SMART

Journal of Business Management Studies

(A Professional, Refereed, International and Indexed Journal)

Vol - 14 Number - 2 **July – December 2018** **Rs.500**

ISSN 0973-1598 (Print) **ISSN 2321-2012 (Online)**

Professor MURUGESAN SELVAM, M.Com, MBA, Ph.D, D.Litt
Founder - Publisher and Chief Editor

SCIENTIFIC MANAGEMENT AND ADVANCED RESEARCH TRUST (SMART)

TIRUCHIRAPPALLI (INDIA)

www.smartjournalbms.org

SMART JOURNAL OF BUSINESS MANAGEMENT STUDIES
(A Professional, Refereed, International and Indexed Journal)
www.smartjournalbms.org

DOI : 10.5958/2321-2012.2018.00012.X

TIME SERIES MODELING OF KSE-100 INDEX

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Abstract

The study aims to establish the Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) model, to analyze stock returns of KS-100 Index of Pakistan Stock Exchange. After applying different GARCH models, this study attempted to select the best model. The daily values of the KSE 100 Index of Pakistan Stock Exchange were collected over the period of 4 years and 9 months, starting from December 2013 to September 2017. The study employed 1200 total observations. The objective was achieved by estimating different Auto Regressive Conditional Heteroskedasticity (ARCH) model and its extension, GARCH model, identification of ARIMA model, estimation of identified ARIMA and then checking it. The goodness of ût was assessed through the Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Standard Error (S.E). Moreover, the parameters of the model

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were estimated, using maximum likelihood method. The present study concludes that GARCH (1, 1) is the most suitable model, to capture the volatility of stock returns of KSE-100 Index and vital for academicians and econometricians. It is also helpful for the policymakers to know the trend and patterns of stock exchange.

Keywords: *Stock Market Anomaly, Pakistan Stock Exchange, Dummy Variable Regression, GARCH (1, 1) Model*

JEL Code: *D53,E47and E44.*

Paper Received : *21.03.2018* ***Revised :*** *15.04.2018* ***Accepted :*** *22.05.2018*

1. Introduction

Originally presented by **Fama (1970),** the Efficient Market Hypothesis (EMH) is still admired in the academic community. According to this hypothesis, stock prices completely reflect all available information while stock prices randomly fluctuate in inefficient stock markets. Moreover, Random Walk Hypothesis asserts that historical share prices do not provide the basis for forecasting expected prices. Hence share prices follow a random walk. Several studies have been conducted on the topic since the seminal study mentioned earlier. Although Efficient Market Hypothes predicts that returns of a stock, are distributed over time, numerous studies have evidenced the existence of Calendar Anomalies. EMH takes three different forms, according to the availability of information; strong, semi-strong, and weak. The weak form contends that returns on stocks vary over the long run and short-term variations do not exist. Hence investors can make abnormal returns. This pragmatic reason has induced academicians and professionals to study calendar anomalies. During the previous years, some researchers have tried to investigate day of the week effect in emerging markets of the world. The inconsistency about results of such studies has made a strong case for the topic to be investigated again to fill the gap that is still there. Moreover, emerging markets, like the one Pakistan has, makes interesting study, given the turbulent economic and financial situation they face. In the past, researchers like Islam and **Gomes (1999)** and **Hossain (2004)** have made attempts to explore the phenomenon in Pakistan but have not added any significant value. Despite the extensive work done before, any valuable addition to the existing literature in finance has not been contributed. This study aims at selecting and identifying a model that best fits the explanation of week of the day effect in the premier capital market of the country-Pakistan Stock Exchange. The results of the research could offer guidelines to different parties in stock exchange, specifically investors, managers and regulatory authorities.

2. Review of Literature

There are numerous studies available on the topic around the world. The academic community seems to be extremely interested in the existence of the calendar anomalies in the stock markets of emerging economies. **French (1980),** in his seminal study, offered two different models, intended to explain share price volatility of Standards and Poor's composite portfolio. The study was conducted over a period from 1953 till 1977. He found that returns calculated from daily stock prices are not consistent with the two models. Moreover, he concluded that Monday average return was negative whereas the number was positive for

