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| RESEARCH ARTICLE

Adaptive Market Efficiency Hypothesis in ASEAN Stock Markets: A Variance Ratio Analysis Across Market Capitalization Segments

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| ABSTRACT

This study examines the efficiency of the ASEAN stock market and investigates the dynamic adaptability of this efficiency over time. Utilizing advanced methodologies, including the Multiple Variance Ratio (MV) and Wild Bootstrapped Variance Ratio (WBVR) tests, in conjunction with the Rolling Window technique, the research assesses market efficiency across different periods from March 2009 to March 2024. The analysis is conducted using daily price data, segmented into the overall market and three sub-groups based on market capitalization, to explore the potential impact of company size on market efficiency. The findings indicate that market efficiency is not static; it fluctuates, particularly during periods of economic crises or significant events, when all market segments exhibit inefficiency, deviating from the Random Walk theory. This suggests that during such periods, stock prices become more predictable, contrary to the expectations of an efficient market. Additionally, the study finds that changes in market efficiency are consistent across different company sizes, suggesting that market or company size does not significantly influence efficiency.

| KEYWORDS

adaptive market efficiency hypothesis, variance ratio, ASEAN stock market, efficient market hypothesis

| ARTICLE INFORMATION

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1. Introduction

The concept of Adaptive Market Efficiency Hypothesis (AMH) offers a nuanced understanding of how stock markets operate, particularly in emerging economies such as those in the ASEAN region. Unlike the traditional view of market efficiency, which is static, AMH suggests that efficiency evolves in response to changing market conditions, investor behavior, and the broader economic environment (Lo,2004). This study explores the efficiency of ASEAN stock markets by applying variance ratio analysis across different market capitalization segments—large-cap, mid-cap, and small-cap. By examining how these segments adapt over time, the research provides critical insights for investors and policymakers navigating these rapidly changing markets.
In a period of heightened global financial integration, understanding market efficiency has become increasingly important for effective investment and regulatory strategies. This research employs a rolling window technique to capture the dynamic nature of market efficiency across various market segments in the ASEAN region. The findings will highlight how different segments react to external shocks and investor behaviors, offering practical recommendations for optimizing investment strategies and improving market regulations. By focusing on the adaptive aspects of market efficiency, this study not only contributes to the ongoing discussion in behavioral finance but also provides a comprehensive analysis of an underexplored region in the literature.

2. Literature Review

Efficiency in financial markets, particularly when comparing developed and emerging markets, has been a focal point of extensive research. Studies, such as those by Memon (2024), consistently find that developed stock markets exhibit greater efficiency, driven by factors like market maturity, robust regulatory frameworks, and effective information dissemination. These elements contribute to the informational efficiency observed in developed markets, where prices more accurately reflect available information, enabling better price discovery and informed investment decisions. Conversely, emerging markets often struggle with informational inefficiencies, making them more susceptible to mispricing and volatility. Research by Sabbaghi & Sabbaghi (2018) highlights this contrast, emphasizing the importance of market transparency and regulatory oversight in promoting efficiency. Recognizing these disparities is crucial for investors and policymakers, who must tailor their strategies to navigate the unique complexities and opportunities presented by different market environments.

Furthermore, comparative analyses, such as those by Lee & Choi (2023), suggest that while developed markets are generally more efficient, these levels of efficiency can vary over time and are influenced by global financial dynamics. The convergence of efficiency levels between developed and emerging markets points to an evolving landscape, where adaptive strategies are necessary to capitalize on emerging trends. Insights from Mynhardt et al. (2014) on market behavior during crises further demonstrate that developed markets tend to maintain higher efficiency during turbulent times, owing to their more sophisticated market structures. Finally, as noted by A. (2023), the ongoing convergence of efficiency between markets signals the need for continuous adaptation in investment and risk management strategies, ensuring they remain aligned with the dynamic nature of global markets.

Efficiency in emerging markets has garnered significant attention in financial research, revealing that these markets often exhibit lower efficiency levels compared to their developed counterparts. Clougherty et al. (2016) highlight that emerging markets generally show less efficiency, which underscores the necessity of evaluating these markets to understand the factors influencing their performance. Factors such as small market size, thin trading, lack of regulations, and various frictions contribute to the inefficiencies observed in these markets (Al Homaidy, 2020). These characteristics pose challenges for achieving market efficiency and navigating investment opportunities. Investors and policymakers need to be aware of these inefficiencies to make informed decisions and optimize strategies in the context of emerging markets.

