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Market efficiency in emerging stock markets: A case study of the Vietnamese stock market

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Abstract: *Investors and researchers have been paying increasing attention to the emerging stock markets. In this research we study whether or not weak-form efficiency, which is relatively popular in emerging stock markets, holds for the Vietnamese stock market. We check the random walk hypothesis for weekly stock market returns employing three statistical techniques namely autocorrelation test, variance ratio test, and runs test. Data for analysis was collected from July 28th2000 (the first trading session) to July 28th 2013 (13 years of market operation). Through the graph showing movements in daily prices of the chosen representative stocks and the Vietnam stock index (VN-Index), it is visual that the Vietnamese stock market is not efficient; the fact that psychological factors strongly influence investors is among elements making stock prices predictable. Estimated results have strongly rejected the random walk hypothesis for the whole period of the samples and for the first two cycles of the market (except for the third cycle). Particularly results from the third cycle of the Vietnamese stock market alone (from February 24th 2009 to July 28th 2013) have provided evidence supporting random walk hypothesis in VN-index. It shows the fact that the efficiency of the Vietnamese stock market has gradually been improved during nearly 10 years in operation. The main conclusion drawn from results of this research is that it may be the case that the weak-form efficient market hypothesis does not hold for the Vietnamese stock market.*

Keywords: *Emerging stock market, weak-form efficient, stock market, random walk, VN-Index.*

I. Introduction

Stock market efficiency has been of great interest of many researchers in the last decades. While there is a school of thought stating that stock market is efficient, another claims that it is insufficient (Mobarek et al. 2008). The efficient market hypothesis (EMH), however, has a vital part in modern financial literature. As a result, for a sufficient market, Magnusson and Wydick (2002) state that movements in such market need to be characterized by a random walk based on current available information. Many researchers have been studying stock market efficiency as once a country's market is found not following a random walk it might be insufficient (Sui Suyin 2007).

The efficient market hypothesis assumes that all available information fully reflected in stock prices at any point of time is the best estimate of the real value of the stocks (Malkiel and Fama 1970). EMH depends on the following three conditions: (1) no transaction cost, (2) public and free information, and (3) current stock prices reflect all available information. Malkiel and Fama (1970), however, argues that infringement of those conditions does not necessarily imply the insufficiency of the market due to competitive environment. Based on the identification of a set of available information, EMH is categorized into three degree namely weak-form efficiency, semi-strong form efficiency and strong form efficiency. Regarding the available information in the market, each level holds a different viewpoint on market efficiency. Weak-form efficiency states that future stock prices cannot be predicted by analysis of information of past prices because such information has already been reflected in the current prices (Fama 1991). This also shows that technical analysis does not hold prediction value as it employs historical prices, volumes and open interest to predict stock prices (Park and Irwin 2004). Semi-strong form efficiency holds for a certain market if all available information is publicly reflected by current market prices. Finally, strong form efficiency claims that stock prices reflect all public and private information. Accordingly it is impossible to use internal information, fundamental analysis and technical analysis to earn excess returns in such market.

In the actual stock market, most of the investors do not believe that market is completely efficient; hence, they try to do better than the market by identifying stocks which can gain returns and are willing to take additional risks. Different schools of thought try to better the market at various levels of risk (Singhvi 2001).

The efficient market hypothesis has been applied in studying both developed and emerging stock markets. While much of the researches have been made in developed stock markets, it is widely accepted that there is a need to focus more on the emerging ones (Mobarek et al. 2008). In emerging stock markets,

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experimental studies mainly focus on the lowest form of EMH which is weak form efficiency. If evidences found cannot support weak form market efficiency, they then support higher forms of EMH which are semi-strong and strong form efficiency (Wong and Kwong 1984).

The Vietnamese stock market with its main representative Hochiminh Stock Exchange (HOSE) is one of emerging stock markets. The first transaction of HOSE started on July 28th 2000 with only two companies listed are Saigon Cable and Telecommunication Material Joint Stock Company (SAM) and Refrigeration Electrical Engineering Joint Stock Company (REE). Over a short period of time, the Vietnamese stock market has significantly been increasing in the quantity of the companies listed, market capitalization and trade volume. On the other hand, it has gone through many fluctuations; the Vietnamese stock index (VN-Index) reached its peak in March 2007 but then declined. After this point of time, there was a rapid decline in the investors' trust in the Vietnamese stock market. The market has just started gaining back investors' trust since the middle of 2009 (Figure 1).

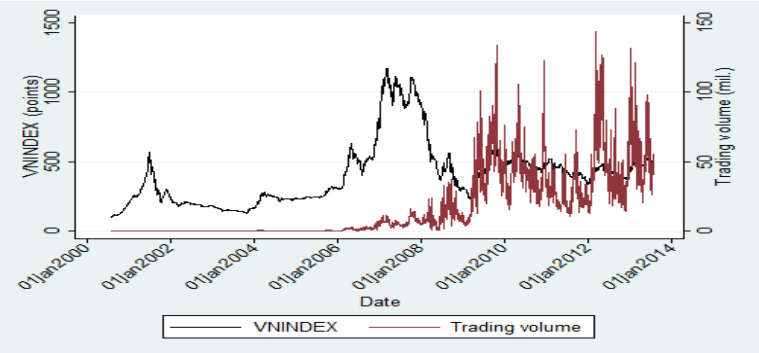

Figure 1. Daily VN-Index and trading volume over the period 28 July 2000 to 28 July 2013

As a result, it is necessary to study the efficiency of the Vietnamese stock market since its foundation. This research aims at investigating if the Vietnamese stock market (particularly HOSE) is weak-form efficient, a popular efficiency form in emerging stock markets. Results achieved from this research are expected to improve the value of current financial model. For this purpose, we will employ autocorrelation test, runs test and variance ratio test, using VN-Index data collected from the first trading session is July 28th 2000 to July 28th 2013.

