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Lim Kai Jie, Shawn and Chadha, Pavneet and Lau, Joshua and Potdar, Nishad

University College London (UCL)

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Is the Mongolian Equity Market Efficient? Empirical Evidence from Tests of Weak-Form Efficiency

Lim Kai Jie Shawn
Department of Economics
University College London
E-mail: kai.lim.11@ucl.ac.uk

Pavneet Chadha
Department of Economics
University College London

Lau Joshua
Department of Economics
University College London

Nishad Potdar
Department of Economics
University College London

Abstract

This paper investigates the empirical validity of the weak-form of the Efficient Market Hypothesis in the Mongolian equity market over Jan 1999 to Jul 2012. We examine the characteristics of the market by testing the fit of returns to a normal distribution using the Jarque-Bera Test, and find strong evidence against normality. The data also exhibits positive skewness and a high level of excess kurtosis. Next, we test for the presence of autocorrelation using the Ljung-Box Q Test and the non-parametric Runs Test, and find strong evidence against the null hypothesis of no autocorrelation for both of these tests. Finally, we test the associated Random Walk Hypothesis using the Augmented Dickey-Fuller Test and the Chow-Denning Multiple Variance Ratio (MVR) Test. We reject the null hypothesis of the presence of a unit root for the Augmented Dickey-Fuller Test. In addition, we find evidence against the Random Walk Hypothesis even after adjusting for the possible presence of heteroscedasticity in the MVR Test. Since all the tests present results consistent with weak-form inefficiency, we reject the weak-form of the Efficient Market Hypothesis for the Mongolian equity market.

Keywords: Weak-form efficient market hypothesis, Mongolian equity market, Random walk hypothesis
JEL Classification Codes: C14, G14

1. Introduction

As the world equity markets floundered in the wake of the US subprime crisis and the continued structural problems of Europe, many investors began to look to emerging and frontier markets as a source of superior, and more importantly, uncorrelated return. Within this space, few markets have performed as remarkably as the Mongolian equity market, which clocked the best returns in the world in 2010 when share prices climbed 121% and the second best global return in 2011 when share prices climbed 73% (Oxford Business Group). As the market delivered such impressive returns, it began to catch the attention of more investors with many beginning to set up funds focused on the region, and this interest is likely to grow in the coming years.

However, for a market with such large returns, the interest it has garnered from the academic community has been fairly muted. This paper attempts to address that gap by examining and testing the characteristics of the Mongolian equity market. We test the weak-form of the efficient market hypothesis using a series of statistical tests to measure how well price movements match up with the expected characteristics of a weak-form efficient market. Firstly, we investigate the distributional characteristics of the financial time series and test its empirical fit with a normal distribution using the Jarque-Bera Test. Next, we employ the Ljung-Box Q Test and the Runs test to examine the evidence of autocorrelation in stock prices. In addition, we test the associated Random Walk Hypothesis using the Augmented Dickey-Fuller Test. Finally, we employ the Chow-Denning Multiple Variance Ratio Test for a stricter test of the Random Walk Hypothesis. To the best of our knowledge, this is the first paper that tests the efficiency of the Mongolian equity market and thus the empirical results from this examination will be helpful in increasing our understanding of the characteristics of this market. This is likely to be of increased importance with continued growth in investor attention, as the presence or absence of an efficient market has numerous implications for asset pricing models and the likely profitability of various trading strategies.

The rest of this paper is set out as follows. Section 2 provides the background to our study by introducing the hypothesis that we are testing, the typical ways that it has been tested in empirical literature, and the characteristics of the Mongolian equity market. Section 3 describes the data that we have used in this study and details the methodology employed for the various tests. Section 4 presents the results from these tests and discusses their implications on weak-form market efficiency. Finally, section 5 summarizes the main findings of our paper and concludes our study.

2. Background

2.1. Efficient Markets and Random Walks

The Efficient Market Hypothesis (EMH) contends that prices fully reflect all available information (Fama, 1965) and is a key assumption often made in the development of other theories to model financial markets. The EMH has implications on the profitability of various forms of analysis and the way in which information is transmitted through markets; hence, it is an area that has been extensively studied and debated in academic circles.

The EMH has been split into three hypotheses with varying definitions of information (Fama, 1970). The weak-form of the EMH defines information as all past information and implies that future price movements cannot be predicted based on past prices, with the practical implication that technical analysis cannot be consistently profitable (Fama 1970). The semi-strong form of the EMH has a broader definition of information and includes past information on price changes as well as all presently available public information, with the implication that both technical and fundamental analysis cannot be consistently profitable. The strong form of the EMH casts the net even wider to include all private information about a company.

