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# APPLYING GARCH FAMILY MODELS FOR ESTIMATING PROPORTIONAL VOLATILITY OF STOCK MARKET INVESTMENT RETURNS: AN EMPIRICAL STUDY FOR AUTOMOBILES SECTOR IN INDIA

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*Abstract*

***The main aim of this paper is to estimate the impact of proportional volatility on investment returns based on a case study for National Stock Exchange (NSE) of India. The empirical analysis includes various GARCH family models. NIFTY Auto index is a representative barometer for automobiles sector in India which includes large two-wheeler and four-wheeler manufacturers, both commercial and domestic vehicles. A great variety of research studies explored the volatility behavior and price returns effect on NIFTY Auto sector considering the essential role played by automobile companies in India. The empirical analysis includes various GARCH family models. The database covers the sample period from October 2010 to September 2019. The index movement pattern identified changed providing investor's return particularly from 2010. The empirical results are relevant and contribute to a better understanding of the dynamic behavior of auto sector in India, especially in the context of globalization.***
***Keywords: proportional volatility, GARCH models, automobile companies, leverage effect, stock return, investment risk***

**JEL classification:** C22, G11, G17, O16, Q01

## I. INTRODUCTION

Indian Automobile represents one of the largest automobile sectors in world's manufacturing two-wheeler and four-wheeler domestic and commercial vehicles. The first imported car ran on Indian road in 1897 and first embryonic industry emerged in 1940s. Today, India manufactures all type of vehicle and in large units of production in every segment. NIFTY Auto index

represents one of index by National Stock Exchange (NSE) India. It reflects performance and behavior of listed Automobile sector and includes all mid and large cap companies. Index represents computation of movement based on free float market capitalization method (FFMC) considering base rate of 1000 from January 2004. Indian automobile sector includes large two-wheeler and four-wheeler manufacturers, commercial and domestic vehicles. Variety of studies explored volatility and price return on NIFTY Auto sector. Singh (2017) suggested that various manufacturing industries depend upon automobile industry in India, such as steel, rubber, glass, machine tools, robots, electronics, software and numerous other industrial sectors. According to official statistics provided by IBEF (India Brand Equity Foundation), auto industry in India became the 4th largest in the world with sales increasing 9.5 per cent year-on-year to 4.02 million units (excluding two wheelers) in 2017 and it was the 7th largest manufacturer of commercial vehicles in 2018. Spulbar et. al (2019) investigated the issue of sustainable investing on Bombay Stock Exchange (BSE) of India and suggested that emerging markets are characterized by rather unstable economic and financial structure.

## II. LITERATURE REVIEW

Girish (2019) suggested that Indian automobile market represents a global hub for experimentation, exposure and economic adventurism considering the most important parameters of entrepreneurial excellence such as the following : business volumes, strategic cost management, technological and operational advancement, employee productivity and financial results. Nagendra and Haritha (2014) consider that NSE stock market of India occupies a decisive position in reforming the Indian securities market regarding microstructure, market practices and trading volumes. Muthu and Akarsh (2017) examined the automobile industry in stock market of India and emphasized that generates a high multiplier effect on the economic growth considering the percentage held, i.e 7.1% of the gross domestic products (GDP) of India. Kumar (2017) explored the impact of earning per share ratio on listed share market price where the analysis and outcome based on multiple regression considering that the index movement pattern identified changed providing investor's return particularly from 2010. Moreover, Alabiet. al (2018) investigated the linkage between financial deepening, foreign direct investment and output performance and concluded that output performance is mainly influenced by foreign direct investment, stock market activities and money supply in the long-run period. According to Pinto et al. (2020) low volatility investment strategy is significant in the sense that it has been able to achieve higher absolute returns, but also risk-adjusted returns.
Thenmozhi and Chand (2016) worked on NIFTY index forecasting based on global stock return transmitting yield considering day trading in emerging and developed stock market. Their findings are of global interest. It suggests that NIFTY is most predictable index particularly daily trading returns. Shanmugasundaram and Bendict (2013) conducted other relevant research study which focuses on risk factor on sectorial indices of National Stock Exchange of India covers CNX Auto sector providing analysis and results that helps to important implications to individual investors and portfolio manager in terms of reducing portfolio risk. Moreover, Kelkar and Mokhade (2016) provided an interesting study focused on tweet sentiments and its impact on NIFTY Auto index while the data range limits confirmation of

volatility presence in any series particularly when time range have been established between 2-8 years. For instance Kumar and Shivakumaran (2016) worked on modeling volatility for NSE considering data range from 2014 to 2016 and have identified no presence of volatility in series returns. In addition to that, short-term period for time series returns generally have positive mean returns and may exhibit a higher degree of standard deviation.