Research also suggests that increased market openness can enhance market efficiency in emerging economies. Bai et al. (2021) found that as markets become more open, efficiency tends to improve, emphasizing the role of economic policies that promote transparency and openness. Additionally, studies on securitized real estate markets, such as those by Schindler (2010), provide insights into efficiency by examining return dynamics and market functionality in these specialized segments. Furthermore, comparative analyses indicate that emerging markets are generally less efficient in processing economic information compared to developed markets (Alam & Akbar, 2015). Recognizing these efficiency disparities allows investors to tailor their strategies to manage risks and capitalize on opportunities effectively within emerging markets.

This research is significant as it bridges a gap in the existing body of knowledge on market efficiency, particularly in the context of emerging markets like those in ASEAN. While much of the previous work has concentrated on developed markets, this study enriches the discourse by offering a detailed examination of the adaptive efficiency of ASEAN stock markets, including considerations of market capitalization. The findings are expected to provide valuable insights that can guide both investors and policymakers in making informed decisions that reflect the unique characteristics and challenges of these markets.
The objectives of this research are:
1. To empirically assess the degree of market efficiency in various capitalization segments of ASEAN stock markets using variance ratio tests.
2. To identify and analyze the external factors that impact market efficiency across different time frames.
This thesis posits the following hypotheses:
1. H1: The degree of market efficiency varies significantly across different market capitalization segments in ASEAN stock markets.
2. H2: External economic shocks and investor sentiment significantly influence the adaptive nature of market efficiency over time.
To achieve these objectives, a quantitative methodology will be employed, primarily utilizing variance ratio analysis to test market efficiency across different segments of the ASEAN stock markets.

3. Methodology

3.1 Data

In this study, daily indices closing prices of the ASEAN stock market were collected from Bloomberg database, measured and provided by MSCI. The ASEAN index (MXSO Index) is further categorized into three sub-indices based on market capitalization, including MXSOLC large-cap, MXSOMC mid-cap and MXSOSC small-cap index. The MXSO Index captures securities representation across 4 emerging markets countries and 1 developed market country, Indonesia, Malaysia, the Philippines, Thailand and Singapore. With 114 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country. The daily time series data in this study covers the period of 3 March 2009 to 3 March 2024. The series of daily closing prices are transformed into a series of returns to induce stationery.

3.2 Traditional Variance Ratio (VR) Test

This study employed three VR tests, namely LMVR, MVR and WBVR, for examining the weak-form EMH for ASEAN stock market. The detailed derivation of each test is explained as follows:

3.2.1 Lo–MacKinlay variance ratio (LMVR)

The LMVR test assumes that if a time series (return) $\{r_t\}$ follows a random walk, then the variance of the increments should be proportional to the length of the observation interval. Specifically, for a time series r_t, the test compares the variance of k-period returns to the variance of single-period returns.

Let $r_t = Ln\frac{r_t}{r_{t-1}}\ x\ 100$ be the return of an asset. The variance of k-period returns under the random walk hypothesis is expected to be k times the variance of single-period returns.

On the other hand, the random walk hypothesis (RWH) can be tested by comparing 1/k times the variance of k-period to the variance of one-period. The result of the comparison must be equal to 1.

$$VR(k) = \frac{\sigma^2(k)}{\sigma^2(1)}$$

where $\sigma^2(k)$ is $1/k$ times the variance of k-period and $\sigma^2(1)$ is the variance of one-period. The significance can be tested statistically by setting the null hypothesis as: $VR(k)$ is not statistically different from 1. While $\sigma^2(1)$ and $\sigma^2(k)$ are calculated as follows.

$$\sigma^2(1) = \frac{1}{T-1}\sum_{t=1}^{T}(r_t - r_{t-1} - \hat{\mu})^2$$

where $\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T}(r_t - r_{t-1})$

and

$$\sigma^2(k) = \frac{1}{Tk}\sum_{t=k}^{T}(r_t - r_{t-q} - k\hat{\mu})^2$$

where $T = (T-k+1)\left(1-\frac{k}{T}\right)$

According to Lo and MacKinlay (1989), the test statistics of weak-form EMH are derived under two assumptions: maintained hypothesis of homoscedasticity and of heteroscedasticity. The asymptotic standard normal test statistic for the variance ratio, $z(k)$, is expressed as follows:

