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Validity of EMH; A Case Study of KSE-100Index

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Abstract:

The emerging markets offer major investments opportunities for a range of investors over the last decades especially after the global financial crises,which attracted the attention of investors and financial researchers towards the market efficiency.This research paper is designed to verify other researchers work, because some of them have provided contradictory results to test the market efficiency of Pakistani stock index (KSE-100). Average daily observations are considered for the period of twenty two years (November 02, 1991 to December 31, 2012). Unit Root tests (ADF, PP and KPSS), Runs test, Serial Autocorrelation (L-Jung-Box Q statistic) techniques are used to analyze the market's informational weak form efficiency. Return time series is not normally distributed because it is negatively skewed and leptokurtic. All of the tests applied provide sufficient statistical evidence to reject the Random Walk Hypothesis thus KSE-100 shares index is informational weak form inefficient.

Keywords: KSE-100 shares index, Random Walk Hypothesis, informational weak form efficiency, unit root, autocorrelation and runs.

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1. Introduction

The capital market is an essential measuring tool of the health of an economy and important constituent of the financial sector. Capital markets provide a platform where funds are accumulated from savers and distributed to the investors. The capital market facilitates mobilization and intermediation to both private and public sectors through a wide range of debt and equity instruments. The capital market plays a crucial role in the national economy. The development and growth of an economy is significantly influenced by the capital markets. If a capital market is efficient enough, it can provide a variety of alluring opportunities to both the domestic and foreign investors.

The capital market not only reflects the general condition of the economy, but also smoothens and accelerates the process of economic growth. For a capital market to be perfect it should be frictionless (No transaction costs, taxes and constraining regulations), perfectly competitive and informationally efficient *Copland and Weston (1988).*

The theory of random walks was proposed by first Bachelier L. (1900) and second by Osborne M.F.M.(1959). The Bachelier and Osborne models are based on two fundamental assumptions. The new available information is independent. And its evaluation would also be independent. On the basis of these assumptions, Bachelier and Osborne suggested that following market price changes would be random Fama E. (1965) proposed an application of Random Walk Theory, 'Efficient Market Hypothesis' (EMH), which suggests that none of the investors can forecast the future stock market prices as the important current information about stocks is freely available to all investors in the market and also incorporated in the stock prices that leads to a competitive market where investors behave rationally.

However, various types of information that influence security values are available in the real market place. Depending on the term "all available information", Efficient Markets Hypothesis is differentiated in three forms (weak, semi-strong and strong) by the financial researchers. The weak form of the efficient markets hypothesis assumes that the only historical available information is fully reflected in the current security prices. The semi-strong-form of market efficiency hypothesis suggests that all publicly available information is absorbed in the current security prices. The strong form of market efficiency hypothesis asserts that the current security prices incorporate all existing both public and private information (sometimes called inside information).

Various researchers have investigated the weak form market efficiency on the average stock prices of developed as well as developing economies. Worthington and Higgs (2006) Borges(2010)examined the efficiency of stock markets of developed European countries, i.e. UK, France, Spain, Greece, Germany and Portugal. Omran and Farrar (2006) tested the randomness of prices in five Middle East countries like Morocco, Jordan, Israel, Turkey, and Egypt. Hamid *et al.* (2010) have investigated the efficiency of emerging stock markets of Pakistan, India, Sri Lanka, China, Korea, Hong Kong, Indonesia, Malaysia, Philippine, Singapore, Thailand, Taiwan, Japan and Australia.

The Karachi Stock Exchange (KSE) was established on September 18, 1947. It is the biggest and most liquid stock exchange in Pakistan with an average daily turnover of 196.76 million shares and market capitalization of 4,256,832.25 million as of the end of the December, 2012.The international investors have given due considerations to the KSE in making decisions regarding foreign investment in equity markets after declaration of the international magazine 'Business Week' as the best performing world stock market in 2002. The total number of listed companies listed on KSE is 573, and for this empirical study, the average daily prices of KSE -100 shares Index were taken.

In the light of the above mentioned introduction, we have applied the unit root tests, serial autocorrelation test and runs test to investigate the effect of information on stock prices and returns. The statistical results provided evidence that Pakistan stock market does not follow RWH and hence market is not efficient.

2. Objective of the Study

The objective of this study is to examine whether the Pakistani stock market (KSE-100 shares index) is informational weak form efficient i.e. current stock prices reflect all past/ historical information and investors cannot predict future stock prices and hence stock market follows random walk.

