Analytical Study on Volatility of Indian Stock Market

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Abstract

Economic growth is essential for improving the quality of life. Standard classical and neo-classical theories emphasize the role of investment in enhancing economic growth. Monetary and financial sectors play a key role in mobilizing resources. Financial stability is crucial for promoting investment. But the instability of the financial markets is a clear indicator of their vulnerability. From an investor's view point, it would be immensely useful if the future stock return volatility could be predicted from the past data. After the global crisis hit the foreign market it became very important to study the extent of the volatility in the Indian market too. The global crisis hit the Indian market after 2008 which caused the high volatility explained in this paper. The ripple effect of the foreign stock market was seen in the stock market of India during the years. The extent of the volatility was quiet evident in 2008 and 2009 followed by steady volatile market since then This paper contains a comprehensive study of the volatility experienced in the stock market of India and has examine the pattern of volatility using closing prices of S&P CNX Nifty and BSE Sensex stock price index from 1st April, 2008 to 31st March, 2013. The study was validated by using the GARCH model. It was seen that the first two years were very crucial and later on the volatility became steady.

Key Words: Stock market, Volatility, global crises, GARCH model

Introduction

Financial market volatility refers to the disproportionate shoot and drop of the market. It is a measure for variation of price of a financial instrument over time. Many economists have proposed models emphasizing regulated flows of cross border capital flows, which has been largely due to the economy wide repercussions of the extreme volatility in financial markets arising out of unregulated cross border movement of portfolio capital. The instability of the financial markets is a clear indicator of their vulnerability. This undermines the significance of the stock price as a true measure of the intrinsic value a firm possesses. Hence, it discourages the importance informational efficiency of markets. Since volatility plays an important role in determining the inclination of the market, it has become a vital factor for risk management. Now it requires the policymakers to have knowledge of both, the stock price as well as its volatility. Since the birth of globalization and liberalization, currency, commodity and stock have formed such linkages across the world that there is a speedy transfer of volatility in one market to another market. For example, you wouldn't get to know how, in the blink of an eye, a blast in one part of the world would affect dramatically the stock prices in another part of the world. Such linkages are growing progressively and as they do, vulnerability of one market due to vulnerability of the other market is on a rise.

To the common man, a small investor, volatility is nothing other than risk. For them, if the security value cannot be used as an estimator of the future price of a company's stock, the markets are not properly functioning. The future price is then, not calculative but random. What then, is the use of fundamental and technical analysis? And hence, volatility is rightfully being referred to, as risk.

Why Study Volatility?

Economic growth is essential for improving the quality of life. Standard classical and neo-classical theories emphasize the role of investment in enhancing economic growth. Monetary and financial sectors play a key role in mobilizing resources. Financial stability is crucial for promoting investment. In all, there will be transparency of market among the investors. One will know the risk and return potential of an investment when making such investment. This will encourage investing among the ctizens. Transparency will bring the confidence of investing to people. Studying volatility will eliminate randomness of stock price movement as it will be foreseeable and hence, apt measures would be taken by investors beforehand.

However, increase in volatility per cent is not a problem but increased volatility reflects underlying problems in fundamental forces affecting economic activities and expectations about them. In fact the more quickly and accurately prices reflect the available information; the more efficient would be pricing of securities and thereby allocation of resources. A market in which prices fully reflect available information is called “efficient” where share prices fluctuate randomly around their “intrinsic” values. The stock market in India has had its fair share of crisis engendered by excessive speculation resulting in excessive volatility. Undoubtedly, the confidence of investors in the early 1990’s to some extent has been eroded by excessive volatility of the Indian Stock Markets. The wide spread concern of the exchange management, brokers and investors alike has realised the importance of being able to measure and predict stock market volatility. From an investor’s view point, it would be immensely useful if the future stock return volatility could be predicted from the past data. Such forecasting capabilities are useful for pricing of sophisticated financial instruments such as futures and options. Here in the present study an attempt has been made to understand the nature of volatility in the Indian Stock Market from the past daily stock return data of BSE and NSE.

