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Modeling Stock Market Return Volatility: GARCH Evidence from Nifty Realty Index

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Abstract

Basic objective of study was to examine the effect of ARCH and GARCH model on price volatility of Nifty Realty Index along with that analysing leverage effects and volatility clustering. Volatility shocks were measured bydaily closing data of Realty Index of National Stock Exchange. Descriptive analysis of study explained distribution of daily returns were non- normal showing negative skewness and excess kurtosis. Unit root test confirms presence of stationarity in the data and ARCH-LM test exhibits presence of heteroskedasticity in the residual series, which thereby directs towards application of ARCH and GARCH model.Study concluded that GARCH (1,1) model explained the impact of past volatility due to its influence on current volatility. The data is also supported by volatility persistence which influence the GARCH (1,1) model and leadto increase in volatility and thereby affect its returns.

JEL Code : C01, C12, C33, C52, D53, E17, R3
Keywords : Volatility, ARCH, GARCH, Unit Root test, Stock, Real Estate, NSE, Nifty, India, Heteroskedasticity

I. Introduction

VOLATILITY EXPLAINED AS variation in value of stock prices due to amount of risk or uncertainty. If volatility of data higher in value than fluctuations cover wider area of spread while lower volatility explains less fluctuations with respect to time period.A combination of both internal and external shockwas due to value of index returns leading to increase in volatility (Poon and Granger, 2003). Every market prefers to stay at low volatility as it minimise the unnecessary risk which investors has to borne, and leads to liquidation of asset without larger price fluctuation. A developed

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market explains its symptoms as high returns and lower volatility. Yadav (2017) claimed that past history of Indian Stock Market points towards higher returns and future growing market. While US and UK markets also provides higher returns with high volatility which makes a risky market.

Indian Real Estate Industry is most globally recognized sector, which contributes 13% of its share in countries GDP. On current situation real estate market is pleading with oversupply of residential properties due to basic shift in demand patterns. He, Lin and Lui (2018) provided empirical explanation that stock trading volume reduces when market becomes volatile and traders get affected by future market activities leading to variation in decision making. In fact, real estate market is highly volatile and illiquid in nature. As in financial market traders buy and sell a security very quickly at equilibrium price but contrary to this market, real estate traders has to make lot of efforts and invest much time to sell or buy an asset. Hence, it is necessary to complete a transaction for making better profits by showing good faith in deal and placing best marketing efforts.

Indian stock market broadly affected by trading in Bombay Stock Exchange (BSE) and National Stock Exchange (NSE). NSE deals better in automated trading platform with variety of stocks and index listed under rules and regulations of SEBI (Malla, Mishra, Pradhan and Mishra, 2010). Nifty realty index constitutes of higher market capitalization of 10 stocks on the basis of their weightage. Although realty sector is most sensitive and fluctuating sector, stock index figures indicates that in 2008 market expressed high boom but shown a sudden downfall from 1878 index figure to 156 index figure due to real estate speculation, commonly termed as housing bubble and credit crisis. Similarly, a fluctuation was observed in 2016 when demonetization was announced in India. According to Patil, Parab and Reddy (2018), Nifty Realty Index experienced negative effects due to demonetization.

To understand and analyse time varying conditional variance, concept of Auto Regressive Conditional Variance (ARCH) modeling was used, leaving past errors as function of constant unconditional variance. Limitation of flexible lag structure and longer memory developed a modified concept of Generalized ARCH (GARCH) model. GARCH model estimates stochastic volatility thus, accountfor volatility clustering and leptokurtosis in stock index series(Banumathy and Azhagaiah, 2015).

II. Review of Literature

Rastogi, Don and Nithya (2018) studied about the accuracy of forecast for volatility estimation by use of GARCH family models. Option prices were compared using weekly closing price of 170 companies' from Prowess IQ, period of 3 years. Concept of implied volatility is situation when prices of options are equal in market and prices discovered by Black and Scholes model. It provides an understanding towards price movement in future. Implied volatility compared with different GARCH models such as EGARCH, IGARCH, CGARCH and TGARCH. Study concluded that integrated GARCH model was best and one sample *t* test has proved that changes which happened in past will remain in future to express market efficiency.