## III. RESEARCH METHODOLOGY AND EMPIRICAL ANALYSIS

This paper aims to measure volatility movements, change in investor's returns and comparative volatility difference on NIFTY Auto sector. Data ranging October, 2010 to September 2019 consisting 2227 daily observations abstracted from National Stock Exchange website. We employ comparative symmetric model GARCH (1,1) by Bollerslev and Taylor GARCH (1, 1) and an exponential GARCH model by Nelson EGARCH (1, 1). Spulbar et al. (2019) argued that financial time series highlights particular features such as the existence of volatility clustering and chaotic behavior. All abstracted observations converted to log returns and first log difference have been considered to overcome white noise process which tested by Augmented Dickey Fuller (ADF). Augmented Dickey-Fuller test was applied in order to determine the stationarity of the selected financial time series. The null hypothesis is that the selected financial time series contains a unit root and it is implicitly non-stationary. Empirical analysis based on the log-returns of the selected indices reflects the fact that ttest_ADF<tcritic (1%, 5%, 10%) so the null hypothesis H0 is rejected and the analyzed time series is stationary. Simultaneous, it is obtain the following result: Prob (0%) < test levels (1%, 5%, 10%) so the null hypothesis H0 is rejected and the selected financial time series is stationary.The continuously-compounded daily returns are calculated using the log-difference of stock markets selected indices as follows :

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \ln(p_t) - \ln(p_{t-1})$$ Where p is the daily closing price.

Augmented Dickey fuller test on east of selected financial market closing returns (first log difference) on each of listed variables, null hypothesis applies that variable has a unit root. However, first difference of variable taken prior to testing considering $Yt$ and key independent variable i.e. first lag of $y$. ADF test model constructed so that coefficient on lagged y equals to the root in problem with (-1).

$$(1 - L)yt = \beta 0 + (\alpha - 1)yt - 1 + \varepsilon i$$

Under null hypothesis of a unit root, coefficient on lagged (y)=0, where under alternative that (y) is stationary this coefficient will be negative. To compare movements of developing and emerging market with each-other and for ranking and accuracy in comparative measurement, Spearman and Kendall produce respectively. Spearman's rank correlation (rho) and Kendall's rank correlation (tau) in place of default Pearson's coefficient, i.e: R=1- (6εd^2)/(n^3-n). . The closer result of r between 1 to -1, represents stronger likely correlation either positively or negatively respectively. However, result in 0 indicate no correlation among selected financial markets. We employ GARCH by Bollerslev (1986) as symmetric GARCH application and EGARCH designed by Nelson (1992), Taylor (1986) and Schwert (1989) GARCH (1, 1) expelled below:

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Bollerslev (1986) designed GARCH (1, 1) as follows : $h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$.
GARCH (1, 1) model represents conditional variance that represented as leinear function of its own lags. The conditional variance of all variables to be dependent upon previous lags. In the process, the first lag of squared residuals will form mean equation and presents idea about volatility from previous time period. Thus GARCH (1, 1) represents Mean equation and Variance equation; Mean equation is the following $grt = \mu + \varepsilon t$. The variance equation is: $\sigma_t^2 = \omega + \alpha\varepsilon_{1t-t}^2 + \beta\sigma_{1\,t-1}^2$. Mean equation represents retuns of asset in time (t) that reprsents sum of average return (above denoted by $\mu$ and residual returns that denoted by $\varepsilon t$. Variance equation assumptions indicates that constant value higher than 0, followed by value of $\alpha$ and $\beta$. EGARCH by Nelson (1991) captures asymmetric responses of time-vary variances to volatilty shocks and also ensures that variance is always positive.

