000126 (0.0024)	0.125107 (0.0000)	0.857966 (0.0000)	0.983073 (0.0000)
Singapore	0.00000087 (0.0005)	0.093130 (0.0000)	0.902086 (0.0000)	0.995216 (0.0000)
Thailand	0.00000981 (0.1396)	0.117066 (0.0000)	0.828143 (0.0000)	0.945209 (0.0000)

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Table 5. Return series estimation results using EGARCH model

Source: Liu and Hung (2010).

Country	ω (ρ-value)	α (ρ-value)	γ (ρ-value)	β (ρ-value)
The Philippines	–0.496596 (–9.33629)	0.249134 (17.7694)	–0.074199 (–10.2034)	0.94265 (157.87)
Indonesia	–0.316007 (–9.68271)	0.216272 (16.9089)	–0.0783377 (–11.0853)	0.962387 (256.675)
Malaysia	–0.286723 (–9.19–84)	0.215639 (16.6135)	–0.0663465 (–10.6039)	0.970114 (310.362)
Singapore	–0.120348 (–5.83638)	0.166985 (13.1825)	–0.0661759 (–8.98003)	0.986656 (452.629)
Thailand	–0.639615 (–12.2083)	0.217691 (12.2216)	–0.11163 (–13.6277)	0.925927 (158.606)

g. The results show that it is the leverage effect where negative shock return creates volatility greater than positive returns. As seen in Table 5, Thailand has the smallest value, indicating that there is a considerable effect on volatility caused by shock negative return.

Table 6 shows the estimation for the FIGARCH method based on alternative distributions such as Student's *t*-test, skewed Student's *t*-test and Generalized Error Distribution (GED) and to determine the distribution, using Akaike Information Criterion (AIC) to measure quality of model, where the selected AIC is the most AIC small (Mandelbrot et al., 1997). Based on the results obtained, the Philippines, Indonesia, Malaysia, Singapore, and Thailand are well suited to skewed Student's *t* distributions. The results in Table 6 are shown for asymmetry and tail statistics. The difference fractional d is a test for long-term memory in which volatility $0 < d < 0.5$ is the evidence of long-term memory. As shown in Table 6, the Philippines, Indonesia, Malaysia, and Thailand have $d < 0.5$, indicating that there is long-term memory. Especially for Singapore, it appears that d is at $0.5 < d < 1$, indicating that short-term memory and shocks that have been passed can have an effect on the current payback. In the GJR-GARCH model the leverage is around l. The results presented in Table 6 show that the shocks are negative and has a large volatility impact compared to positive shocks. Thailand has the greatest value so the effects of negative shocks have a big impact on volatility rather than positive shocks. This effect is followed by the state Indonesia, the Philippines, Malaysia and Singapore.

Table 6 determines whether or not the mono-fractal return series is multifractal, the graph of the scaling function should be prepared. The scaling function of the five composite stock indexes is graphed with the *x*-axis being *q* that runs from –5 to 5. In Figure 2, the scaling function graph is not linear like the one in the mono-fractal time series. So, it can be concluded that this return series is multifractal (Jamdee, 2005).

Source: Hurst (1956), Jamdee (2005).