The next parts of this paper are developed as follows. Part 2 briefly reviews previous experimental studies on weak-form efficiency in emerging stock markets. Part 3 describes data and develops hypothesis and approach. Part 4 discusses the experimental results of the study. Finally part 5 draws the conclusions.

II. Literature Review

During the last decades since Fama (1970) started studying the randomness of stock price movements, EMH and the random walk model have become center of many debates in financial literature. Researchers have been focusing on whether market efficiency or anomalies exist (Abuzarour 2005). Weak-form efficiency in EMH indicates that current market prices of stocks are independent from their past prices. In other words, market is weak-from efficient if stock prices follow a random walk process. In order to test the weak form market efficiency, it is necessary to test the random walk hypothesis (RWH) considering the interrelationship between current stock prices and past stock prices (Fawson et al. 1996). Several popular statistical techniques such as runs test, serial correlation tests, unit root test, and spectral analysis have been employed when studying weak-form efficiency of stock markets (Truong 2006). Rcently investors and researchers have been paying increasing attention to the emerging stock markets. A huge number of studies has been testing the validity of weak-form of EMH (Chung 2006). Most of the studies testing stock market efficiency in developing countries have shown supporting evidence for either weak-form or semi-strong form efficiency (Sui Suyin 2007, Mobarek et al. 2008). As in his study, Claessens, Dasgupta et al. (1995) showed the significant serial correlation in equity returns observed in 19 emerging stock markets and claimed that stock prices in emerging markets violate weak-form efficiency. A similar result was presented by Harvey (1995) when he studied the movements and predicted returns of some emerging stock markets all over the world with representatives from countries in Asia, Europe, Africa, and South America. The study finds a strong serial correlation in the stock returns, which makes stock prices more predictable.

When studying efficiency of emerging stock markets in Europe, Smith and Ryoo (2003) employed variance ratio test to investigate market efficiency of five stock markets including Greece, Hungary, Poland, Portugal, and Turkey. Results found show the fact that RWH is rejected due to the existence of auto-correlation in stock returns in the markets of all investigated countries except for Turkey, which implies a rejection of EMH towards stock market Gilmore and McManus (2003) investigated whether or not the Central European stock markets including Czech, Hungary, and Poland are weak-form efficient. In order to do that, they used different

tests consisting of univariate methods, multivariate test, and model-comparison approach. Based on the results found, they came to the conclusion that such markets are not yet weak-form efficient.

In another study testing the efficiency of 7 European emerging stock markets (Greece, Czech, Slovakia, Hungary, Turkey, Russia, and Poland), Hassan, Haque et al. (2006) employed the methods of Q-statistic, runs, variance ratio tests and data of weekly stock index from international financial companies in the period of December 1988 - August 2002. Using the results found, they came to a conclusion that the European emerging markets in general are unpredictable. Finally, results found showed the existence of auto-correlation in the European emerging markets.

Abrosimova et al. (2002), in their study, tested weak-form in the Russian stock market. In order to test RWH, they used unit root, auto-correlation, variance ratio tests, and model comparison approach (ARIMA and GARCH). Results showed evidence for the existence of weak-form efficiency in the Russian stock market. Testing weak-form efficient of the Serbian stock market, Cvetkovic (2007) employed two different approaches which were tests of RWH and tests of predictability of technical analysis. His study proved the fact that the Serbian stock market does not follow a random walk, that changes in stock prices in the market are predictable. Implication from such results is that the Serbian stock market is not weak-form efficienct.

Regarding Latin American emerging stock markets, Urrutia (1995) employed both variance ratio test and run tests to study the random walk in the stock markets of Argentina, Brazil, Chile and Mexico. Results from variance ratio test reject RWH for all markets but run tests prove that such stock markets are weak-form efficient. He used these testing results to conclude that there is mixed evidence for the existence of weak-form efficiency in these stock markets. Experimental results from a study conducted by Grieb and Reyes (1999) in Brazilian and Mexican stock markets are also in conformity with results reported by Urrutia. In addition, Ojah and Karemera (1999) used runs tests, multiple variance ratio and single variance ratio to test random walk for 4 emerging stock markets studied by Urrutia in 1995. Results show evidence for the conclusion that all of these 4 emerging stock markets are weak-form efficiency.

In Africa, when studying the Nairobi stock exchange in Kenya, Parkinson (1987) investigated the validity of weak-form efficient by using runs tests with data coming from monthly prices of private companies in the period of 1974-1978 and results reject RWH. Studying the same topic, Dickinson and Muragu (1994) went further on Parkinson's work with data of prices of 30 most transacted stocks from 1979 to 1989 in Nairobi Stock exchange and employment of autocorrelation and runs tests. They found supporting evidence for the existence of weak-form efficient of EMH in this stock market, which is contradictory of the conclusion made Parkinson.

In 2003, Appiah-Kusi and Menyah (2003) employed the model by Miller, Muthuswamy et al. (1994), EGARCH-M model and a logistic map to test efficiency of all 11 markets in African stock market (Kenya, South Africa, Botswana, Egypt, Ghana, Ivory Coast, Mauritius, Morocco, Nigeria, Swaziland, and Zimbabwe). Results showed that weak-form efficiency does not hold for such markets, except for the ones in Morocco, Egypt, Kenya, Mauritius, and Zimbabwe. Particularly they recognized the Nigerian stock market as not weak-form efficiency, which is contradictory to previous studies. However in a research made by Akinkugbe (2005) with data of 738 weekly observations from June 1989 to December 2003, he employed Phillip-Perron unit root tests, autocorrelation and Augmented Dickey-Fuller to investigate the weak-form efficiency in the Botswana stock exchange. His results find evidence supporting weak and semi-strong form in the Botswanian stock market.