$$Log(\sigma_t^2) = \omega + \sum_{j-i}^{p} \beta i \; Log(\sigma_{t-i}^2) + \sum_{j-1}^{q} \alpha i \left\langle \frac{\varepsilon\, i-t}{\sigma}_{i-t} \right| - \frac{\sqrt{2}}{n} \Big| - yi \frac{\varepsilon\, i-t}{\sigma\, i-t} \Big\rangle$$

Taylor (1986) and Schwert (1989) designed GARCH (1, 1) model as follows:

$$\sigma t = \omega + \alpha 1\,|\varepsilon t-1\,| + \beta 1 \sigma t-1$$

## IV. EMPIRICAL RESULTS

NIFTY Auto index consisting of 2227 daily observations was processed for analysis, interpretation and measure comparative volatility pattern by using symmetric and asymmetric GARCH models. Table no.1 represents summary of statistics that indicates positive mean returns. Further it is interesting to note that difference between minimum and maximum is over double returns. The degree of standard deviation indicates (0.012) comparatively very high during small sample. It is cause of high variation of movement of Index that doubled stock returns. The following figure presents the trend of NIFTY Auto Index daily prices (actual series) for the sample period.

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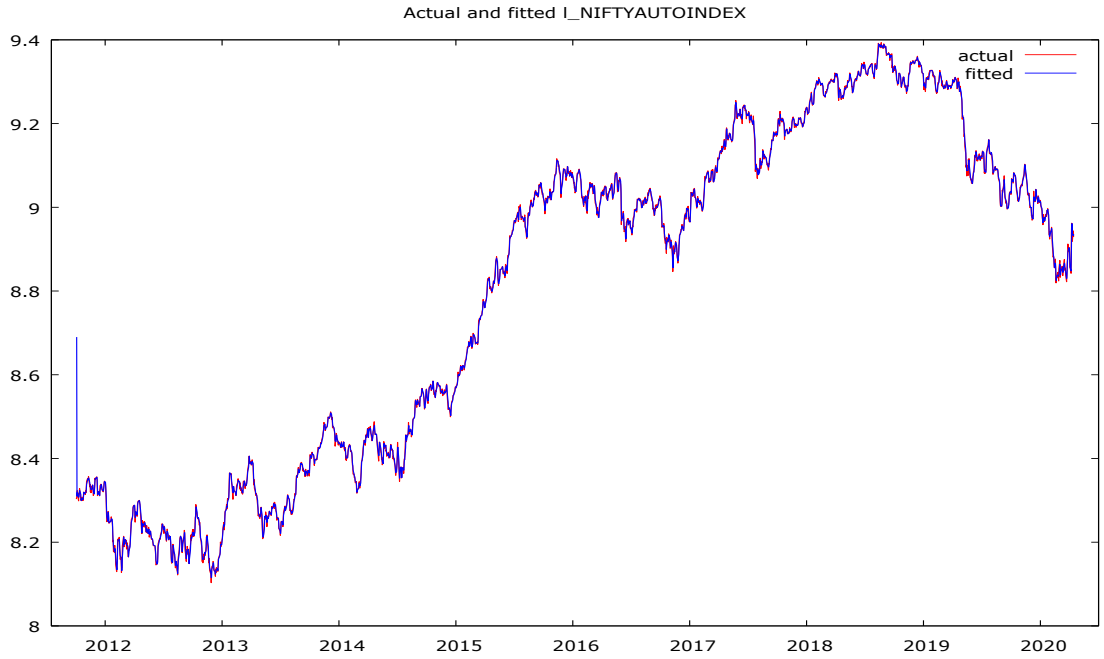


**Figure 1 : The movement of NIFTY Auto Index daily prices (actual series)**
Source: Own computations based on selected financial data series

**Table no.1 Descriptive Statistics**

| Mean | Median | Minimum | Maximum |
|---|---|---|---|
| 0.000281617 | 0.000676892 | -0.0753367 | 0.0944152 |
| Std. Dev. | C.V. | Skewness | Ex. kurtosis |
| 0.0124875 | 44.3420 | 0.0588163 | 2.88893 |
| 5% Perc. | 95% Perc. | IQ range | |
| -0.0196759 | 0.0200283 | 0.0141861 | |

