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INVESTIGATING THE WEAK FORM EFFICIENCY OF AN EMERGING MARKET USING PARAMETRIC TESTS: EVIDENCE FROM KARACHI STOCK MARKET OF PAKISTAN

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Abstract: *This paper focuses on the existence of weak from efficiency whether the Karachi Stock Exchange (KSE) is efficient market or not. The sample includes the daily and monthly closing prices of KSE- 100 indexes for the period of 1st January1999 to 31st August 2009. Several different parametric approaches: unit root test, autocorrelation tests and ARIMA model are used to test the certainty of the KSE market. All parametric methods tell us that both return series do not follow the random walk model and the significance autocorrelation reject the hypothesis of weak from efficiency. Generally, results from the observed analysis strongly recommend that the Karachi Stock Market of Pakistan is not efficient in weak from.*

Keywords: *KSE, Random Walk, Efficient market, ARIMA.*

1. Introduction

Market inadequacy is the key negative aspect for developing countries like Bangladesh, Pakistan and India. A great deal of the work on weak from efficiency is based on the parametric approaches, on develop markets of Europe and Latin American, (for example Hudson et al. (1994) consider the UK stock market; Nicolaas and Groenewold (1997) study the Australia and New Zealand markets while Ojah and Karemera (1999) examine the Latin American markets with many researchers).
There exists enough literature on weak efficiency of emerging markets as well, such as, of Asia (for instance Mobarek and Keasey (2000), Ahmad (2002), Hossain (2004) and Moustafa (2004)

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checked for Bangladesh stock exchange, Hussain (1996) Pakistan Market, Poshakwale (1996) consider the Indian stock market). However, a few studies have appeared in the literature focusing on the Karachi Stock Market (KSE). The objective of this research work is to test and investigate whether the Karachi Stock market (KSE) is an efficient market or not. A brief review of findings of some of earlier research work is presented as under:

Abrosimova et al. (2005) investigated the existence of week from in the Russian stock market for the period of 1995 to 2001 by using daily, weekly and monthly Russian Trading System (RTS) index. Numerous dissimilar approaches are used to check the weak from efficiency of the RTS. The results indicated that daily and weekly data do not follow the normal hypothesis but the results support the null hypothesis for the monthly data only. Their research results provide some limited evidence of short-term market predictability on the RTS.

Chakraborty (2006) examined the weak from efficiency of the Pakistan stock market using KSE -100 index. The author was applying the variance ratio tests, runs tests and serial correlation tests. Serial correlation test and runs test reject the random walk hypothesis which means that KSE is not an efficient stock market. Furthermore, he reported that autocorrelation and heteroscedasticity is present in the data. It has been also found that ARMA (3, 0) was a suitable model for forecasting purpose to the Karachi Stock Market.

There are three main stock exchanges in Pakistan. Karachi Stock Exchange (KSE) is the largest stock market in Pakistan which was established on September 18, 1947. Other two are Islamabad and Lahore which are inactive as compared to Karachi stock exchange. It was declared that KSE is the best performing stock market in all over the World for the year of 2002. 654 companies were listed at the end of 30 May, 2008. KSE -100 is used as a benchmark Pakistani index. Some information is given in Table. 1 about KSE.

Table 1. Overview of KSE

Karachi Stock Exchange (KSE)	
Type	Stock Exchange
Location	Karachi, Pakistan
Owner	Karachi Stock Exchange Limited
Key People	Adnan Afridi, CEO
Currency	PKR
No of listing companies	671
Market Capital	US$ 56 Billion
Volume	US$ 12 Billion
Indexes	KSE- 100 & KSE-30
Website	www.kse.com.pk

The objectives of this research paper are mainly having an idea about whether the Karachi stock market of Pakistan is efficient market or not, to do this we used parametric approaches to check this and conclude that KSE is weak from efficiency market in other words do not follow the random walk model.

The rest of the article is prepared as follows. The second section reviews the methodology and data; the third section presents the empirical results and discussion; and the fourth section concludes the study.

