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Equity Price Indices and Random Walk: The Case of Malaysia, the Philippines and Taiwan

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This study applies Lo and MacKinlay's methodology on the weekly movements of equity indices in Malaysia, the Philippines, and Taiwan over the period from the first week of 2000 to the second week of 2012. Contrary to the conventional wisdom and empirical results of earlier studies, the results suggest that the equity markets in these Asian countries follow a random walk over the sample period. These findings indicate that investors and portfolio managers cannot profit by trading based solely on past price movements in these selected Asian countries. They however now can include stocks from these economies in their portfolios as international diversification strategies.

Field of Research*: Financial Economics*

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1. Introduction

In perfectly efficient markets, new information is reflected in all markets simultaneously; however, markets in most emerging and developing economies are traditionally not expected to be efficient. As articulated by Floros (2011), if the markets are not efficient, investors and traders can use past information to predict prices or returns in the future.

Additionally, recent technological advances in telecommunications, internet capabilities, transportation, and computerization usage in production facilitated rapid accelerations in world trade and travel, the flow of goods and services, and the movement of financial assets between different nations. The increases in the volume of international trade are based on the exponential growth in the international flow of financial assets, which in turn, has been fueled by the adherence to post-World War II neoclassical export development as well as higher membership and participation in the World Trade Organization.

However, international equity markets have recently provided highly profitable investment opportunities to investors seeking optimum rates of return on a worldwide basis. Among the international equity markets, certain economies such as those in Latin

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American countries, the Middle East and North Africa, European Union, advanced Pacific Rim countries, and Asian countries share many common features as developed economies. The impacts of these new developments on the emerging markets are two folds. First, they broaden and deepen the equity markets. Secondly, they provide resources to improve the infrastructures of the markets, including the information technology. The improvement in the infrastructures and information technology in turn remove some of the opaque characteristics in their equity markets. These are the necessary foundation for an efficient market.

From a different perspective, it is also reasonable to conjecture that those differences in their stages of development, national economic policies, governance, culture, and other institutional arrangements in each of the countries in these groups may result in different equity holding risk profiles. Different equity risk profiles may cause the indices and the returns on the market equity portfolios to be different and independent among seemingly similar economies.

Moreover, it appears that nations are becoming less segmented and more efficient over time. A possible explanation for this is a shift toward liberalization within the region. To this end, Bakaert and Harvey (1997) find that index returns for emerging markets that have undergone liberalization tend to exhibit a lower variance and a higher correlation with other liberalized emerging markets. Gentzoglanis (2007) argues that liberalization should be matched with regulations to protect investors in order to increase market efficiency and economic growth. Lamba (2005) observes that countries in the South and Southeast Asian region have experienced considerable political and social turmoil over the past few years.

This empirical analysis is motivated by the following factors. First, perhaps among these groups of countries, Asian countries are the most unique in relation to themselves and to developed nations. Secondly, nations undergo the processes of privatization and investors' protection at different points in time. Third, previous studies have covered periods from the early 1990s to early 2000s. More importantly, the 1997 Asian financial crisis of international dimension has precipitated the new level of international macroeconomic policy coordination among international economies and particularly the Asian region.

Given the aforementioned, it is important to empirically investigate the efficiency of equity markets in Malaysia, the Philippines, and Taiwan over the period from the first week of 2000 to the second week of 2012 which is the post 1997 Asian financial crisis. Contrary to the conventional wisdom and empirical results of earlier studies, the results of this study suggest that the equity markets in these Asian countries follow a random walk. These findings indicate that investors and portfolio managers cannot profit by trading based solely on past price movements in these selected Asian countries. They however now can include stocks from these economies in their portfolios as international diversification strategies.

The remainder of the study is organized as follows: Section 2 reviews the literature; Section 3 discusses the methodology and model's specification; Section 4 describes the

data reports the empirical results; Section 5 discusses Analysis of the empirical results; and Section 6 provides some concluding remarks and implications.