$$z(k) = (VR(k) - 1) \times [\hat{s}^2(q)]^{-1/2}$$

Under the assumption of homoscedasticity, the estimator $\hat{s}^2(k)$, can be obtained from:

$$\hat{s}^2(k) = \frac{2(2k-1)(k-1)}{3kT}$$

While under the assumption of heteroscedasticity-robust the estimator $\hat{s}^2(k)$ is:

$$\hat{s}^2\,(k) = \sum_{j=1}^{k-1}\left(\frac{2(k-j)}{k}\right)^2 \times \hat{\delta}_j$$

where $\hat{\delta}_j = \frac{\left(\sum_{t=j+1}^{T}(r_{t-j} - \hat{\mu})^2(r_t - \hat{\mu})^2\right)}{\left(\sum_{t=j+1}^{T}(r_{t-j} - \hat{\mu})^2\right)^2}$

3.2.2 Multiple variance ratio (MV)

The Multiple Variance Ratio (MV) test is an extension of the classic Variance Ratio (VR) test, allowing for the simultaneous testing of multiple time horizons or holding periods. This method is particularly useful in assessing market efficiency over various time scales, providing a more comprehensive evaluation than the single VR test. The idea behind the MV test is to assess whether a time series, such as stock returns, follows a random walk by testing the variance ratios across multiple lag lengths $k_1, k_2, \ldots, k_m$. If the market is efficient and follows a random walk, all the variance ratios should be close to 1 Chow and Denning (1993).

The Multiple Variance Ratio (MV) test simultaneously evaluates the null hypothesis for each k_i:

H_0 : $VR(k_i) = 1$ for all $i=1,2,\ldots,m$

against the alternative hypothesis:

H_A : $VR(k_i) \neq 1$ for at least one i

Since any rejection of H_{0_i} will lead to the rejection of RWH. The test statistic can be formulated as:

$$MV = \underset{1\le i\le m}{MAX}|\hat{s}^2(q_i)|$$

The decision regarding null hypothesis can be made based on the maximum absolute value of the individual *VR* statistic. The *MV* statistic follows the studentized maximum modulus distribution with *m* and *T* degree of freedom, where *m* is the number of *q* values whose critical values are tabulated in the study of Stoline and Ury (1979). When *T* is large ($T = \infty$), the null hypothesis is rejected at α level of significance if the *MV* statistic is greater than the $\left[1-\frac{\alpha^*}{2}\right]^{th}$ percentile of the standard normal distribution where $\alpha^* = 1-(1-\alpha)^{1/m}$.

3.2.3 Wild bootstrap variance ratio (WBVR)

The Wild Bootstrap Variance Ratio (WBVR) test is an advanced method for testing market efficiency, particularly addressing some of the limitations of traditional variance ratio tests, such as heteroskedasticity in return series. The WBVR test leverages the wild bootstrap method to generate robust p-values and confidence intervals, making it a more reliable tool in empirical finance(Kim ,2006). The wild bootstrap approach is computed in three steps described below:

1. Form a bootstrap samples of *T* observations $r_t^* = \eta_t r_t \, (t = 1, \dots, T)$ where η_t is a random sequence with zero mean and unit variance.
2. Calculate the *MV**, which is the *MV* statistic of Chow and Denning obtained from the bootstrap sample in first step.
3. Repeat the first two steps *K* times to form a bootstrap distribution$\{MV^*(j)\}_{j=1}^{K}$.

The bootstrap distribution $\{MV^*(j)\}_{j=1}^{K}$ is used to approximate the sampling distribution of the MV statistic. The p-value of the test can be obtained as the proportion of $\{MV^*(j)\}_{j=1}^{K}$ that is greater than the MV statistic calculated from original data.

3.3 Rolling window Technique

To capture the dynamic nature of market efficiency over time, the study employs a rolling window technique. This approach allows for the continuous assessment of market efficiency by calculating the MV and WBVR test statistics over overlapping sub-periods within the dataset. This method is supported by Kim et al. (2011) study, suggesting that the rolling windows approach allows the achievement of results that are robust to outlier and structural changes. It is interesting to apply this method to obtain more exact and robust results. In this study, the WBVR tests will be deployed over the whole dataset using a one-year window length (252 trading days) for daily data. The rolling windows method is deployed in the following steps

1. **Window Selection:** A rolling window of 252 trading days, equivalent to one year, is selected for the period of 3 March 2009 to 3 March 2024.
2. **Moving the Window:** The rolling window is moved forward one day at a time, recalculating the MV and WBVR test statistic for each new window. This process generates a time series of MV and WBVR statistics, which reveals how market efficiency evolves over time.
3. **Adaptive Efficiency Analysis:** By analyzing the MR and WBVR statistics across rolling windows, the study can identify periods of efficiency and inefficiency, providing insights into how market conditions and external factors influence market behavior.