2. Methodology

Efficient market hypotheses (EMH) claim that stock price indices are basically random. The basic model for estimating volatility in stock returns is the random walk model (RWM):

$$Y_t = \alpha + u_t \tag{1}$$

Secondly, the simplest ways to state Autoregressive of order one AR (1) model may also be estimated as:

$$Y_t = \alpha + \rho Y_{t-1} + u_t \qquad -1 \le \rho \le 1 \tag{2}$$

Where in both above equations 1 & 2 α is the constant parameter, ρ is the estimated parameter and u_t is an uncorrelated random error term with zero mean and constant variance σ^2 (i.e., it is white noise). This model looks like the Markov first order autoregressive model. If $\rho \ge 1, Y_t$ becomes non stationary series which means a unit root problem occurs in the returns. The term non stationary, random walk and unit root can be treated as identical. If $\rho < 1$, Y_t be converted into stationary series.

2.1 Auto Regressive (AR) Model

The most widely used model of serial correlation is the first-order autoregressive. The AR (1) model is specified as:

$$Y_t = \alpha + \rho Y_{t-1} + u_t \qquad -1 \le \rho \le 1 \tag{3}$$

Where α is the vector of constant term, here the value of Y at time t depends on its value in the previous time period and a random term; the Y values are expressed as deviations from their mean value. The higher order autoregressive model or autoregressive model of order "p" denoted by AR (p) is given as:

$$Y_t = \alpha + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + . \; . \; . + \theta_p Y_{t-p} + u_t \tag{4}$$

Then Y_t is said to follow a random walk model with drift because the presence of its constant parameter α, θ_p are the parameters of Autoregressive coefficients and u_t is an uncorrelated random error term.

2.2 Moving Average (MA) Model

Moving average process of order q is created by a weighted average of random error term and written its equation as:

$$Y_t = \alpha + u_t + \beta_1 u_{t-1} + \beta_2 u_{t-2} + \;\ldots + \beta_q u_{t-q} \tag{5}$$

Where α is the intercept term, uncorrelated random error term u_t having zero mean and variance σ_u^2 and β_q are unknown parameters. In short we can say a moving average process is simply a linear combination of white noise error term.

2.3 Auto Regressive Moving Average (ARMA) Model

If Y_t has characteristic of both AR and MA components as an ARMA (p, q) model, where p and q are the orders of the AR and MA component, respectively. The algebraic representation of the ARMA model is:

$$Y_t = \alpha + \theta_1 Y_{t-1} + ... + \theta_p Y_{t-p} + u_t + \beta_1 u_{t-1} + ... + \beta_q u_{t-q} \quad (6)$$

Where the intercept parameter α is related to the mean of Y_t, the errors are assumed to be uncorrelated random variable with zero mean and constant variance, θ_p are the unknown parameters of autoregressive process and β_q are the unknown parameters of moving average process. A simplest form of the autoregressive moving average model of order 1 of both p and q orders ARMA (1, 1) can be written as:

$$Y_t = \alpha + \theta_1 Y_{t-1} + u_t + \beta_1 u_{t-1} \quad (7)$$

Where α is an intercept term and u_t is assumed to be uncorrelated random variables, θ_1 is an unknown parameter of autoregressive model and β is an unknown parameter of moving average process.

2.4 Forecasting Performance

The common measures of forecasting performance are: MAE, RMSE and Theil- U (Abrosimova et al., 2005). The reported forecast error statistics are:

$$\text{MAE} = \frac{\sum_{t=T+1}^{T+k} \left| \hat{y}_t - y_t \right|}{h} \quad (8)$$

$$\text{RMSE} = \sqrt{\frac{\sum_{t=T+1}^{T+k} \left(\hat{y}_t - y_t \right)^2}{h}} \quad (9)$$

$$\text{Theil-U} = \frac{\sqrt{\frac{\sum_{t=T+1}^{T+k} \left(\hat{y}_t - y_t \right)^2}{h}}}{\sqrt{\frac{\sum_{t=T+1}^{T+k} \hat{y}_t^{\,2}}{h}} + \sqrt{\frac{\sum_{t=T+1}^{T+k} y_t^{\,2}}{h}}} \quad (10)$$