2. Review of Literature

The early work of Fama (1965) suggests that stock price movements exhibit insignificant auto-correlations. Thus, one cannot profit by trading based solely on past price movements. This idea is substantiated later in a survey of the extant literature (Fama and French, 1988). Since then, a number of authors have nevertheless discovered significant autocorrelations in both U.S. and non-U.S. stock returns. These findings put to question the perception that stock returns follow a random walk.

As indicated by Azad, (2009) Chan, Gup and Pan (1997) investigate the inter-linkages among international equity markets and interpret their empirical findings of no cointegration among these markets as evidence of joint market efficiency. Lence and Falk (2005) cite a sample of studies that apply cointegration procedures to test for market efficiency in equity markets, security markets, foreign exchange markets, commodity markets and banking product markets. However, Lence and Falk (2005) argue that cointegration of asset prices may not be used for assessing market integration and/or market efficiency but may be used to draw inferences about preferences and endowment processes. Dwyer and Wallace (1992) also articulate that the cointegration is neither a necessary nor a sufficient condition for market efficiency.

Worthington and Higgs (2004) and Olienyk, Schwebach and Zumwalt (1999) interpret the evidence of Granger causal relationships between the cointegrated markets as a violation of (joint) market efficiency. Lim, Gallo and Swanson (1998) also posit that investors can devise trading strategies to exploit any inherent inefficiency between markets.

Lo and MacKinlay (1988) not only refuted the random walk hypothesis for US weekly returns, but they also presented later researchers with a powerful variance ratio test for the investigation of the applicability of the random walk hypothesis as a description of stock price movements for non-U.S. markets. This test is predicated upon the fact that for price movements that follow random walks, the variance of the log-price relatives, $\log P_t - \log P_{t-1}$, sampled at regular intervals of length time t, is n times the variance of the log-price relatives sampled at intervals of length time t/n. Hence, the variance of the monthly sampled log-price relatives with a sampling interval of length four weeks is four times that of the weekly sampled. The test statistic derived by Lo and MacKinlay (1988) to test if a series of price movements follows a random walk is robust to many forms of heteroscedasticity and nonnormality.

Chang and Ting (2000) apply Lo and MacKinlay's methodology on the weekly movements of the Taiwan composite value-weighted stock market index over the period of 1971-1996. These authors conclude that these movements do not fit a random walk. Lock (2007) applies the same model over the 1990-2006 sample and finds that the

Taiwan composite stock index moves in a random walk fashion as well as returns for the individual stocks within the index.

3. Methodology and Model Specification

As revealed in the literature review section, the methodology and the model were developed by Lo and MacKinlay in the 1980s. However, this study contributes to the literature by applying the old methodology and model to the newly available data from Asian emerging markets. Additionally, Guidi et al. (2011) argue that the Lo and MacKinlay's methodology has gained popularity and has become the standard tool in random walk testing.

To specify the model for the empirical investigation, this study follows Lo and MacKinlay's (1988) methodology and lets X_t denote the log of the price of a stock at time t. If $X_t = \mu + X_{t-1} + \varepsilon_t$, then the price variable is said to follow a random walk. Here, μ stands for an arbitrary drift parameter, and ε_t is the random disturbance allowed to vary specification of which restricts with time and deviate from normality. This X_t is far more lenient than the traditional random walk specification; typically random walk models assume ε_t is identically and independently distributed (*i.i.d.).* If the movement of X_t does follow a random walk, then the variance of $(X_t - X_{t-1})$ is 1/n times the variance of $(X_t - X_{t-n})$. Furthermore, as shown by Lo and MacKinlay (1988), given a finite number of price movements represented by nq+1 consecutive X_t s, written as X_0 , X_1 , X_2 ,..., X_{nq} and taken to be a segment from an infinite series, the question of whether $X_t = \mu + X_{t-1} + \varepsilon_t$ holds true for the entire series can be addressed by estimating the ratio of the variance of $(X_t - X_{t-n})$ to 1/n the variance of $(X_t - X_{t-1})$. Under the random walk hypothesis, this variance ratio has a value close to one.