3. Literature Review

Awad and Daraghma (2009) applied Augmented Dicky Fuller (1979) and Philip-Perrons (1988) unit root test, serial correlations and runs test to investigate tested the Weak Form Efficiency of Palestinian stock market. The statistical results reported that market was inefficient. Lima and Tabak (2004) reported the results in the favor of weak form efficiency hypothesis in the case of Hong Kong. Oskooe *et al.*(2010) explored the equity market of Iran by applying the ADF (1979), PP (1988) and KPSS (1992)techniques and findings of the study revealed that Iranian equity market is informationally weak form efficient. Abraham *et al* (2002) studied capital markets of Saudi Arabia, Bahrain and Kuwait by using runs test and variance ratio test. Saudi Arabian and Bahrain markets supported market efficiency while Kuwaiti markets do not follow EMH. Omran and Farrar (2006) have observed the EMH for the equity markets of Egypt, Israel, Jordan, Morocco, and Turkey and all the markets do not follow the EMH. Marasdeh and Shrestha (2008) tested the randomness of stock markets of Emirates(UAE)and the results of statistical techniques ADF and PP verified the informationally weak form efficient market. Chung (2006) examined the stock market of china and found it to be weak form inefficient, while the statistical results of the Xinping *et al*. (2010) are contrary to the previous research. Cooray and Wickermaisgle (2005) investigated the weak form efficiency of the South Asian equity markets, including Bangladesh, India, Pakistan, and Sri Lanka by employing the unit root tests and Elliot-Rothenber-Stock (ERS) test. The results of empirical study revealed that excluding Bangladesh all of the stock markets supported the weak form efficient hypothesis. Worthington and Higgs (2006) have conducted a detailed empirical study on twenty-seven emerging markets by applying the unit root tests (ADF, PP and KPSS), serial correlation test, runs test of randomness, and variance ratio test. The findings of empirical study suggested most of the emerging markets to be informationally weak form inefficient. Haque *et al*. (2011) and Hamid *et al.*(2010)also tested the weak market efficiency on Pakistani stock market and concluded that emerging markets do not follow random walk.

To ensure the robustness of the results, we have applied different techniques that are previously used in mentioned literature and background.

4. Methodology

The average daily observations of KSE-100 Index are used in this study to examine the randomness of security prices. The observations are taken from 2nd November 1991 to 31st December 2012.

As the purpose of this research study is to explore the informationally weak form efficiency of emerging stock market of Pakistan (KSE-100).We have used the various statistical techniques unit root tests (ADF, PP and KPSS), serial autocorrelation (Ljung Box statistics) and variance ratio to verify randomness of prices and returns.

4.1. Descriptive Statistics

Descriptive Statistics for the stock returns include the Mean, Median, Range, Standard Deviation, Jarque-Bera, Variance, Kurtosis and Skewness.

4.2. Unit root tests

Unit root tests are widely used to ensure the randomness that the stock prices are independent of historical prices (lags of current price) and are stochastically deterministic. Or we may say that current price (P) is independent of past prices (P_{t-1}, P_{t-2}, …) and the current prices will not support in predicting the future prices (P_{t+n}). A uni-variate time series of stock returns will become a random walk series if it contains unit root at the levels and may become stationary at the differenced form. In this study we have used widely accepted unit root tests, ADF (1979), PP (1988) and KPSS (1992).

Augmented Dickey and Fuller (ADF) unit root test

ADF was proposed by Dickey and Fuller in (1979), the basic objective of this technique is to test the presence of unit root (stationarity) or confirmation of RWH.

$$\Delta Rt = b0 + b1 + \pi 0Rt - 1 + \sum_{t=1}^{j} \psi i\, \Delta Rit - 1 + \epsilon t$$

4.3. Phillips- Perron (PP) unit root test

Proposed by Phillip and Perron in (1988), it is a nonparametric approach for testing unit root in a time series. The tests are similar to ADF tests, but it incorporates an automatic correction to the DF procedure to allow for autocorrelated residuals.To control serial correlation in the uni-variate time series ADF take k lagged differenced equation while PP test modify the t-statistic so that the asymptotic distribution of t_β is unchanged. t_β Modified is as given below:

$$\tilde{t}_\beta = t_\beta \sqrt{\frac{\gamma_0}{f_0}} - \frac{T\,(f_0 - \gamma_0)\{se\,(\hat{\beta})\}}{2\sqrt{f_0}\,.\,s}$$

Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) unit root test

Kwiatkowski et al. (1992) developed this test to check the stationarity of time series around a deterministic trend. For return series of P_t following equation is given:

$P_t = r_t + \beta t + \varepsilon_t$ t = 1,2, …., n

$r_t = r_{t-1} + \mu_t$ μ_t ~ iid N (0, δ_μ^2)

LM statistics of KPSS = $N^{-2}\sum_{t=1}^{n}\frac{S_t^2}{\delta^2}(P)$

4.4. Runs Test for Randomness

The runs test also known as Wald-Wolfwitz test is a Non-Parametric statistical technique used for measuring the randomness; i.e. that a data set is a random process or in case of time series to check that whether the data are independent of each other. The runs test is based on the assumption that the number of Runs (Expected) should be equal or closer to the number of Runs (Actual), if the change in stock price is random.

Mean= $\mu = \frac{2\,N_+\;N_-}{N} + 1$

Standard Deviation = $\delta = \sqrt{\frac{(\mu-1)(\mu-2)}{N-1}}$

Z= $\frac{r-\mu_r}{\delta_r}$~ N (0, 1)

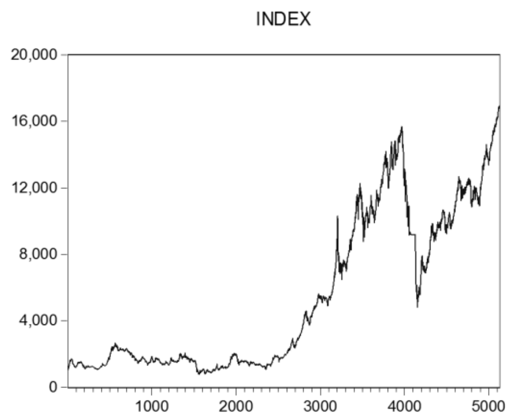
4.5. Serial Autocorrelation Test

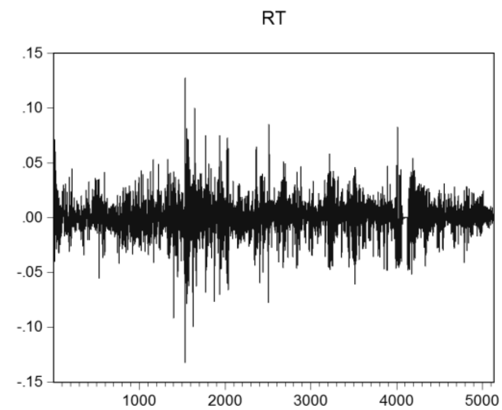
The serial correlation test L-Jung-Box was developed by Box and Pierce. The L-Jung-Box test assesses the relationship between the current and past values on the values of data lags. The autocorrelation function (ACF) and partial autocorrelation function (PACF) defines the presence of residual autocorrelation in the time series. The L-Jung-Box Q-test is computed as follows:

$$Q\ Stat = T(T+2)\sum_{K=1}^{L}\left\{\frac{\rho(k)^2}{(T-k)}\right\}$$

5. Results and Discussion

This study is conducted on average daily prices of KSE-100 index for the period of about twenty two years i.e. November 02, 1991- December 31, 2012. The average daily returns R_t are calculated through $R_t = \ln(P_t/P_{t-1})$; where P_t and $P_{t-1}$are defined as the log index at time t and t-1.





The index graph shows that over the time period of twenty two years index has upward drift with non-constant mean and variance. And the return R_t given graph shows the first differenced stationary returns.

5.1. Descriptive Statistics

The daily returns indicate that data are negatively skewed -0.23 and leptokurtic with kurtosis value of 8.279 with standard deviation of 0.0158. Other detailed Descriptive Statistics of the data (price and return) is given below:

Stats	**P_t**	**R_t**
Mean	5424.599	0.000547
Median	2325.000	0.000809
Maximum	16943.19	0.128
Minimum	765.740	-0.132
Std. Dev.	4700.122	0.0158
Skewness	0.704	-0.23
Kurtosis	1.983	8.279
Jarque-Bera	644.544	6001.95
Probability	0.000	0.000
Sum	27833619	2.808
Sum Sq. Dev.	1.13E+11	1.2750
Observations	5131	5130

5.2. Unit Root Test

For the estimation of unit root tests to investigate Weak Form Efficiency as an application of Random Walk Hypothesis in Pakistani Stock Exchange -100 shares Index, the study applied ADF (1979), PP (1988) and KPSS (1992) to the log returns of KSE-100. The results are reported in annexure in Table 1, 2 and 3. All the three unit root tests significantly reject the hypothesis of stationarity of the time series at 1%, 5% and 10% significance level. The results revealed that Pakistani Stock Exchange prices are predictable and do not follow random walk thus investors can explore arbitrage opportunities.