Review of Literature

Eichengreen and Hui Tong University of California (2003), in this paper had studied the long run volatility of stock markets. They first recognized that volatility was not persistent. Majority of countries considered in the paper, a u-shaped outline was found with volatility dropping before rising back in the past decades.The early decline was explicable in terms of enhancements within the data and acquiring setting. The recent rise was quite distressful and debatable. They also thought about the roles of financial policy and monetary group action. The authors found a positive relation of financial volatility with exchange volatility; associate interpretation is that the conduct of financial policy and therefore the nature of the financial regime area unit necessary for exchange volatility. They found a constructive effect of monetary volatility on stock market volatility even after the exchange rate regime was controlled. Not only the acknowledged exchange rate system mattered for the volatility of financial market outcomes, was it also important to check the credibility and conduct of monetary policy under that system. The authors further found, that for the maximum of countries taken, that financial globalisation was positively related with stock market volatility. That financial markets were open both in the 19th century and in past 28 decades may thus becoming a reason for why it was observed a u-shaped outline in stock market volatility. This interpretation was similar to that of Calvo and Mendoza’s inference that the globalization of financial markets had decreased the inducement for investors to gather and develop information about individual market conditions, resulting in higher financial volatility. An anodyne conclusion may be that the effects of financial globalisation are multifaceted and dependent. **Bandivadekar and Ghosh (2003)** in the paper studied the effect of introducing index futures volatility of both S&P CNX Nifty and BSE Sensex in the spot market using the GARCH model. The empirical study pointed out a decrease in the volatility of the spot market subsequently after introducing index futures because of an increase in the effect of latest news and decreased impact of uncertainty created from the old news. However, further study also showed that the market spread volatility had decreased across the period under study. Surrogate indices like BSE 200 and Nifty Junior were introduced to study whether introducing index futures had been influential in decreasing the volatility in the spot market or whether the volatility had decreased in accordance with general fall in market spread volatility. Thus it was concluded the future effect did play an important role in decreasing volatility with respect to S&P CNX Nifty, but in respect of BSE Sensex, where derivative turnover was seen considerably low, the role seemed to be ambiguous.

Harvinder (2004) in the paper used asymmetrical GARCH models to outdo the symmetrical GARCH models and conservative OLS models. It was seen that the “ day of the week effect” and “the January effect” were not present whereas the return and volatility showed intra week and intra year seasonality after using the asymmetrical GARCH models along with EGARCH(1,1) to Sensex and TARCH (1,1) to Nifty returns. It was also seen that after introducing rolling settlements the volatility and returns on certain weekdays had altered. Lastly, varied evidence of return and volatility having spill over effect between the US and the Indian markets was witnessed. Though S&P500 showed substantial positive correlation with returns of Nifty, returns of NASDAQ showed substantial although feeble positive correlation with BSE Sensex. Likewise, substantial negative correlation was witnessed between US indices and domestic indices during the 1993-1999. But after significant study she could not find hard and substantial evidence of the presence of aggregate market level relation between the US and the Indian markets.

Diebold & Yilmaz (2008) in this paper developed an empirical study of the relations between central volatility and stock market volatility. Their study was driven by financial economic theory, which suggested that the volatility of actual activity must be associated to stock market volatility). The experimental approach used cross-sectional disparity in fundamental and stock market volatilities to discover relations that is possible to be eliminated in a time series analysis. The masses indicated wide variations in volatilities across majority of the countries. Furthermore, the distributions exhibited to be right skewed, because developing countries tend to have unusual high volatility. It was also indicated that there was a distinct positive relationship between volatilities in stock return and GDP, as depicted in the scatter plot of stock market volatility against GDP volatility, along with fitted nonparametric regression curve.

FJ Jr. (2008) in the paper found that risk occurs to some extent in all investment markets, and volatility was one of the reflections of this risk. A rational amount of volatility in an investment option was a trade-off for high long-term return expectations. It was suggested that the people investing should not change their portfolio in reaction to short-term volatility, but should appraise the rational long-term expectations for volatility while formulating their strategic asset allocation. It was seen that the correlation of the VIX and standard deviation was 0.88 for the period of study. The percentage of days of volatility measure was 0.81 correlations to the VIX and a 0.86 correlation to the standard deviation for the S&P 500 Index.

Antonio Mele (2008) quoted that "Stock market volatility is higher in bad times than in good times". The focus of the paper was about the fluctuations in the stock market. So the author did not discuss whether the levels of stock market volatility and risk premium were consistent with reasonable levels of risk aversion characteristics of investors. The paper discovered three experimental issues, which were currently being studied previously. First, the author established that stock market volatility could be forecasted by using macroeconomic variables. Secondly, he showed that in turn, stock market volatility contained pertinent information associated to the development of the business cycle. Thirdly, he showed that volatility trading is related to the business cycle and that volatility risk-premium is strongly countercyclical.