The EMH is closely associated with the Random Walk Hypothesis (RWH) which asserts that prices follow a random walk and subsequent price changes can be modeled as independently distributed random variables; thus, changes in future prices cannot be predicted based on historical price changes. Stated in an alternate manner, for a given point in time, the size and direction of the next price change is random with respect to the knowledge available at that point in time (Dyckman & Morse, 1986). As the implication of price movements in accordance with the RWH is that markets will be weak-form efficient, tests of weak-form efficiency are often conducted by analysing the validity of the RWH.

The empirical evidence for the validity of the EMH has been mixed, with developed markets often exhibiting the presence of weak-form efficiency (Borges, 2008), with some also displaying evidence consistent with the semi-strong form of the EMH (Gersdorff & Bacon, 2009). Emerging and frontier markets, on the other hand, often display evidence of weak-form inefficiency (Worthington & Higgs, 2005), as expected for markets with less investor attention (Peng & Xiong, 2006). The strong form of the EMH has generally not been supported by the empirical evidence in both types of markets (Fama, 1991).

In this study, we will be focusing on testing the weak-form of the EMH in the Mongolian equity market.

2.2. Mongolian Equity Market

Mongolia is a landlocked country in Central Asia and is the most sparsely populated independent country in the world. It is a quickly growing nation, with GDP growth of 6.4% in 2010 and 17.3% in 2011, largely on the strength of its commodity exports to its surrounding countries (CIA World Factbook).

The Mongolian Stock Exchange (MSE) is a key player in the financial market of the country and is pivotal in the continued growth in the Mongolian economy. It was established in 1991 as a venue primarily to facilitate the primary issuance of equity to facilitate the privatisation of state owned enterprises and secondary market activity in these shares commenced from 1995. The market is open for two hours each day, five days a week. The MSE has seen rapid growth, with its market capitalisation growing from US$83 million in 2006 (Dow Jones Financial News Online) to US $2 billion by 2011 (Bloomberg).

The MSE has been investing heavily in its infrastructure in anticipation of greater investor interest and security market activity. The MSE has improved its technological capability by adopting the Millennium IT integrated trading platform from Millennium IT Software Limited, a Subsidiary of the London Stock Exchange Group. With the improved infrastructure and impressive returns over the past few years, we are likely to see more players begin to enter this market in the years to come. As investor attention increases, there will be an increased need to understand the characteristics of the Mongolian equity market. This has been an area that has been largely neglected by the academic community and this paper attempts to address that gap by presenting the results from empirical tests of weak-form efficiency and tests on the distributional characteristics of returns in this market.

3. Methodology

3.1. Testing the Empirical Fit of the Data with a Normal Distribution

The use of statistical models to approximate the observed distribution of financial data is a common approach employed in financial analysis. From the calculation of risk statistics like Value at Risk to the application of numerous financial models, the ability of prices to be approximated with a normal distribution is often a critical assumption. In this section, we investigate the empirical validity of a normality assumption by testing the fit of the prices from the Mongolian equity market with a lognormal distribution using the Jarque-Bera Test.

The Jarque-Bera Test is a goodness-of-fit test that examines whether the sample data has the kurtosis and skewness that matches a normal distribution. The test statistic *JB* is calculated using the following equation:

$$JB = \frac{n}{6}\left(S^2 + \frac{1}{4}\left(K-3\right)^2\right) \tag{1}$$

$$S = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^3}{\left(\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2\right)^{\frac{3}{2}}} \quad (2)$$

$$K = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^4}{\left(\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2\right)^{2}} \quad (3)$$

Where

JB: Jarque-Bera Test Statistic

S: Sample skewness

K: Sample kurtosis

n: Number of observations in the sample

$\bar{x}$: Sample mean

The null hypothesis for this test is that skewness and excess kurtosis is zero, the expected skewness and kurtosis if the sample followed a normal distribution. To conduct this test the *JB* statistic is compared with a chi-squared distribution with two degrees of freedom and the results from this test are reported in table 1.

3.2. Testing for the Presence of Autocorrelation

Autocorrelation refers to the phenomenon where a given variable is correlated with itself over successive time periods. Within the context of the efficient market hypothesis, if stock prices exhibit evidence of autocorrelation, then past prices can be used as predictors of future returns and the weak-form of the efficient market hypothesis is thus violated. Hence, testing whether stock prices exhibit autocorrelation is a fairly intuitive way of testing for weak-form efficiency and is a well established approach within academic literature. We adopt the methodology of Borges (2008) and test for serial correlation using the Ljung-Box Q Test which is a parametric tests as well as the Runs Test which is a non-parametric test.

