# STUDY ON VOLATILITY OF STOCK MARKET DATA OF SELECTED COMPANIES ENGAGING IN RETAIL FINANCE IN INDIA

**N. Srinivas Kumar, PhD, Professor, SRTIST, Nalgonda** E-Mail: karthick_narayana@yahoo.com, drsrinivaskumar23@gmail.com

**ABSTRACT**

*Consumer finance industry is highly volatile owing to many reasons. Consumer affordability and readiness to obtain loan from retail finance companies are very much influenced by several factors. Study data of such companies might require novel modeling approaches such as ARMA, ARIMA, ARCH and GARCH. GARCH model appears to be appropriate model for studying volatility of stock market data especially markets that are highly agile for small changes. This study tries to verify the authenticity of these models by analyzing stock market data for four firms engaging in retail finance such as Bajaj, Kotak Mahindra, HDFC and Reliance Capital. GARCH methods were used to study the volatility of data related to these firms. All companies tend to have non-linear trends and the data is highly stochastic. Autocorrelations were not significant for first three but reliance capital has rather interesting trend as there is close relationship between residuals and predicted values.*

**Keywords: Stock Market Analysis, Prediction, Autoregression, Autocorrelation, Volatility, Conditional Variance, Heteroskedasticity.**

## INTRODUCTION

Volatility is a key parameter used in many financial applications, from derivatives valuation to asset management and risk management. Volatility refers to the ups and downs in the stock prices. Volatility in the stock return is an integral part of stock market with the alternating bull and bear phases. Without volatility superior returns cannot be earned. However, too much volatility is considered as a symptom of an inefficient stock market. Higher the volatility, higher the risk. Volatility of returns in financial markets can be a major stumbling block for attracting investment in small developing economies. It has an impact on business investment spending and economic growth through a number of channels. Moderate returns, high liquidity & low level of volatility are taken to be a symptom of a developed market. Low volatility is preferred as it reduces unnecessary risk borne by investors thus enables market traders to liquidate their assets without large price movements.

The rise and the fall of shares are linked to a number of reasons such as political climate, economic cycle, economic growth, international trends, budget, general business conditions, company profits, product demand etc. Investment decisions are governed significantly by this volatility apart from other interdependent factors like price, volume traded, stock liquidity, among many others. Volatility estimation is important for several reasons: Investment decisions, as characterized by asset pricing models, strongly depend on the assessment of future returns and risk of various assets. The pricing of options is based on expected volatility of a security. Various linear and nonlinear methods by which volatility can be modeled have been developed in the literature and extensively applied in practice to describe the stock return volatility. The distribution of financial time series shows certain characteristics such as:

1. Leptokurtosis: i.e. fat tails as compared to normal distribution.
2. Volatility clustering: Statistically, volatility clustering implies a strong autocorrelation in returns. Large changes tend to be followed by large changes and small changes tend to be followed by small changes
3. Heteroskedasticity: i.e. non constant variance. Economic time series have been found to exhibit periods of unusually large volatility followed by periods of relative tranquility (Engle, 1982). In such circumstances, the assumption of constant variance (homoskedasticity) is inappropriate (Nelson, 1991).

## LITERATURE REVIEW

Mittal & Goyal (2012) studied stock price behavior while modeling the volatility of an emerging stock market. Authors used *S&P CNX Nifty returns* for 10 years i.e. *April 1$^{st}$, 2000- June 30$^{th}$, 2010.* The authors report the presence of heteroskedasticity, volatility clustering with a fat tails. The study reports that the GARCH (1,1) model is very appropriate to capture the symmetric effects. Engle (2001) in his article titled "the use of ARCH/GARCH models is applied econometrics" concludes that ARCH and ARCH models have been applied to a wide range of time series analyses, but applications in finance have been particularly successful and have been the focus of this introduction. Financial decisions are generally based upon the tradeoff between risk and return; the econometric analysis of risk is therefore an integral part of asset pricing, portfolio optimization, option pricing and risk management. This paper has presented an example of risk measurement that could be the input to a variety of economic decisions. The analysis of ARCH and GARCH models and their many extensions provides a statistical stage on which many theories of asset pricing and portfolio analysis can be exhibited and tested.