2.4.1 Data and statistical features of daily & monthly market returns

We used the daily and monthly closing prices of KSE- 100 indexes for the period of 1st January1999 to 31st August 2009 (2610 and 128 observations respectively) covering a sufficient period of ten and half years after removing the holidays, which is easily available on yahoo finance. Both daily and monthly close prices are calculated by taking the logarithm transformation (e.g. Mobarek and Keasey, 2000; Moustafa, 2004 and Abrosimova et al., 2005 ;). We estimated the models using both EViews 5.1 and Minitab 15 programs.

2.4.2 Descriptive statistics

The essential assumption of random walk model is that the distribution of the return series must be normal. To assess the distributional property various descriptive statistics are reported in Table 2.

From Table 2. It can be seen that the distribution of the return series are not normal. The return series of both daily and monthly are leptokurtic because of its large Kurtosis value which means non normal according to the Jarque and Bera test (1980), which rejects the normality at the 1% level.

Table 2. Descriptive Statistics of daily & monthly returns

Variables	KSE Daily Return	KSE Monthly Return
Mean	0.001324	0.070259
Median	-0.031234	-0.164143
Maximum	13.02460	36.20007
Minimum	-13.23272	-44.92556
Standard deviation	2.195419	12.91119
Skewness	0.322022	0.077577
Kurtosis	6.925056	4.115535
Jarque and Bera	1720.518	6.659578
Probability	0.000000	0.035801

The evidence of positive skewness in both returns is similar to the findings of Poshokwale (1996) in Indian stock market but their positive skewness coefficient (0.98) is much larger and Mobarek and Keasey (2000) in Dhaka stock market of Bangladesh who find the positive skeweness (1.203) is a larger amount. In other words, Jarque and Bera test, Skewness and Kurtosis values for both series of stock return series on the KSE indicates that the distribution is not normal.

2.4.3 Hypotheses

The study looks for evidence whether the Karachi Stock Market follows random walk mode or not and second market is efficient or not i,e.

H_o : The Karachi Stock Market follows a random walk model

H_1 : The Karachi Stock Market do not follow random walk model

H_o' : The Karachi Stock Market is efficient in weak from

H_1' : The Karachi Stock Market is not efficient in weak from.

3. Empirical Analysis and Results

Figure 1 and 2 illustrate firstly daily and monthly time series plots which indicates clearly that data is non-stationary and continuous trend and secondly after taking the logarithm transformation, the daily and monthly return series confirm that the mean of the series are now about constant which indicate clearly stationary, even though the variance becomes unusually high which clearly exhibit volatility clustering (Nourrendine (1998), Moustafa (2004) and Irfan et al. (2010)).