Raju (2010) in the paper showed that developed and evolving markets showed discrete pattern in return and volatility performance. It was observed that intraday returns and standard deviations were high for evolving markets compared to developed markets. Both evolving and developed markets had logged extremely volatile values in returns and standard deviation during the global crisis of 2008. Secondly, an asymmetric shape was depicted by skewness and kurtosis which was different for developed and evolved markets. This pattern had experienced noteworthy changes during the global crisis and demands for further study in the area. Thirdly, in the set of evolving markets India depicted a sensibly decent position because from 2003 to 2007 India showed positive returns with medium volatility and consequently asymmetries calculated by skewness and kurtosis had been less for Indian indices. Lastly, the global crisis had a major effect on the statistical characteristics of financial time series which furthermore demanded study in the same field.

Gahan, Mantri, Parida and Sanyal (2012) took the paper to study the level and pattern of volatility of BSE Sensex and NSE Nifty during the post derivative period. Several volatility models have been developed to get roughly perfect estimates of volatility by recognizing features of Stock market data like heteroskedasticity, clustering, asymmetry autoregressive and persistence. MA (q,p), GARCH (q, p), EGARCH (q, p) and IGARCH (q, p) had been used for the estimation of volatility in Sensex and Nifty during pre-derivative period, past-derivative period and whole period of study. After analysis it was found that there was noticeable difference between the volatility of pre and post derivative period. It was also found that the Conditional volatility estimated in all the models for Sensex and Nifty was less in pre derivative period than that of the post derivative period.

Bekaer & Hoerova (2013) in the paper concluded that the conditional variance was strongly correlated with latest financial stress indicators, in comparison to variance premium. They also concluded that the variance premium is a substantial forecaster of stock returns, but the conditional variance failed to be a substantial forecaster. Though, conditional variance strongly and ominously predicted economic activity showing an undesirable sign, whereas variance premium had no prognostic power for upcoming output growth.

Research Methodology

Objectives: The objective of the study is to find out volatility in the Indian stock market. **Data Collection**: Data is collected for Indian stock indices (SENSEX &Nifty 50) from 1st April 2008 to 31st March 2012. Daily observations of SENSEX & Nifty 50 were gathered from historical data section of www.nseindia.com, www.bseindia.com and www.onada.com.

Statistical Tool applied: The following statistical tools were used:

Normality Test

The Data distribution is said to be normal if its skewness is zero and kurtosis is three. The descriptive statistics like mean, standard deviation, skewness and kurtosis of the return data over the period under study for Sensex and Nifty are obtained by using a statistical software package called E views-7. The normality test of the descriptive statistics is carried on by using an asymptotic Jarque-Bera (1981) test statistic. JB test of normality is the test of the joint null hypothesis if S & K are 'O' and 3, respectively.

Stationarity test

The financial time series data is called stationary if it's mean, variance and auto covariance at different lags are same and so are independent. For a stationary series, stocks of the system die away gradually. If the effect of the stocks to the system persists for a longer period, the system will be explosive due to the stock. If the data would not be stationary, no study can be done as non-stationary data leads to spurious regression. The study has therefore conducted stationarity test on the data by using Augmented Dickey Fuller (ADF) test which is stated below:

ADF test statistics: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \in_t$

Where, Y_t = Return data over time 't'

$\Delta Y_t = Y_t - Y_{t-1}$

δ = Coefficient of Y_{t-1}

β_1 = Drift parameter

t = time or trend variable

β_2 = coefficient of 't'

The ADF test will speak whether the return distribution of Sensex and Nifty over the period of study is stationary or not.

Heteroscedasticity Test

Heteroscedasticity refers to the unequal variance ( ) in the error term (ut) obtained from the regression of Yt with Yt-I under Ordinary Least Square (OLS) method. In other words, the coefficient of Yt-1 if is statistically significant, it indicates the presence of autocorrelation in the return series between Yt and Yt-1. In the presence of heteroscedasticity, Classical Linear Regression Method if is applied, the best Linear Unbiased Estimates (BLUE) will not be obtained. Hence, the study here intends to develop volatility models under the presence of heteroscedasticity. In order to known the number of autoregressive (AR), moving average (MA), and ARMA terms, the data of Sensex and Nifty have been tested for period of study. **GARCH Model:** After the above mentioned tests, Garch model was used.