Algebraically, let

$$\hat{u} = \frac{1}{nq}\sum_{k=1}^{nq}(X_k - X_{k-1}) = \frac{1}{nq}(X_{nq} - X_0)$$

$$\hat{\sigma}_a^2 = \frac{1}{nq-1}\sum_{k=1}^{nq}(X_k - X_{k-1} - \hat{u})^2$$

and

$$\hat{\sigma}_c^2(q) = \frac{1}{q(nq-q+1)(1-\frac{q}{nq})}\sum_{k=q}^{nq}(X_k - X_{k-q} - q\hat{u})^2$$

then, as proven by Lo and MacKinlay (1988), $\hat{\sigma}_a^2$ and $\hat{\sigma}_c^2(q)$ are unbiased estimators of $X_t - X_{t-1}$ and $X_t - X_{t-q}$, respectively. Additionally, let the variance ratio VR (q) be defined as:

$$VR(q) = \frac{\hat{\sigma}_c^2(q)}{\hat{\sigma}_a^2}$$

where q =2, 4, 8, and 16, then under the random walk hypothesis, the four variance ratios V(2), VR(4), VR(8) and VR(16) will all have values close to one since the variance of increments of a random walk is linear in the sample interval.

To test whether the variance ratios of the sampled price movements deviate enough from unity to reject the random walk hypothesis, Lo and MacKinlay (1988,) derive the asymptotically standard normal statistic z(q) where

$$z(q) = \frac{\sqrt{nq}[VR(q) - 1]}{\sqrt{\sum_{j=1}^{q-1} \left(\frac{2(q-j)}{q} \right)^2 \hat{\delta}(j)}}$$

and

$$\hat{\delta}(j) = \frac{nq \sum_{k=j+1}^{nq} (X_k - X_{k-1} - \hat{\mu})^2 (X_{k-j} - X_{k-j-1} - \hat{\mu})^2}{[\sum (X_k - X_{k-1} - \hat{\mu})^2]^2}$$

Additionally, Lo and MacKinlay (1988) show that when q =2, [VR(q)-1] estimates the first-order autocorrelation coefficient of $(X_t - X_{t-1})$s. Therefore, if X_t's are weekly prices, then VR(2) approximates that first-order autocorrelation of weekly returns. As to the movement of the weakly returns, Lo and MacKinlay (1988) articulate and later restated by Lock (2007) that if the calculated statistic z(2) is neither large or small enough to reject the hypothesis that variance ratio VR(2) is approximately equal to 1 (the null hypothesis of random walk), the increments or the weakly returns of the equity index under consideration also follow a random walk.

Also as shown by Richardson and Smith (1991), under the aforementioned assumption of *i.i.d.,* the joint covariance matrix of ratio test statistics can be formed to calculate the standard Wald statistic to test the joint hypothesis that all q variance ratio statistics equal to 1. Under the null hypothesis of a random walk, the Wald statistic is asymptotic Chi-Square (χ^2) with *q* degrees of freedom (The Wald statistic which compound the vector of individual Variance Ratio statistics and their correlations follows the χ2 distribution. However, the χ^2 distribution may not be an appropriate approximation to the sampling distribution of Wald statistic because of the well-known right-skewness problem).

4. Data and Empirical Results

4.1 Data

This study utilizes weekly stock price indices in Malaysia, the Philippines, and Taiwan. The rationale for selecting these countries is partially due to the availability of consistent data and partially due to the characteristics of their economies. As to the data frequency, Lo and MacKinlay (1988) stated that since daily sampling yields many observations, the biases associated with non-trading, the bid-ask spread, asynchronous prices, etc., are

troublesome; weekly sampling is the ideal compromise, yielding a large number of observations while minimizing the biases inherent in daily price data. The weekly data set, used in this investigation, covers the period from the first week of 2000 to the second week of 2012. The stock price indices for Malaysia, the Philippines, and Taiwan are denoted by MY, PH, and TW respectively. All time-series data for these Asian countries are obtained from the DataStream database.