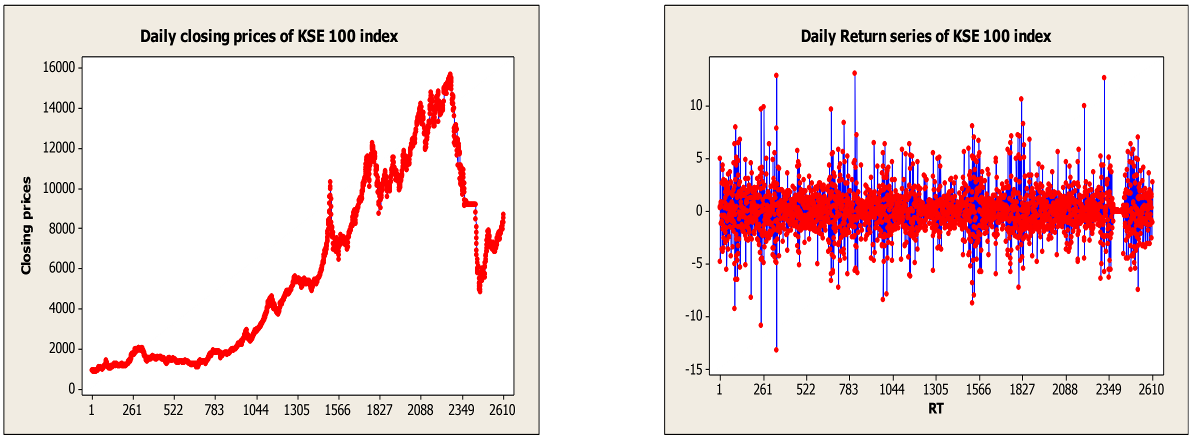

Figure 1. Time series plot of daily closing prices & Return series of KSE – 100 indexes

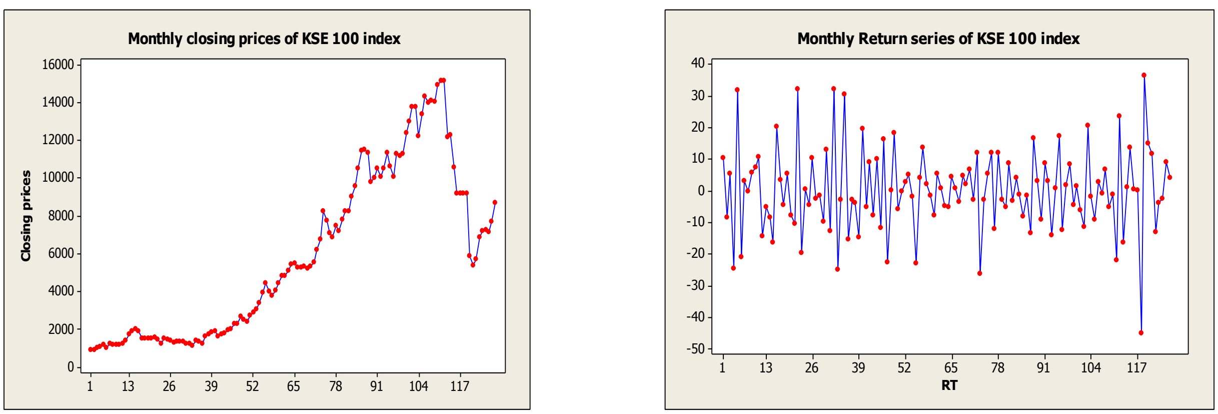

Figure 2. Time series plot of monthly closing prices & Return series of KSE –100 index.

3.1 Unit Root Test

The KSE indexes are tested for the occurrence of unit roots using the Augmented Dickey Fuller (ADF) (see in Table. 3) and Phillips Perron (PP) tests (not reported). Augmented Dickey Fuller (ADF) test is the most powerful test rather than other unit root tests. The ADF test examines the unit root of the observed data by taking the unit root (non stationarity) as taking the null hypothesis. The rejection of H_o implies that the return series R_t is stationary. Table. 3 reports the results of the ADF test for both indexes of KSE. We will employ the critical values offered by Mckinnon (1991) to estimate the null hypothesis. As a second step, another method to calculate unit root tests is applied (not reported). Therefore, daily and monthly returns series are stationary. The significance of all the coefficients and the value of Durbin-Waston Statistic

(DWS) which is approximately 2 in both indexes (see in Table. 4 & Table. 5) indicate the correct specification of the test equation. So the Karachi Stock Market is not efficient in weak from.