5.3. Runs Test of Randomness

	R_t
K	0.00081
Cases < K	2565
Cases >= k	2566
Total Cases	5131
Number of Runs	2266
Z-Score	-8.391
Asymp. Sig. (2-tailed)	0.000

Another technique Runs test is employed to verify the mentioned results of RWH. Under the null hypothesis of randomness the test assumes the sequence of positive (increasing) and negative (decreasing) runs i.e. log returns to be independent of each other and do not follow any systematic pattern of occurrence and thus are not of any help in predicting the pattern of occurrences. Based on our analysis, statistical results show K=0.000806 and the negative value of z-scores is -8.391, therefore time series of returns have nonrandom behavior at 1% level of significance. We can conclude that returns of stock prices are informationally weak form inefficient.

5.4. Serial Autocorrelation Test (L-Jung-Box Q Stat)

Q-statistics assumes that time series is stochastic random process or pure white noise i.e. all the autocorrelations are equal to zero which means past prices are not helpful in predicting future prices. The results of this analysis revealed that autocorrelation is not zero hence current stock prices are dependent on previous prices because Q-statistic shows serial autocorrelation. The Correlogram of 1st differenced return series is given in annexure.

6. Conclusion

This empirical study analyzed the data on KSE-100 over the period of twenty two years, i.e. November 02, 1991 to December 31, 2012 to test the weak form of efficiency in Pakistani stock market. The study examines the weak form of efficient market hypothesis through various techniques which include Unit Root tests of stationarity (ADF, PP and KPSS), Serial Autocorrelation test (L-Jung Box Q-Statistic) and Runs test of Randomness by using Eviews, SPSS and Minitab. The descriptive statistics explored the data to be distributionally non-normal, negatively skewed and leptokurtic. The results of unit root tests (ADF, PP and KPSS) significantly rejected the market weak form efficiency in Pakistani stock index. Whereas the Runs test of randomness; used to investigate Random Walk Hypothesis, the statistical results of the test are in favor of inefficient market. To verify the robustness of the empirical results, this study employs the Serial Autocorrelation test (L-Jung Box Q-Statistic). Q-statistics used twelve lags to estimate the serial autocorrelation, the reported results revealed that joint autocorrelation among twelve lags is not equal to zero which suggests that the future prices are dependent on current prices.

Thus, overall results of the study leads to the conclusion that Pakistani stock market is informationally weak form inefficient i. e current stock prices do not reflect all past/ historical information and investors can predict future stock prices. Hence KSE-100 shares index do not follow Random Walk Hypothesis. Consequently the investors can exploit the arbitrage opportunities by predicting future prices to earn abnormal returns

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Annexure

Table 1: (ADF-test)

Null Hypothesis: D(RT) has a unit root
Exogenous: Constant

Lag Length: 16 (Automatic based on SIC, MAXLAG=32)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-30.32495	0.0000
Test critical values:	1% level	-3.431448	
	5% level	-2.861910	
	10% level	-2.567010	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RT,2)

Method: Least Squares

Date: 01/07/13 Time: 01:09

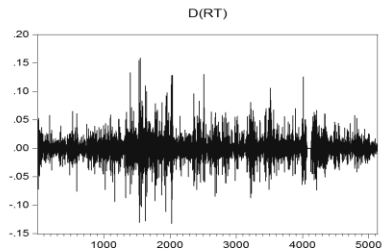
Sample (adjusted): 20 5131

Included observations: 5112 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RT(-1))	-8.425427	0.277838	-30.32495	0.0000
D(RT(-1),2)	6.581892	0.272587	24.14605	0.0000
D(RT(-2),2)	5.809652	0.263729	22.02884	0.0000
D(RT(-3),2)	5.108336	0.251994	20.27168	0.0000
D(RT(-4),2)	4.445303	0.238008	18.67715	0.0000