Analysis

Analysis of CNX Nifty

Normality test

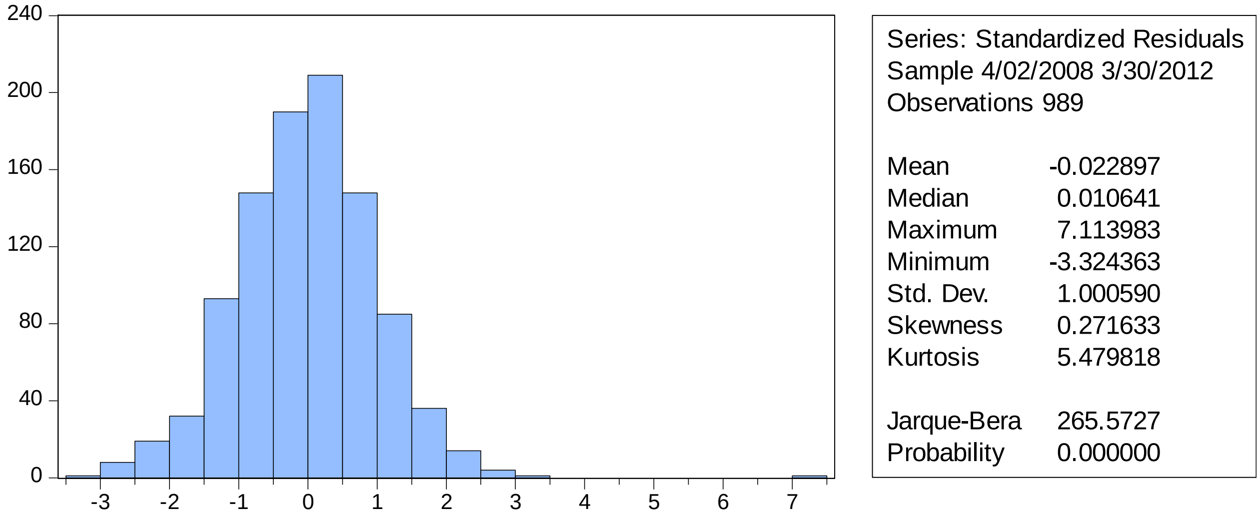

Figure 1: Normality Test CNX NIFTY

Hypothesis

Null: data is normally distributed

Alternate: not normally distributed

The Data distribution is said to be normal if its skewness is zero and kurtosis is three. The normality test of the descriptive statistics is carried on by using Jarque-Bera (1981) test statistic. From the above table we can see that calculated values of skewness (0.31) and kurtosis (12.48) do not meet the above said criteria. Also the corresponding p-value is 0.00 which implies we reject the null hypothesis meaning that the data is not normally distributed.

Stationarity test

Null Hypothesis: ASSET_RETURNS has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on HQ, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-29.67296	0.0000
Test critical values:	1% level	-3.436749	
	5% level	-2.864254	
	10% level	-2.568267	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(ASSET_RETURNS)

Method: Least Squares

Date: 03/12/14 Time: 11:13

Sample (adjusted): 4/03/2008 3/30/2012

Included observations: 988 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ASSET_RETURNS(-1)	-0.944194	0.031820	-29.67296	0.0000
C	0.000104	0.000584	0.178325	0.8585

R-squared	0.471734	Mean dependent var	1.94E-05
Adjusted R-squared	0.471198	S.D. dependent var	0.025243
S.E. of regression	0.018356	Akaike info criterion	-5.155669
Sum squared resid	0.332235	Schwarz criterion	-5.145758
Log likelihood	2548.900	Hannan-Quinn criter.	-5.151900
F-statistic	880.4843	Durbin-Watson stat	1.995527
Prob(F-statistic)	0.000000		

Table 1: Stationarity Test CNX NIFTY

Hypothesis

Null: a variable has a unit root

Alternate: a variable is stationary

The study has conducted stationarity test on the data by using the Augmented Dickey fuller (1976) test. It is clear from above tables that each variable of t-statistic does not fall in the range of critical values at different significant levels. Now each variable is free from variations in data which does not violate the assumptions of linear regression model. Also, the corresponding p-value is less than 0.05 implying rejection of the null hypothesis.

Heteroskedasticity test

Heteroskedasticity Test: ARCH

F-statistic	5.412050	Prob. F(1,986)	0.0202
Obs*R-squared	5.393424	Prob. Chi-Square(1)	0.0202

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 03/18/14 Time: 21:54

Sample (adjusted): 4/03/2008 3/30/2012

Included observations: 988 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000312	3.77E-05	8.271943	0.0000
RESID^2(-1)	0.073882	0.031758	2.326381	0.0202

R-squared	0.005459	Mean dependent var	0.000337
Adjusted R-squared	0.004450	S.D. dependent var	0.001139
S.E. of regression	0.001137	Akaike info criterion	-10.71964
Sum squared resid	0.001274	Schwarz criterion	-10.70973
Log likelihood	5297.502	Hannan-Quinn criter.	-10.71587
F-statistic	5.412050	Durbin-Watson stat	2.019141
Prob(F-statistic)	0.020200		

Table 2: Heteroscedacity Test CNX NIFTY

Hypothesis

Null: residuals are homoscedastic

Alternate: residuals are heteroscedastic

The p-value is less than 0.05, we can reject null hypothesis. Residuals do not have constant variance meaning that residuals are heteroskedasticity.