Table 3. Test of Unit Root Augmented Dickey Fuller (ADF) Test statistic

Indexes	ADF Test Statistic	Critical value at 1%	P- Value
Daily KSE - 100	-21.51545	-3.432679	0.0000
Monthly KSE - 100	-10.10967	-3.484653	0.0000

(*MacKinnon critical values for rejection of hypothesis of a unit root*)

Table 4. Augmented Dickey Fuller (ADF) Test Equation for Daily closing prices

Variable	Coefficient	Std. Error	T- Statistic	P- Value
RETURN (-1)	-8.609276	0.400144	-21.51545	0.0000
Constant	0.004685	0.032453	0.144345	0.8852

R-squared	0.808178	Mean dependent var	0.001047
Adjusted R-squared	0.806912	S.D. dependent var	3.760813
S.E. of regression	1.652570	Akaike info criterion	3.849458
Sum squared residuals	7032.294	Schwarz criterion	3.890141
Log likelihood	-4972.822	F-statistic	638.1708
Durbin-Watson stat	2.005089	Prob(F-statistic)	0.000000

Table 5. Augmented Dickey Fuller (ADF) Test Equation for Monthly closing prices

Variable	Coefficient	Std. Error	T- Statistic	P- Value
RETURN (-1)	-2.974430	0.294216	-10.10967	0.0000
Constant	0.134156	0.940065	0.142709	0.8868

R-squared	0.785565	Mean dependent var	0.235693
Adjusted R-squared	0.778234	S.D. dependent var	22.04662
S.E. of regression	10.38219	Akaike info criterion	7.558181
Sum squared residuals	12611.42	Schwarz criterion	7.673100
Log likelihood	-456.0491	F-statistic	107.1553
Durbin-Watson stat	2.019298	Prob(F-statistic)	0.000000

3.2 Autocorrelation and Partial Autocorrelation Tests

Autocorrelation and Partial Autocorrelation are performed for 36 lags of daily return series (See Table. 6 for only 10 lags). It was found that only 1st lag of daily data is significant different from zero at the 95 % confidence level. Box- Pierce Q statistic and Ljung- Box (LB) statistic give similar results. Autocorrelation (ACF) and Partial Autocorrelation (PACF) up to 10 lags due to insufficient sample of size for the KSE monthly return index that covers the period of 1999 to 2009 is performed in Table. 7, the coefficient for only on 1st lag is significant for weekly data. On the basis of both Autocorrelation tests we can reject the hypothesis of the random walk i,e.

the Karachi Stock Market do not follow the random walk model in both daily and weekly cases. A similar observation was made in the study of Abrosimova et al. (2005) and Irfan et al. (2010).

Table 6. Autocorrelation and Partial Autocorrelation Functions of the daily returns of the KSE index

Autocorrelation	Partial Correlation	lags	AC	PAC	Q-Stat	Prob
****| |	****| |	1	-0.471	-0.471	578.53	0.000
| |	***| |	2	-0.035	-0.329	581.65	0.000
| |	**| |	3	0.020	-0.225	582.72	0.000
| |	**| |	4	-0.021	-0.196	583.92	0.000
| |	*| |	5	0.026	-0.131	585.71	0.000
| |	*| |	6	-0.027	-0.133	587.59	0.000
| |	*| |	7	0.021	-0.093	588.74	0.000
| |	*| |	8	-0.049	-0.148	594.94	0.000
| |	*| |	9	0.047	-0.101	600.64	0.000
| |	*| |	10	-0.003	-0.080	600.66	0.000

Table 7. Autocorrelation and Partial Autocorrelation Functions of the monthly returns of the KSE index

Autocorrelation	Partial Correlation	lags	AC	PAC	Q-Stat	Prob
***|. |	***|. |	1	-0.451	-0.451	26.198	0.000
.|. |	**|. |	2	-0.011	-0.269	26.214	0.000
*|. |	**|. |	3	-0.071	-0.268	26.870	0.000
.|. |	**|. |	4	0.010	-0.234	26.883	0.000
.|. |	*|. |	5	0.037	-0.158	27.068	0.000
.|. |	*|. |	6	0.011	-0.104	27.085	0.000
*|. |	**|. |	7	-0.081	-0.195	27.972	0.000
.|* |	.|. |	8	0.119	-0.040	29.905	0.000
.|. |	.|* |	9	0.021	0.084	29.964	0.000
.|. |	.|* |	10	-0.021	0.117	30.026	0.001

