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Testing Weak Form Market Efficiency on the Stock Market of Srilanka

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Abstract: *This paper examines the weak-form market efficiency of Srilankan stock markets namely Colombo Stock Exchange for the period 14th December 2010 to14th December 2020. Daily returns are examined for random walks using Auto correlation, Runs tests, Unit Root Test, and Variance ratio test. From the Auto correlation, Runs tests, Unit root test, and Variance ratio test, it has been found that the return series is not efficient in the weak form. All the statistical test conclude that the null hypothesis of random walk was not accepted.*

Keywords*: Weak form Market Efficiency, Colombo Stock Exchange (CSE), Autocorrelation test, Runs test.*

1. INTRODUCTION:

The Efficient Market Hypothesis is very popular concept in stock market analysis. Several studies have been carried out almost in every corner of the world for the validity of Efficient Market Hypothesis. It is usually believed that developed markets are more efficient than developing and underdeveloped market due to flow, adjustment and magnitude of information. There are two aspects to the price adjustment to new information that is speed and quality of information (Choudhry, 1994).Efficient market is the one in which the available information is fully reflected in stock prices. This definition is referred to informational efficiency. This means no trading strategies can be used to predict the market prices and no one can earn abnormal returns. Before making the investment strategies, every investors analyze the past price information. According to the theory, the successive price changes are independent and identically random variable. This implies the series of prices have no memory (Eugene, 1965). Stock market Efficiency has great implications to the policy makers and investors. Stock market efficiency can be divided into three forms based on the set of information namely weak, semi-strong and strong form. We have tried to find out the empirical evidences on weak form of market efficiency of Colombo stock index of Srilanka. Weak form of efficient market hypothesis assumes that the current market price reflect all information contained in the historical prices of assets. The idea of random walk was first put forward by Jules Regnault in 1863 followed by Louis Bachelier in 1900.

Considering the extensive literature in abroad, we intend to test the weak form of market efficiency for Srilankan stock markets because of transformational change and economic reforms in the last couple of decades. The observations of the literature also motivate us to have a fresh look at weak form of Market efficiency of Srilankan Stock Market.

2. LITERATURE REVIEW:

The stock market efficiency has generated a lot of controversy over a couple of decades in finance and economics discussions. The investor and analysts try to analyze a company's business by publishing various historical financial statements and hence uncovering information about its profitability that will shed light on the value of its stock. The efficient market hypothesis is theory that supports the assertion that the stock market leads economic activities since market efficiency ensures that past and available current information are fully reflected in current stock prices. (Fama, 1970) explored the review of efficiency theory and subsequently revised it further on the basis of development in research (Fama, 1991). Fama ventured to organize the growing empirical evidence on the theory and he presented the efficient market theory in terms of the current market price fully reflects all available information. Fama also divided market efficiency into three sub-hypotheses depending on the information set involved: (1) weak form efficiency, (2) semi-strong form efficiency and (3) strong form efficiency.

(Worthington & Higgs, 2004) examined twenty European equity markets for random walk including, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom ,Czech Republic, Hungary, Poland and Russia. They use Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and multiple variance ratio (MVR) tests for empirical analysis. the empirical explored that only Hungary, Germany, Ireland, Portugal, Sweden and the United Kingdom markets follow random walk model.

(Gan, Lee, Hwa, & Zhang, 2005) looked into the stock markets of New Zealand, Australia, US and Japan for the period 1990-2003, and reaffirmed the findings of the granger causality between New Zealand and Australian stock markets. They used conventional methods (ADF and PP unit root test) for finding efficiency levels. (Nakamura & Small, 2007) investigate random walk on Standard & Poor's 500 in US market and Nikkei225 in Japanese market,

exchange rate and commodity markets .They found the presence of random walk in markets whose first differences are independently distributed random variables. The study used autocorrelation, runs test and unit root test for the analysis. (Torun & Kurt, 2008)conducted a study on European Monetary Union Countries taking panel data of stock price index, consumer price index and purchasing power of euro for the period 2000-2007 to investigate weak-form and semi-strong efficiency. The study used panel unit root test, panel cointegration and causality test and found result consistent with weak-form efficiency.

(Borges, 2010)investigated the stock markets indices of France, Germany, UK, Greece, Portugal and Spain, from January 1993 to December 2007 for the presence of random walk by taking monthly and daily stock returns. He used both parametric and non-parametric tests including serial correlation test, runs test, multiple variance ratio test proposed by (Lo & MacKinlay, 1988), and ADF test. The presence of random walk was found in all six countries for the monthly returns series. But the daily returns hypothesis of random walk was rejected for Greece and Portugal.