Source: Own computations based on selected financial data series

Statistics property indicates that NIFTY Auto treaded minimum level point of 3304 which is merely four times smaller than maximum 12010 during 2012 and 2018. It suggests that sector has given exceptional returns to long term investors of 2012 and generated portfolio returns almost four times in just five years. Average return is skewed by 0.058 but does not have fat tailed as Kurtosis ranging within level normality level. Fig1 represents comparative presentation of actual index movement and stationary returns (log difference). That suggests that index moved very positive and stable movement. It means that it result very predictable movement up to year 2016. Many large and strong negative magnitude shocks captured in stationary series return graph that indicates strongest negative returns (See Fig1) particularly after 2016. The property of descriptive statics suggests that there is high probability of earning returns which is <mean.

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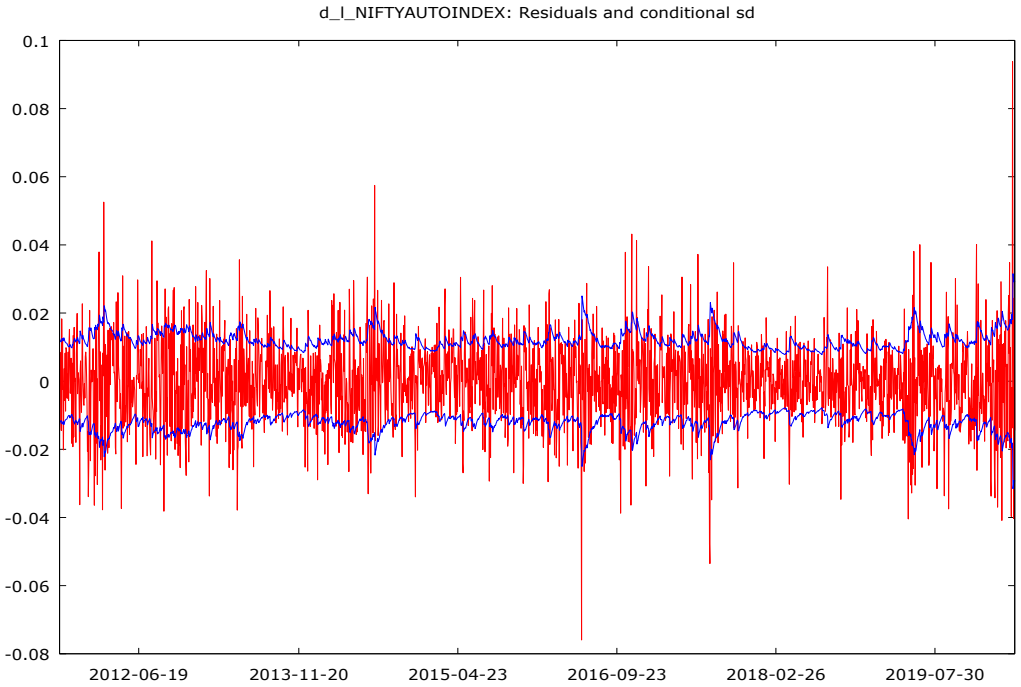


**Figure 2: The movement of NIFTY Auto Index log-returns (stationary series)**
Source: Own computations based on selected financial data series