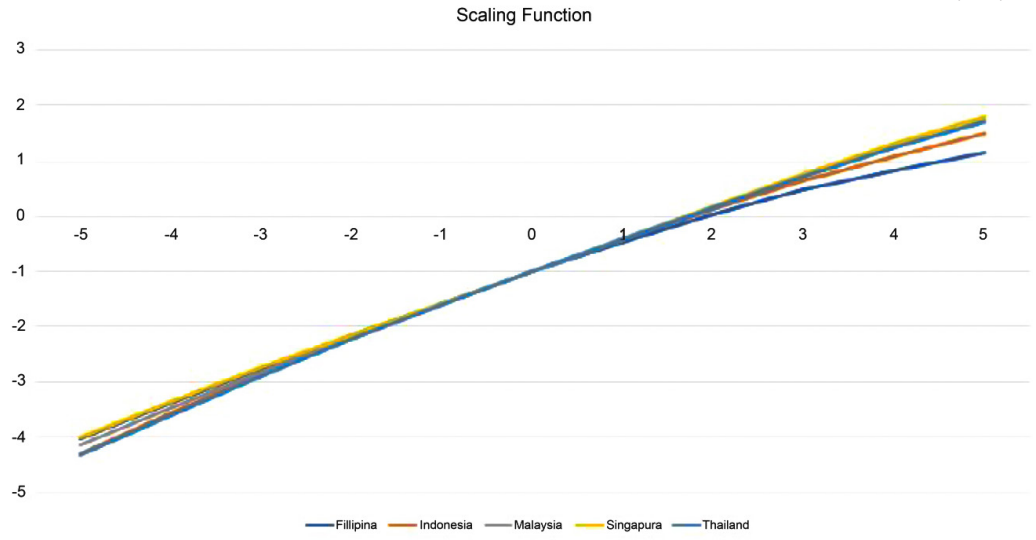

Figure 2. The scaling function of the nonlinear return sequence that shows an existing series of returns is multifractal

Source: Jamdee and Los (2005).