Shaker (2013) tested the weak-form efficiency of Finnish and Swedish stock markets by using ADF, variance ratio test proposed by (Lo & MacKinlay, 1988) this particular study rejected the hypothesis of random walk in these markets.

(Smith & Ryoo, 2003) studied about the stock market of five European countries markets of Greece, Hungary, Poland, Portugal and Turkey. They use multiple variance ratio test. The random walk model hypothesis was rejected in all markets except for Istanbul stock exchange due to higher turnover than other markets. (Guidi, Gupta, & Maheshwari, 2011) studied about the stock market of European countries equity markets for the period of 1999-2009. They used autocorrelation analysis, runs test, and variance ratio test for assessing the hypothesis of random walk. It was concluded that most of the European markets do not follow the random walk. So the investor can earn abnormal profits from this market.

Another study on Istanbul stock exchange (ISE) National 100 index was made by (Kapusuzoglu, 2013)for the period of 1996-2012.They found contradictory result as compared to the findings of (Smith & Ryoo, 2003) .The study focused for locating the presence of random walk in the daily returns series by using unit root test and rejected the hypothesis of random walk.

Another study by (Dragota & Tilica, 2014)examined the stock market of East-European Countries. The study focused about improvement in efficiency based on the historical prices. They had taken 20 countries for the study. The sample countries were Poland, Romania, Russia, Serbia, Slovakia, Bosnia-Herzegovina, Bulgaria, Croatia, Republic of Macedonia, Moldova, Montenegro, Slovenia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Former Yugoslav and Ukraine for the period of 2008-2010.The empirical study was based on the unit root tests, runs test, filter rules test and variance ration tests. In some of the markets the hypothesis of EMH was not rejected but the results were not consistent in all markets. Mixed results were observed in case of Eastern European stock markets with the presence of random walk in stock exchanges of Athens and Turkey.

(Mlambo & Biekpe, 2007) investigated ten African stock markets naming, Botswana, Egypt, Ghana, Johannesburg, Kenya, Mauritius, Morocco, Namibia, Tunisia and Zimbabwe and West African Regional Stock Exchange. The markets returns were calculated on trade-to-trade basis. The null hypothesis of random walk in Namibia was not rejected in due to its correlation with Johannesburg stock exchange. Likewise Kenya and Zimbabwe were not rejected as weak-form efficient. Mauritius, Egypt, Botswana and West African Regional Stock Exchange deviated from random walk hypothesis. The empirical result suggested the need for nonlinear serial correlation testing in these markets for testing efficiency level, since markets with weak microstructures where return generating process is expected to be non-linear. So, a test on linear correlation could lead to wrong inferences.

(Lagoarde-Segot & Lucey, 2008) studied about the Middle-Eastern North African (MENA) stock markets for the period of 1998-2004.They used individual and multiple variance ratio tests, and unit root test model to examine the efficiency level in these markets. Result revealed unique efficiency levels explained by differences in size of stock markets and corporate governance. Another study by (Emenike, 2010)disclosed the rejection of random walk hypothesis in Nigerian Stock Exchange (NSE) from the period of 1985-2007.The study employed the runs test, Kolmogorov-Smirnov, and Q-Q normal chart. The study also disclosed the improvements in NSE trading system over time, have positive impact on efficiency.

The study conducted by (Ntim, Opong, Danbolt, & Dewoto, 2011) about 24 African markets along with eight African national stock price indices. The objective of the research work was to demonstrate the comparison between continent-wide stock prices with the national based African indices. The study employed variance ratio test which concluded that continent-wide stock markets are have better weak-form informational efficiency as compare to their national counterparts. The research work suggests improvements in efficiency of national price indices by integrating their operations.

(Phan & Zhou, 2014) Studied on stock market of Vietnam for the period of 2000-2013. The study employed autocorrelation test, variance ratio test, and runs tests. Vietnamese stock market was not accept the efficient market

hypothesis in the initial periods of the study but shown gradual improvement in the operations of the market about random walk hypothesis in only VN-index during the study period of last year.

3. OBJECTIVES :

The main objective of this study is to examine whether the Srilankan stock markets are weak-form efficient over the defined period. Purpose of this study is also to find out whether Srilankan stock returns violate the random walk hypothesis, to determine whether the selected stock market exhibits a trend towards increased efficiency over time.