Higher market volatility indicates higher degree of gains and losses, also express greater uncertainty, Jain, Arekar and Kumar (2018) explained volatility pattern for three (3) developed markets (US, UK and India) and 6 emerging markets (France, Taiwan, Malaysia, Singapore, Japan and Spain). Data of 10 years was collected from nine (9) stock markets of those countries. EGARCH and TGARCH models were chosen for analysis. Findings of study resulted that bas news of market leads to higher fluctuations in market and market of France, US, Japan, Spain, Malaysia and Singapore indicates presence of leverage effect.

Lama, Jha, Paul and Gurung (2015) explained modeling and forecasting of varied time series index including domestic edible oil, international edible oil and Cotlook A Index (Raw Cotton International price). Data collected from year 1982 to 2012, and modeling captured by ARIMA model, GARCH and EGARCH model. After model analysis, diagnostic check was executed by residuals of fitted models. Data forecasting proceeded by root mean square error (RMSE) and relative mean absolute prediction error (RMAPE). For forecasting accuracy, domestic and international edible oil price index has proved the performance by AR (2) - GARCH (1,1) model, while higher forecasting accuracy explained by RMSE and RAMPE. EGARCH model best fitted in case of Cotlook A index series rather than GARCH and ARIMA model.

Data from Khartoum Stock Exchange of Sudan was used for GARCH analysis including both symmetric and asymmetric models. This study captured leverage effect and volatility clustering effect for period tenure of 2006 to 2010. Study results that asymmetric models outperformed over symmetric model and index return data was highly volatile in nature (Ahmed and Suliman, 2011). In Contrary, Kalyanaraman (2014) estimated conditional volatility of Saudi stock market by making use of symmetric GARCH (1,1) models. Findings of the research stated that current volatility shows impact of past volatility on prices of stock market and symmetric models explains its application on AR (1) GARCH (1,1) model.

Poon and Granger (2003) forecasted volatility in financial market, explained that GARCH model was better over ARCH model. But asymmetric models including EGARCH and GJR-GARCH model were appropriate over GARCH model. Although this study also provides an insight that historical volatility models are working equally with ARCH model. Measurement of actual volatility can fine down the research and helps in gaining certain rewards.

III. Research Methodology

3.1 *The Study*

Basic objective of this paper is to study modeling of price volatility on Nifty Realty Index of Indian Stock Market. The present study is descriptive in nature and explains performance of Realty Index using ARCH and GARCH model.

3.2 *Sample and Tools for Data Collection*

This study collected secondary data from official website of National Stock Exchange (NSE), India. Data was collected from period of 1st April 2007 to 31st March 2018, including 2725 observations, excluding public holidays. A major negative impact of global recession 2008 and demonetisation 2016 has affectedIndian real estate market. The purpose of covering 11 years long data is to cover all the negative and positive impact of real estate market. Nifty realty index constitutes of 10 stocks belonging to residential as well as commercial properties based on the basis of free float market capitalization.The return data of Nifty realty index of NSE was computed by using daily closing price data. As the returns data is not stationary in nature, therefore, close price data was converted into log form to make data stationary.

3.3 *Tools for Data Analysis*

An exclusive and detailed analysis was performed on the collected data.For statistical analysis, different statistical and econometric techniques were performed including Graphical Analysis, Descriptive Statistics (Mean, Standard Deviation, Skewness and Kurtosis), Unit Root analysis, Correlogram Q Statistics, Correlogram Squared Residuals, ARCH LM Test, ARCH and GARCH (Generalized Auto Regressive Conditional Heteroskedasticity) model.