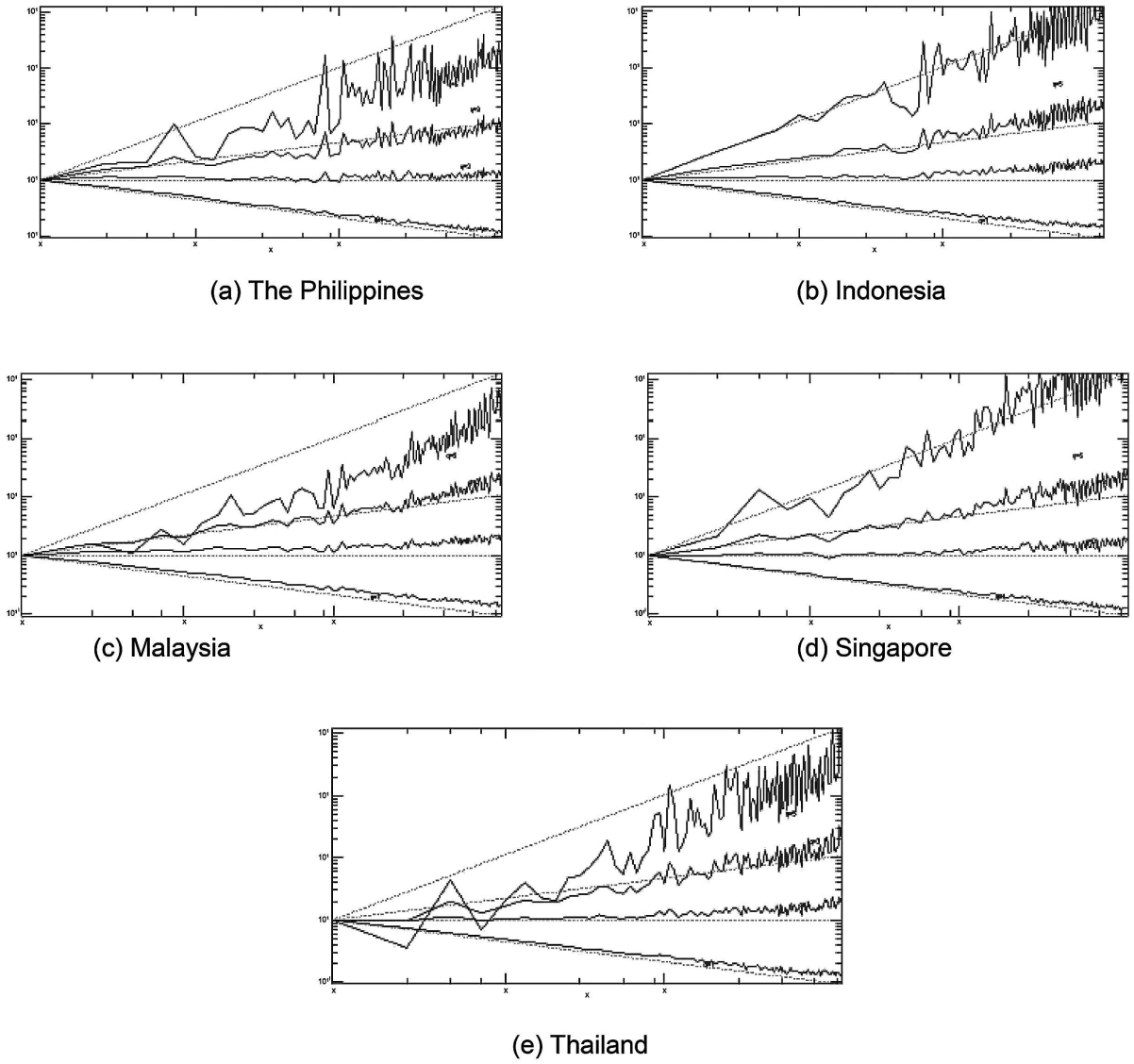

Figure 3. Partition function each country parallel with the horizontal axis on range two

According to Jamdee and Los (2005), the partition function should be parallel to a horizontal line, reflecting a connection with Hurst. The exponent and q values shown are at the two values seen in Figure 3. With the estimated q results contained in Table 6, the q for the Philippines, Indonesia, Malaysia, Singapore, and Thailand runs parallel to the horizontal axis that lies in the range number two.

Table 6. Order q of returning series

Source: Hurst (1956), Jamdee (2005).

Country	The Philippines	Indonesia	Malaysia	Singapore	Thailand
q	1.916	1.760	1.684	1.703	1.714

Based on Jamdee and Los (2005), for the MMAR, four parameters are required: Hurst exponent (H), possibly the value of Hurst exponent at transaction time α_0, and the average and variance of log normal distribution λ and σ^2. Based on the obtained result shown in Table 7, it appears that Malaysia has the highest Hurst exponent among other countries. This shows that the stock index of Malaysia's merger is persistent or can be said to have long-term memory. Although the Philippines has long-term memory but it is not as high as that of Indonesia, Malaysia, Singapore, and Thailand. This is based on the results that show the existing stock index is not a random walk series. Figure 3

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Table 7. Return series estimation results using multifractal model

Source: Hurst (1956), Di Matteo et al. (2005), Kim (2014).

Country	H	α_0	Λ	σ^2
The Philippines	0.521921	0.5529	1.059356	0.171266
Indonesia	0.568182	0.58289	1.025886	0.074692
Malaysia	0.593824	0.5962	1.0040011	0.011544
Singapore	0.587119	0.5996	1.021119	0.060936
Thailand	0.583431	0.58984	1.010986	0.031698

shows that Singapore has the largest q result = 1, indicating that there is a relationship between market persistent level and persistent level information process on the Singapore stock market. But for the variance, the Philippines have the greatest variance compared to other countries. This shows that the Philippine stock market is affected by the vast range of information events.

Based on the parameters calculated in Table 8, i.e. GARCH, EGARCH, FIGARCH, GJR-GARCH, and MMAR, 1,000 simulations were created for each model with the Monte Carlo method. The purpose of simulation with Monte Carlo method is to analyze the performance of the method (Hurst, 1956). This is done to calculate the scaling function of the simulation results obtained and then compare it to the scaling function derived from the actual data. The results of scaling function for q from −5 up to 5 and for each country are shown in Table 9. The best model is that whose simulated results are the closest to its original scaling function. It was found that GARCH is the best model for the Philippines because of scaling function for the point q from −5 to 5; the GARCH model has the value closest to the original return sequence. The MMAR model is the best model for Malaysia, Singapore, and Thailand with a difference value on the scaling function that is not far from the original return sequence. For Indonesia, the best model is EGARCH. The comprehensive result also calculated the standard deviation of the difference between the scaling function of the original return sequence with scaling function simulation data given in Table 7. The MMAR model has the least standard deviation compared to other methods, except for the Philippines and Indonesia as each country has its own best model, i.e. GARCH and EGARCH, respectively (Figure 4).

Source: Hurst (1956), Kim (2014).