4.2 Empirical Results

As previously mentioned, the variance ratio VR(q), q = 2, 4, 8 and 16 specifies more than one test period; therefore, there are two sets of test results which are reported in the estimation results. The "Joint Tests" are the tests of the joint null hypothesis for all periods and the "Individual Tests" are the variance ratio tests applied to individual periods. More specifically, the Chow-Denning maximum |z| statistics and their approximated *p-values,* which are used to test the joint random walk hypothesis of the first four periods, are reported. The Chow-Denning maximum |z| statistic is calculated using the standardized maximum modulus with infinite degrees of freedom. Additionally, the Wald (Chi-Square) statistic is used to test the joint hypothesis of a random walk of all 16 periods. The degrees of freedom and *p-value* associated with the Wald statistic are reported. The normal statistics $z(q)$, q = 2, 4, 8 and 16 testing a random hypothesis for each of the periods (2, 4, 8 and 16) and their *p-values* are also calculated.

The empirical results for Malaysia, Philippines, and Taiwan are reported in Table 1 through Table 3, respectively. The variance test ratio statistics with their ± 2* standard error bands are also reported in Figure 1 through Figure 3, respectively.

Table 1: Malaysia—Variance Ratio Test Results, Data 2000:01:07-2012:01:13

A. Joint Tests	Value	Degree of Freedom	Probability
Max |z| (at period 16)*	2.092807	627	0.1377
Wald (Chi-Square)	4.990797	4	0.2882

B. Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	1.059403	0.039936	1.487454	0.1369
4	1.142278	0.074714	1.904311	0.0569
8	1.236878	0.118133	2.005188	0.0449
16	1.367889	0.175787	2.092807	0.0364

*Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of Freedom.

Figure 1: Malaysia—Variance Ratio Statistic with ± 2*Standard Error Bands.

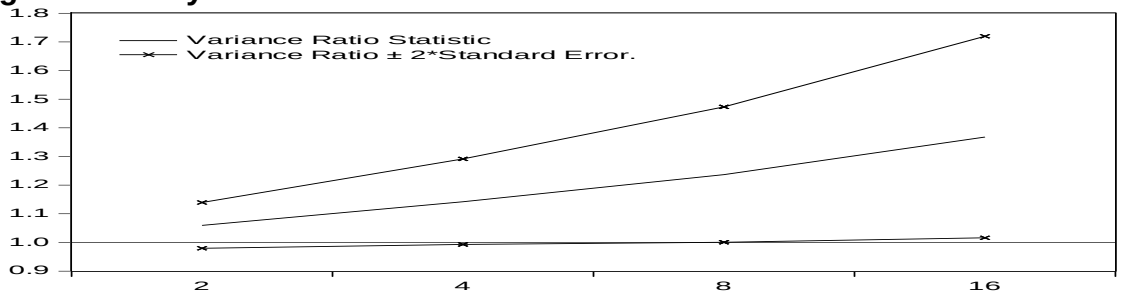


Table 2: The Philippines—Variance Ratio Test Results, Data 2000:01:07-2012:01:13

A. Joint Tests	Value	Degree of Freedom	Probability
Max |z| (at period 8)*	1.356572	627	0.5366
Wald (Chi-Square)	3.578566	4	0.4660

B. Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	1.000547	0.039936	0.013708	0.9891
4	1.083449	0.074714	1.116917	0.2640
8	1.160256	0.118133	1.356572	0.1749
16	1.221305	0.175787	1.258939	0.2081

*Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of Freedom.

Figure 2: Thailand—Variance Ratio Statistic with ± 2*Standard Error Bands.