4. Results and Discussion

The time series plots of ASEAN market indices are illustrated in Figure 1. The daily price indices are presented on the top row, while the daily indices returns are displayed on the bottom, overall market data, large-cap, mid-cap, and small-cap from the left to the right respectively. It is obviously visualized from the plots that all the price series are non-stationary, presenting non-constant mean and non-constant variance. It should be noted that the returns indices exhibit several extreme outliers during the market events, Eurozone financial crisis (2011-2012), US revised QE policy (2013-2014), global commodity price slump due to economic slowdown (2015-2016), and the COVID-19 pandemic crisis (2020-2021). Summary statistics of ASEAN indices returns are reported in Table 1. The skewness values suggest that all indices are negatively skewed. Kurtosis values for all series exceed 3, indicating leptokurtic distributions with heavy tails. The Jarque-Bera test statistics are extremely high, and the associated probabilities are zero, rejecting the null hypothesis of normality for all series at any conventional significance level.

Furthermore, the unit root tests were conducted to measure data stationary indicating whether the data follows a random walk hypothesis or not. The results of ADF and PP tests consistently reject the null hypothesis of a unit root at conventional significance levels, indicating that all series are stationary and do not follow a random walk. Lastly, the ARCH test statistics indicate the presence of autoregressive conditional heteroskedasticity in all series. The LM test for heteroskedasticity also reveals significant results across all series. These results confirm that all series exhibit significant heteroskedasticity, requiring appropriate modeling techniques to account for changing volatility over time. However, r, Lo and MacKinlay (1989) stated that variance ratio test is more powerful than conventional test, such as ADF test, and when using an appropriately time interval and accounting of heteroskedasticity.

Figure 1. Time series plots for ASEAN stock market indices

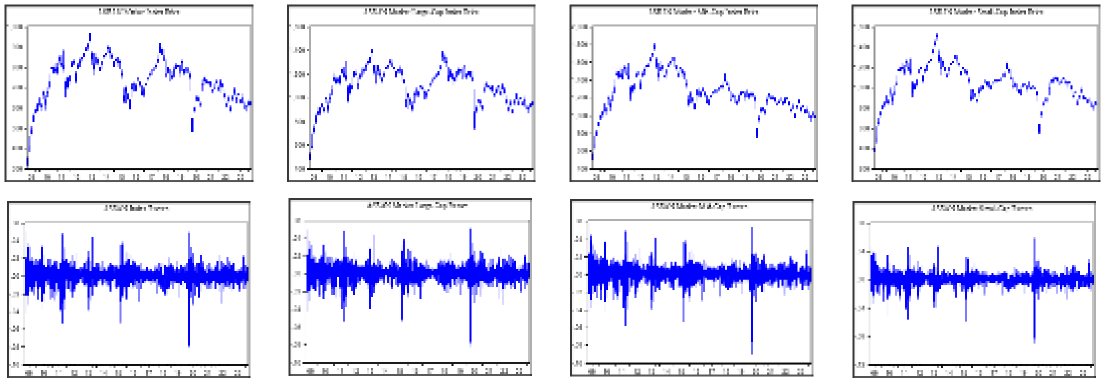


Table 1. Summary statistics for returns of indices

	Market index	Large Cap	Mid Cap	Small Cap
Mean	0.0176	0.0182	0.0165	0.0194
Median	0.0222	0.0231	0.0259	0.0424
Maximum	5.1519	5.1345	5.7318	5.9070
Minimum	-7.9600	-8.2009	-8.8923	-9.0528
Std. Dev.	0.9282	0.9375	0.9575	0.9059
Skewness	-0.4669	-0.4348	-0.4747	-1.0502
Kurtosis	10.5443	10.3505	10.4532	15.9405
Jarque-Bera	9426.8160	8936.9219	9208.6708	28036.1074
Probability	0.0000	0.0000	0.0000	0.0000
Observations	3915.0000	3915.0000	3915.0000	3915.0000
Unit root test				
ADF	-39.1931*	-39.1043*	-39.3722*	-22.3660*
PP	-58.2819*	-58.2798*	-58.8005*	-58.9335*
Heteroskedasticity test				
ARCH test	244.1025*	241.1402*	206.5590*	611.8855*
LM test	10.5319*	9.3442*	12.2397*	71.9613*

*Indicate significant level at 1%

Figure 2. The p-value of the ASEAN market index using the MV and WBVR methods.