Recently many experimental studies on weak-form efficiency of stock markets in Asian have been conducted (Truong 2006, Cvetkovic 2007). Huang (1995) conducted the experiment of random walk hypothesis in nine countries and territories in Asia (including Korea, Singapore, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Taiwan, and Thailand). He employed the single variance ratio tests with data collected from January 1988 to June 1992. His results prove that stock markets in Hong Kong, Korea, Malaysia, Philippines, Singapore, and Thailand themselves show various levels of positive serial correlations hence RWH is rejected in such markets.

Laurence (1986) used observations of price of the individual stock in the period of 1973-1978 in both the KualaLumpur stock exchange (KLSE) of Malaysia and the Stock exchange of Singapore (SES). Both runs and auto-correlation test were employed showing the fact that not only KLSE but also SES is not weak-form efficient. Findings from Barnes' study (1986), on the other hand, are of contradiction when he found evidence for KLSE holding a high level of weak-form efficiency (Barnes 1986). Yet the study made by Lai, Melvin et al. (2002) rejects random walk in KLSE.

Many researches have been carried out in the Chinese stock market. One of them is Groenewold, Tang et al. (2003) who developed evidence for market efficiency and found evidence for market inefficiency as there were returns predicted using past stock prices. It was further reinforced by a study conducted by Mookerjee and Yu (1999), who claimed that Shanghai stock exchanges and Shenzhen stock exchanges are not weak-form efficiency. Lee, Chen et al. (2001) in their study used variance ratio tests rejecting the hypothesis that stock returns in the Chinese stock exchange follow random walk. In addition, Araújo Lima and Tabak (2004) showed in their research that B-shares index for both Shanghai stock exchanges and Shenzhen stock exchanges do not

follow the random walk. However, they also claimed that weak form efficiency hypothesis cannot be rejected for A-shares index in both markets. An experimental study also acknowledges that the Shanghai stock exchange was weak-form efficient in the period of January 2000 – December 2000 (Seddighi and Nian 2004). Chung (2006) examined RWH using statistical methods such as non-parametric runs test, Augmented Dickey-Fuller unit root tests, auto-correlation test, and variance ratio tests in order to specify the validity of weak-form efficient for both Shanghai and Shenzhen stock exchanges. Experimental findings from this research have further supported previous studies which claim that Chinese stock market is weak-form inefficient. Besides, the null hypothesis of random walk for cannot be rejected for the Hong Kong stock exchange (Alam, Hasan et al. 1999, Cheung and Andrew Coutts 2001, Araújo Lima and Tabak 2004). Other researches developed by Fawson et al. (1996), Chang and Ting (2000) also prove weak-form efficiency of the Taiwanese stock market.

Regarding the Middle Eastern stock markets, an experimental study investigating the validity of RWH in 5 Middle Eastern emerging markets in Egypt, Jordan, Morocco, Turkey, and Israel was conducted by Omran and Farrar (2006). Their findings reject RWH in all of the markets of study. They are in line with findings made by Abraham, Seyyed et al. (2002) when studying three major Gulf stock markets and Abuzarour (2005) when using observed index levels to study Egyptian and Jordanian stock markets. A research on efficiency of United Arab Emirates (UAE) stock market in the period of October 2001 - September 2003 shows that UAE stock market is weak-form efficiency (Moustafa 2004).

Regarding South Asian stock markets, Abeysekera (2001) employing unit root tests, serial correlation, and runs found out evidence rejecting RWH hence came to a conclusion that the Colombo stock market (SriLanka) is weak-form inefficient. In another research in the Dhaka stock exchange (Bangladesh) in the period of 1988-1997, findings prove that returns in this market do not follow random walk (Mobarek and Keasey 2000). A conclusion was made by Mobarek et al. (2008) in the case Dhaka stock exchange of Bangladesh. Their results provides evidence that the stock returns don't follow the random walk and autocorrelation coefficient at different lags, rejected the null hypothesis of weak-form efficiency of the market.

Similarly Poshakwale's research also proves that Indian stock market is weak-form inefficient (Poshakwale 1996, Poshakwale 1997). In his following research, Poshakwale analyzed daily stock returns data in the period of January 1990 to November 1998 of 38 most actively traded stocks in the Bombay stock exchange to find statistical evidence rejecting RWH for the new Indian stock market (Poshakwale 2002).

In general, findings from researches studying whether or not the emerging stock markets follow the random walk are quite contradictory. Therefore results are not the same from literature on emerging stock market efficiency are themselves not surprising since it has been observed that emerging markets are basically less efficient than the developed markets (Chung 2006). In opposite of developed markets, it is obvious that in emerging stock markets there is more information asymmetry with thin trading and shallower market depth. The main reason comes from their weak institutional infrastructure (Islam and Khaled 2005). Not all emerging stock markets, however, are absolutely inefficient since some experimental studies have found evidence supporting weak-form efficiency in some stock markets in developing countries.

III. Data and Research Methodology

3.1 Data description and hypothesis

As aforementioned, the research explores the weak-form of the efficient market hypothesis in the Vietnamese stock market on basis of the Vietnam stock index (VN-Index). The Vietnam stock index is a composite index calculated from prices of all stocks traded on the stock exchange. Accordingly, the main purpose of the research is to examine whether the VN-index follows a random walk or not. The research hypothesis is defined as:

H_0: The Vietnamese stock index follows a random walk;

H_1: The Vietnamese stock index does not follow a random walk.