rest of the days of the week. **Gibbons and Hess (1981**) also investigated whether calendar anomaly existed in the United States stock market, Dow Jones Industrial Average. By using the data related to stocks and bills, this study also pointed out Monday to be significant. Since the study took only socks and bills, the results produced a negative average return for Monday and less than average returns for the bill on that day. **Keim and Stambaugh (1984)** conducted a similar study in which time horizon was long enough to go back till 1928 and more stocks were added. By focusing on Standard and Poors Composite, they decided to go with exchange-traded (over the counter) stocks selected by active trading. The study yielded similar results. **Jaffe and Westerfield (1989)** performed a cross-country analysis for the purpose by considering United States, United Kingdom, Australia, Canada,and Japan as sample countries. The study came up with an effect called weekend effect for the sample countries. Moreover, in the cross-country comparison, it was found that for stock markets of Japan and Australia, the minimum average return popped up on Tuesday. **Harris (1986)** conducted a week-wise and day-wise analysis of data related to transactions. He divided the companies into two distinct groups-large and small firms. By doing so, the results showed that Monday is the most significant day for both groups but the study also introduced some other implications. While studying large firms, he concluded that Monday produced significantly negative returns for the group and this return accumulated during the off days between Friday and Monday. On the other hand, small firm stocks also reported negative average returns over the period. The study also claimed that on an average, stock price tended to fall on Monday morning while it recorded an upward trend on any other day morning.

Thoebald and Price (1984) provided evidence regarding the significance of Monday and Friday, and they mostly concurred with the previous literature. By carefully reviewing the preceding citations, following conclusion can be drawn that on an on average, stock returns were negative on Mondays, positive on Fridays, which further drives us to the stance that stock prices have shown a declining trend on Monday (the opening day of the week) and an increasing trend on Friday (the closing day of the week). **Lakonishok and Smidt (1988)** conducted a study on Dow Jones Industrial Average stocks to find out whether there existed calendar anomalies over a period of 90 years and daily stock returns were chosen for the purpose. The results of the study showed the existence of calendar anomaly in weekly stock returns for the said period. **Aggarwal and Rivoli (1989)** performed research in the context of emerging economies, including Philippines, Singapore, Malaysia, and Hong-Kong, taking daily stock returns for their stock markets. The study concluded that calendar anomalies existed in the markets, under consideration, over the period. The day of the week effect was observed in the markets, with significant negative mean returns for Monday. **Lakonishok and Smidt (1988)** hypothesized slightly differently by splitting investors into two classes - individual and institutional investors.

Agarwal and Tandon (1994) explored the phenomenon, by observing stock markets of 18 different nations and the study found five patterns, related to the calendar. After performing the analysis over stock price data, it was concluded that day of the week effects did exist in almost all the countries but the weekend effect was found only in nine nations. **Dubois and Louvet (1996)** conducted a similar study of 11 stock market indices, selected from nine

different nations, over a period from 1969 to 1992. The research observed smaller stock returns during the start of the week but not necessarily on Monday. Calendar anomalies still exist in select countries of Europe, in the United States of America, though it has not been observed lately over the same period. **Mehdian and Perry (2001)** conducted a study on United States, by taking five stock markets, from 1964 to 1999, with data related to stock prices on a daily basis. The intention was to investigate the Monday effect. **Wang and Erickson (1997)** added more implications that day of the week effect specifically related to Monday, did not appear on all four Mondays of the week. Instead it was observed for last two Mondays of a particular month. Also, the research showed that difference of average returns of stocks, starting 3 weeks from zero, was not significant.

The topic has also been rigorously studied in the South Asian context. A similar study was conducted by **Islam and Gomes (1999)** in the context of emerging market. Specifically, the case of Dhaka Stock Exchange was taken into account. By applying a similar analysis over stock price mean returns, the study evidenced that the weekend effect did exist with bigger and positive average return on Monday. Hence weekend effect was known to be significant. Efforts were made to explore the calendar anomalies. Stock price data were collected, for a period of six years, 1990 to 1995. The study indicated the existence of calendar anomalies to a significant extent. This significance was related to both aspects-mean returns and variation in returns. However, the results differed across all seven countries. **Nath and Dalvi (2007)** conducted a study according to which there was significant calendar anomalies, due to pre-rolling settlement in 2002.

3. Statement of the Problem

The main issue was to identify the models, for calculating the stock returns and to choose a best fit model to measure the stock returns. The Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) model was used to analyze stock returns of 100-Index of Pakistan Stock Exchange (KSE) for the sample period.

4. Need of the Study

This study is important for academicians, researchers as well as for econometricians as it is expected that it would provide the knowledge and basis for further study in the same field or other related areas of study. This research article could also be helpful for the policymakers to know the trend and patterns of stock exchange, to shape their policies.

5. Objective of the Study

The objective of this study was manifold. The main objective of this study was to develop the Generalized Auto Regressive Conditional Heteroskedasticity(GARCH) model, to analyze stock returns of KSE-100 of Pakistan Stock Exchange, for the selected period. Moreover, after applying different GARCH models, this study also proposes to select the best model by different criteria.