3.2.1. Ljung-Box Q Test

The Ljung-Box Q Test is a portmanteau test that tests the presence of autocorrelation in a series and thus tests for the strongest form of the Random Walk Hypothesis. To perform this test, we first conduct OLS regressions on daily and monthly returns of lag 1 to 10 for the return series using the following specification:

$$R_t = \alpha + \hat{\rho}_k R_{t-k} + \varepsilon_t \quad (4)$$

Where

R_t: Return at time *t*

ρ_k: Slope of the OLS regression for lag *k*

R_{t-k}: Return at time *t* - *k*

Next, we calculate the Q-Statistic using the following equation:

$$Q = n\left(n+2\right)\sum_{c=1}^{k}\frac{\hat{\rho}_c^2}{n-c} \quad (5)$$

Where

Q: Test statistic

n: Sample size

k: Maximum lag considered, where k = 1, …, 10

The Q-Statistic at lag k is a test for the null hypothesis that there is no autocorrelation up to order k. The calculated Q-Statistic is then compared with $X^2_{0.95,k}$ and we can conclude that there is sufficient evidence to reject the null hypothesis at the 95% confidence level if $Q > X^2_{0.95,k}$.

The results from the Ljung-Box Q Test are reported in table 2.

3.2.2. Runs Test

The Runs Test determines whether successive price changes are independent. Unlike the Ljung-Box Q Test, the Runs Test is a non-parametric test and is robust to a non-normal distribution in the return of stock prices. In this test, the observed number of runs is compared against the expected number if the series followed a random walk. There are two types of Runs Tests, those that include unchanged prices (Wallis & Roberts, 1965) and those that ignore unchanged prices (Mood, 1940; Geary, 1970). As the Runs Test that includes the unchanged prices is more effective for markets where trading is thin (Ma, 2004), we have adopted that specification in our study. A run is defined as a series of successive price changes with the same sign. A '+' stands for a positive change, a '0' stands for no change and a '-' stands for a negative change. A sequence of +, +, +, +, 0, 0, -, -, -, -, 0, 0, +, +, + would thus give us a total of 5 runs for the purpose of our test.

We define a return as positive if it is greater than zero and as negative if it is smaller than zero. Having classified the returns, the next step is to count the number of '+', '-' and '0' runs and compare it with the expected number from a random walk. We can calculate the expected number of runs and standard deviation with the following equations:

$$\mu_R = \frac{n(n-1) - \sum_{i=1}^{3} \varphi_i^2}{n} \tag{6}$$

$$\sigma_R = \sqrt{\frac{\sum_{i=1}^{3} \varphi_i^2 \left(\sum_{i=1}^{3} \varphi_i^2 + n(n+1)\right) - 2n\sum_{i=1}^{3} \varphi_i^3 - n^3}{n^2(n-1)}} \tag{7}$$

Where

μ_R: Expected number of runs

n: Number of observations

φ_i: Total number of changes for each type of sign, where i = 1, 2, 3 denotes the signs of plus, minus and no change

For large sample sizes, the distribution can be approximated by the normal distribution and the standard normal distribution can be used to test the null hypothesis (Fama, 1965). The standard score is calculated using the following equation and compared to a N(0,1) population at the 95% confidence level to test the null hypothesis:

$$Z = \frac{R - \mu_R \pm 0.5}{\sigma_R} \tag{8}$$

Where

R: Actual number of runs

The 0.5 is a correction factor for continuity adjustment (Wallis & Roberts, 1965), in which the sign of the continuity adjustment is positive if $R \le \mu_r$ and the sign of the continuity adjustment is negative if $R \ge \mu_r$.

The results from the Runs Test are reported in table 3.

3.3. Unit Root Test

The Augmented Dickey-Fuller (ADF) Test is used to test for the presence of a unit root in the series of log price changes in our market index. The logarithmic transformation is often applied in the analysis of financial price series and we apply it before conducting the test for 2 reasons. Firstly, a logarithmic transformation often stabilizes the variance of the price series (Granger & Hallman, 1991). Secondly, a logarithmic transformation is often required if the prices are to conform closely to an I(1) process as is tested in the ADF Test.

We conduct the ADF Test with a constant and a time trend by running an OLS regression based on the following specification:

$$\Delta \ln\left(P_t\right) = \alpha_0 + \beta t + \rho_0 \ln\left(P_{t-1}\right) + \sum_{i=1}^{q} \rho_i \Delta \ln\left(P_{it-1}\right) + \varepsilon_{it} \quad (9)$$

$$\Delta \ln\left(P_t\right) = \ln\left(P_t\right) - \ln\left(P_{t-1}\right) \quad (10)$$

Where

P_t: Stock index level at time t

ρ_i: Coefficients to be determined

q: Number of lagged terms

α_0: Constant

β: Estimated coefficient for the trend

t: Time trend

The test is conducted to test the null hypothesis that stock prices follow a random walk. Formally we test the following hypothesis H_0 against the alternative hypothesis H_1:

$$H_0 : \rho_0 = 0$$

$$H_1 : \rho_0 \neq 0$$

We use the critical values of MacKinnon (1994) to determine the significance of the t-statistic for this hypothesis test. In order to determine the number of lags to include in the regression, we begin from a maximum number of 10 and conduct multiple iterations where we reduce the number of lags by 1 if the last lagged difference is not statistically different from zero. When we arrive at a difference that gives results that are statistically different from zero, then we employ that number of lags for our regression.