In the research, the null hypothesis of a random walk is investigated using a set of statistical tests including autocorrelation tests, variance ratio test, and runs test. A random walk process implies that it is impossible to predict the future movement of stock price. However, if autocorrelation tests, variance ratio test, and runs test all reject the existence of a random walk process for VN-Index, there will be sufficient statistical evidence to prove that stock price can be predicted.

The data used in our study consists of VN-Index's weekly price and daily price of 05 oldest stocks listed[2] on the Vietnamese stock market (including SAM, REE, HAP, TMS and AGF)[3] during the period from 28 July 2000 (the first trading session) to 28 July 2013. This data is retrieved from Saigon Securities Inc.'s website[4].

[2] Shares traded since the first trading sessions are used to ensure data to be statistically continuous.

[3] SAM (Cable and Telecommunications Material Co.); REE (Refrigeration Electrical Engineering Co.); HAP (Hai Phong Paper Joint Stock Co.); TMS (Transimex Joint Stock Co.); AGF (An Giang Fisheries Import & Export Joint Stock Co.)

The weekly price is used in this research for following reasons: (1) During the startup period of the Vietnamese stock market (from 28 July 2000 to 1 March 2002), the market only held three trading sessions per week which were on Monday, Wednesday and Friday; therefore, there was no daily stock price. From 1 March 2002, the exchange has conducted five trading sessions per week; (2) Dickinson and Muragu (1994) noted that infrequent trading of particular shares can introduce serious bias in statistical researches. To solve this problem, we suggest using a longer period to improve the power of statistical test for a random walk; and (3) Weekly data is not affected by the market's frequent transactions.

A natural logarithm transformation is applied to the primary data to create a time series of continuously compounded returns. As illustrated in Figure 2, weekly returns are used to test market efficiency. The returns are computed as following:

$$r_t = Log\left(\frac{P_t}{P_{t-1}}\right)$$

where r_t is the returns at time t, P_t is the price at time t and P_{t-1} is the price at time $t-1$.

The weekly returns are computed as the natural logarithm of the index and stock prices from Wednesday's closing price minus the natural logarithm of the previous Wednesday's closing price. If the Wednesday's closing price is missing, Thursday's price will be used, or Tuesday's if Thurday's is missing. If no price is available, that weekly return will be noted as missing. Wednesday's closing price is used to avoid the effect of weekend trading and to minimize the number of holidays (Lo and MacKinlay 1988, Huber 1997).

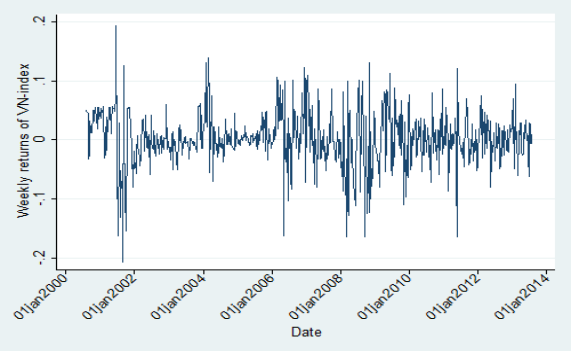

Figure 2. Weekly returns of the VN-INDEX over the period 28 July 2000 to 28 July 2013

Figure 3. Fluctuations in the VN-INDEX and its market cycles

The departure of the prices is illustrated in Figure 3 indicating the fluctuations of the Vietnamese stock market from 28 July 2000 to 28 July 2013. During this period, VN-Index dropped to the bottom twice on 24 October 2003 and 24 February 2009, which can be considered as "market trough". As may be seen in Figure 3, there were obviously 03 market cycles created in this period. The first cycle was from 28 July 2000 to 22 October 2003 with VN-Index reaching the presumably market peak on 25 June 2001. The second cycle was from 23 October 2003 to 25 February 2009 with the highest VN-Index on 12 March 2007. The last one was from 26 February 2009 to 28 July 2013 with VN-Index peaking on 22 October 2009. In practice, those cycles can be considered as three remarkable "ups and down" stages in the Vietnamese stock market from its establishment to July 2013. As a result, any investigation regarding to the random walk process is conducted on both the full sample of VN-Index during the whole period and on the three subsamples corresponding with the three cycles mentioned above.

The purpose of dividing the full sample into three subsamples is to identify the performance of the statistical tests more precisely. In the meantime, it also helps to reduce the risk of incorrectly rejecting H_0 if the result of tests on the three subsamples also rejects the hypothesis of efficient market. Data of weekly returns is presented as following:

- Full sample: 28July2000 – 28July2013 (T = 663)
- 1st Cycle: 28July2000 – 22Oct.2003 (T = 165) (Subsample one)
- 2nd Cycle: 23Oct.2003 – 25Feb.2009 (T = 271) (Subsample two)
- 3rd Cycle: 26Feb.2009 – 28July2013 (T = 227) (Subsample three)

The returns of VN-Index will be analyzed on basis of mean, standard deviation, skewness (S), kurtosis (K), and Jarque-Bera (J.B). Skewness is a measure of the asymmetry of the data set about its mean. Kurtosis is a

[4] www.ssi.com.vn

measure of the peakedness and flatness of the probability distribution and the thickness of the tails of a distribution. In case of a normal distribution, skewness = 0 and kurtosis = 3 (Brooks 2008). The Jarque-Bera test is used to determine the normality of the sampling distribution, in which the null hypothesis states that the population follows a normal distribution. Normality test, therefore, makes parametric or non-parametric tests become more practical when examining a random walk. The test statistics of S, K and J.B are defined as:

$$S = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{r_t - \bar{r}}{\sqrt[S]{(T-1)/T}}\right)^3; \qquad K = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{r_t - \bar{r}}{sd\sqrt{(T-1)/T}}\right)^4; \qquad J.B = \frac{T}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

where T is the sample size, $\bar{r}$ is the sample mean of the returns, and sd is the standard deviation.