Autocorrelation

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.056	0.056	3.0803	0.079
		2	-0.024	-0.027	3.6351	0.162
		3	-0.011	-0.008	3.7492	0.290
		4	-0.012	-0.012	3.8948	0.420
		5	-0.029	-0.029	4.7512	0.447
		6	-0.060	-0.058	8.3600	0.213
		7	0.038	0.044	9.8329	0.198
		8	0.085	0.078	17.059	0.029
		9	0.007	-0.002	17.104	0.047
		10	0.005	0.007	17.131	0.072
		11	0.021	0.020	17.584	0.092
		12	0.019	0.017	17.936	0.118
		13	0.030	0.039	18.856	0.128
		14	0.033	0.039	19.922	0.133
		15	-0.016	-0.024	20.181	0.165
		16	0.032	0.032	21.184	0.172
		17	0.073	0.074	26.501	0.066
		18	-0.039	-0.045	28.059	0.061
		19	0.019	0.028	28.413	0.076
		20	-0.049	-0.055	30.853	0.057
		21	-0.007	-0.009	30.905	0.075
		22	-0.037	-0.038	32.302	0.072
		23	-0.062	-0.054	36.203	0.039
		24	0.008	-0.007	36.264	0.052
		25	0.059	0.045	39.778	0.031
		26	0.065	0.056	44.137	0.015
		27	0.030	0.019	45.054	0.016
		28	0.009	0.009	45.133	0.021
		29	-0.029	-0.032	45.994	0.023
		30	-0.002	0.011	46.000	0.031
		31	-0.026	-0.009	46.714	0.035
		32	-0.033	-0.022	47.807	0.036
		33	0.023	0.014	48.372	0.041
		34	0.048	0.041	50.776	0.032
		35	-0.055	-0.062	53.884	0.022
		36	0.006	0.016	53.920	0.028

Figure 2: Autocorrelation CNX NIFTY

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.894994	Prob. F(2,986)	0.1509
Obs*R-squared	3.786963	Prob. Chi-Square(2)	0.1505

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 03/12/14 Time: 21:13

Sample: 4/02/2008 3/30/2012

Included observations: 989

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.69E-07	0.000583	0.001317	0.9989
RESID(-1)	0.057312	0.031859	1.798940	0.0723
RESID(-2)	-0.026882	0.031859	-0.843783	0.3990

R-squared	0.003829	Mean dependent var	-1.68E-19
Adjusted R-squared	0.001808	S.D. dependent var	0.018367
S.E. of regression	0.018350	Akaike info criterion	-5.155357
Sum squared resid	0.332005	Schwarz criterion	-5.140504
Log likelihood	2552.324	Hannan-Quinn criter.	-5.149709
F-statistic	1.894994	Durbin-Watson stat	1.998928
Prob(F-statistic)	0.150866		

Table 3: Autocorrelation Test CNX NIFTY

Hypothesis:

Ho: There is no Serial correlation

Ha: There is serial correlation

From the above table, we fail to reject the null hypothesis that there is serial correlation or in other words there is no autocorrelation in the series as the p value is more than 0.05. Thus, after this test we can conclude that the series is not affected by its historical data.

GARCH (2,1)

Dependent Variable: ASSET_RETURNS

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 03/14/14 Time: 22:17

Sample (adjusted): 4/02/2008 3/30/2012

Included observations: 989 after adjustments

Convergence achieved after 22 iterations

Presample variance: backcast (parameter = 0.7)

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-2)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
CLOSE	8.12E-07	5.93E-07	1.369932	0.1707
DATE	-4.99E-09	4.14E-09	-1.206123	0.2278
	Variance Equation			
C	4.10E-06	1.33E-06	3.084269	0.0020
RESID(-1)^2	-0.018450	0.007811	-2.362007	0.0182
RESID(-2)^2	0.123491	0.021723	5.684872	0.0000
GARCH(-1)	0.883497	0.019648	44.96516	0.0000

R-squared	0.001746	Mean dependent var	0.000112
Adjusted R-squared	0.000734	S.D. dependent var	0.018367
S.E. of regression	0.018360	Akaike info criterion	-5.503310
Sum squared resid	0.332699	Schwarz criterion	-5.473603
Log likelihood	2727.387	Hannan-Quinn criter.	-5.492013
Durbin-Watson stat	1.884150		