Ahmad & Suliman (2011) did a study on stock market volatility in Sudan. Authors used GARCH models to estimate in the daily returns of the principal stock exchange of Sudan namely, Khartoum Stock Exchange (KSE) over the period from January 2006 to November 2010. The models include both symmetric and asymmetric models that capture the most common stylized facts about index returns such as volatility clustering and leverage effect. The empirical results shows that the conditional variance process is highly persistent (explosive process), and provide evidence on the existence of risk premium for the KSE index return series which support the positive correlation hypothesis between volatility and the expected stock returns. Findings also shows that the asymmetric models provide better fit than the symmetric models, which confirm the presence of leverage effect. These results, in general, explain that high volatility of index return series is present in Sudanese stock market over the sample period.

Banumathy & Azhagaiah (2013) did a study on Indian stock market data. The study empirically investigates the volatility pattern of Indian stock market based on time series data which consists of daily closing prices of Nifty Index for ten years period from 1st January 2003 to 31st December 2012. The analysis has been done using both symmetric and asymmetric models of Generalized Autoregressive Conditional Heteroscedastic (GARCH). As per Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC), the study proves that GARCH (1,1) and TGARCH(1,1) estimations are found to be most appropriate model to capture the symmetric and asymmetric volatility respectively. The study also provides evidence for the existence of a positive and insignificant risk premium as per GARCH-M (1, 1) model. The asymmetric effect (leverage) captured by the parameter of EGARCH (1, 1) and TGARCH (1, 1) models show that negative shocks have significant effect on conditional variance (volatility).

Islam (2013) did a study on Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models to estimate volatility of financial asset returns of three Asian markets namely; Kuala Lumpur Composite Index (KLCI) of Malaysia, Jakarta Stock Exchange Composite Index (JKSE) of Indonesia and Straits Times Index (STI) of Singapore. Results provide strong evidence that daily stock returns can be characterized by these two symmetric GARCH models. From the results of risk-return hypothesis test in GARCH-M model, we found evidence of positive correlation between the risk and return for all markets as expected. However, only for Indonesian market which is found to be more volatile than the other two markets, the estimated coefficient of risk premium appeared to be statistically significant indicating that increased risk leads to a rise in the returns. The risk-premium coefficients for other two markets are positive but statistically insignificant suggesting that increased risk does not necessarily produce higher return.

Augustine O. Ekechi (1989) did a study on Nigerian Stock Exchange. The authors concluded that the Nigerian Stock Markets are weak form inefficient. The study rejected the null hypothesis that the data so studied did not follow random walk. Authors also used serial correlation test, runs test and descriptive statistics to validate the results (Bhat, I A., *et al 2014*).

Sunil Poshakwale (1996) did a study on Bombay Stock Exchange. The returns for the period 1987 to 1994 was analyzed the by using various techniques like descriptive statistics, Kolmogorov-Smirov, Runs test, Serial Correlation test. The study concluded (on the basis of interpretation of runs test and serial correlation test) that the returns in Indian Capital Markets were non-random and therefore rejected the null hypothesis of Indian Capital Markets being efficient in weak form (Poshakwale, S., 1996).

Sharma and Mahendru (2009) in their paper attempts to investigate the validity of the Efficient Market Hypothesis on the Indian Securities Market. Initially, the paper discusses the definitions and types of the EMH, as also the literature available on the same. Taking a sample of eleven securities listed on the Bombay Stock Exchange (BSE), the oldest stock exchange of Asia, runs tests coupled with the autocorrelation tests in order to judge the efficiency of the Stock Markets. The study confirms that the Autocorrelation test when directly applied to share prices gives conflicting results with Runs test and thus, making it difficult to reach a definite conclusion. The autocorrelation test is applied to first differenced series, which gives satisfactory results. In a nutshell, the study observed that the effect of stock prices for the sample companies on future prices is very meager and an investor cannot reap profits by using the share price data as the current share prices already reflect the effect of past share prices (Sharma & Mahendru, 2009).