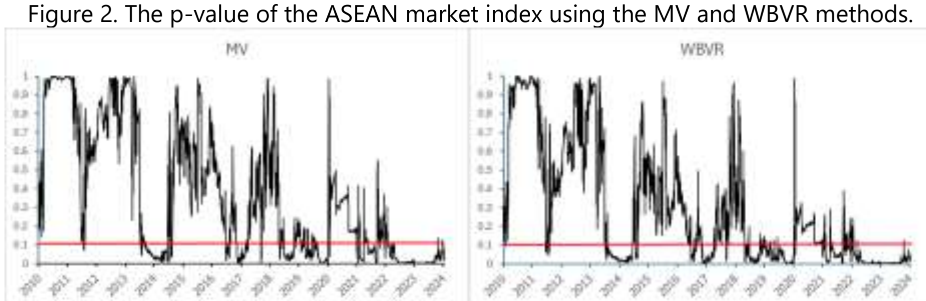


Figure 3. The p-value of the ASEAN Large-Cap market index using the MV and WBVR methods.

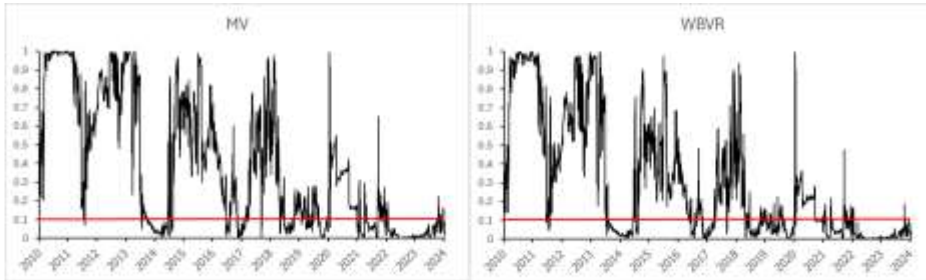


Figure 4. The p-value of the ASEAN Mid-Cap market index using the MV and WBVR methods.

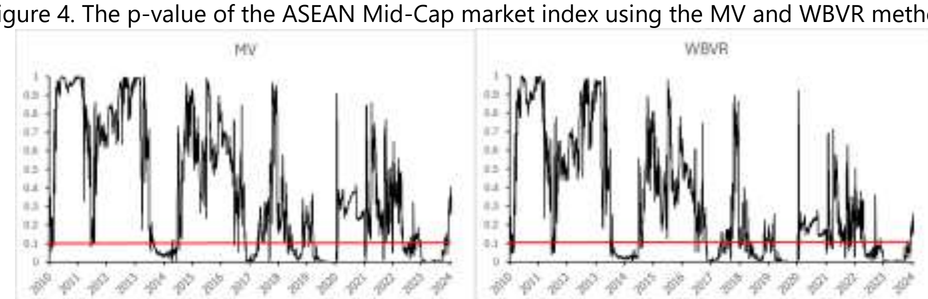
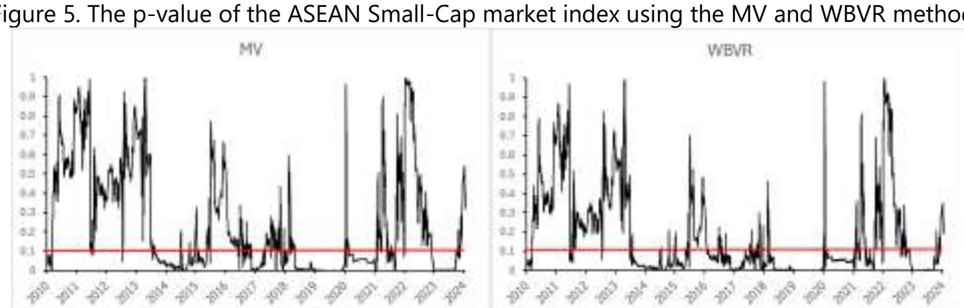


Figure 5. The p-value of the ASEAN Small-Cap market index using the MV and WBVR methods.