3.2 Methodology

In this research, we perform several tests to examine the weak form efficiency of the Vietnamese stock market, mostly on the basis of information reflected by past prices. Firstly, autocorrelation test is used to determine if the consecutive stock returns are independent to each other. Secondly, we use runs test to check if continuous changes in price are randomly distributed. The runs test implies that the elements of the sequence are mutually independent over time if the number of runs is not significantly higher or lower than expected. Finally, Variance ratio test as suggested by Lo and MacKinlay (1988) is used. It implies that a random walk indicates a linear relationship between the variance of first difference and variance of *q*-differences.

- ***Autocorrelation tests***

In this research, auto-correlation tests are first used to determine if stock returns follow a random walk or not. Auto-correlation measures the correlation between time t stock return and time $t - k$ stock return. The test statistic of auto-correlation test is defined as:

$$\rho_k = \frac{\sum_{t=1}^{T-k}(r_t - \bar{r})(r_{t-k} - \bar{r})}{\sum_{t=1}^{T}(r_t - \bar{r})^2}$$

where ρ_k is the serial correlation coefficient of lag k, T is the sample size, k is the lag length, r_t is the stock return at time t, and $\bar{r}$ is the sample mean of the stock returns.

The main objective of the auto-correlation test is to determine if the serial correlation coefficients significantly deviate from zero. If they do, it indicates that price is dependent and predictable. Moreover, significant serial correlation coefficients indicate that the weak-form EMH should be rejected.

The Ljung-Box Q-statistics (Ljung and Box 1978) is used to test the joint null hypothesis that all auto-correlations are equal to 0. The Ljung-Box Q-statistics follows a chi-squared distribution and is defined as:

$$Q_{LB} = T(T+2)\sum_{k=1}^{m}\frac{\rho_k^2}{T-k} \sim \chi^2_{\mathrm{m}}$$

where ρ_k is the serial correlation of lag k, T is the number of observations, k is the lag length, and m is the maximum lag length and degrees of freedom. The null hypothesis of this test is $\rho_1 = \rho_2 = ... = \rho_k = 0$.

Moreover, prior researches have suggested that the selection of m can potentially affect the strength of Q_{LB}. If m is too small, the presence of a higher-order auto-correlation can be missed. Otherwise, if m is too large, the test may not have much power due to insignificant higher-order autocorrelation (MacKinlay et al. 1997). Therefore, Tsay (2005) suggested using $m \approx Ln(T)$ to improve performance power of the test. Accordingly, in this paper, we apply this principle at the maximum lag of ten.

- ***Runs test***

Runs test is a popular tool to examine statistical independencies. It is a non-parametric test to investigate if successive price changes are independent or not. The test bases on a premise that if a series of data is random, the observed number of runs in the series should be close to the expected number of runs.

In empirical research, a run is defined as a sequence of consecutive price changes with the same sign. Therefore, in case of stock price, we categorize 3 types of runs, including (1) an upward run, where prices go up, (2) a flat run, where prices do not change, and (3) a downward run, where prices go down. Expected number of runs (m) is estimated as:

$$m = \frac{T(T+1) - \sum_{i=1}^{3} n_i^2}{T}$$

where T is the sample size, i is the signs of plus, minus, and no change, n_i is the total number of changes in each category of signs. For a large number of the sample size, we usually have n>30, and m is approximately normally distributed. The standard deviation (σ_m) of runs is defined as:

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + T(T+1) \right] - 2T \sum_{i=1}^{3} n_i^3 - T^3}{T^2 (T-1)} \right]^{\frac{1}{2}}.$$

Then the standard normal Z-statistic which can be used to do a run test is given by:

$$Z = \frac{(R \pm 0.5) - m}{\sigma_m}$$

where R is the number of observed runs, m is the expected number of runs, and *0.5* denotes the correction factor for continuity adjustment. The runs test checks the randomness of the runs on basis of a two-tailed test. The sign of the continuity adjustment is negative (20.5) if $R \geq m$, and positive if $R \leq m$ (Wallis and Roberts 1956). The positive serial correlation indicates a positive dependence of stock price, which accordingly violates the RWH.

- ***Variance ratio test***

The variance ratio test suggested by Lo and MacKinlay (1988) is used to test for a random walk in stock returns. Returns are independent and normally distributed with a constant mean and a finite variance, constituting a linear function of the holding period. This bases on the hypothesis that the changes of price in a random walk is linear in the sampling interval, which means if a return series follows a random walk, the variance of its q-differences would be q times the variance of its first differences. With a sample size of nq+1 observations (p_0, p_1,...,p_{nq}), the equation of the variance ratio is defined as:

$$VR(q) = \frac{Var(p_t - p_{t-q})}{Var(p_t - p_{t-1})} = \frac{\sigma_b^2(q)}{\sigma_a^2}$$

with

$$\sigma_b^2(q) = \frac{1}{m} \sum_{t=q}^{nq} (p_t - p_{t-q} - q\mu)^2 \; ; \qquad \sigma_a^2 = \frac{1}{nq-1} \sum_{t=1}^{nq} (p_t - p_{t-q} - \mu)^2$$

where

$$m = q(nq - q + 1)\left(1 - \frac{q}{nq}\right); \qquad \mu = \frac{1}{nq}(p_{nq} - p_0).$$

$VR(q)$ is the variance ratio of q-difference, $\sigma_b^2(q)$ is the scaled variance of the q-difference, σ_a^2 is the variance of the first difference, and p is the closing price.