Andrew C. Worthington and Helen Higgs (2003) analyzed the markets of Latin America with the objective to detect whether these markets follow the theory of random walk or are weak form efficient. The other researchers analyzed the daily returns of seven countries Latin America i.e. Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela through various techniques like correlation coefficient analysis, runs test, Augmented Dickey Fuller test, Phillips Perron Test and Multiple Variance Ratio Tests and concluded that significant correlation existed between returns and therefore rejected the presence of randomness in the daily returns in these seven emerging markets.

Bhat, Mir, & Zargar (2014) mentions that the concept of efficient market hypothesis ever since being proposed by Fama (1965) has been widely been a focus of the researchers of finance with the aim being to analyze the efficiency of different capital markets of the world. The study focuses on analyzing and comparing the efficiency of the capital markets of India and Pakistan. For the purpose of realizing the objectives, Adjusted Daily closing prices of CNX Nifty (NSE India) and KSE 100 (KSE Pakistan) are taken into consideration for the period ranging between 01/04/2003 to 31/03 2013.The researchers have relied on Descriptive Statistics, ADF test, Auto-Correlation test and Jarque-Bera Statistic, Runs test to analyze the data and reach to the results. The results derived by using various parametric and non-parametric tests clearly reject the null hypothesis of the stock markets of India and Pakistan being efficient in weak form. The study provides vital indications to investors, hedgers, arbitragers and speculators as well as the relevance of fundamental and technical analysis as far as the trading/investing in the capital markets of India and Pakistan is concerned.

Mishra (2012) analyzed the returns of capital markets of emerging and developed markets of the world (India, China, South Korea, Russia, Germany, US, Brazil, UK) from 2007 to 2010. After applying Augmented Dickey Fuller test, Unit root tests and GARCH (1,1) model the researcher concluded that all these markets don not follow the theory of random walk. Amalendu Bhunia (2012) found Indian stock markets inefficient in weak-form.

Saqib Nisar and Muhammed Haneef (2012) rejected the null hypothesis as they found the South-Asian stocks inefficient in weak form. Authors applied four statistical tests including runs test, serial correlation, unit root and variance ratio test. Findings suggest that none of the four major stock markets of south-Asia follows Random-walk and hence all these markets are not the weak form of efficient market. To our knowledge this is the first ever study is being conducted which covers leading South Asian markets, hence an evidence on market efficiency of this region is being contributed in literature.

**About ARCH/GARCH models**

A number of researches have been carried out to understand cause of business cycle. One of them was the unpredictability of inflation, as proposed by Friedman (1977). The autoregressive conditional heteroskedasticity (ARCH) model was used primarily for measuring the unpredictability of inflation (Engle, 2004). Uncertainty due to this unpredictability would affect the investor's behavior. Let $\epsilon_t$is a random variable that has a mean and a variance conditionally on the information set $F_{t-1}$ (which is a field generated by$\epsilon_t$). Then, the ARCH model of $\epsilon_t$ has two vital properties. First, $E(\epsilon_t|F_{t-1}) = 0$; and the second, $h_t = (\epsilon_t{}^2|F_{t-1})$. In which case the sequence $\epsilon_t$can be observed directly as $\epsilon_t = y_t - \mu(y_t)$. Where $y_t$ is observable random variable and$\mu(y_t) = E(y_t|F_{t-1})$. While there is nothing special about such expressions but Engle brought enormous emphasis on the forms of $h_t$ and the form is as follows.

$$\epsilon_t = z_t h_t{}^{1/2}$$

$$h_t = \alpha_0 + \sum_{j=1}^{q} \alpha_j \, \epsilon^2{}_{t-j} \qquad - \qquad 1$$

The above equation (1) forms the basis for conditional variance. All the coefficients i.e. $\alpha_0$, $\alpha_j \geq 0$. Though the earlier derivative of ARCH models were not thought of as financial but later developments proved the efficiency of ARCH models in computational finance especially in relation to investment behavioral studies such as studying interest rates, exchange rates and stock market data (Bollerslev, Chou and Kroner, 1992).