If the null hypothesis is rejected, then there is sufficient evidence to reject the hypothesis that stock prices follow a random walk and this can be interpreted as evidence in favour of weak-form inefficiency.

The results of this test are reported in table 4.

3.4. Multiple Variance Ratio Test

There are two main implications of the Random Walk Hypothesis: a unit root and uncorrelated residuals. Variance ratio tests exploit the later, and are considered to be stricter, more robust tests of the Random Walk Hypothesis than unit root tests as, among other flaws, unit root tests are known to have very low power and cannot detect some departures from the random walk (Shiller & Perron, 1985; Hakkio, 1986; Gonzalo & Lee, 1996). On the other hand, the version of variance ratio test which we are employing for this paper, the multiple variance ratio test, has good size and power properties (Chow & Denning, 1993).

Consider a random walk with drift process

$$p_t = p_{t-1} + \mu + \varepsilon_t \quad (11)$$

Where

p_t: The natural logarithm of a stock price index at time t

μ: Arbitrary drift parameter

ε_t: Random disturbance term with $E\left[\varepsilon_t\right] = 0 \;\&\; E\left[\varepsilon_t \varepsilon_{t-g}\right] = 0, g \neq 0$, for all t

In a random walk with uncorrelated increments in the residuals, the variance of these increments increases linearly in any and all the sampling intervals.

$$Var\left(p_t - p_{t-q}\right) = qVar\left(p_t - p_{t-1}\right) \quad (12)$$

Where

q: Sampling interval (Any positive integer)

The variance ratio is given by

$$VR(q) = \frac{\frac{1}{q} Var(p_t - p_{t-q})}{Var(p_t - p_{t-q})} = \frac{\sigma^{2(q)}}{\sigma^{2(1)}} \tag{13}$$

$$M_r(q) = VR(q) - 1 \tag{14}$$

For a single variance ratio test, the null hypothesis is $VR(q) = 1$ or $M_r(q) = 0$.

However, since the Random Walk Hypothesis is rejected if any one of the $M_r(q_i)$ is significantly different from zero, only the maximum absolute value in the set of statistics needs consideration. Chow and Denning's Multiple Variance Ratio test exploits this, and is based on the result

$$PR\left[Max\left(|Z(q_1)|, \ldots, |Z(q_m)| \ \leq SMM(\alpha; m; T) \geq 1 - \alpha\right)\right] \tag{15}$$

Where

$SMM(\alpha;m;T)$: The upper α point of the Studentized Maximum Modulus (SMM) distribution with parameters m and T (sample size) degrees of freedom.

Asymptotically, when T is infinite,

$$SMM(\alpha; m; T) = Z_{\frac{\alpha^*}{2},} \ in \ which \ \alpha^* = 1 - (1 - \alpha)^{\frac{1}{m}} \tag{16}$$

Given our large sample size, we can use the standard normal distribution to calculate two test statistics, $Z(q)$ and $Z^*(q)$. The former assumes homoscedastic disturbances, while the later treats them as heteroscedastic. The rest of this section will expand on the calculations involved in this test.

Consider a sample size of $nq + 1$ observations ($p_0, p_1, \ldots, p_{nq}$). Unbiased estimates of $\sigma^2(1)$ and $\sigma^2(q)$ can be calculated as

$$\hat{\sigma}^2(1) = (nq - 1)^{-1} \sum_{k=1}^{nq} (p_k - p_{k-1} - \hat{u})^2 \tag{17}$$

$$\hat{\sigma}^2(q) = (h)^{-1} \sum_{k=q}^{nq} (p_k - p_{k-q} - q\hat{u})^2 \tag{18}$$

$$h \equiv q(nq + 1 - q)\left(1 - \frac{q}{nq}\right) \tag{19}$$

Where

u: Sample mean of $(p_t - p_{t-1})$

$$\widehat{M}_r(q) = \frac{\sigma^2(q)}{\sigma^2(1)} - 1 \tag{20}$$

The standard normal test statistic, under homoscedasticity, is

$$Z(q) \ = \ \frac{\sqrt{n\hat{q}} M_r(q)}{\sigma_0(q)}. \tag{19}$$

$$\sigma_0(q) = \left(\frac{2(2q-1)(q-1)}{3q}\right)^{\frac{1}{2}} \tag{20}$$

The estimated value of $M_r(q)$ is asymptotically equal to a weighted sum of autocorrelation coefficient estimates, and can also be calculated using this formula

$$\widehat{M}_r(q) = 2\sum_{k=1}^{q-1}\left(1 - \frac{k}{q}\right)\hat{\rho}(k) \tag{21}$$