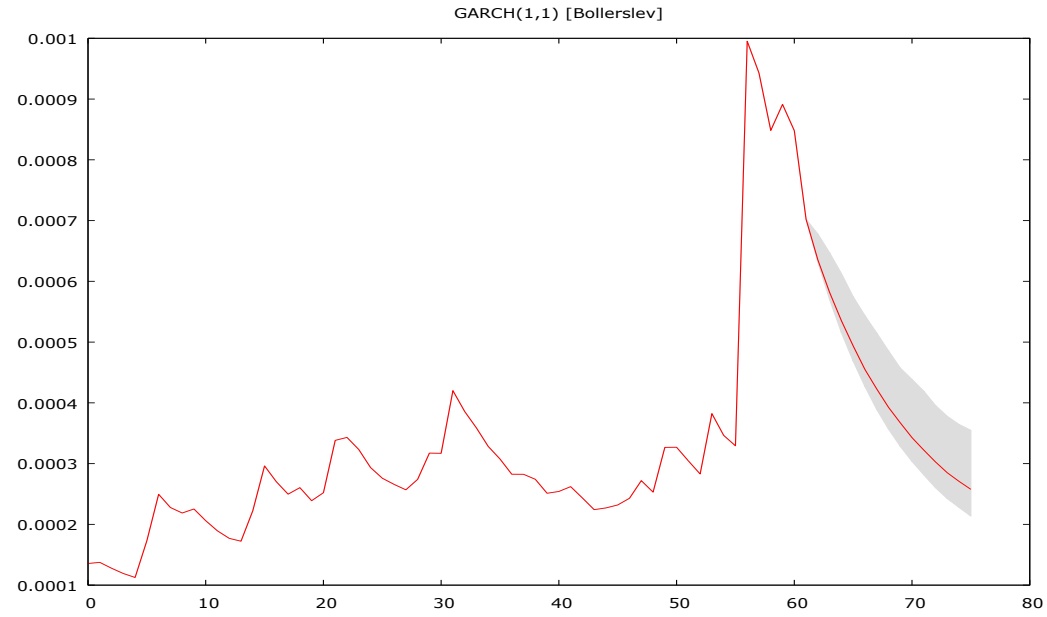


**Figure 3: Forecasting the impact of Bollerslev's GARCH (1,1) model**
Source: Own computations based on selected financial data series

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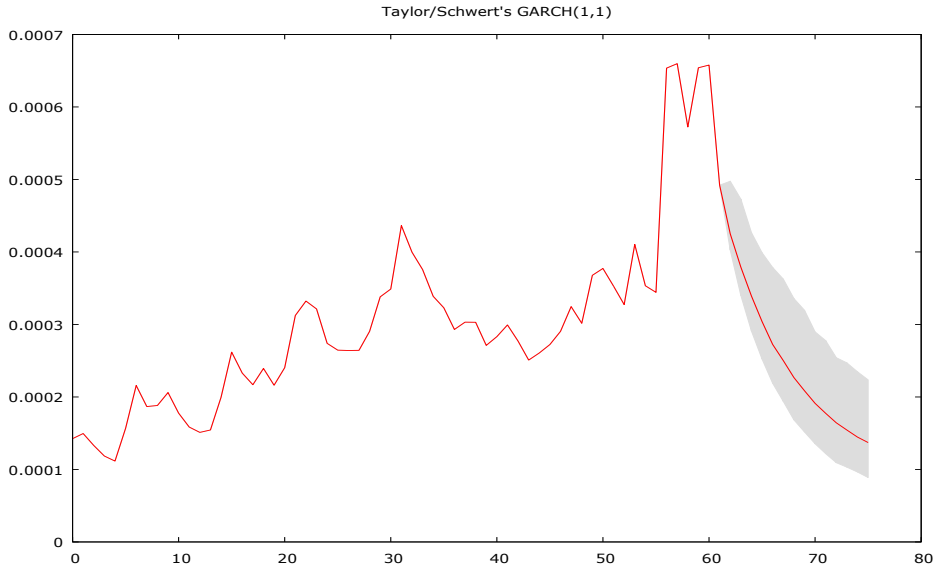


**Figure 4: Forecasting the impact of Taylor/Schwert's GARCH (1,1) model**
Source: Own computations based on selected financial data series

Figure 4 represents a comparative analysis on the differences in forecasting pattern of NIFTY Auto between Bollerslev (1986) autoregressive model and Taylor and Schewert's GARCH model indicates strong positive series movement.