The theory of Generalized ARCH (GARCH) has brought by Bollerslev (1986) and Taylor (1986) independently of each other. The original GARCH specification assumes the response of the variance to a shock to be independent of the sign of the shock and just be a function of the size of the shock. In this model, conditional variance $h_t$ is linear function of its own lag $h_{t-1}$and has the below given form.

$$h_t = \alpha_0 + \sum_{j=1}^{q} \alpha_j \, \epsilon^2{}_{t-j} + \sum_{j=1}^{q} \beta_j \, h_{t-j} \qquad - \qquad 2$$

The most simple GARCH model is GARCH (1,1) that is *p=q=1* in equation 2 with sufficient condition for the conditional variance to be positive with probability one is $\alpha_0 > 0$; $\alpha_j \geq 0$ and

$\beta_j \geq 0$. The following conditions must be true to identify the parameters (i.e. to identify the model)

1. At least one $\alpha_j > 0$.
2. At least one $\beta_j > 0$.
3. If all $\alpha_1, \alpha_2, \ldots . = 0$ ; and all conditional variances of $\epsilon_t$ are equal then all $\beta_j$are regarded as nuisance parameters.

**The other forms of GARCH models**

The theory of auto regression and conditional heteroskedasticity has undergone lot of changed from the time it is proposed in 1970s and 1980s. As it was mentioned earlier the study of GARCH is to notice the response of variance to shock. This response might be studied as whether it is dependent or independent of sign of the shock. Several studies brought necessary improvements in the general form of GARCH model. For instance, Glosten, Jagannathan and Runkle (1993) proposed the idea of GJR-GARCH, in which they introduced another term in the model known as indicator function$I(\epsilon_{t-1} > 0$; and the form of the model is $h_t = \alpha_0 + \sum_{j=1}^{q}\{\alpha_j + \delta_j I(\epsilon_{t-1} > 0)\}\epsilon^2{}_{t-j} + \sum_{j=1}^{q}\beta_j\, h_{t-j}$ . The other model is known as Asymmetric GARCH proposed by Engle, Ng (1993). This model accommodates the opportunity to study the shift in symmetry from zero. The conditional variance in the model is defined as $h_t = \alpha_0 + \sum_{j=1}^{q}\alpha_j\,(\epsilon_{t-j} - \gamma)^2 + \sum_{j=1}^{q}\beta_j\, h_{t-j}$; where $\gamma > 0$. Third development is Quadratic GARCH by Sentana (1995). Sentana defines the conditional variance as $h_t = \alpha_0 + \alpha' \varepsilon_{t-j} + \varepsilon_{t-j} A \varepsilon'_{t-j.}$ For instance, Hentschel (1995) brought the idea of family of GARCH models which would accommodate a group of individual models.

Autocorrelation and autoregression are two most sought after issues that needs to be computed while studying risk and volatility of stocks. GARCH models help a great extent in studying these aspects of volatility. R has wonderful environment to work with data sets. Packages like FinTS, TSeries and FGarch helps a great extent to solve various problems of studying volatility. There is sufficient description regarding such methods in subsequent section i.e. analysis and discussion.

**RESEARCH METHODOLOGY**

Four data sets related to certain non-banking financial institutions like BAJAJ, RELIANCE, KOTAK and HDFC were taken for the study. The data sets were analyzed through Gnumeric and R language.

**ANALYSIS & DISCUSSION**

The following section illustrates the analysis done on aforementioned data sets in R. R is very efficient alternative for quantitative research for computational finance. The model used for the analysis is GARCH(0, 1). Which means $p$ = 0 and $q$ = 1. $p$ is the constraint for $\alpha$ and q is the constraint for $\beta$. The following is the R output model specifications i.e. series initialization.