Lo and MacKinlay (1988) suggested two test statistics in order to cope with the assumption of homoscedasticity and heteroscedasticity. The result is that the null hypothesis of no auto-correlation coefficient can be examined by using standardized statistics (Campbell et al. 1998). With the null hypothesis of homoscedasticity and of heteroscedasticity assumption, two standard normal test statistics $Z(q)$ and $Z^*(q)$ are expressed as follows:

$$Z(q) = \frac{VR(q) - 1}{\left[\phi(q)\right]^{1/2}} \sim N(0,1); \quad Z^*(q) = \frac{VR(q) - 1}{\left[\phi^*(q)\right]^{1/2}} \sim N(0,1)$$

where, according to Lo and MacKinlay (1988), $\phi(q)$ *and* $\phi^*(q)$ are the asymptotic variance of the variance ratio under the assumption of homoscedasticity and heteroscedasticity, respectively. The following estimators are used:

$$\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)}; \quad \phi^*(q) = \sum_{j=1}^{q-1} \left(\frac{2(q-j)}{q} \right)^2 \delta(j)$$

and

$$\delta(j) = \frac{\sum_{t=j+1}^{nq}(p_t - p_{t-1} - \mu)^2 (p_{t-j} - p_{t-j-1} - \mu)^2}{\left[\sum_{t=1}^{nq}(p_t - p_{t-1} - \mu)^2\right]^2}$$

where $\delta(j)$ is the heteroscedasticity consistent estimator, and μ is the average return. The value of the variance ratio is 1 under the null hypothesis. But if the heteroscedastic random walk is rejected, there is evidence of autocorrelation in return series (Worthington and Higgs 2004). Moreover, in this research, we follow suggestions by Lo and MacKinlay (1988) to set up a statistical test for a random walk, in which p_t denotes the log price process.

IV. Empirical Findings

- ***Visual indicators of the weak-form inefficiency of the Vietnamese stock market***

Prior researches have suggested that investment decisions of individual investors in emerging stock markets are significantly affected by psychological factors (Murgea 2008, Sehgal and Singh 2012), which makes stock prices predictable. Figure 4 illustrates the fluctuations in trading price of 05 sample stocks and VN-Index from the very first trading session to 28 July 2013. It is noticeable that trading prices of both 05 sample stocks and VN-Index all follow almost the same trend. This feature is the most visible in the first period from July 2000 to the beginning of 2004.

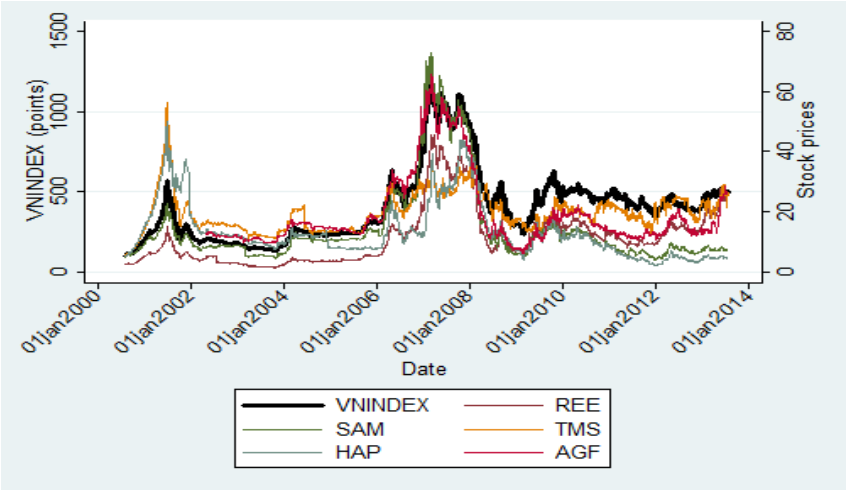

Figure 4. Fluctuations in the VN-INDEX and share prices of the five stock listed companies

During this period, stock trading database hardly indicates any difference among those stocks (insignificant particular fluctuations). Basically, "the health" of the economy is usually reflected by fluctuations on stock market. However, if assuming that other objective factors remain unchanged, this is the period when investor psychology has the strongest influence on the Vietnamese stock market.

In a research on emerging stock market in Latin America, Urrutia (1995) suggests that non-randomness of price may be resulted from economic growth other than market inefficiency. However, this feature may be also explained by the limited number of listed shares on the Vietnamese stock market at the initial stage (only 26 listed companies by December 2004). Moreover, almost all investors on the market at that time were just following the trend with the introduction of their friends and relatives. They lacked of relevant knowledge about stock market and stock investment. They especially did not consider stock investment as a professional business. Meanwhile, Government's policies to regulate the stock market were quite limited and insufficient. In the next stage (from 2005), improved Government's regulatory oversight and framework, more experienced investors and the increasing number of listed companies on The Vietnamese stock market provided more investment opportunities for investors. However, psychological factor still remained on the market in this period, which is implied by a relatively similarly changing pattern of all listed shares' trading prices as illustrated in Figure 4. Since 2009, the Vietnamese stock market efficiency has been significantly improved indicating by deviation in fluctuating patterns of listed shares' trading prices. When observing general market movement in Figure 4, it is noticeable to identify three market cycles created during the sampling period.

Conclusively, after 13 years (2000-2013) of operation of the Vietnamese stock market, investors still follow the trend and have their investment decisions strongly affected by psychological factors. This is a clear visual indicator of the weak-form inefficiency of the Vietnamese stock market.

The following empirical results will re-examine this visual signs of the weak-form inefficiency.

- ***Test of normal distribution of weekly returns***

Firstly, the descriptive statistics of weekly returns are calculated to determine whether a parametric or non-parametric test is more appropriate to examine the random walk process of VN-Index. Data noted in Table 1 illustrates the descriptive statistics of the Jarque-Bera test for the full sample and three subsamples (corresponding to three market cycles).