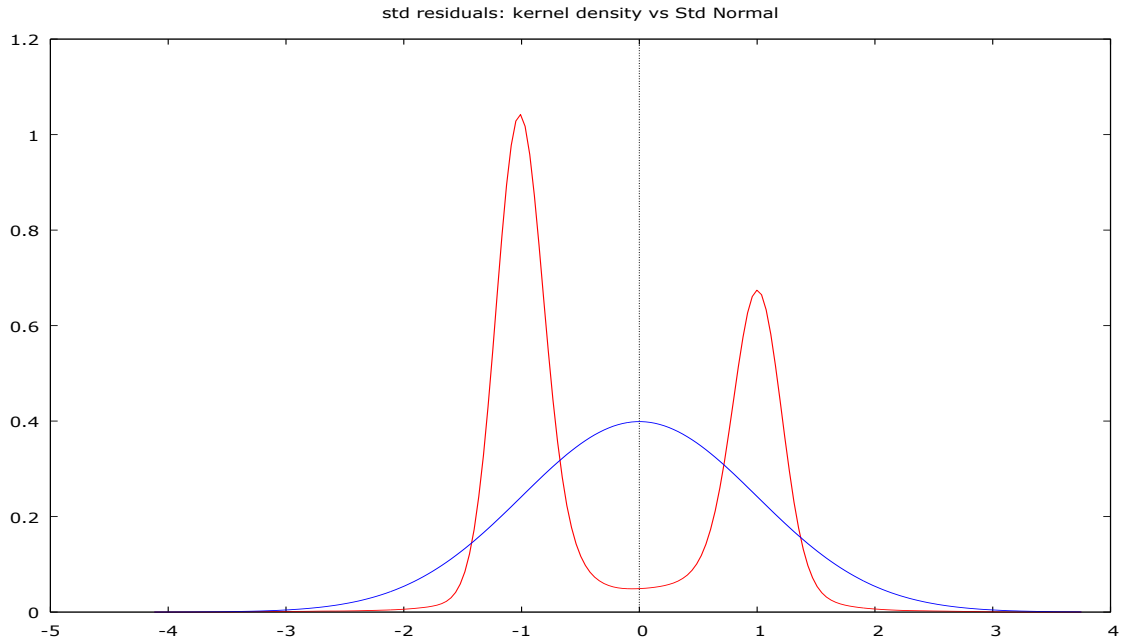


**Figure 5: Standard residual test – Kernel density vs Standard Normal**
Source: Own computations based on selected financial data series

The study of Figure 5 suggests that despite of small time-range considering time series analysis, the series not exceed out of abnormality.