**Table 1: Model specifications**

| Specifications | Details |
|---|---|
| ARMA Model | ARMA |
| Formula Mean | ~ ARMA(0, 0) |
| GARCH Model | GARCH |
| Formula Variance | ~ GARCH(1, 1) |
| ARMA Order | 0 0 |
| Max ARMA Order | 0 |
| GARCH Order | 1 1 |
| Max GARCH Order | 1 |
| Maximum Order | 1 |
| Conditional Dist | QMLE |
| h.start | 2 |
| llh.start | 1 |
| Length of Series | 4489 |
| Recursion Init | mci |
| Series Scale | 2322.707 |

The above shows the details of initialization of GARCH model in R. From the table it is clear that initialization for mean and variance is *mu-current-initialization (mci*). The initialization values for mu and variance are 0 and 1. Hence, it is clear that the underlying hypothetical distribution is normal distribution. The algorithm used for conditional distribution which means for estimating coefficients of objective function in this case it is $\sigma^2$ is QMLE which stands for Quasi Minimum Likelihood Estimation, which is a robust algorithm compared to rest of the algorithms. One of the main purposes of using QMLE is to multiple values of estimates, which is one of the problems in optimization theory. Initialization used for modeling is *mci* which recursive in nature. The following is the information regarding parameters of the model.

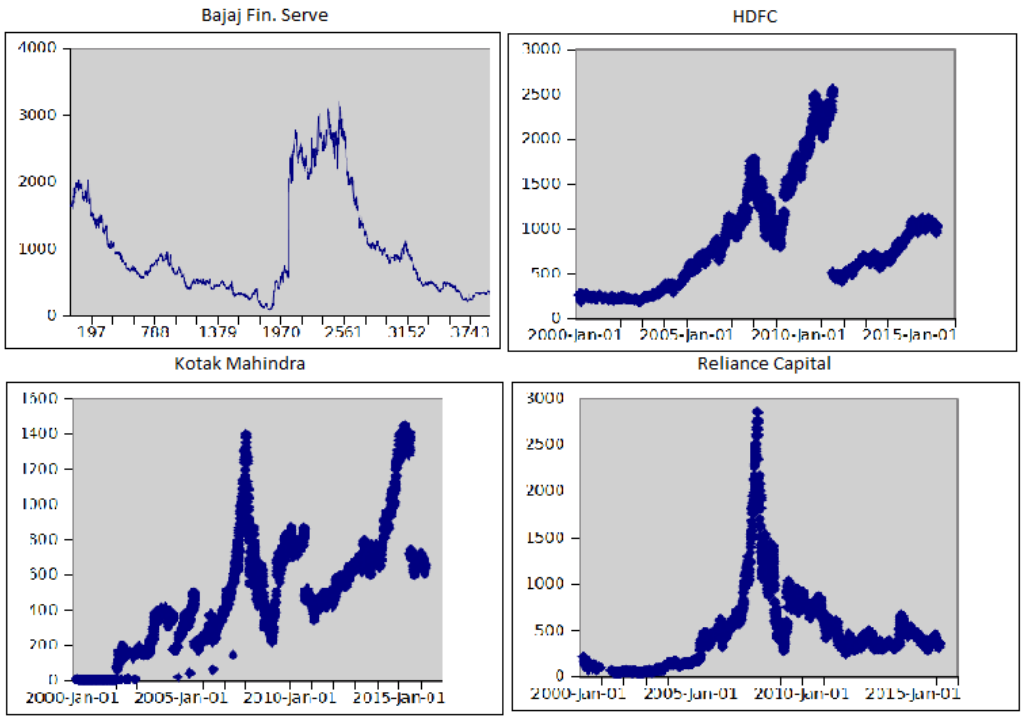
**Table 2: Parameter Estimation**

| **Bajaj Fin. Serve (Persistence : 0.9)** | | | | |
|---|---|---|---|---|
| Name | U | V | parameter | Include |
| Mu | -13.22717837 | 13.22718 | 1.322718 | TRUE |
| omega | 0.00000100 | 100.00000 | 0.100000 | TRUE |
| alpha1 | 0.00000001 | 1.00000 | 0.100000 | TRUE |
| gamma1 | -0.99999999 | 1.00000 | 0.100000 | FALSE |
| beta1 | 0.00000001 | 1.00000 | 0.800000 | TRUE |
| delta | 0.00000000 | 2.00000 | 2.000000 | FALSE |
| skew | 0.10000000 | 10.00000 | 1.000000 | FALSE |
| shape | 1.00000000 | 10.00000 | 4.000000 | FALSE |
| **HDFC (Persistence : 0.9)** | | | | |
| Name | U | V | parameter | Include |
| Mu | -15.02938022 | 15.02938 | 1.502938 | TRUE |