Hypothesis

The hypothesis of the study as,
H0: The Srilankan stock market is a weak-form efficient.
H1: The Srilankan stock market is a weak-form inefficient

4. MATERIALS AND METHODS

The literature on the Efficient Market Hypothesis is much uncontrolled, most of the studies based on daily data and some of the studies focus on weekly and monthly data to maintain data synchronization. Some researchers do pursue their analysis using high frequency data. A careful review of the available literature explores conflicting results on weak-form market efficiency for many markets, depending on which test a particular study used, or which type of data the researchers employed. The results are also conflicting with different statistical tests. So the study is required to examine market efficiency of Srilankan Stock Market (Colombo Stock Exchange). Daily data for Colombo Stock Exchange index using the longest possible sample sizes and various types of the statistical tests like Auto correlation, Runs tests, Unit Root Test, and Variance ratio test are employed to examine market efficiency into consideration. To examine whether the time series predictability in Srilankan stock returns.

To examine Srilankan market efficiency, the data used in this study are daily price index data for Colombo stock exchange. The data of daily price index is collected from Yahoo Finance and the 2327 observations are taken from the period of 14th December 2010 to14th December 2020.

5. EMPIRICAL RESULTS AND FINDINGS:

Descriptive Statistics

A summary of descriptive statistics of Colombo stock Market index for the entire sample period 14th December 2010 to14th December 2020 is presented in Table 1. From the Table 1, it can be seen that CSE index has positive mean returns with lower amount of standard deviation. The kurtosis or degree of excess, in index return is positive. The positive value indicates that the data is clustered around the center, and that the curve is highly peaked, thereby indicating leptokurtic distributions. The empirical result of Jarque-Bera statistics and corresponding p values in Table 1 are used to test the null hypotheses that the daily distribution of CSE index returns is normally distributed. The p values is smaller than the 1 percent level of significance suggesting the null hypothesis cannot be accepted. Therefore, none of the return series is then well approximated by the normal distribution. As can be seen in Table 1, the skewness and kurtosis values indicate that returns of both indices are not normally distributed as consistent with Jarque-Bera statistics. Returns of CSE index is negatively skewed or skewed to the left, this indicates, there is greater probability of large deceases in returns than rises.

Table-1 Descriptive statistics of index return

	Daily index return
Mean	4.21E-05
Median	-3.83E-05
Maximum	0.050816
Minimum	-0.076525
Std. Dev.	0.007327
Skewness	-0.878601
Kurtosis	15.84340
Jarque-Bera	16292.94
Probability	0.000000
Sum	0.097960
Sum Sq. Dev.	0.124881
Observations	2327

Auto Correlation Test

Auto correlation test is the most common statistical tool to measure weak form efficiency of the stock market. It measures the correlation between series of returns and lagged series and tested whether the correlation coefficients are significantly different from zero that means the returns of both stock markets are tested about the serial dependence of stock returns. The results of the first ten sample autocorrelation coefficients and Ljung-Box statistics of both indices for the full sample period 14th December 2010 to14th December 2020 are presented in Table 5.

Table-5 provides the results of the sample autocorrelation coefficients and the Ljung- Box statistics for the daily returns on the index of CSE. All returns are compounded continuously. Stock market index of CSE shows significant positive autocorrelation at a lag of one period to sixteen period except lag ten and lag fourteen for return series. For higher-order autocorrelation lag 1, all return series also show a consistent pattern of positive autocorrelation. The result of Positive autocorrelation shows the predictability of returns in short horizon that is the evidence against market efficiency. On the other hand, the presence of negative autocorrelation indicates mean reversion in returns series, with mean reversion being higher in CSE markets. CSE Sensex appears the significant negative autocorrelation at lag 10 and 14. Ljung-Box statistics explored that the proof of possible serial dependence in the first and higher moments of the return distributions. Looking at the Ljung-Box Q-statistics, the null hypothesis is not accepted for all returns on CSE index at lag 1 through 16 at the 5% level of significance.