The standard normal test statistic, under heteroscedasticity, is

$$Z^*(q) = \frac{\sqrt{nq}\widehat{M}_r(q)}{\widehat{\sigma}_s(q)} \tag{22}$$

$$\widehat{\sigma}_s(q) = 4\left(\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \widehat{\delta}_k\right)^{\frac{1}{2}} \tag{23}$$

$$\widehat{\delta}_k = \frac{nq\sum_{j=k+1}^{nq}\left(p_j - p_{j-1} - \widehat{u}\right)^2\left(p_{j-k} - p_{j-k-1} - \widehat{u}\right)^2}{\left[\sum_{j=1}^{nq}\left(p_j - p_{j-1} - \widehat{u}\right)^2\right]^2} \tag{24}$$

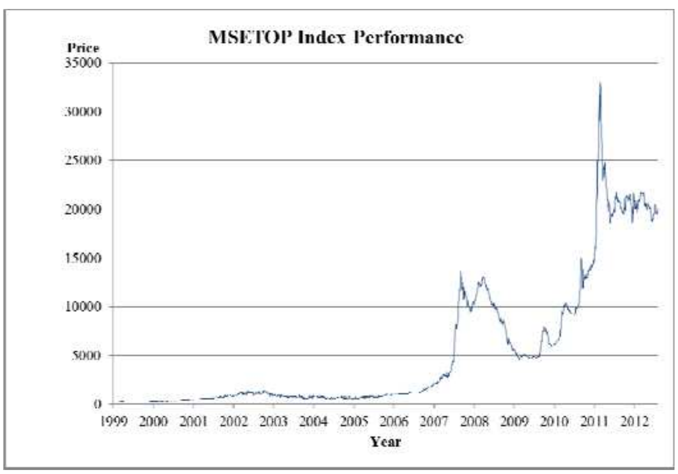
We conducted the test for sampling intervals of 2, 4, 8, 16 days and the results of this test are presented in table 5.

4. Results and Discussion

4.1. Data

For the purpose of this study, we obtained daily prices for the MSETOP Index from Bloomberg over the time period January 1999 to July 2012 which yields 3216 daily price observations. The MSETOP Index is regarded as the most representative index for this market and is a market capitalisation weighted index that is rebalanced every 6 months to reflect the top 20 securities listed on the Mongolia Stock Exchanged based on the market capitalisation and average trading value over the past 6 months. Figure 1 shows the price evolution of the MSETOP Index over this period.

Figure 1: MSETOP Index [Jan 1999 – Sep 2012]



4.2. Testing Normality

Table 1: Summary Statistics

Metric	Value
Mean Annual Return	160.69%
Median Annual Return	31.66%
Max Annual Return	400.82% (2007)
Min Annual Return	-45.10% (2008)
Annual Returns Standard Deviation	107.45%
Kurtosis	7.00
Skewness	2.38
JB Statistic	22.58
P-Value	<0.01

Table 1 presents the summary statistics of our data and the results from the Jarque-Bera Test. The annual return data for this market exhibits a large amount of kurtosis and is positively skewed. We find strong evidence against the null hypothesis of a normal distribution from the Jarque-Bera Test, consistent with the high kurtosis and skewness. In addition, this market is a fairly volatile market with large deviations in returns between years with some years giving large returns and others resulting in large losses. Due to the fact that the data exhibits strong evidence of non-normality, we have employed non parametric tests in our investigation of weak-form efficiency as well that do not require the assumption of a normal distribution to make our results more robust.

4.3. Ljung-Box Q Test

Table 2: Results from the Ljung-Box Q Test

Daily Returns										
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
α	1.208	1.041	1.053	1.068	0.959	1.009	0.964	1.026	0.966	1.040
(P-Value)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ρ_k	-0.205	-0.039	-0.049	-0.066	0.044	-0.006	0.038	-0.023	0.037	-0.037
(P-Value)	<0.001	0.0288	0.005	<0.001	0.013	0.719	0.031	0.194	0.038	0.036
Q-Statistic	135.172	139.958	147.96	161.800	167.947	168.077	172.761	174.455	178.790	183.187
P-Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Monthly Returns										
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
α	0.812	1.050	1.120	1.0144	0.882	0.908	0.920	1.089	1.013	1.006
(P-Value)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ρ_k	0.217	-0.012	-0.080	0.023	0.150	0.126	0.114	-0.047	0.027	0.034
(P-Value)	0.006	0.883	0.318	0.776	0.059	0.116	0.155	0.560	0.742	0.680
Q-Statistic	7.736	7.760	8.802	8.890	12.611	15.232	17.398	17.777	17.909	18.112
P-Value	0.005	0.021	0.032	0.064	0.027	0.019	0.015	0.023	0.036	0.053

From the Ljung-Box Q Test, we see that there is sufficient evidence to reject the null hypothesis of no autocorrelation at the 95% confidence level for all the daily returns and all the monthly returns with the exception of the lag up to 4 and the lag up to 10. This presence of autocorrelation in the data can be interpreted as evidence against weak form efficiency in the Mongolian equity markets.