| | | | | |
|---|---|---|---|---|
| omega | 0.00000100 | 100.00000 | 0.100000 | TRUE |
| alpha1 | 0.00000001 | 1.00000 | 0.100000 | TRUE |
| gamma1 | -0.99999999 | 1.00000 | 0.100000 | FALSE |
| beta1 | 0.00000001 | 1.00000 | 0.800000 | TRUE |
| delta | 0.00000000 | 2.00000 | 2.000000 | FALSE |
| skew | 0.10000000 | 10.00000 | 1.000000 | FALSE |
| shape | 1.00000000 | 10.00000 | 4.000000 | FALSE |
| **Kotak Mahindra (Persistence : 0.9)** | | | | |
| Name | U | V | parameter | Include |
| Mu | -14.60313487 | 14.60313 | 1.460313 | TRUE |
| omega | 0.00000100 | 100.00000 | 0.100000 | TRUE |
| alpha1 | 0.00000001 | 1.00000 | 0.100000 | TRUE |
| gamma1 | -0.99999999 | 1.00000 | 0.100000 | FALSE |
| beta1 | 0.00000001 | 1.00000 | 0.800000 | TRUE |
| delta | 0.00000000 | 2.00000 | 2.000000 | FALSE |
| skew | 0.10000000 | 10.00000 | 1.000000 | FALSE |
| shape | 1.00000000 | 10.00000 | 4.000000 | FALSE |
| **Reliance Capital (Persistence : 0.9)** | | | | |
| Name | U | V | parameter | Include |
| Mu | -15.51293614 | 15.51294 | 1.551294 | TRUE |
| omega | 0.00000100 | 100.00000 | 0.100000 | TRUE |
| alpha1 | 0.00000001 | 1.00000 | 0.100000 | TRUE |
| gamma1 | -0.99999999 | 1.00000 | 0.100000 | FALSE |
| beta1 | 0.00000001 | 1.00000 | 0.800000 | TRUE |
| delta | 0.00000000 | 2.00000 | 2.000000 | FALSE |
| skew | 0.10000000 | 10.00000 | 1.000000 | FALSE |
| shape | 1.00000000 | 10.00000 | 4.000000 | FALSE |

The above table illustrates the parameter estimation of the model. The information provided in the Name column is the name of the parameter. In GARCH generally it is observed six parameters of estimation. They are mu, omega, alpha, gamma, beta and delta. The mu is the mean value of the return distribution. Omega is the constant or intercept of the model i.e. conditional variance. Alpha is the coefficient of $|\varepsilon_{t-1}|$. Gamma is the coefficient of error term $\varepsilon_{t-1}$. Beta is the coefficient of lag of the conditional variance. Delta deals with power of the model. If we observe the data the $\delta, \beta = 0$ which shows that the model is special case of NARCH. So the model seems to be non-linear in nature. Let us look at the time series graph to confirm the same.

**Figure 1: Time series plot for data sets**




From the graph it is clear that there are certain random fluctuations in all the graphs. Interestingly each graph is distinct when compared to other graph, which means the behavior or performance of stocks are different from each other with distinct changes. The following is the output from the statistical diagnosis on stock market data.