Table-2: Autocorrelation test

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	.194	.021	88.014	1	.000
2	.092	.021	107.827	2	.000
3	.050	.021	113.544	3	.000
4	.045	.021	118.287	4	.000
5	.022	.021	119.373	5	.000
6	.014	.021	119.844	6	.000
7	.024	.021	121.168	7	.000
8	.068	.021	132.052	8	.000
9	.036	.021	135.005	9	.000
10	-.006	.021	135.085	10	.000
11	.011	.021	135.369	11	.000
12	.040	.021	139.150	12	.000
13	.005	.021	139.205	13	.000
14	-.016	.021	139.801	14	.000
15	.055	.021	146.848	15	.000
16	.024	.021	148.143	16	.000

Runs Test:

A runs test is another common approach to test for statistical independencies, but dissimilarity of autocorrelation coefficient is that it does not require normally distributed returns. A run can be defined as a subsequent change of consecutive price with the same sign. This means the direction of change in the price will be repetitively. The runs test is a non-parametric test. The null hypothesis of randomness is tested by observing the number of runs for successive price changes. The results of the runs tests for index return is presented in Table-3. For the study period, the runs test clearly shows that CSE stock market index is weak form inefficient. The estimated Z statistic values is significant at the 1%, 5% and 10% level. The significant negative Z statistic value and P value for index return indicate that the actual number of runs falls short of the expected number of runs under the null hypothesis of return independence. Alternatively, the negative Z values for index return is indication of positive autocorrelation, which is also consistent with the results from autocorrelation tests.

Table-3: Runs test

Test Value	-0.000038
Cases < Test Value	1163
Cases >= Test Value	1164
Total Cases	2327
Number of Runs	970
Z	-8.066
Asymp. Sig. (2-tailed)	0.000

Unit Root

Since a unit root is a necessary condition for a random walk, to test the null hypothesis of unit root, the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test were used. The results of ADF and PP test for a unit root of the return of CSE index is presented in Table 4. ADF and PP unit root test were performed for the whole sample period 14th December 2010 to14th December 2020. The t statistic value of ADF is -21.96363 but the critical value at 1%, 5% and 10% are - 3.432983, -2.862589 and -2.567374 respectively. The null hypothesis of a unit root is not accepted at the 1%, 5% and 10% level of significance. The t statistic value of PP test is -446.5134 which is higher than critical value at 1%, 5% and 10% therefore the null hypothesis is not accepted. As well as the probability is less than the 1%, 5% and 10% level of significance which indicates that the return series is stationary or no unit root.

Table -4: Unit Root Test

Tests	t-statistics	Probability
ADF test	-21.96363	0.00000
PP test	-446.5134	0.0001

Variance Ratio test

The variance ratio test in this study was conducted under the null hypothesis that daily index return follow a martingale (followed a Random Walk), the variance ratios were expected to be less than one. Individual and joint variance ratio tests were conducted for multiples of 2, 4, 8 and 16 days. The results of both individual and joint variance ratio test expressed in table 5 under the null hypothesis that stock returns does not follow a martingale (Random Walk) showed the probability is less than 0.05 and statistical value is higher than the critical value at 5% level of significance. This implies that the random walk hypothesis is rejected and that the return index is not weak-form efficient. This means that the CSE returns does not follow a systematic pattern and could be predicted with historical return values.

Table -5: Variance Ratio test

Tests	Z-statistics	P-value
Joint test	8.004556	0.0000
Individual test: Periods	-	-
2	-8.004556	0.0000
4	-7.738516	0.0000
8	-6.672179	0.0000
16	-5.362445	0.0000

CONCLUSION:

The overall results from the empirical analysis suggest that the Srilankan Stock Markets are not weak form efficient for the study period. For the study period of 14th December, 2010 to 14th December, 2020, it is found that there is significant autocorrelation, which indicate weak form of inefficiency. Runs Test is also consistent with Autocorrelation Test which indicates that CSE market is in weak form of inefficient in study period. The unit root test explored the result of the return series is stationary which indicates that the return series of CSE index is weak form of inefficient. The result of both joint test and individual variance ratio test indicates the return series of CSE index does not follow the random walk and the market is weak form inefficient.

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Appendices

Appendix-1

Autocorrelations

Series:Rc					
Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	.194	.021	88.014	1	.000
2	.092	.021	107.827	2	.000
3	.050	.021	113.544	3	.000
4	.045	.021	118.287	4	.000
5	.022	.021	119.373	5	.000
6	.014	.021	119.844	6	.000
7	.024	.021	121.168	7	.000
8	.068	.021	132.052	8	.000
9	.036	.021	135.005	9	.000
10	-.006	.021	135.085	10	.000
11	.011	.021	135.369	11	.000
12	.040	.021	139.150	12	.000
13	.005	.021	139.205	13	.000
14	-.016	.021	139.801	14	.000
15	.055	.021	146.848	15	.000
16	.024	.021	148.143	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