3.3 ARIMA Model Building

ADF test statistic for both indexes is highly significant means reject the null hypothesis that KSE returns for both daily and monthly have a unit root; therefore the order of integration is set as zero. The results are in accordance with the findings of Moustafa (2004) and Abrosimova et al. (2005). ARIMA (1, 0, 1) appear to be fitted the best model for daily return series according to the different criterion like Akaike criterion and Schwarz criterion (see Table. 8). The correlogram of ARIMA (1, 0, 1) residuals shows no autocorrelation and partial Autocorrelation is left (see Table. 9), therefore, there is no need to search out another ARIMA model. Similarly, for monthly return series ARIMA (0 0, 1) is a suitable model according to the both criterion (see Table. 10). The correlogram of ARIMA (0, 0, 1) residuals shows no autocorrelation and partial Autocorrelation is present (see Table. 11). A graphical analysis for both daily and monthly return series also indicates that the fitted and the actual values are very close to each other (see Figure. 3). Therefore, there is no need to look for another ARIMA model.

Table 8. ARMA (p, q) Order Selection

	p/q	1	2	3
Akaike info criterion	1	**3.815108**	3.832726	3.830319
Schwarz criterion		**3.821854**	3.829474	3.827069
Akaike info criterion	2	3.824230	4.408478	4.410493
Schwarz criterion		3.830976	4.415226	4.417243
Akaike info criterion	3	4.162319	4.412093	4.410065
Schwarz criterion		4.169065	4.418841	4.416816

Table 9. Correlogram of ARIMA (1, 0, 1) residuals

Autocorrelation	Partial Correlation	lags	AC	PAC	Q-Stat	Prob
| |	| |	1	-0.004	-0.004	0.0424	
| |	| |	2	0.030	0.030	2.4459	
| |	| |	3	0.048	0.048	8.4526	0.004
| |	| |	4	0.018	0.018	9.3388	0.009
| |	| |	5	0.037	0.034	12.897	0.005
| |	| |	6	-0.000	-0.003	12.897	0.012
| |	| |	7	0.019	0.016	13.880	0.016
| |	| |	8	-0.013	-0.016	14.312	0.026
| |	| |	9	0.056	0.054	22.615	0.002
| |	| |	10	0.031	0.029	25.057	0.002
| |	| |	11	0.019	0.017	25.985	0.002
| |	| |	12	0.006	-0.002	26.074	0.004
| |	| |	13	0.008	0.003	26.231	0.006

Table 10. ARMA (p, q) Order Selection

	p/q	0	1	2
Akaike info criterion	0	7.961970	7.754411	7.985485
Schwarz criterion		7.984481	7.799664	8.030973
Akaike info criterion	1	**7.388279**	7.400126	7.411865
Schwarz criterion		**7.433299**	7.468005	7.480098
Akaike info criterion	2	7.977668	7.401632	7.944539
Schwarz criterion		8.022688	7.469512	8.012772

Table 11. Correlogram of ARIMA (0, 0, 1) residuals

Autocorrelation	Partial Correlation	lags	AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.074	0.074	0.7009	
.|. |	.|. |	2	-0.022	-0.028	0.7654	0.382
*|. |	*|. |	3	-0.086	-0.082	1.7257	0.422
.|. |	.|. |	4	-0.026	-0.014	1.8123	0.612
.|. |	.|. |	5	0.039	0.038	2.0101	0.734
.|. |	.|. |	6	0.022	0.009	2.0768	0.838
.|. |	.|. |	7	-0.035	-0.040	2.2456	0.896
.|* |	.|* |	8	0.125	0.140	4.3963	0.733
.|* |	.|* |	9	0.089	0.074	5.4815	0.705
.|. |	.|. |	10	0.014	-0.001	5.5076	0.788
.|. |	.|. |	11	0.021	0.043	5.5666	0.850
.|. |	.|. |	12	0.002	0.022	5.5674	0.901
.|. |	.|. |	13	0.010	0.005	5.5825	0.936