IV. Data Analysis

4.1 *Stock Index Returns*

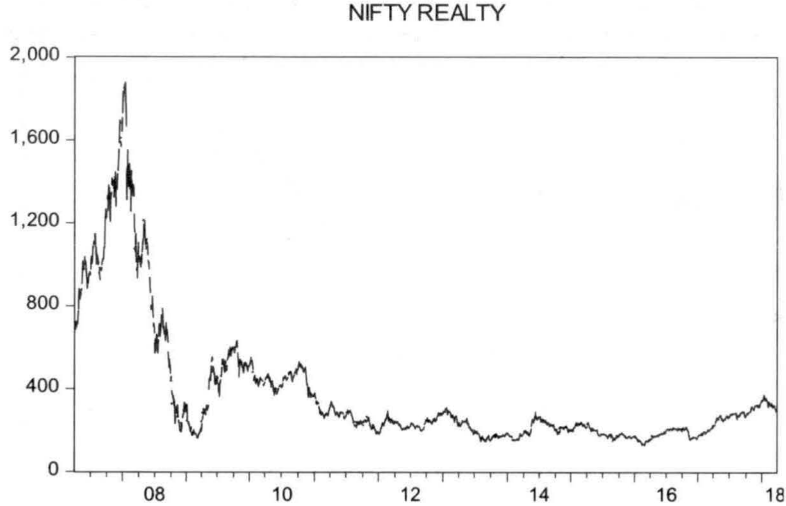
Secondary data collected from NSE sectoral index was used. Closing price of Nifty realty index was gathered for duration of 11 years. Extensive research utilize a scale free data and thus, easier to handle. According to Namugaya, Weke and Charles (2014), return series is complete and appropriate for investor's calculation providing most desirable statistical properties. Hence, close price data converted into logarithmic form data series. An equation designed for converting data as log returns or continuous compounded returns expressed below:

$$rt = \log\left(\frac{X_t}{X_{t-1}}\right)$$

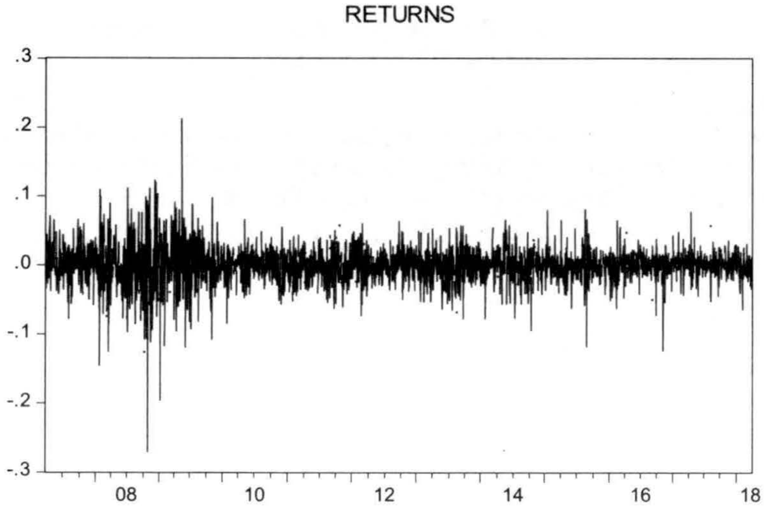
where, X_t and X_{t-1} indicates close price of Nifty realty index at current time (t) and previous day (t-1) respectively.

Figure (1) indicates the graphical depiction of Nifty realty index (Figure 1A) and Nifty realty return series (Figure 1B). The return series figure shows the distribution of periods of high volatility followed by periods of low volatility. Period from 2008-2009 shows high volatility followed by high volatility whereas, from the period of 2010 onwards low volatility followed by low volatility. Further, from the figure it can be also depicted that period between 2013-16 medium level volatility followed by medium level volatility.

This indicated that this series has conditional heteroskedasticity and ARCH family models can be applied.