Appendix-2

Runs Test

	Rc
Test Value[a]	-.000038
Cases < Test Value	1163
Cases >= Test Value	1164
Total Cases	2327
Number of Runs	970
Z	-8.066
Asymp. Sig. (2-tailed)	.000
a. Median	

Appendix-3

Null Hypothesis: D(RC) has a unit root
Exogenous: Constant
Lag Length: 13 (Automatic - based on SIC, maxlag=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-21.96363	0.0000
Test critical values:	1% level	-3.432983	
	5% level	-2.862589	
	10% level	-2.567374	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RC,2)

Method: Least Squares
Date: 12/15/20 Time: 23:28
Sample (adjusted): 16 2327
Included observations: 2312 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RC(-1))	-6.570692	0.299162	-21.96363	0.0000
D(RC(-1),2)	4.802444	0.291314	16.48545	0.0000
D(RC(-2),2)	4.129023	0.278321	14.83549	0.0000
D(RC(-3),2)	3.508681	0.261312	13.42717	0.0000
D(RC(-4),2)	2.951444	0.241384	12.22716	0.0000
D(RC(-5),2)	2.438066	0.219237	11.12067	0.0000
D(RC(-6),2)	1.960915	0.195000	10.05599	0.0000
D(RC(-7),2)	1.524337	0.169117	9.013516	0.0000
D(RC(-8),2)	1.187121	0.142662	8.321235	0.0000
D(RC(-9),2)	0.901668	0.116324	7.751350	0.0000
D(RC(-10),2)	0.626608	0.090493	6.924384	0.0000
D(RC(-11),2)	0.394027	0.065468	6.018576	0.0000
D(RC(-12),2)	0.240014	0.041998	5.714858	0.0000
D(RC(-13),2)	0.114623	0.020717	5.532825	0.0000
C	2.11E-06	0.000153	0.013843	0.9890

R-squared	0.785546	Mean dependent var	4.92E-07
Adjusted R-squared	0.784239	S.D. dependent var	0.015799
S.E. of regression	0.007339	Akaike info criterion	-6.984837
Sum squared resid	0.123709	Schwarz criterion	-6.947559
Log likelihood	8089.472	Hannan-Quinn criter.	-6.971250
F-statistic	600.9940	Durbin-Watson stat	2.010595
Prob(F-statistic)	0.000000		

Appendix-4

Null Hypothesis: D(RC) has a unit root
Exogenous: Constant
Bandwidth: 131 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-446.5134	0.0001
Test critical values:	1% level	-3.432967	
	5% level	-2.862582	
	10% level	-2.567370	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	7.00E-05
HAC corrected variance (Bartlett kernel)	1.09E-06

Phillips-Perron Test Equation
Dependent Variable: D(RC,2)
Method: Least Squares
Date: 12/15/20 Time: 23:30
Sample (adjusted): 3 2327
Included observations: 2325 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RC(-1))	-1.436608	0.018666	-76.96412	0.0000
C	1.71E-06	0.000174	0.009862	0.9921

R-squared	0.718304	Mean dependent var	1.64E-07
Adjusted R-squared	0.718183	S.D. dependent var	0.015772
S.E. of regression	0.008373	Akaike info criterion	-6.726756
Sum squared resid	0.162858	Schwarz criterion	-6.721808
Log likelihood	7821.854	Hannan-Quinn criter.	-6.724953
F-statistic	5923.476	Durbin-Watson stat	2.245422
Prob(F-statistic)	0.000000		

Appendix - 5

Null Hypothesis: RC is a martingale
Date: 12/15/20 Time: 23:31
Sample: 1 2327
Included observations: 2326 (after adjustments)
Heteroskedasticity robust standard error estimates
User-specified lags: 2 4 8 16

Joint Tests	Value	df	Probability
Max |z| (at period 2)*	8.004556	2326	0.0000

Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.563877	0.054484	-8.004556	0.0000
4	0.296781	0.090873	-7.738516	0.0000
8	0.144845	0.128167	-6.672179	0.0000
16	0.076187	0.172275	-5.362445	0.0000

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

Test Details (Mean = 1.1334619431e-06)

Period	Variance	Var. Ratio	Obs.
1	8.7E-05	--	2326
2	4.9E-05	0.56388	2325
4	2.6E-05	0.29678	2323
8	1.3E-05	0.14484	2319
16	6.6E-06	0.07619	2311