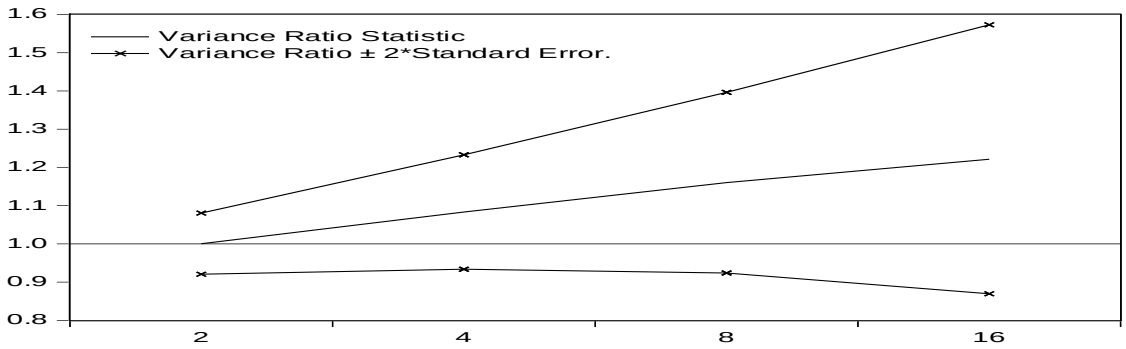


Table 3: Taiwan—Variance Ratio Test Results, Data 2000:01:07-2012:01:13

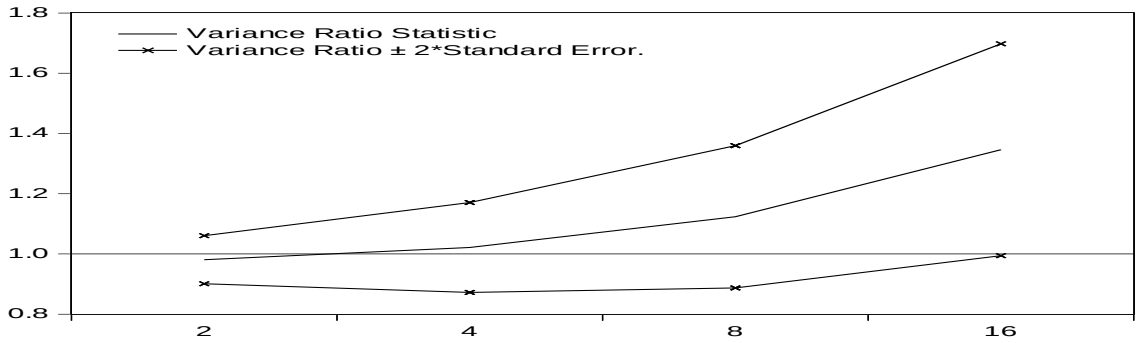
A. Joint Tests	Value	Degree of Freedom	Probability
Max |z| (at period 16)*	1.967556	627	0.1825
Wald (Chi-Square)	6.704849	4	0.1523

B. Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.980580	0.039936	-0.486274	0.6268
4	1.021370	0.074714	0.286029	0.7749
8	1.123265	0.118133	1.043449	0.2967
16	1.345871	0.175787	1.967556	0.0491

*Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of Freedom.

Figure 3: Taiwan—Variance Ratio Statistic with ± 2*Standard Error Bands.



5. Analysis of the Empirical Results

Tables 1 through 3 report the Chow-Denning maximum |z| statistics, the Wald (Chi-Square) statistics as well as their approximated *p-values* which are used to test the joint null hypothesis and variance ratios and the test statistics $z(q)$, q = 2, 4, 8 and 16 for the equity indices in Malaysia, the Philippines, and Taiwan. The "Joint Tests" are the tests of the joint null hypothesis for all periods and the "Individual Tests" are the variance ratio tests applied to individual periods.

A close look at the Chow-Denning maximum |z| statistics and the Wald statistics reported in Tables 1-2 and 3 also reveals that the null hypothesis of a random walk of joint and individual periods cannot be rejected for the important emerging economies of Malaysia, the Philippines and Taiwan.