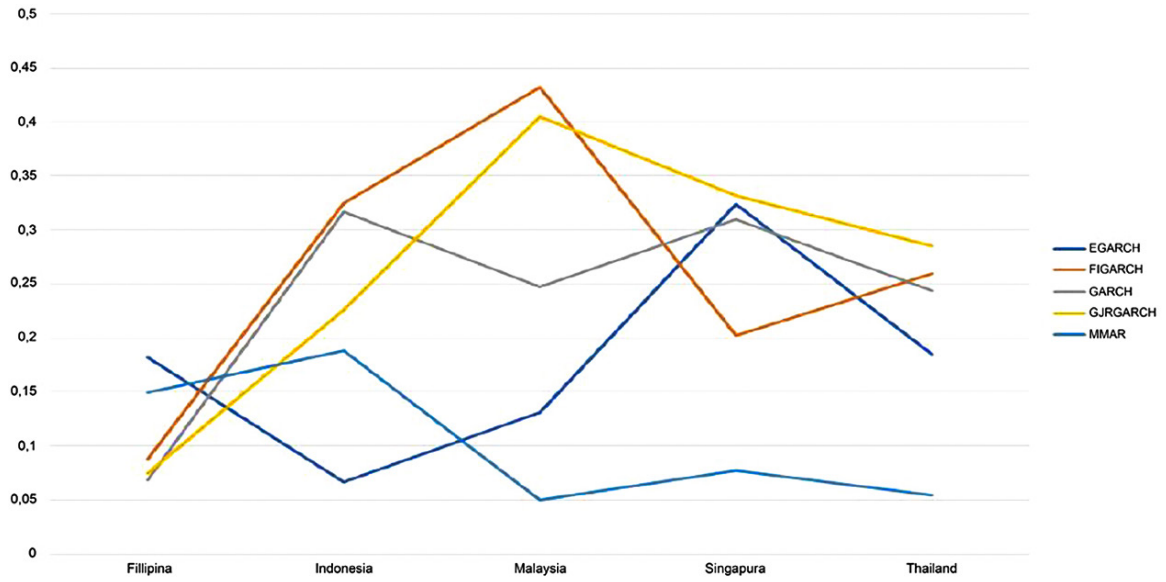

Figure 4. The path of standard deviation shows the MMAR model has the smallest value compared to other models

Table 8. Standard deviation from difference between original and simulated

Source: Toggins (2008), Kim (2014).

Country	EGARCH	FIGARCH	GARCH	GJR-GARCH	MMAR
The Philippines	0.18167	0.08794	0.06867	0.07412	0.14927
Indonesia	0.06656	0.32472	0.31685	0.22604	0.18811
Malaysia	0.13104	0.43203	0.24718	0.40460	0.04982
Singapore	0.32411	0.20228	0.30950	0.33160	0.07757
Thailand	0.18474	0.25932	0.24395	0.28486	0.05437

Table 9. Scaling function

Source: Hurst (1956), Kim (2014).