Figures 2 through 5 present the results of hypothesis testing on the adaptability of ASEAN stock market efficiency, both in aggregate terms and for each sample group categorized by company size (Market Capitalization). These figures depict the p-values obtained from tests conducted using the MV and WBVR methods for each time window of 252 days. As the time window is rolled forward (Rolling), new p-values are generated using the MV and WBVR methods, and these p-values are displayed continuously until the completion of the Rolling Windows process.

The horizontal line across the x-axis represents the 10% statistical significance level. If the p-value falls below this significance level, it indicates a rejection of the null hypothesis that returns are unpredictable or that changes in index returns do not follow a random walk (Non-Random Walk). Such a result may suggest that the stock market is inefficient. Conversely, if the p-value is above the statistical significance line, it indicates insufficient evidence to reject the null hypothesis, allowing us to conclude that index returns follow a random walk (Random Walk), or that investors cannot predict returns (Return Unpredictability), which reflects the efficiency of the stock market.

The empirical results suggest that the overall stock market, large-cap indices, mid-cap, and small-cap indices exhibited inefficiency during several periods, which linked to the economic crisis or market event, Eurozone financial crisis (2011-2012), US revised QE policy (2013-2014), global commodity price slump due to economic slowdown (2015-2016), and the COVID-19 pandemic crisis (2020-2021). Furthermore, the results show that the overall ASEAN stock market has demonstrated efficiency since after the Covid-19 pandemic. These test results support the Adaptive Efficient Market Hypothesis (Adaptive EMH) for the ASEAN stock market and are consistent with Kok & Geetha (2023), Shaik & Maheswaran (2017), Setiawan (2020), and Trung & Quang (2019) even using difference methodology.

5. Conclusion

This research conducts a comprehensive analysis of the ASEAN stock market to evaluate its efficiency and examine how this efficiency evolves or adapts over time. The study specifically investigates whether company capitalization has an influence on market efficiency. The outcomes of this research are significant to various stakeholders, including investors, financial institutions, and regulatory organizations, as they provide valuable insights for developing effective investment strategies and enhancing the overall efficiency of the market. In this study, two advanced testing methods, MV (The Multiple Variance Ratio) and WBVR (Wild-Bootstrapped Variance Ratio), are utilized. These methods were developed by Chow and Denning (1993) and Kim (2006). The Rolling Window technique is employed to capture dynamic changes in efficiency over time. This technique allows for continuous observation of market behavior, providing a clearer picture of how market efficiency adapts to different economic conditions and external shocks.

The analysis is based on a robust dataset comprising daily price data from March 2009 to March 2024, measured by MSCI. The dataset is segmented into one overall marker index and three sub-segments based on market capitalization. This segmentation enables the study to explore the potential differential impacts of company size on market efficiency.
The findings from the analysis reveal that market efficiency is not static; instead, it exhibits significant variability across the studied period. The results show that during periods of economic crisis or significant market events, all four market groups—large-cap, mid-cap, small-cap, and the overall market—display inefficiency. This inefficiency manifests itself as a deviation from the Random Walk theory, suggesting that during these turbulent periods, stock prices become more predictable, contrary to what is expected in an efficient market.

Furthermore, the study examines the impact of company size on market efficiency. The results suggest that market capitalization does not play a significant role in determining the efficiency of the ASEAN stock market. This conclusion is drawn from the observation that when the overall market undergoes a change in efficiency, the sub-markets, regardless of their size, tend to exhibit similar adaptive behavior. This uniformity in response indicates that factors other than size may be more critical in influencing market efficiency. One possible explanation for the observed uniformity across different market segments is the selection criteria employed by MSCI (Morgan Stanley Capital International) in constructing their indices. MSCI tends to select securities with high liquidity and strong performance for inclusion in their indices. As a result, these selected securities might inherently possess similar characteristics that contribute to the observed lack of size-related differences in market efficiency.

The implications of these findings are far-reaching. For investors, understanding that market efficiency can vary over time, particularly during periods of economic distress, is crucial for making informed investment decisions. Financial institutions can use these insights to refine their risk management strategies, while regulatory bodies might consider these findings when formulating policies aimed at maintaining market stability and efficiency. Moreover, the study's results contribute to the broader academic discourse on market efficiency by providing empirical evidence that supports the Adaptive Market Hypothesis, which posits that market efficiency is not a fixed state but rather evolves in response to changing market conditions.

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