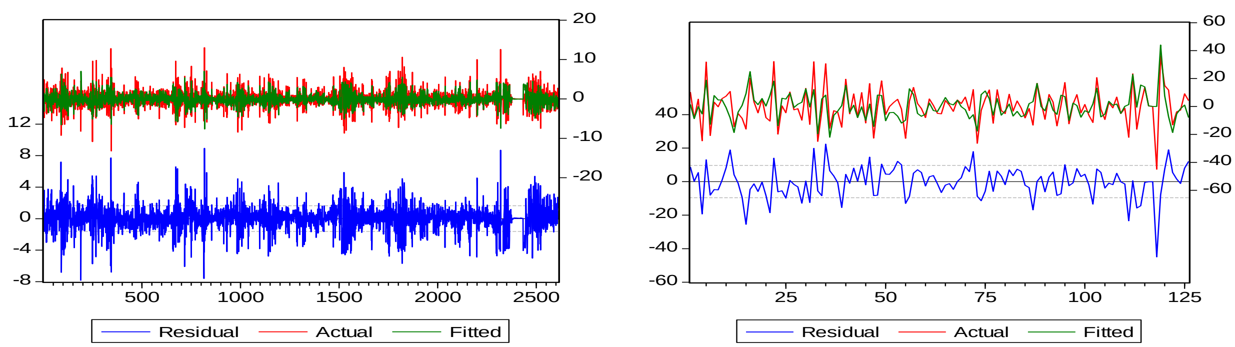

Figure 3. Residual, Actual and Fitted graph for the ARIMA (1, 0, 1) & ARIMA (0, 0, 1)

Results of the ARIMA study for both return series (see Table 12 & 13) suggest that both ARIMA Models (1, 0, 1) and (0, 0, 1) do not support the random walk model. The coefficients of AR (1) and MA (1) for daily return series (0.096848 & -0.997226) with standard errors of (0.019565 & 0.001683) and probabilities of (0.0000 & 0.0000) reject the null hypothesis of random walk which indicates also that KSE daily return series do not follow the random walk hypothesis. Similarly, same results have found for monthly return series of KSE. Our results are similar with the findings of Sharma et al. (1977) on the Bombay, London and New York Stock Exchanges, Nourredine (1998) on the Saudi Arabian market, Moustafa (2004) Bangladesh stock Exchange, Abrosimova et al. (2005) Russian stock market and Poshakwale (1996) Indian stock market who find the evidence of weak-form efficient.

Table 12. ARIMA (1, 0, 1) model estimation

Variable	Coefficient	Std. Error	T- Statistic	P- Value
Constant	-7.32E-05	0.000118	-0.618067	0.5366
AR(1)	0.096848	0.019565	4.950029	0.0000
MA(1)	-0.997226	0.001683	-592.6071	0.0000

Table 13. ARMA (0, 0, 1) model estimation

Variable	Coefficient	Std. Error	T- Statistic	P- Value
Constant	-0.029575	0.029895	-0.989282	0.3245
MA(1)	-0.980228	0.011360	-86.29049	0.0000

3.4 Forecast Analysis

We mentioned in the previous discussion that ARIMA (1, 0, 1) and ARIMA (0, 0, 1) are the best fitted model for both daily and monthly return series on the basis Akaike criterion, Schwarz criterion and residuals correlogram also tell us the same status.

By using these fitted models, the forecasting performance is done on the basis of different error criteria. Theil inequality in daily return series (0.443843) and in monthly return series (0.431625) is not close to zero thus we conclude that model is not an ideal fit in both cases. We also noted that bias proportion in daily and monthly returns is approximately zero but the variance proportion in daily return 19 % and in monthly return 13 % (see in Figure 4 & 5). Hence in the end we can say that both models are not good for forecasting purpose.