The above failures to reject these null hypotheses suggest that equity markets in these countries follow a random walk. These empirical findings are quite surprising as they are inconsistent with the conventional wisdom that stock markets in developing and emerging economies are not even weak-form inefficient. Additionally, these empirical results are also quite unexpected for at least to one of the authors, Nguyen et al. (2012) who has investigated the same issue for the a group of South Asian countries (India, Pakistan and Sri Lanka) using the same method and data which is from the same source, having the same frequency and is over the same sample period; and found that the equity markets of these South Asian countries do not follow a random walk. As to the implication for investment strategy, the empirical results are consistent with the early findings by Fama (1965) that stock price movements exhibit insignificant auto-correlations. Thus, one cannot profit by trading based solely on past price movements.

As aforementioned, a possible explanation for the above empirical findings may be international equity markets have recently provided highly profitable investment opportunities to investors seeking optimum rates of return on a worldwide basis and Asian countries share many common features as developed economies. The impacts of these new developments on the emerging markets are that they broaden and deepen their equity markets. Also, they provide resources to improve the infrastructures of their markets, including the information technology. The improvement in the infrastructures

and information technology in turn removes some of the opaque characteristics in their equity markets. These are the necessary foundation for an efficient market.

As articulated by Floros (2011), these empirical results reveal that investors and traders cannot use past information to predict future prices or returns in these selected emerging markets. Consequently, the results affirm that international portfolio diversification may still reduce the portfolio risk. Furthermore, economic policy makers must have a comprehensive understanding of the transmission of price movements in regional equity markets, especially during periods of high volatility. Appropriate policies may be designed to lessen the impact of financial crises.

6. Concluding Remarks and Implications

This study applies Lo and MacKinlay's methodology on the weekly movements of the equity indices in Malaysia, the Philippines, and Taiwan over the period from the first week of 2000 to the second week of 2012 which is the post 1997 Asian financial crisis. The empirical findings are inconsistent with the conventional wisdom that equity markets in emerging Asian countries are still not efficient—even in the weak-form. In fact, the important contribution of this study is the findings that the equity markets in these Asian countries follow a random walk over the sample period which are contrary to the conventional wisdom and empirical results of earlier studies.

As to the investment strategies relating to predicting the behavior of one market based on the behaviors of other international equity markets, the empirical findings provide investors, portfolio managers, and policy makers the updated information and causality across equity markets, especially markets in a neighboring area. This information provides better views of the markets' movement and, therefore, enables them to appropriately price underlying assets and their derivatives, as well as to hedge and to diversify the associated portfolio risks.

The findings suggest that investors and traders can no longer use past information from one equity market to predict prices or returns in the future in the three selected Asian countries. Also these empirical findings are different from earlier results (Lamba 2005) and put into question the conjecture that the Asian stock markets will start being more inter-related in the time to come (Sharma and Bodla 2010).

A plausible explanation for the findings may be that international equity markets have recently provided highly profitable investment opportunities to investors seeking optimum rates of return on a worldwide basis. The impacts of these new developments on the Asian emerging markets are that they broaden and deepen the equity markets. Also, they provide resources for their markets to improve the infrastructures, including the information technology. The improvement in the infrastructures and information technology in turn removes some of the opaque characteristics in their equity markets. These are the necessary foundation for an efficient market.

Clearly, the empirical findings suggest that investors who invest in these selected Asian markets cannot take advantage of pricing inefficiencies; but can use their component

stocks for portfolio diversification. Furthermore, economic policymakers must have a comprehensive knowledge on transmission of price movements in regional equity markets, especially during periods of high volatility. Appropriate policies may be designed to lessen the impact of financial crises.

The limitation of this investigation is that the sample period ended in February 2012 which may not fully reflect the impact of the US subprime mortgage crisis and the European sovereign debt which may alter the level of international macroeconomic policy coordination among international economies and particularly the Asian region, precipitated by the 1997 Asian financial crisis of international dimension.

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