(A) Nifty Realty Index Series



(B) Nifty Realty Return Index Series

Figure 1
Nifty Realty Index Series and Return Series

4.2 *Basic Statistics of Nifty Realty Return series*

4.2.1 A Quantile-Quantile (Q-Q) Plot

The Q-Q graphical examination also named as Quantile-Quantile (Q-Q) plot used for checking normality of return series. Apart from descriptive statistics, normality of Nifty realty series can be verified by Q-Q plot, figure (ii) depicts the graphical representation. According to Adesina (2013) when graphical representation provides straight line indicates normal distribution of return series, while s-shape graph was plotted for extreme values. Figure (2) results that Nifty Realty return series show greater departure from straight line, indicate larger evidence of a series which is not normally distributed.

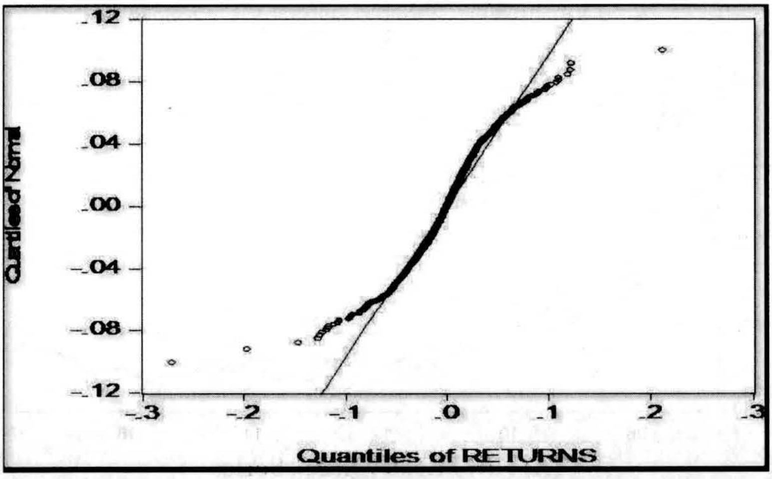


Figure 2
Quantile-Quantile Plot for Nifty Realty Return Series (Mar 2007-April 2018)

4.2.2 *Descriptive Statistics*

Panel A of Table I indicates basic descriptive statistics of Nifty realty return series. For normality testing diagnostic tools were studied listed in table below as skewness, kurtosis and Jarque-Bera test.

Testing volatility, standard deviation values indicated highest level of fluctuation (0.028117). Skewness of data series was negative (-0.473394) indicated long left tail and kurtosis value of normal distribution being 3, while for nifty realty series value was high positive (10.21050) with distribution being leptokurtic in nature. In Jarque - Bera test, null hypothesis is not rejected.The Jarque - Bera statistic used to test normal probability distribution of null hypothesis was not rejected, but values of Nifty realty return series affirmed the non-normal distribution due to rejection of null hypothesis and hence emphasizing on stationarity of data.

4.2.3 *A Stationarity Test*

Before model application, it was necessary to test whether data is stationary or not. To check stationarity of data, unit root test was applied and technique used for analysis was Augmented Dickey Fuller (ADF) Test. Under this study, unit root test was used for investigating stationarity of both Nifty realty index price series and return series. Panel B of Table I resulted that index price series was not rejected on null hypothesis and hence indicated that index price series is non stationarity. Therefore, index series was converted into a return series by applying the log returns. Result of ADF test on Nifty realty returns series (Panel C, Table I) highlighted that null hypothesis is rejected. Hence it indicated that nifty realty return series is stationary and has no unit root. Further, this series can be used for modeling purpose and measuring risk in nifty realty stock returns.