6. Hypotheses of the Study

The following null hypotheses were tested in the study.

NH-1: R100-IDEX has no unit root (Non-Stationary).

NH-2: There is no ARCH effect.

7. Research Methodology

7.1 Sample Selection

The KSE-100 Index of Pakistan Stock Exchange, was taken as the sample stock index, to analyse the returns.

7.2 Source of Data

The secondary data of daily values of the KSE-100 of Pakistan Stock Exchange were collected for a period of four years and nine months, from December 2013 to September 2017. Trading takes place five days a week. The study was based on 1200 total observations.

7.3 Period of the Study

The study period covered four years and nine months, from December 2013 to September 2017.

7.4 Tools Used

The GARCH model was selected, based on how well the model captures the random variation in the values. The goodness of fit was assessed through the Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Standard Error (S.E.). Moreover, the parameters of the model were estimated by using the maximum likelihood method.

8. Results and Discussion

Figure-1 presents the basic properties of the data. There was a total of 1200 observations of the KSE-100 index, used for this analysis. The mean of the distribution was found to be 0.00124, showing that there was positive trend in stock return, with the standard deviation of 0.0114 while the Minimum and Maximum values of the series were -0.05005 and 0.05444 respectively. In the case of normal distribution, the two parameters of Skewness and Kurtosis recorded values of "0" and "3" respectively. The Jarque-Bera statistic, which follows the Chi-Square distribution, was also used to check the symmetry and peakedness of a distribution. According to the Jarque-Bera statistics, 'The distribution is normal' and the alternative was 'The distribution is not normal'. The coefficient of Skewness was – 0.0425, which indicated that our series of stock return recorded flatter tails relative to normal distribution and the series recorded asymmetric distribution, skewed towards left. The coefficient of Kurtosis was 5.4843, which was more than three, indicating that our series was leptokurtic. This phenomenon has been extensively observed in the studies related to stock returns. Since P-value calculated, from Jarque–Bera ($0.000 < 0.05$), was another indication, which leads towards the acceptance of the hypothesis that series is not normally distributed. Further, it supported the evidence that the daily stock return series was skewed as well as highly peaked.

The Quantile-Quantile (Q-Q plot) is another technique, which can be used to analyze the properties of a distribution. Under this technique, quantiles of a variable's distribution are plotted against any number of a test distribution and the study tested the data for normal distribution. If the values of a sample distribution, with mean (meu) and standard deviation (Sigma), then the resulting plot should be roughly scattered around the 45-degree line with positive slope. The scattering of the values, around the line, provides evidence for rejecting null hypothesis and acceptance of the alternative hypothesis. It is obvious from **Figure-2** that values are scattered and they do not conform to the theoretical normal distribution. Hence it may be concluded that the stock returns were not normally distributed. It is also noted that the variance of the series, related to daily returns, is not constant over time and this feature is known as volatility clustering.The figure depicts the pattern in the values of KSE-100 index. This suggests that GARCH model can be employed to tackle the issue related to heteroskedasticity.

The building of ARCH / GARCH consists of two phases. In the first phase, the mean equation is estimated, using ARIMA and for this purpose, maximum likelihood method is applied. In the second phase, the study

estimates the variance equations. Before estimating the ARIMA model, it is essential to check that the series are stationary. In a more precise way, the stationary can be explored by applying the unit root test. This can be done by applying Augmented Dicky Fuller (ADF) Test,and Philip- Perron (P-P) Test. The results obtained are provided in **Table-1.** According to the results, the null hypothesis **NH-1** (R100-IDEX has no unit root (Non- Stationary)), is rejected. Hence it may be concluded that series R100-INDEX is stationary at 1%, 5% and 10% levels of significance.

After observing the stationary in series R100-INDEX, the next step is to estimate the mean equation. Majority of stock return following ARMA (1,0), which is traditionally called AR(1) and the results of estimated AR(1), are given below:

$$Rt = 0.0012 + 0.0997\ Rt_{-1} \quad \text{———— (1)}$$

t-values	(3.3069)	(3.3940)
P-Value	(0.0000)	(0.0000)

The formal statistical test, to check the presence of ARCH effect, is the Ljung-Box-Pierce Q-Test. It is an examination of ACF & PACF of residual obtained from equation (1). A more precise test, which can be applied to test the ARCH effect, is the ARCH LM-Test. This test follows χ^2 -test statistic since F-Statistics is 41.4407 (P-Value 0.000). It may be concluded that there is ARCH effect. Hence **NH-2** (There is no ARCH effect), is rejected.