The results show that the third market cycled has the highest mean with the lowest Std. Deviation while the first cycle has the lowest mean with higher Std. Deviation. Mean and Std. Deviation of the full sample are in the middle. The negative skewness of both the full sample and subsamples indicates that most distribution is concentrated on the right side of the mean. Meanwhile, kurtosis of all samples is greater than 3, which indicates high peaks and fat tails of all samples. Finally, the result of Jarque-Bera test shows that returns of both the full samples and three subsamples are not normally distributed at significance level of 1%.

Table 1. Descriptive statistics for weekly returns of the VN-INDEX

Statistics	Weekly returns of VN-INDEX			
	Full sample 28/7/2000-28/7/2013	**1st cycle** 28/7/2000- 22/10/2003	**2nd cycle** 23/10/2003- 25/2/2009	**3rd cycle** 26/2/2009- 28/72013
Observations	663	165	271	227
Maximum	0.1935	0.1935	0.1391	0.1201
Minimum	-0.2055	-0.2055	-0.1626	-0.1632
Mean	0.0024	0.0015	0.0024	0.0029
Median	0.0005	-0.0004	0.0012	0.0005
Std. Deviation	0.0455	0.0457	0.0500	0.0394
Skewness	-0.325	-0.638	-0.249	-0.120
Kurtosis	5.331	7.791	4.245	4.330
Jarque-Bera stat.	162.005**	170.033**	20.313**	17.277**

Note: *** Indicates that the null hypothesis of normality is rejected at the 1% significant level.*

Therefore, it is reasonable to use a non-parametric test to examine the weak-form efficiency of The Vietnamese stock market.

- ***Autocorrelation tests***

To identify the weak form of EMH for VN-Index, we first perform the auto-correlation test at lag 10 on weekly returns of all samples. The test results are illustrated in Table 2. Estimated results indicates that auto-correlation coefficients of the full sample is significant at 1st, 2nd and 4th lag at 1% level; and at 3rd and 5th lag with at 5% level. Besides, the Ljung-Box Q-statistic indicates that all the coefficients are significant at 1% level, which rejects the absence of auto-correlation in stock returns.

Table 2. Results of autocorrelation tests for the observed weekly-return data

Lag	Full sample		1st cycle		2nd cycle		3rd cycle	
	AC	***Q*-stat**	**AC**	***Q*-stat**	**AC**	***Q*-stat**	**AC**	***Q*-stat**
1	0.211**	29.543**	0.335**	18.905**	0.199**	10.821**	0.100	2.317
2	0.140**	42.620**	0.288**	32.938**	0.129*	15.421**	0.011	2.346
3	0.101*	49.416**	0.164	37.483**	0.139*	20.778**	-0.027	2.515
4	0.127**	60.119**	0.199*	44.235**	0.134*	25.726**	0.064	3.473
5	0.100*	66.817**	0.223*	52.804**	0.097	28.325**	0.008	3.487
6	0.057	69.021**	0.111	54.924**	0.121	32.427**	-0.089	5.332
7	0.050	70.676**	0.127	57.743**	0.025	32.596**	0.063	6.273
8	0.051	72.429**	-0.044	58.077**	0.071	34.019**	0.150*	11.621
9	0.021	72.730**	0.054	58.588**	0.072	35.483**	-0.092	13.619
10	-0.003	72.735**	-0.116	60.973**	0.028	35.710**	0.050	14.214

Note: **, * *indicates the 1% and 5% significant levels, respectively.*

Meanwhile, results of auto-correlation tests on three market cycles show that the autocorrelation coefficient is significant in the first and second cycle. Significant auto-correlation coefficients are found at the 1st, 2nd, 4th and 5th lag for the first cycle; at 1st, 2nd, 3rd and 4th lag for the second one and at the 8th lag for the third one. The Ljung-Box Q-statistic test rejects the joint hypothesis that all auto-correlation coefficients from lag one to

lag ten are equal to 0 for the series of observed returns of all market cycles. For the third cycle in particular, the test result of the Ljung-Box Q-statistic cannot reject the null hypothesis at the significance level of 5%. In other words, there is no statistical evidence for autocorrelation in weekly returns in the third cycle.

- ***Runs test***

To further examine the weak form efficiency of the Vietnamese stock market, we next use the runs test to examine a random walk process for VN-Index. Since it is a non-parametric test, it is a better measure for all kinds of samples as suggested above by Jarque-Bera test. In Table 3 illustrates the results of the runs test, including actual runs, expected runs, Z-statistics, and P-value of Z.

Table 3. Results of the runs test for weekly returns of the VN-INDEX

Statistics	Weekly returns of VN-INDEX			
	Full sample	**1st cycle**	**2nd cycle**	**3rd cycle**
Observations	663	165	271	227
Actual runs	268	52	108	103
Expected runs [a]	332	83	136	114
Z-statistics	-5.014	-4.919	-3.469	-1.530
P-value of Z	0.000**	0.000**	0.000**	0.000**

Note: *a The closest integer*

*** Indicates the 1% significant level*

The actual runs of all samples are lower than the expected runs. Moreover, Z-statistics is -5.014, -4.919, -3.469 and -1.530 for the full samples and the three market cycles respectively. This result and P-value of Z indicates that the runs test rejects the existence of a random walk in both the full samples and the three cycles at the significance level of 1%.

- ***Variance ratio tests***

As mentioned in methodology section, this study also employs the variance ratio test to examine the weak-form of EMH. More specifically, this test is use to check both null hypothesis, including homoscedastic and heteroscedastic increments random walk.

Based on Lo and MacKinlay's (1988) variance ratio tests, the hypothesis is defined as:

H_0: *VR(q) = 1 The return series follow a random walk*

H_1: *VR(q) ≠ 1 The return series does not follow a random walk*

VR(q) >1, imply positive serial correlations and VR(q) <1, imply negative serial correlations.