**Table 3: Parameter Estimation – Error Analysis**

| | | | | |
|---|---|---|---|---|
| **Bajaj Fin. Serve (Log Likelihood: -27446.02 normalized: -6.985498)** | | | | |
| | Estimate | Std. Error | T value | P value |
| mu | 480.91974 | 2.90617 | 165.48 | <2e-16 *** |
| omega | 48.23488 | 0.95483 | 50.52 | <2e-16 *** |
| alpha1 | 0.80957 | 0.02563 | 31.59 | <2e-16 *** |
| beta1 | 0.20256 | 0.01344 | 15.07 | <2e-16 *** |
| **HDFC (Log Likelihood: -27214.12 normalized: -6.985144)** | | | | |
| | Estimate | Std. Error | T value | P value |
| mu | 663.69124 | 1.13306 | 585.749 | <2e-16 *** |
| omega | 67.35967 | 5.39920 | 12.476 | <2e-16 *** |
| alpha1 | 1.00000 | 0.04298 | 23.267 | <2e-16 *** |
| beta1 | 0.03452 | 0.04278 | 0.807 | 0.42 |
| **Kotak Mahindra (Log Likelihood: -27106.07 normalized: -6.689553)** | | | | |
| mu | 426.8967 | 15.1425 | 28.192 | < 2e-16 *** |
| omega | 124.4136 | 26.7998 | 4.642 | 3.45e-06 *** |
| alpha1 | 0.6739 | 0.1703 | 3.957 | 7.58e-05 *** |
| beta1 | 0.3574 | 0.1785 | 2.002 | 0.0453 * |
| **Reliance Capital (Log Likelihood: -25529.61 normalized: -6.461557)** | | | | |
| mu | 366.48043 | 2.18910 | 167.411 | < 2e-16 *** |
| omega | 84.62265 | 0.33968 | 249.125 | < 2e-16 *** |

| | | | | |
|---|---|---|---|---|
| alpha1 | 0.85354 | 0.03171 | 26.913 | < 2e-16 *** |
| beta1 | 0.14936 | 0.02820 | 5.296 | 1.18e-07 *** |
| Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 | | | | |

The above table shows the information regarding the first part of *error analysis* i.e. estimated parameters and their significance. Coefficients for four companies are significant at 5 % significance level. This shows that the data is not as expected. These coefficients are significantly different from their respective standards or benchmark values. For instance, as per regression theory the null hypothesis for *beta* is $H_0$: $\beta = 0$, which is not the case here. The alternative hypothesis is true. So there are certain random differences among the data points. The data might be stochastic in nature instead of stationary. This observation might need further analysis in terms of statistical diagnosis. The following table gives sufficient information regarding the nature of data sets.

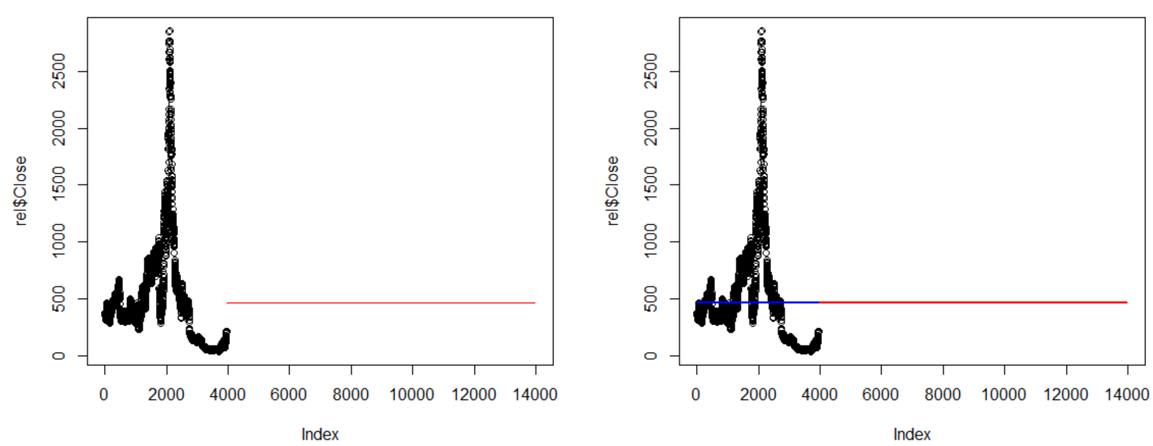
**Table 4: Error Analysis - Statistical Diagnosis**