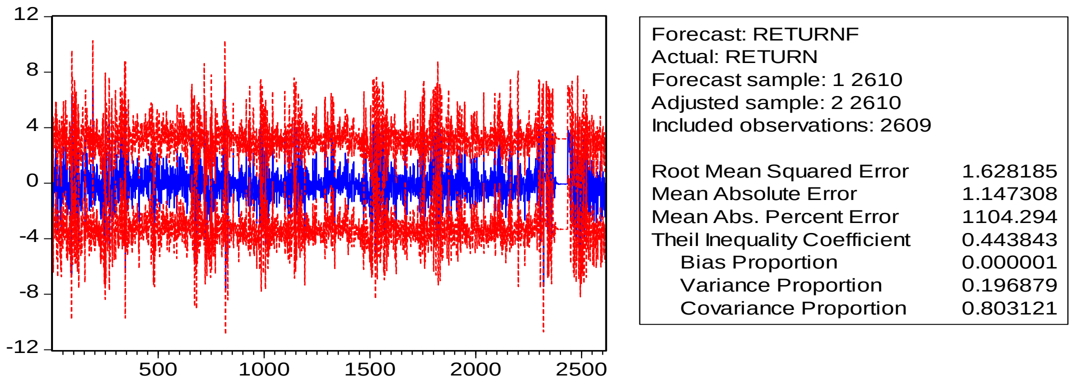

Figure 4. Static forecast for 1999 to 2009 of daily return series

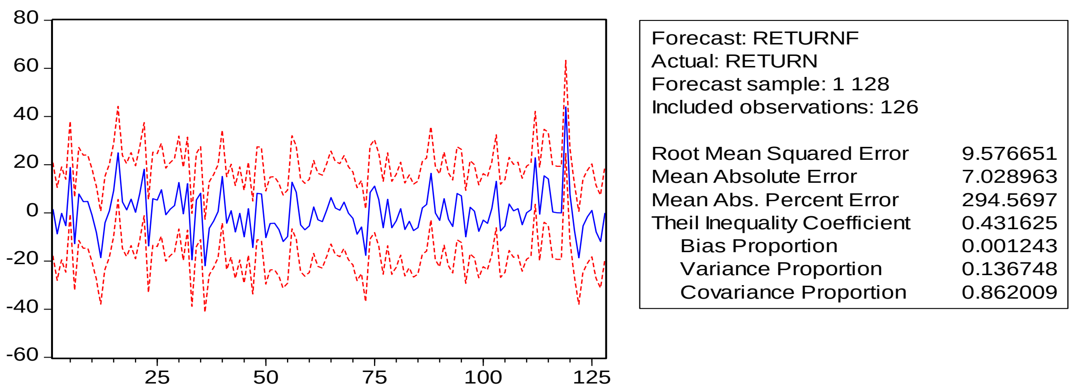

Figure 5. Static forecast for 1999 to 2009 of monthly return series

4. Conclusion

In this paper, we tested for weak from efficiency using the daily and monthly closing prices of Karachi Stock Exchange (KSE) 100 indexes for the period of 1st January1999 to 31st August 2009. Several different parametric approaches: unit root test, autocorrelation tests and ARIMA model are used to test the sureness of the KSE market. The parameters of AR (p) and MA (q) were compared according to the different criterion like Akaike criterion and Schwarz criterion to select the best fitting model in both returns. Correlogram of ARIMA residuals show no autocorrelation and partial Autocorrelation is left in both series, therefore, there is no need to search out another ARIMA model. ARIMA (1, 0, 1) for daily return series and ARIMA (0, 0, 1) for monthly return series are selected. All parametric methods strongly recommended that both return series do not follow the random walk model and also reject the hypothesis of weak from efficiency. Overall results from the empirical analysis powerfully proposed that the Karachi Stock Market of Pakistan is not efficient in weak from.

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