4.4. Runs Test

Table 3: Results from the Runs Test

	Daily	**Monthly**
Number of positive returns	1625	94
Number of negative returns	1494	69
Number of zero returns	97	0
Total number of observations	3216	163
Number of positive runs	784	36
Number of negative runs	776	35
Number of zero runs	85	0
Total number of runs	1645	71
Expected number of runs	2834.385	146.534
standard deviation	140.455	31.638
Z-statistic	-8.472	-2.403
P-value	<0.001	0.008

Table 3 presents the results from the Runs Test, which is a non-parametric investigation of the presence of autocorrelation in time series data. We find sufficient evidence to reject the null hypothesis of no autocorrelation for both the monthly and daily data, a result consistent with the findings of the Ljung-Box Q Test. Hence, the evidence from the investigation of the presence of autocorrelation supports the hypothesis of weak-from inefficiency in the Mongolian equity markets.

4.5. Augmented Dickey-Fuller Test

Table 4: Results from the ADF Test using Daily Data

Lag	1	2	3	4	5	6	7	8	9	10
Dickey-Fuller Statistic	-20.90	-18.01	-14.47	-13.05	-12.30	-11.55	-11.63	-10.79	-10.43	-9.60
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

From the ADF Test using daily data, we see strong evidence against the presence of a unit root in the series of log price changes in our market index up to lag 10. This result suggests that the RWH is not valid for this market and hence presents evidence against weak-form efficiency in the Mongolian equity market, consistent with the tests on the presence of autocorrelation.

4.4. Multiple Variance Ratio Test

Figure 2: Variance Ratio Plot

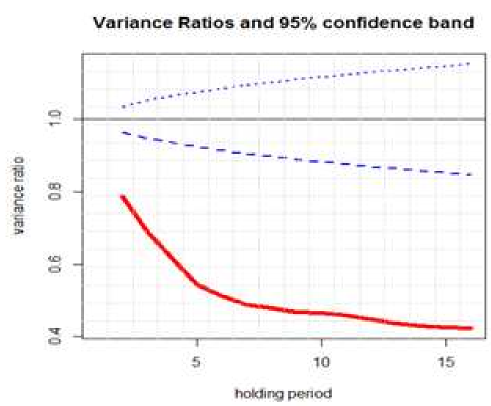


Figure 2 plots the unstandardized variance ratios against holding periods with 95% confidence band standard errors under the assumption of iid returns and was constructed using R. It illustrates graphically the variance ratios computed from the data using different holding periods.

Table 5: Multiple Variance Ratio Tests

Holding period	q =2	q =4	q =8	q =16	Chow Denning Statistic
Z(q)	-12.101	-11.645	-9.980	-7.416	12.101
$Z^*(q)$	-4.560	-5.078	-4.993	-4.141	5.078

Following Chow and Denning's procedure, only the maximum absolute values of $Z(q)$ & $Z^*(q)$ need to be considered, which have been mentioned in the "Chow Denning Statistic" column in Table 5. The 0.05 critical value for $Z(q)$ & $Z^*(q)$ is 2.49. The 0.01 critical value for $Z(q)$ & $Z^*(q)$ is 3.022.

Since $Max|Z(q)| = 12.101 > 3.022$, we strongly reject the null hypothesis that the logarithm of the stock price index follows a homoscedastic random walk. Similarly, Since $Max|Z^*(q)| = 5.078 > 3.022$, we strongly reject the null hypothesis that the logarithm of the stock price index follows a heteroscedastic random walk.

The null hypothesis that the logarithm of the stock price index follows a homoscedastic random walk can, in principle, be rejected either due to heteroscedasticity or autocorrelation in the stock price index. However, since we have we strongly rejected the null hypothesis that the logarithm of the stock price index follows a heteroscedastic random walk, we can conclude that autocorrelation of daily increments in the natural logarithm of the stock market price index results in the Random Walk Hypothesis being rejected for the Mongolian equity market. This is consistent with the other tests conducted in this paper which show evidence against weak-form efficiency in the Mongolian equity markets.