The variance ratio test is conducted on the logarithm of prices for both the full samples and three market cycles. The variance ratio (VR) is calculated for the intervals (q) of 2, 4, 6, 8, and 16 observations. The result of the variance ratios VR(q) and the Z-statistics under both homoscedasticity and heteroscedasticity assumption is illustrated in Table 4.

Table 4. Results of variance ratio tests for VN index for the weekly base observation period

Statistics	Number of $n \times q$ of base observations	Number of q of base observations aggregated to form variance ratio			
		2	4	8	16
Full sample	**664**				
VR(q)		1.21	1.51	1.98	2.40
Z(q)		5.50**	7.09**	8.55**	8.19**
Z*(q)		3.72**	4.98**	6.06**	5.98**
1st cycle	**166**				
VR(q)		1.35	1.92	2.88	3.70
Z(q)		4.47**	6.30**	8.17**	7.89**
Z*(q)		2.81**	4.13**	5.13**	4.92**
2nd cycle	**271**				
VR(q)		1.20	1.50	2.02	2.61
Z(q)		3.33**	4.43**	5.65**	6.00**
Z*(q)		2.36*	3.23**	4.22**	4.67**
3rd cycle	**227**				
VR(q)		1.11	1.18	1.23	1.26
Z(q)		1.66	1.45	1.19	0.88
Z*(q)		1.20	1.14	1.00	0.80

Note: ***, * indicates the 1% and 5% significant levels, respectively.*

The test results presented in Table 4 shows that the null hypothesis of a random walk for the full sample, the first cycle and the second cycle (under the assumption of homoscedasticity or heteroscedasticity increments) can be rejected at a significance level of 5% for all values of q. Additionally, the estimates of VR(q) are larger than 1 for all cases, indicating positive auto-correlation for weekly holding period returns (Lo and MacKinlay 1988). This also rejects the null hypothesis of a linear relationship between the variance ratios, which indicates that VN-Index does not follow a random walk.

However, for cycle 3, the results of the variance ratio test imply that the null hypothesis of a random walk cannot be rejected at a significance level of 5% for all values of q under the assumption of homoscedasticity or heteroscedasticity increments.

V. Conclusions

This study investigates whether efficiency of the Vietnamese stock market is weak-form, a relatively popular form in emerging stock markets all over the world. Testing the weak-form efficiency of EMH for VN-Index and its three suggested market cycles was conducting using weekly stock market returns and daily prices of five selected representative stocks from July 28th 2000 to July 28th 2013 (13 years of market operation).

Observing the graph showing daily price movements of 5 separated stocks as well as VN-Index, visualization shows that during the market's operation, stock transaction prices usually fluctuate at the same rhythm with market index hence there are rarely separate movements. This finding is visual evidence proving that the market is not yet efficient, though investors usually act similarly making transaction prices predictable. It actually is the situation of the Vietnamese market at the beginning time when legal corridors related to stock market by the Vietnamese Government are not yet comprehensive and the market is still in small size. Moreover, investors in stock market are not yet professional allowing psychological factors to strongly influence their investment decisions. Since February 2009, however, the Vietnamese stock market efficiency has been improving remarkably with signs of separate movements in transaction prices of traded stocks. It reflects the situation in Vietnam where legal corridors for stock market has been improving, market size has rapidly been developing, commodities traded are more diversified and particularly investors have become more professional in their investment process.

In order to prove for the previous visual statements, we employed three testing methods including auto-correlation test, the runs test, and variance ratio test to investigate weak-form efficiency of the Vietnamese stock market by testing random walk in VN-Index.

Results from autocorrelation test point out that RWH is rejected for the full sample and the first two cycles of the market. It proves that following price changes in the market are not random. However with the third cycle, there is not enough evidence to reject hypothesis H_0. In addition, results from runs test also provide evidence rejecting RWH for observed weekly returns of the full sample and three subsample. Such results are in line with a study conducted by Mookerjee and Yu (1999) when they used autocorrelation test and runs test to reject EMH in Shanghai and Shenzhen stock exchange. Finally, results from Lo and MacKinley's variance ratio test do not support WRH for both the full sample and the first two cycles under both homoscedasticity and heteroscedasticity assumptions. It is similar with findings from Truong (2006)'s research when he used variance ratio test in VN-Index and some individual stocks traded in HOSE. Moreover, the study conducted by Urrutia (1995) on some Latin American emerging stock markets point out that non - random prices might be the result of economic growth but not the inefficient market alone. However, for the third cycle (Feb.2009 – July.2013), test results cannot reject RWH under the assumption of homoscedastic or heteroscedasticity increments.

In summary, the results of tests all indicate that the RWH is strongly rejected for the Vietnamese stock market (despite there is evidence supporting RWH in the third cycle of the market). However, Lo and MacKinlay (1988) state that the rejection of the random walk hypothesis does not necessarily imply that the stock market is inefficient or that prices are not rational assessments of "fundamental" values. Therefore, we cannot conclude that the Vietnamese stock market is inefficient. Given the evidence from the results of our tests, however, it may be the case that the weak-form efficient hypothesis does not hold for the Vietnamese stock market. Particularly in the third cycle alone (February 24th 2009 to July 28th 2013), results from the tests support the RWH in VN-Index. Such findings prove that there is significant improvement in the efficiency of the Vietnamese stock market after nearly 10 years in operation (since its first transaction). At the same time, they are in conformity with the fact that recently Vietnamese economy in general and stock market in particular have been noticeably improving in all aspects. Stock investors have gradually become more professional in their investment. Furthermore, no matter whether the rejection of RWH is the consequence of market inefficiency or not, further study on probabilities of predicting changes in stock prices should be conducted.

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