Table I
Descriptive Statistics and Stationarity Test of Nifty Realty Return Series

Panel A: Descriptive Statistics			
Mean	-0.000328	Skewness	-0.47339
Median	0.000932	Kurtosis	10.21050
Maximum	0.212548	Jarque-Bera	6002.759
Minimum	-0.270600	Probability	0.000000
Std. Dev.	0.028117	Observations	2724

Panel B: Stationarity Test for Nifty Realty Price Index		
Augmented Dickey Fuller Test	**t-Statistic**	**Probability**
Test Statistic:	-1.680770	0.4410
Test Critical Values:		
1% level	-3.432560	
5% level	-2.862402	
10% level	-2.567274	

Panel C: Stationarity Test for Nifty Realty Return Series		
Augmented Dickey Fuller Test	**t-Statistic**	**Probability**
Test Statistic:	-47.10004	0.0001
Test Critical Values:		
1% level	-3.432560	
5% level	-2.862402	
10% level	-2.567274	

Source : Self Computed

4.3 *ARCH LM Test for Heteroskedasticity*

To check the evidence of heteroskedasticity in the residuals of individual series, Autoregressive Conditional Heteroskedasticity (ARCH) Lagrange Multiplier (LM) test was used. To ensure that there exist ARCH effect in the series Engle (1982) check for conditional heteroskedasticity, also referred as ARCH effect. Individual data series checked for ARCH effect by regressing particular series with a constant.

Table II
Result of ARCH LM Test for Heteroskedasticity

Heteroskedasticity Test: ARCH			
F-statistic	39.39334	Prob. F(5,2713)	0.0000
Obs*R-squared	184.0407	Prob. Chi-Square(5)	0.0000

Source : Self Computed

Results of ARCH LM test in Table II concluded that null hypothesis being rejected and there exist ARCH effect in the series up to 5 lags. Hence the series confirms the presence of heteroskedasticity effect indicated a direction towards application of ARCH and GARCH models.

4.4 *Model Estimation*

4.4.1 *ARCH Model*

ARCH model stated as Autoregressive Conditional Heteroskedasticity model used for analysing the time series which contains heteroskedastic data. The basic objective of ARCH model focus on measuring volatility that further helps in financial decision making. Engle (1982) explained ARCH model as a non-linear model which assumes that variance is not constant and hence explained the way in which errors in variance evolves. Alam, Siddikee and Masukujjaman (2013) described the concept of volatility clustering or volatility pooling showing that ARCH model indicates motivation for financial asset returns. As volatility of high periods are followed by high periods and vice versa.

Table III explains the output of ARCH model specifying that constant coefficient of mean equation is not significant but coefficient ofvariance equation signifies positive values. Value of residuals in variance equation aresignificant at 1% level. Hence,it specify that volatility risk influenced by past square residual terms.

Table III

Output of ARCH model on Nifty Realty Return series

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000420	0.000427	0.984162	0.3250
		Variance Equation		
C	0.000260	1.30E-05	19.99945	0.000
RESID(-1)^2	0.181417	0.022276	8.143993	0.000

Source : Self Computed

4.4.2 *GARCH (1,1) Model*

GARCH (1,1) model was an extension of ARCH model, developed by Bollerslev (1986). GARCH model stated as linear function of past squared residual and lagged conditional variance. Model helps in estimating the future price and selects better asset for higher returns. A model can be considered as a best fitted model, when variance equation hasall parameterspositive and volatility persistence ($\alpha + \beta$) less than one or near to 1.

Outputs of GARCH (1,1) model for Nifty realty return series explained in Table IVstates thatcoefficient of mean equationis not significant butvariance equation being statistically significant. Coefficient of squared residual term of variance equation indicated that it is significant. Further, it revealed the effect of past residual on volatility risk. Coefficient of GARCH termexplains that past volatility affects the current volatility.While calculation volatility persistencefor GARCH (1, 1) model was less than 1 ($\alpha + \beta = 0.9752$) which revealed that this model can be considered as best fitted model to measures the risk of volatility in nifty realty index.