5. Conclusion

In this paper, we examined the weak-form of the EMH for the Mongolian equity market. First, we tested the characteristics of returns using the Jarque-Bera Test and found evidence against a distribution consistent with a normal distribution. We also calculated summary statistics which show that this is a highly volatile market with a large amount of return deviation between years. Next, we tested for the presence of autocorrelation in prices using the Ljung-Box Q Test and the Runs Test. We adopted the specification from Wallis & Roberts (1965) for the Runs Test which is more effective for markets where trading is thin. The presence of autocorrelation suggests that some of the variation in prices might be related to past changes and is indicative of a trending market. If past prices can be used to predict future price changes, however, then the weak-form of the efficient market hypothesis is violated. We find evidence of autocorrelation in these 2 tests which supports weak-form inefficiency in this market. Next, we tested the associated Random Walk Hypothesis using the Augmented-Dickey Fuller Test and the Chow-Denning Multiple Variance Ratio Test. We find evidence against the hypothesis that prices follow a random walk. The results from all the tests that we conducted provide strong evidence against the weak-form of the Efficient Market Hypothesis for the Mongolian equity market.

While an analysis of the reasons for this departure from efficiency is beyond the scope of this paper, we believe there are a number of characteristics of this market that could provide a clue to its inefficient nature. Firstly, it is a fairly small market with limited stock market activity. The MSE operates for 2 hours each day, which provides a very short window of time for the process of price discovery. Next, there has been limited attention from investors in this market, with more firms just starting to set up funds focused on this region after the impressive returns in the previous 2 years. The combination of limited activity and limited attention would likely result in a general lack of liquidity in the market, and what would be a small order in another market might be a fairly large order for the Mongolian equity market and could move prices significantly for a period of time as the order is gradually executed. This would result in the phenomenon of prices that trend and hence the presence of autocorrelation that we found in the various tests. Finally, the lack of liquidity and volatile nature of the market could make it difficult and unattractive for arbitrageurs to enter the market to exploit this inefficiency, a necessary condition for the market to be weak-form efficient. Further study is needed to analyse the causal factors for this inefficiency and thus how likely it is to persist in the future.

References

[1] Abraham, A., Seyyed, F.J. and Alsakran, S.A., 2002. “Testing the Random Walk Behavior and Efficiency of Gulf Stock Markets”, *The Financial Review,* Vol. 37, pp. 52-71

[2] Aga, M. and Kocaman, B., 2011. “Efficient Market Hypothesis and Emerging Capital Markets: Empirical evidence from Istanbul Stock Exchange”, *Journal of Financial Markets Research Issue 3*

[3] Borges, M.R., 2008. “ Efficient Market Hypothesis in European Stock Markets”, *Working paper no.20* (School of Economics and Management, Technical University of Lisbon)

[4] Chow, K.V. and Denning, K.C., 1993. "A Simple Multiple Variance Ratio Test", *Journal of Econometrics*, Issue 58, pp. 385-401. North-Holland

[5] Dahel, R. and Laabas, B., 1999. "The Behavior of Stock Prices in the GCC Markets", *Working Paper 9917,* Economic Research Forum

[6] Dickey, D.A. and Fuller, W.A., 1979. "Distribution of the Estimators for Autoregressive Time Series With a Unit Root", *Journal of the American Statistical Association,* Vol. 74, No. 366 , pp. 427-431

[7] Dickey, D.A. and Fuller, W.A, 1981. "Likelihood Ratio statistics for Autoregressive Time Series With a Unit Root", *Econometrica*, Vol. 49, No.4

[8] Dyckman, T.R. and Morse, D., 1986. "Efficient Capital Markets and Accounting: A Critical Analysis", *Prentice-Hall*

[9] Errunza, V.R. and Losq, E. 1985. "The Behavior of Stock Prices on LDC Markets", *Journal of Banking and Finance,* Issue 9, pp. 561-575. North-Holland

[10] Fama, E.F., 1965. "The Behavior of Stock-Market Prices", *Journal of Business*, Vol. 38, Issue 1, pp. 34-105

[11] Fama, E.F., 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work", *Journal of Finance*, Volume 25, Issue 2, pp. 383-417.

[12] Fama, E.F., 1991. "Efficient Capital Markets: II", *The Journal of Finance*, Vol. 46, No. 5, pp. 1575-1617

[13] Geary, R.C., 1970, "Relative Efficiency of Count of Sign Changes for Assessing Residuals Autoregression in Least Squares Regression", *Biometrika*, Vol. 57, pp. 123-127.

[14] Gersdorff, N.V. and Bacon, F., 2009, "U.S. Mergers and Acquisitions: A Test of Market Efficiency", *Journal of Finance and Accountancy*.