After identifying the ARCH effect in residual of the mean equation, our next step is to estimate the different GARCH model. In this study, GARCH(0,1),GARCH(1,1) and GARCH(1,2) were estimsted, using EVIEWS. The estimated parameters of the models are given in **Table-2.** The variance equation, for the above three models, are written as:

GARCH (0,1)

Mean equation: $R_t = \alpha_0 + \alpha_1 R_{t-1}$

$R_t = 0.013 + 0.1120\ R_{t-1}$

Variance equation: $\sigma_t^2 = \beta_1 + \beta_2 \square^2_{t-1}$ ———————————————— (1)

$\sigma_t^2 = 0.0001 + 0.2116\ \tilde{o}^2_{t-1}$

GARCH (1,1)

Mean equation: $R_t = \alpha_0 + \alpha_1 R_{t-1}$

$R_t = 0.014 + 0.0765\ R_{t-1}$

Variance equation: $\sigma_t^2 = \beta_1 + \beta_2 \square^2_{t-1} + \gamma_1\ \sigma_{t-1}^2$ ———————————————— (2)

$\sigma_t^2 = 2.20E\text{-}06 + 0.0875 \tilde{o}^2_{t-1} + 0.8941\ \sigma_{t-1}$

GARCH (1,2)

Mean equation: $R_t = \alpha_0 + \alpha_1 R_{t-1}$

$R_t = 0.0014 + 0.0762\ R_{t-1}$

Variance equation: $\sigma_t^2 = \beta_1 + \beta_2 \square^2_{t-1} + \gamma_1\ \sigma_{t-1}^2 + \gamma_2\ \sigma_{t-2}^2$ ———————————————— (3)

$\sigma_t^2 = 2.11E\text{-}06 + 0.0826 \tilde{o}^2_{t-1} + 0.9657\ \sigma_{t-1}^2 - 0.0659\ \sigma_{t-2}^2$

9. Findings of the Study

Three different GARCH models were developed. The model, which captures many variations in the data, is supposed to be the best one. The best model has lower values of Akaike Information Criterion (AIC) and Schwarz Criterion (BIC). **Table–3** presents the values of AIC, SC, S.E, and Log-Likelihood of our three suggested models. It is obvious that GARCH (1,1) recorded lower AIC and SC, along with lower S.E. at 0.0105. Hence it is considered to be the best model, to capture volatility, in 100 Stock return.

$$\sigma_t^2 = \beta_1 + \beta_2 \varepsilon^2_{t-1} + \gamma_1 \sigma_{t-1}^2$$

$$\sigma_t^2 = 2.20E\text{-}06 + 0.0875 \varepsilon^2_{t-1} + 0.8941 \sigma_{t-1}^2$$

This model satisfies the equation $\beta_{2+}\gamma_1 < 1$, i.e., $\beta_{2+}\gamma_1 = 0.9861$, which shows that the model satisfied the equation of stationarity. It is obvious that since p-value of Jarque–Bera test was < 0.05, the distribution of residuals was not normal but skewed left, as at -0.24911 **(Figure-3).**

10.Suggestions

A best-fitted model must have the following properties. The residuals of the model must show random patterns and it must follow the white noise process and independently distributed. The residuals were normally distributed and there was no serial correlation between the values of residuals. According to econometricians, this model could be used for forecasting because the estimate of the models is consistent.

11. Conclusion

The study concludes that GARCH (1,1) is the best model to capture the volatility of stock returns of KSE-100 Index. This study is important for academicians, researchers as well as for econometricians as it is expected that it will provide the knowledge and basis for further study in the same field or other related areas of study. This research article is also helpful for the policymakers to know the trend and patterns of stock exchange, to guide the policymaking.

12. Limitations of the Study

The study covered only Pakistani Stock exchange. It cannot be generalized for the rest of the stock in the region and particularly not for the whole world.

13. Scope for Future Research

This limitation is the opportunity for future research. The same model can be employed for more than one stock exchange in Asia.