Table 4: GARCH Model CNX NIFTY

In the above table, RESID (-1)^2 represents ARCH and GARCH is represented by GARCH(-1). The p value (probability) of the ARCH 1 is found to be 0.0182, whereas ARCH 2 is 0.00 and GARCH is also 0.00 which is less than 0.05 meaning that ARCH and GARCH effects are noteworthy. The table also suggests that the coefficients α1 (-0.018450), α2 (0.123491) and β1(0.883497) are statistically significant and are within parametric restriction for all the period under the study, thus implying a greater impact of shocks (or news) on volatility. A significant ARCH coefficient α1 indicates a larger degree of shocks on day t-1 which leads to large (conditional) variance on day news which has a greater impact on price changes which suggest that the impact of yesterday's news on today's volatility. α1 is the "news" component that explains that recent and also the internal news, and the GARCH coefficient β1 measures the impact of "old news" and external news. Thus, we can conclude that older and external news have more effect on the stock price than latest and internal news. The average volatility per day witnessed during the period was 39%.

Conditional Variance

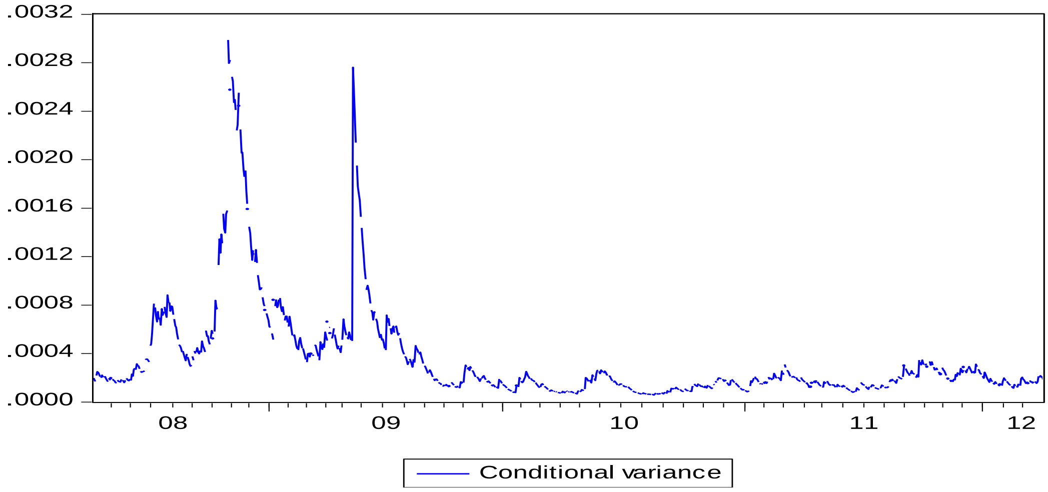

Figure 3: Conditional Variance CNX NIFTY

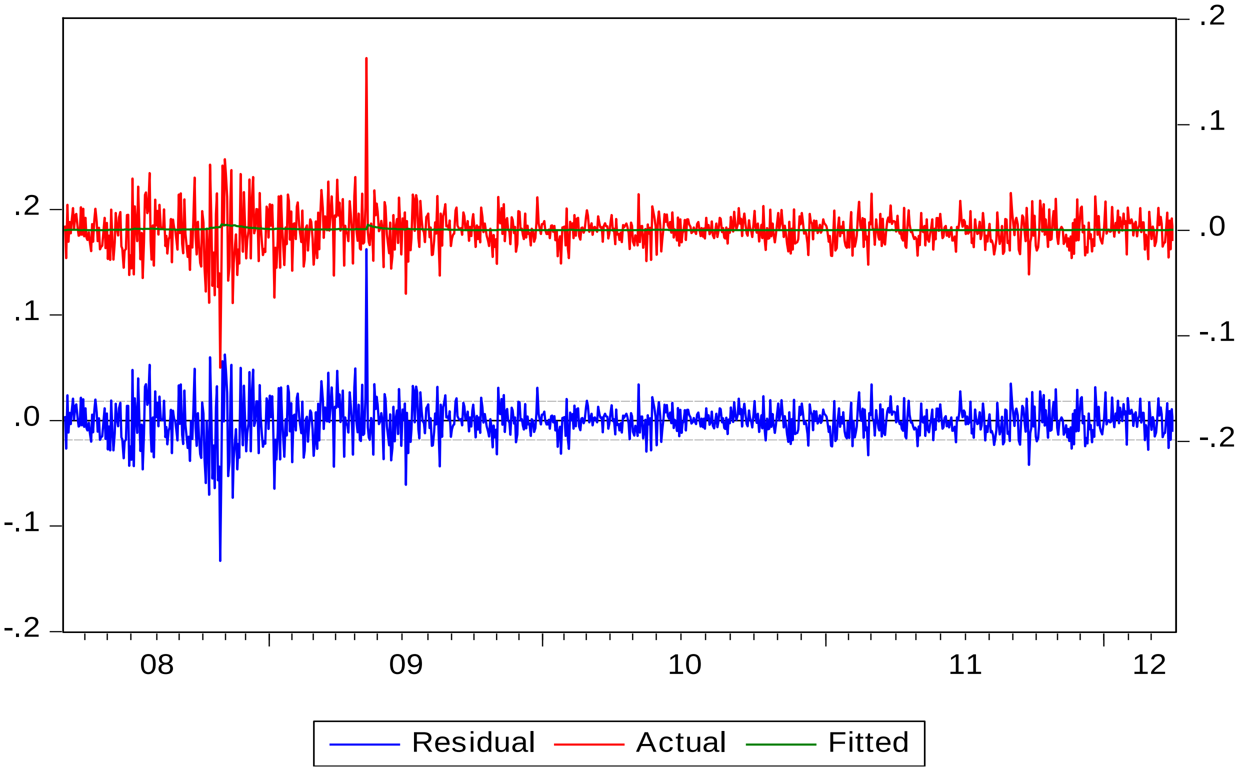

Figure 4: Residual Table CNX NIFTY

From the above two figures we can see that there was high volatility in the CNX Nifty Index from 2008 to 2009 for a prolonged period followed by low volatility for a prolonged period.

Analysis of BSE Sensex

Normality test

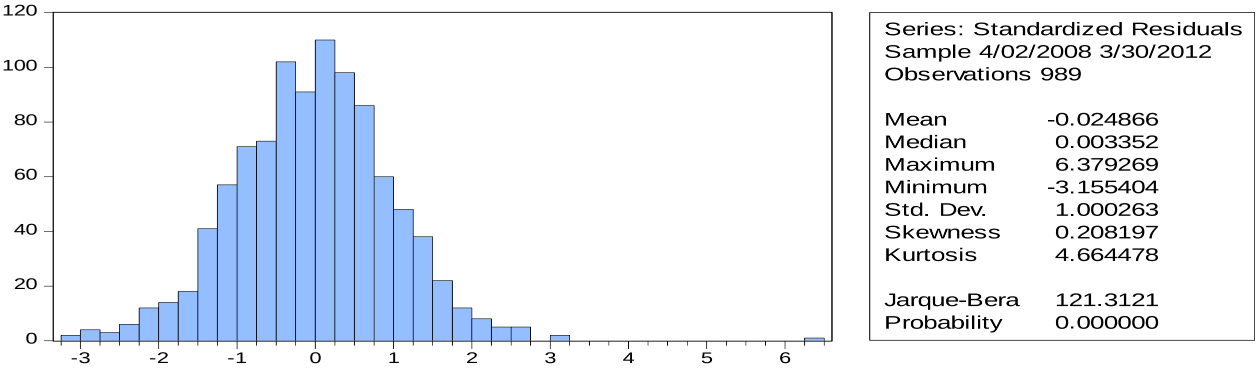

Figure 5: Normality Test BSE SENSEX

Hypothesis

Null: data is normally distributed

Alternate: not normally distributed

The Data distribution is said to be normal if its skewness is zero and kurtosis is three. The normality test of the descriptive statistics is carried on by using Jarque-Bera (1981) test statistic. From the above table we can see that calculated values of skewness (0.38) and kurtosis (10.77) do not meet the above said criteria. Also the corresponding p-value is 0.00 which implies we reject the null hypothesis meaning that the data is not normally distributed.