[15] Gonzalo, J. and Lee, T.H., 1996. "Relative power of t type tests for stationary and unit root processes", *Journal of Time Series Analysis 17,* pp. 37-47

[16] Granger, C., and Newbold, P., 1991. "Nonlinear Transformations of Integrated Time Series", *Journal of Time Series Analysis 12*, pp 207-224

[17] Hadi, M.M., 2011. "Review of Capital Market Efficiency: Some Evidence from Jordianian Market", *Journal of Financial Markets Research Issue 3*

[18] Hakkio, C.S., 1986. "Does the Exchange Rate follow a Random Walk? A Monte Carlo Study of four tests for a Random Walk", *Journal of International Money and Finance 5*, pp. 221-229

[19] Hamid, K., Suleman, M.T., Shah, S.Z.A. and Akash, R.S.I., 2010. "Testing the Weak form of Efficient Market; Hypothesis: Empirical Evidence from Asia-Pacific Markets", *Journal of Financial Markets Research Issue 3*

[20] Huang, B.N., 1995. "Do Asian Stock Market Prices Follow Random Walks? Evidence From the Variance Ratio Test", *Applied Financial Economics*, 5:4, pp. 251-256

[21] Iulia, S., 2009. "Testing the Efficient Market Hypothesis: A Behaviorial Approach to the current Economic Crisis", *Working Paper* (University of California Berkley)

[22] Larcker, D.F., Gordon, L.A. and Pinches, G.E., 1980. "Testing for Market Efficiency: A Comparison of the Cumulative Average Residual Methodology and Intervention Analysis", *Journal of Financial and Quantitative Analysis*, Volume XV, No. 2

[23] Latham M., 1985. "Defining Capital Market Efficiency", *Working paper no. 150* (Research Program in Finance, Institute of Business and Economic Research, University of California, Berkeley)

[24] Lazăr D., 2007. "Testing Efficiency of the Stock Market in Emerging Economies", Babes-Bolyai University, Faculty of Economics and Business Administration

[25] Lin, J.Y. and Tsendsuren, S., 2012. "Efficient Portfolio Selection in Mongolian Financial Market", *2012 Conference on East Asia Finance* (Tamkang University, Taiwan)

[26] Lindsay, G., 2005. "An Empirical Test of German Stock Market Efficiency", *Working Paper* (Center for Applied Statistics and Economics, Institute for Statistics and Econometrics, Humboldt-Universität zu Berlin)

[27] Ljung, G.M. and Box, G.E.P., 1978. "On a measure of lack of fit in time series models", *Biometrika*, 65, 2, pp. 297-303

[28] Lo, A. and MacKinlay, A.C., 1988. "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test", *Review of Financial Studies 1,* pp. 41-66.

[29] Ma, S., 2004. "The efficiency of China's stockmarket", *Ashgate Publishing Limited*

[30] MacKinnon, J.G. (1994), "Approximate Asymptotic Distribution Functions for Unitroot and Cointegration Tests," *Journal of Business and Economic Statistics*, 12, pp. 167–176

[31] Magnusson, A.M. and Wydick, B. 2000. "How Efficient are Africa's Emerging Stock Markets"

[32] Mood A.M., 1940. "The Distribution Theory of Runs", *Ann. Math. Stat*. Volume 11, Number 4 (1940), pp. 367-392

[33] Ojah, K. and Karemera, D., 1999. "Random Walks and Market Efficiency; Tests of Latin American Emerging Equity Markets: A Revisit", *The Financial Review,* Vol. 34 (1999) pp. 52-71

[34] Peng, L. and Xiong, W., 2006. "Investor attention, overconfidence and category learning", *Journal of Financial Economics,* 80, pp. 563-602.

[35] Phillips, P.C.B., 1987. "Time Series Regression with a Unit Root", *Econometrica*, Vol. 55, No. 2, pp. 277-301

[36] Phillips, P.C.B. and Perron, P., 1988. "Testing for a Unit Root in Time Series Regression", *Biometrika*, Vol. 75, No. 2, pp. 335-346

[37] Shiller, R.J. and Perron, P., 1985. "Testing the random walk hypothesis: Power versus frequency of observation", *Economics Letters, Elsevier, vol. 18(4),* pp. *381-386*

[38] Smith, G., Jefferis, K. and Ryoo, H.J., 2002. "African stock markets: multiple variance ratio tests of random walks," *Applied Financial Economics, Taylor and Francis Journals*, Vol. 12(7), pp. 475-484.

[39] Solnik, B.H., 1973. "Note on the Validity of the Random Walk for European Stock Prices", *The Journal of Finance*, Vol. 28, No. 5 , pp. 1151-1159

[40] Vulic, T.B., 2009. "Testing the Efficient Market Hypothesis and its Critics - Application on the Montenegrin Stock Exchange"

[41] Wallis W. A. & Roberts H. V., 1965. "Statistics: A New Approach", Twelfth printing.

[42] Worthington, A. and Higgs, H., 2004. "Random Walks and Market Efficiencies in European Equity Markets", *Global Journal of Finance and Economics 1,* pp. 59-78.

[43] Worthington, A. and Higgs, H., 2005. "Weak-Form Market efficiency in Asian Emerging and Developed Equity Markets: Comparative Tests of Random Walk Behavior", *Working paper no.5/*03 (School of Accounting and Finance, University of Wollongong)