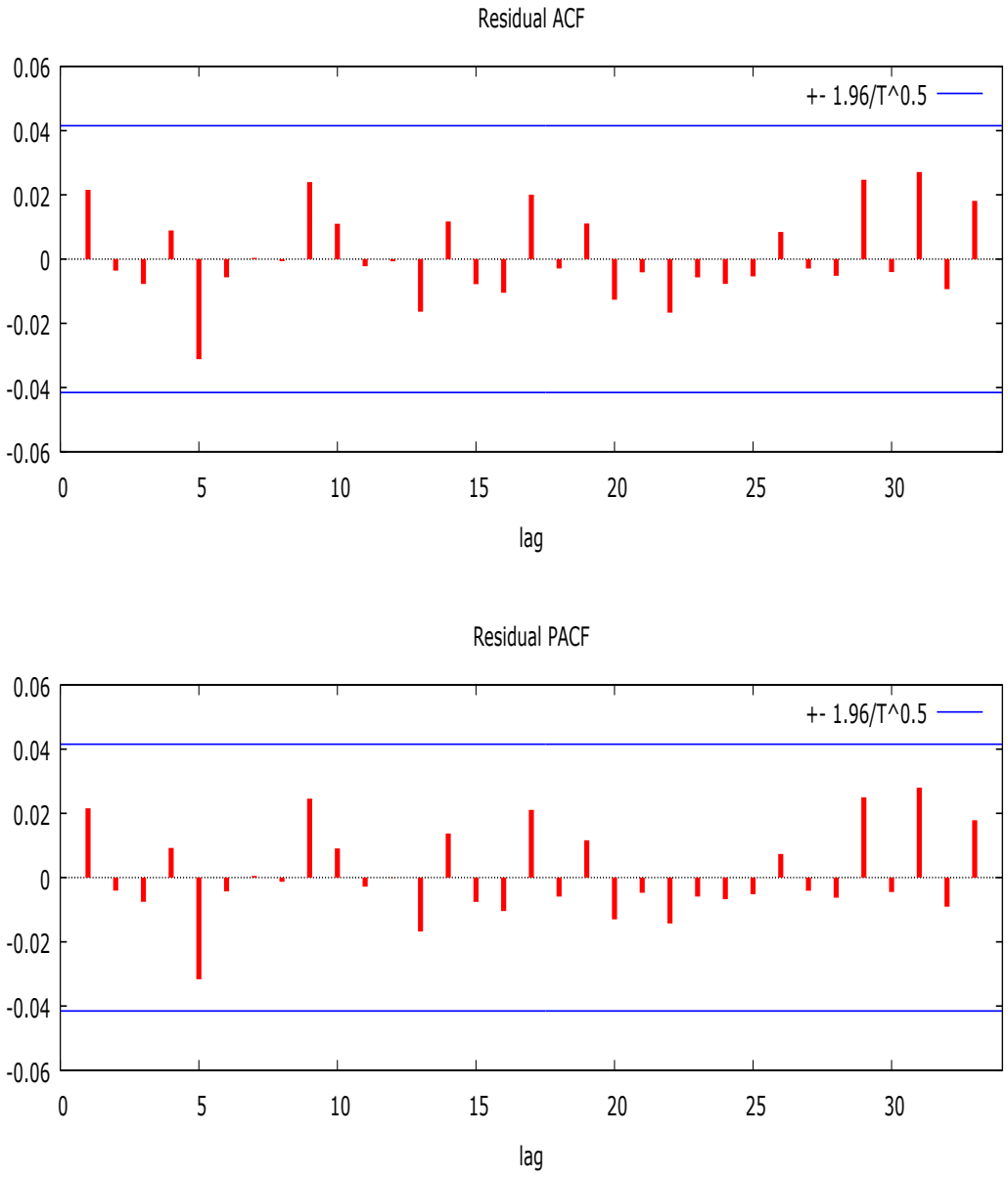


**Figure 6: ACF and PACF applied for NIFTY Auto index log-returns series**
Source: Own computations based on selected financial data series

The GARCH (1,1) model applied for NIFTY Auto sector indicates that sum of coefficient (α+β) is 0.97 which implies volatility highly persistent for covered period considering at level of 10% and 5%. Taylor/Schewert's GARCH (1,1) indicates sum of coefficient (α+β) is 0.99 that not only makes volatility highly persistent but also creates marginal vary from Bollerslev GARCH. The volatility is stretched by Taylor and Schewert's GARCH model. Both the symmetric model indicates that positive mean variance which is in the mean equation suggests that higher market risk provided by conditional variance may not necessarily create higher returns. The asymmetric effect is captured by EGARCH by Nelson in coefficient of leverage (γ) is negative and statistically significant at level of 1% confirming presence of leverage effect in series return of NIFTY Auto index. This strongly indicates to investors that negative shocks have higher impact on conditional variance than positive shocks. The best fitted model considering both symmetry and an asymmetry model is Bollerslev's GARCH (1,1) moel. The selection of best fit model is based on considering minimum AIC and BIC value.

**Table no.2 Econometric models statistical property**

| Mean equation | | | |
|---|---|---|---|
| Variable | Constant | Sig % | Econometric models |
| Bollerslev -GARCH(1,1) | 0.000608406 | 5% | |
| Taylor/Schewert's GARCH (1,1) | 0.000511893 | 5% | |
| EGARCH | 0.00958913 | 1% | |
| AR(1) | 0.998943 | 1% | |
| Conditional variance equation | | | |
| | Bollerslev - GARCH(1,1) | Taylor/Schewert's GARCH(1,1) | EGARCH |
| Omega | 0.0000048602 (10%) | 0.0000045414 (10%) | -0.510917 (5%) |
| Alpha | 0.07912 (1%) | 0.0901116 (1%) | 0.150256 (1%) |
| Beta | 0.893073 (1%) | 0.902232 (1%) | 0.0920042 (1%) |
| Gamma | N.A | N.A | -0.955351(1%) |

Source: Own computations based on selected financial data series

## V. CONCLUSIONS

The study objected to compare symmetric volatility between Bollerslev's GARCH (1,1) model and Taylor/Schewert's GARCH (1,1) model in order to identify the presence of any leverage (asymmetric) effect using Nelson's EGARCH (1,1) model. Results indicate that Bollerslev's GARCH (1,1) model fitted best among other GARCH models based on AIC and BIC value. Volatility of NIFTY Auto found persistent during covered period. Application of asymmetric model and result of EGARCH model indicates presence of leverage effect. The other objective of study is to find change in investor's returns. Result of data analysis, outcome of statistical

property and change in volatility indicates that investors have higher probability to return not assuring promising return in short time period.

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