D(RT(-5),2)	3.843839	0.222119	17.30532	0.0000
D(RT(-6),2)	3.278721	0.204727	16.01506	0.0000
D(RT(-7),2)	2.756243	0.186128	14.80836	0.0000
D(RT(-8),2)	2.285086	0.166575	13.71803	0.0000
D(RT(-9),2)	1.886224	0.146210	12.90082	0.0000
D(RT(-10),2)	1.510596	0.125591	12.02794	0.0000
D(RT(-11),2)	1.171951	0.105014	11.16001	0.0000
D(RT(-12),2)	0.874002	0.084760	10.31151	0.0000
D(RT(-13),2)	0.613666	0.065067	9.431290	0.0000
D(RT(-14),2)	0.388284	0.046433	8.362156	0.0000
D(RT(-15),2)	0.207869	0.029134	7.134853	0.0000
D(RT(-16),2)	0.066955	0.013939	4.803405	0.0000
C	-2.38E-05	0.000222	-0.107287	0.9146

R-squared	0.801432	Mean dependent var	-9.50E-07
Adjusted R-squared	0.800770	S.D. dependent var	0.035505
S.E. of regression	0.015848	Akaike info criterion	-5.448043
Sum squared resid	1.279390	Schwarz criterion	-5.425017
Log likelihood	13943.20	Hannan-Quinn criter.	-5.439982
F-statistic	1209.395	Durbin-Watson stat	2.004057
Prob(F-statistic)	0.000000		



Graph of return series at 1st difference.

Table:2 (PP-test)

Null Hypothesis: D(RT) has a unit root
Exogenous: Constant
Bandwidth: 153 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-748.5255	0.0001
Test critical values:	1% level	-3.431444	
	5% level	-2.861908	
	10% level	-2.567009	

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

Residual variance (no correction)	0.000342
HAC corrected variance (Bartlett kernel)	4.53E-06

Phillips-Perron Test Equation
Dependent Variable: D(RT,2)
Method: Least Squares
Date: 01/07/13 Time: 01:14
Sample (adjusted): 4 5131
Included observations: 5128 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RT(-1))	-1.458934	0.012410	-117.5652	0.0000
C	-5.62E-06	0.000258	-0.021771	0.9826

R-squared	0.729464	Mean dependent var	-9.50E-07
Adjusted R-squared	0.729411	S.D. dependent var	0.035534
S.E. of regression	0.018484	Akaike info criterion	-5.143425
Sum squared resid	1.751354	Schwarz criterion	-5.140873
Log likelihood	13189.74	Hannan-Quinn criter.	-5.142531
F-statistic	13821.58	Durbin-Watson stat	2.289257
Prob(F-statistic)	0.000000		

Table: 3 (KPSS test)

Null Hypothesis: RT is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 29 (Newey-West using Bartlett kernel)

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.073938
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000249
HAC corrected variance (Bartlett kernel)	0.000474

KPSS Test Equation
Dependent Variable: RT
Method: Least Squares
Date: 01/07/13 Time: 01:16
Sample (adjusted): 2 5131
Included observations: 5130 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000357	0.000440	0.810230	0.4178
@TREND(1)	7.43E-08	1.49E-07	0.499610	0.6174

R-squared	0.000049	Mean dependent var	0.000547
Adjusted R-squared	-0.000146	S.D. dependent var	0.015767
S.E. of regression	0.015768	Akaike info criterion	-5.461296
Sum squared resid	1.274952	Schwarz criterion	-5.458745
Log likelihood	14010.22	Hannan-Quinn criter.	-5.460403
F-statistic	0.249610	Durbin-Watson stat	1.740176
Prob(F-statistic)	0.617371		

Correlogram of Autocorrelation (AC)

Date: 01/07/13 Time: 21:23
Sample: 1 5131
Included observations: 5129

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.459	-0.459	1080.9	0.000
		2	-0.038	-0.315	1088.4	0.000
		3	0.014	-0.217	1089.3	0.000
		4	-0.024	-0.195	1092.4	0.000
		5	0.017	-0.146	1093.9	0.000
		6	-0.010	-0.132	1094.5	0.000
		7	-0.006	-0.127	1094.7	0.000
		8	-0.004	-0.129	1094.8	0.000
		9	0.035	-0.070	1101.0	0.000
		10	-0.026	-0.077	1104.5	0.000
		11	-0.000	-0.075	1104.5	0.000
		12	0.005	-0.067	1104.6	0.000