Table IV

Output of GARCH model on Nifty Realty Return series

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000280	0.000446	0.628566	0.5396
		Variance Equation		
C	1.82E-05	2.19E-05	8.324094	0.000
RESID(-1)^2	0.087140	0.007614	11.44467	0.000
GARCH(-1)	0.888141	0.008409	105.6131	0.000

Source : Self Computed

V. Conclusion

Volatility of Nifty Realty Index series designed for period 2007 to 2018 using ARCH and GARCH model. For detailed empirical analysis, certain points being observed as Nifty realty index series was not normal and heteroskedastic in nature which directs towards application of GARCH models. High kurtosis value proves that data series was leptokurtic in nature. Jarque Bera Statistic and Q-Q plot both justify that return series data show non normal distribution. ARCH model specify significant variance equation with risk of volatility due to past squared residuals. GARCH (1,1) model show significant variance equation along with persistent values specifying unconditional variance where past volatility influenced by related market news. Hence, this study surveys many practical issues with univariate GARCH model and though it is necessary to estimate multivariate GARCH models for better analysis. Further,it can be concluded that increase in volatility in nifty realty index would also increase the risk in returns. All the testing criteria states that GARCH (1,1) model owes highest point in comparison to other models. However, this model can be considered as best fitted for estimating future volatilityand understanding the effect of past volatility based on the squared residuals on current volatility in Nifty realty index.

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Appendix I
ARCH

Dependent Variable: RETURNS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/22/19 Time: 06:08
Sample (adjusted): 4/03/2007 3/28/2018
Included observations: 2724 after adjustments
Convergence achieved after 13 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*RESID(-2)^2 + C(5)*RESID(-3)^2 + C(6)*RESID(-4)^2 + C(7)*RESID(-5)^2

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000420	0.000427	0.984162	0.3250
		Variance Equation		
C	0.000260	1.30E-05	19.99945	0.0000
RESID(-1)^2	0.181417	0.022276	8.143993	0.0000
RESID(-2)^2	0.146901	0.021004	6.994044	0.0000
RESID(-3)^2	0.125031	0.018835	6.638313	0.0000
RESID(-4)^2	0.124015	0.015691	7.903588	0.0000
RESID(-5)^2	0.127469	0.014352	8.881759	0.0000
R-squared	-0.000708	Mean dependent var		-0.000328
Adjusted R-squared	-0.000708	S.D. dependent var		0.028117
S.E. of regression	0.028127	Akaike info criterion		-4.528770
Sum squared resid	2.154207	Schwarz criterion		-4.513583
Log likelihood	6175.185	Hannan-Quinn criter.		-4.523280
Durbin-Watson stat	1.794218			

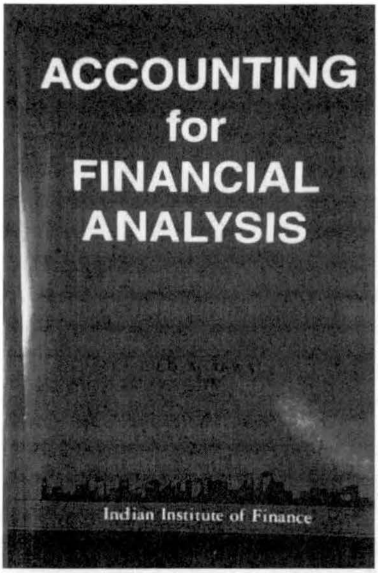
Source : Self Computed

Appendix II
GARCH

Dependent Variable: RETURNS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 03/22/19 Time: 07:19
Sample (adjusted): 4/03/2007 3/28/2018
Included observations: 2724 after adjustments
Convergence achieved after 16 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000280	0.000446	0.628566	0.5296
		Variance Equation		
C	1.82E-05	2.19E-06	8.324094	0.0000
RESID(-1)^2	0.087140	0.007614	11.44467	0.0000
GARCH(-1)	0.888141	0.008409	105.6131	0.0000
R-squared	-0.000468	Mean dependent var		-0.000328
Adjusted R-squared	-0.000468	S.D. dependent var		0.028117
S.E. of regression	0.028123	Akaike info criterion		-4.562104
Sum squared resid	2.153691	Schwarz criterion		-4.553425
Log likelihood	6217.585	Hannan-Quinn criter.		-4.558967
Durbin-Watson stat	1.794648			

Source : Self Computed



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