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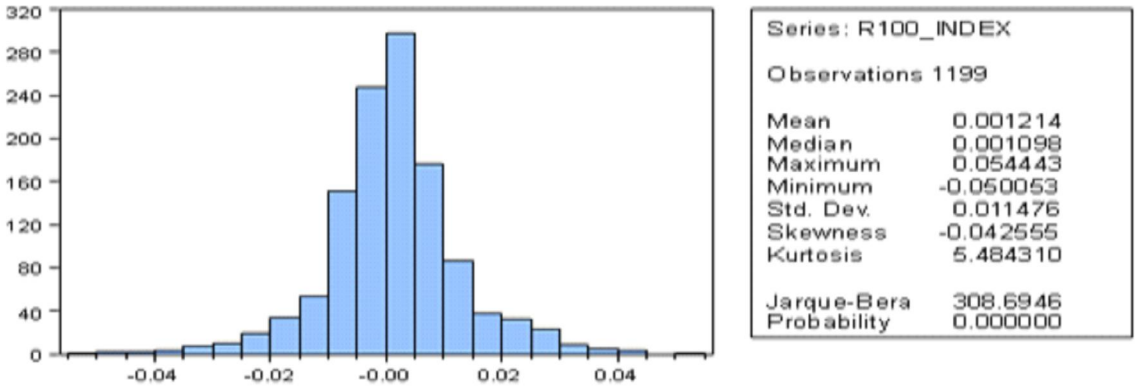
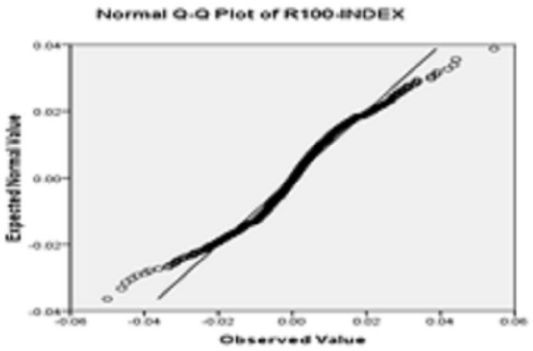
Figure-1: KSE-100 Index Skewness and Kurtosis



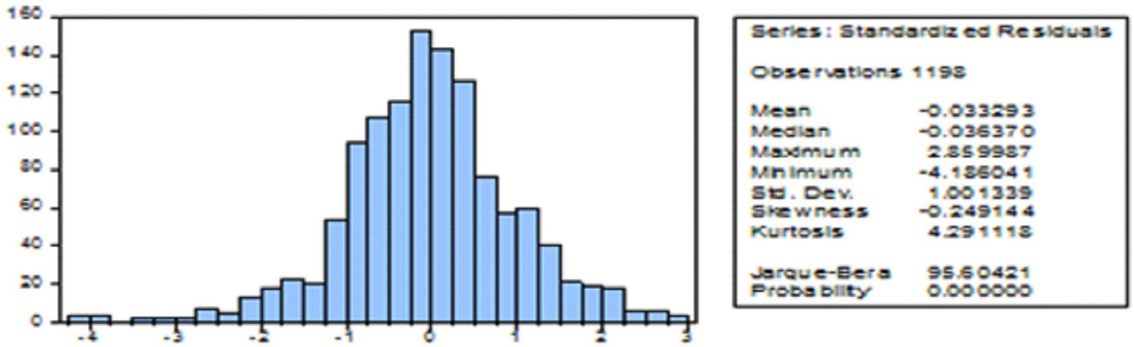
Source: www.psx.com.pk using SPSS (version 16)

Figure-2: KSE-100 The Quantile – Quantile (Q-Q plot)



Source: www.psx.com.pk using SPSS (version 16)

Figure-3: Distribution of GARCH (1,1)



Source: www.psx.com.pk using SPSS (version 16)

Table-1: Stationary Test

	ADF Test Statistics			Philps - Peron Test Statistics	
	Max. Lag	None	Trend & Intercept	None	Trend & Intercept
R100-INDEX	22	-31.16041 (0.0000)	-31.30760 (0.0000)	-31.40737 (0.0000)	-31.48892 (0.0000)

Source: www.psx.com.pk using SPSS (version 16)

Table-2: Estimated GARCH models

Model	α_0	α_1	β_1	β_2	γ_1	γ_2
GARCH (0,1)	0.0013 (0.0003)	0.1120 (0.0004)	0.0001 (0.0000)	0.2116 (0.0000)		
GARCH (1,1)	0.0014 (0.000)	0.0765 (0.0138)	2.20E-06 (0.0000)	0.0875 (0.0000)	0.8941 (0.0000)	
GARCH(1,2)	0.0014 (0.0000)	0.0762 (0.0134)	2.11E-06 (0.0087)	0.0826 (0.0078)	0.9657 (0.0060)	-0.0659 (0.8355)

Source: www.psx.com.pk using SPSS (version 16)

Table-3: Criteria of best-fitted model

Models	AIC	SC	S.E.	Log Likelihood
GARCH (0,1)	-6.1507	-6.1337	0.0114	3688.288
GARCH (1 ,1)	-6.3471	-6.3259	0.0105	3806.964
GARCH (1,2)	-6.3455	-6.3200	0.0109	3806.994

Source: www.psx.com.pk using SPSS (version 16)