Q	Original	EGARCH	FIGARCH	GARCH	GJR-GARCH	MMAR
The Philippines						
–5	–1.565	–1.550	–1.550	–1.572	–1.526	–1.557
–4	–2.152	–2.162	–2.162	–2.190	–2.092	–2.127
–3	–2.758	–2.985	–2.839	–2.850	–2.707	–2.718
–2	–3.383	–3.753	–3.575	–3.547	–3.374	–3.332
–1	–4.025	–4.559	–4.357	–4.276	–4.086	–3.969
1	–0.461	–0.447	–0.507	–0.484	–0.512	–0.446
2	0.040	0.061	–0.068	–0.033	–0.063	0.112
3	0.478	0.526	0.321	0.352	0.341	0.666
4	0.839	0.954	0.667	0.787	0.701	1.203
5	1.142	1.351	0.979	0.987	1.023	1.715
Indonesia						
–5	–4.298	–4.135	–-3.984	–4.236	–4.080	–4.498
–4	–3.567	–3.467	–3.309	–3.468	–3.400	–3.373
–3	–2.871	–2.818	–2.668	–2.758	–2.747	–3.008
–2	–2.214	–2.190	–2.065	–2.113	–2.126	–2.313
–1	–1.593	–1.582	–1.508	–1.530	–1.543	–1.646
1	–0.425	–0.447	–0.546	–0.528	–0.503	–0.370
2	0.130	0.072	–0.150	–0.133	–0.058	0.244
3	0.642	0.559	0.191	0.169	0.326	0.842
4	1.091	1.015	0.481	0.393	0.653	1.423
5	1.480	1.447	0.731	0.571	0.935	1.989
Malaysia						
–5	–4.146	–4.309	–3.653	–4.142	–4.253	–4.326
–4	–-3.467	–3.566	–3.079	–3.440	–3.488	–3.602
–3	–2.815	–2.857	–2.523	–2.768	–-2.765	–2.904
–2	–2.191	–2.192	–1.988	–2.132	–2.103	–2.237
–1	–1.591	–1.574	–1.478	–1.540	–1.514	–1.603
1	–0.405	–0.465	–0.562	–0.513	–0.565	–0.426
2	0.185	0.034	0.170	0.075	–0.212	0.121
3	0.743	0.494	0.174	0.322	0.069	0.643
4	1.254	0.913	0.475	0.684	0.296	1.143
5	1.724	1.297	0.743	1.019	0.488	1.623
Singapore						
–5	–3.998	–3.990	–4.385	–4.069	–3.931	–4.166
–4	–3.356	–3.337	–3.630	–3.374	–3.277	3.478
–3	–2.738	–2.707	–2.906	–2.712	–2.652	–2.817
–2	–2.144	–2.104	–2.221	–2.093	–2.060	–2.185
–1	–1.568	1.533	–1.584	–1.522	–1.508	–1.580
1	–0.420	–0.518	–0.472	–0.532	–0.540	–0.443
2	0.178	–0.101	–0.002	–0.121	–0.129	0.091
3	0.762	0.247	0.407	0.239	0.235	0.600
4	1.305	0.538	0.761	0.562	0.558	1.087
5	1.807	0.788	1.076	0.858	0.849	1.552
Thailand						
–5	–4.332	–4.050	–4.037	–4.049	–3.942	–4.121
–4	–3.599	–3.388	–3.351	–3.372	–3.306	–3.472
–3	–2.897	–2.749	–2.702	–2.726	–2.695	–2.838
–2	–2.230	–2.137	–2.094	–2.115	–2.108	–2.218
–1	–1.600	1.554	–1.527	–1.540	–1.545	–1.606
1	–0.415	–0.475	–0.509	–0.495	–0.480	–0.402
2	0.165	0.021	–0.051	–0.027	–0.006	0.184
3	0.722	0.489	0.376	0.402	0.398	0.751
4	1.234	0.933	0.777	0.794	0.735	1.297
5	1.699	1.356	1.156	1.156	1.024	1.820

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CONCLUSION

Based on the estimation of GARCH, EGARCH, FIGARCH, GJR-GARCH, and MMAR parameters, there is a long-term memory in the stock indexes of the Philippines, Indonesia, Malaysia, Singapore, and Thailand that build the characteristics of the market due to the asymmetry information. Based on the MMAR parameter estimation, the sequence of the largest persistent values reflected in Hurst exponent is as follows: Malaysia, Singapore, Thailand, Indonesia, and the Philippines. In ASEAN countries, the value of Hurst exponent greater than 0.5 indicates that the stock indexes of those countries has long-term memory, so they do not follow the random walk by creating 1000 simulations of return series from each model and each country using parameters that have been previously obtained. The value of the scaling function is calculated and compared for the original return sequence and the simulated return series for the starting q from 1 to 5. When comparing the scaling function, the model found to be suitable in general is the MMAR.

Therefore, to calculate the volatility, especially the stock index, the MMAR model should be used. The MMAR model is generally suitable for stock indexes in ASEAN countries. This MMAR model shows that the stock index in ASEAN countries has long-term memory; this is also supported by the calculation results of EGARCH parameters, FIGARCH, GARCH, and GJR-GARCH. For the Philippines and Indonesia, the suitable models are GARCH and EGARCH, respectively. The Philippines has another alternative model that is not much different from the GARCH model, i.e., EGARCH model, which is influential. For the state of Indonesia, the MMAR model is suitable. Malaysia and Thailand have the same alternative model, i.e., EGARCH model. This shows that there are asymmetrical effects. Singapore has an alternative model, i.e., FIGARCH, which shows long-term memory. Thus, if you want to suspect the volatility in stocks in those countries, it is better to consider the best model based on this research. This can support each country that has the best model suitable for each country.

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