| | | | | |
|---|---|---|---|---|
| **Bajaj Fin. Serve** | | | | |
| Test | Residual | Statistic | Value | P value |
| Jarque-Bera Test | R | Chi^2 | 481.5766 | 0 |
| Shapiro-Wilk Test | R | W | 0.6987635 | 0 |
| Ljung-Box Test | R | Q(10) | 31376.92 | 0 |
| Ljung-Box Test | R | Q(20) | 58092.74 | 0 |
| Ljung-Box Test | R^2 | Q(10) | 22.98686 | 0.0107952 |
| Ljung-Box Test | R^2 | Q(20) | 27.08141 | 0.132989 |
| Information Criterion Statistics: | | | | |
| AIC | 13.97303 | BIC | 13.97942 | |
| **HDFC** | | | | |
| Test | Residual | Statistic | Value | P value |
| Jarque-Bera Test | R | Chi^2 | 1068.704 | 0 |
| Shapiro-Wilk Test | R | W | 0.7303333 | 0 |
| Ljung-Box Test | R | Q(10) | 31261.14 | 0 |
| Ljung-Box Test | R | Q(20) | 58423.05 | 0 |
| Ljung-Box Test | R^2 | Q(10) | 0.05238817 | 1 |
| Ljung-Box Test | R^2 | Q(20) | 0.1152669 | 1 |
| AIC | 13.97234 | BIC | 13.97878 | |
| **Kotak Mahindra** | | | | |
| Test | Residual | Statistic | Value | P value |
| Jarque-Bera Test | R | Chi^2 | 5645.219 | 0 |
| Shapiro-Wilk Test | R | W | 0.732455 | 0 |
| Ljung-Box Test | R | Q(10) | 33199.44 | 0 |
| Ljung-Box Test | R | Q(20) | 64172.93 | 0 |
| Ljung-Box Test | R^2 | Q(10) | 0.4564267 | 0.9999957 |
| Ljung-Box Test | R^2 | Q(20) | 0.8106619 | 1 |
| AIC | 13.38108 | BIC | 13.38731 | |
| **Reliance Capital** | | | | |
| Test | Residual | Statistic | Value | P value |
| Jarque-Bera Test | R | Chi^2 | 437.7022 | 0 |

| | | | | |
|---|---|---|---|---|
| Shapiro-Wilk Test | R | W | 0.7812804 | 0 |
| Ljung-Box Test | R | Q(10) | 31633.17 | 0 |
| Ljung-Box Test | R | Q(20) | 57466.85 | 0 |
| Ljung-Box Test | R^2 | Q(10) | 41.22378 | 1.029983e-05 |
| Ljung-Box Test | R^2 | Q(20) | 63.57441 | 1.964952e-06 |
| AIC | 12.92514 | BIC | 12.93150 | |

From the above table it is clear that all tests related normality are significant (p-value = 0), which means that the sample distributions of data are not normal. The difference between Jarque-Bera Test and Shapiro-Wilk Test is that the former tests normality subjected to the condition that the underlying distribution is *iid*. And the test uses skewness and kurtosis in to account while computing the sample statistic. On the other hand, the Shapiro wilk test uses covariance matrix of the sample data to arrive at sample statistic. In this study both statistics for normality test fail to accept null hypothesis so the data under study is not normal. All the p-values for Ljung-Box test at lag 10 are significant, which means the autocorrelations are significant and it in turn shows that the data has certain negative shocks and bad for prediction. However, this observation might need further diagnosis through certain other tests for stochastic or randomness of data. Autocorrelations for reliance capital appears to be significant. This shows the effect of historical prices on prediction. The chi-square test of independence is significant for actual and predicted values. The chi-square statistic appeared as 200.1082 and the p-value is 7.965e-09 which shows that the predicted values pretty much depends on actual values which is not the case. The following figure illustrates the nature of prediction against the actual observations. The blue line shows the trend line drawn with the help of fitted values from the model and red line shows the prediction which is drawn with the help of predicted values from the model.

Figure -2: Predicted values for reliance capital




**CONCLUSION**

The stock market data for four companies analyzed for random effects. The stock market data is randomly distributed for all samples. the trend detected are non-linear in nature. There might be certain interesting patterns in the data which might be useful while studying the market. These companies are engaging in non-financial consumer credit industry. The market response is not same for all companies. For instance, autocorrelations are not significant for first three companies but found significant for reliance. So, the effect of past performance on prediction would be more on reliance than other three companies.

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