Stationarity test

Null Hypothesis: BSE_LOG has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-29.48205	0.0000
Test critical values:	1% level	-3.436749	
	5% level	-2.864254	
	10% level	-2.568267	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(BSE_LOG)

Method: Least Squares

Date: 03/13/14 Time: 19:49

Sample (adjusted): 4/03/2008 3/30/2012

Included observations: 988 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BSE_LOG(-1)	-0.937520	0.031800	-29.48205	0.0000
C	9.55E-05	0.000598	0.159648	0.8732

R-squared	0.468518	Mean dependent var	1.23E-05
Adjusted R-squared	0.467979	S.D. dependent var	0.025782
S.E. of regression	0.018805	Akaike info criterion	-5.107355
Sum squared resid	0.348681	Schwarz criterion	-5.097445
Log likelihood	2525.033	Hannan-Quinn criter.	-5.103586
F-statistic	869.1915	Durbin-Watson stat	1.994225
Prob(F-statistic)	0.000000		

Table 5: Stationarity Test BSE SENSEX

Hypothesis

Null: a variable has a unit root

Alternate: a variable is stationary

The study conducted stationarity test on the data by using the Augmented Dickey fuller (1976) test. It is clear from above tables that each variable of t-statistic does not fall in the range of critical values at different significant levels. Now each variable is free from variations in data which does not violate the assumptions of linear regression model. Also, the corresponding p-value is less than 0.05 implying rejection of the null hypothesis.

Heteroscedacity test

Heteroskedasticity Test: ARCH

F-statistic	9.560144	Prob. F(1,986)	0.0020
Obs*R-squared	9.487546	Prob. Chi-Square(1)	0.0021

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 03/18/14 Time: 22:15

Sample (adjusted): 4/03/2008 3/30/2012

Included observations: 988 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000319	3.68E-05	8.671189	0.0000
RESID^2(-1)	0.097990	0.031692	3.091948	0.0020

R-squared	0.009603	Mean dependent var	0.000354
Adjusted R-squared	0.008598	S.D. dependent var	0.001106
S.E. of regression	0.001102	Akaike info criterion	-10.78201
Sum squared resid	0.001197	Schwarz criterion	-10.77210
Log likelihood	5328.313	Hannan-Quinn criter.	-10.77824
F-statistic	9.560144	Durbin-Watson stat	2.026660
Prob(F-statistic)	0.002044		

Table 6: Heteroscedacity Test BSE SENSEX

Hypothesis

Null: residuals are homoscedastic

Alternate: residuals are heteroscedastic

The p-value is less than 0.05, thus we can reject null hypothesis. Residuals do not have constant variance meaning that residuals are hetroscedastic

Autocorrelation

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.062	0.062	3.8638	0.049
		2	-0.034	-0.038	5.0082	0.082
		3	-0.018	-0.013	5.3205	0.150
		4	-0.028	-0.028	6.1115	0.191
		5	-0.029	-0.027	6.9510	0.224
		6	-0.043	-0.042	8.7593	0.188
		7	0.034	0.037	9.9102	0.194
		8	0.084	0.076	17.000	0.030
		9	0.011	0.001	17.114	0.047
		10	0.010	0.013	17.209	0.070
		11	0.033	0.034	18.270	0.076
		12	0.009	0.011	18.358	0.105
		13	0.030	0.039	19.278	0.115
		14	0.009	0.014	19.366	0.151
		15	-0.010	-0.012	19.473	0.193
		16	0.021	0.021	19.932	0.223
		17	0.069	0.071	24.762	0.100
		18	-0.028	-0.037	25.550	0.111
		19	0.017	0.024	25.858	0.134
		20	-0.045	-0.052	27.930	0.111
		21	0.009	0.013	28.017	0.140
		22	-0.037	-0.042	29.384	0.134
		23	-0.059	-0.052	32.868	0.083
		24	0.005	-0.006	32.895	0.106
		25	0.066	0.052	37.308	0.054
		26	0.080	0.069	43.743	0.016
		27	0.021	0.010	44.213	0.020
		28	0.018	0.021	44.535	0.025
		29	-0.026	-0.026	45.208	0.028
		30	-0.001	0.016	45.208	0.037
		31	-0.050	-0.032	47.803	0.027
		32	-0.009	0.001	47.892	0.035
		33	0.007	-0.006	47.941	0.045
		34	0.080	0.071	54.450	0.014
		35	-0.057	-0.072	57.819	0.009
		36	-0.006	0.002	57.852	0.012

Figure 6: Autocorrelation BSE SENSEX

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.646822	Prob. F(2,986)	0.0714
Obs*R-squared	5.281396	Prob. Chi-Square(2)	0.0713

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 03/13/14 Time: 20:02

Sample: 4/02/2008 3/30/2012

Included observations: 989

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.87E-07	0.000598	0.001149	0.9991
RESID(-1)	0.064867	0.031842	2.037140	0.0419
RESID(-2)	-0.038054	0.031843	-1.195061	0.2324

R-squared	0.005340	Mean dependent var	4.14E-19
Adjusted R-squared	0.003323	S.D. dependent var	0.018824
S.E. of regression	0.018793	Akaike info criterion	-5.107622
Sum squared resid	0.348237	Schwarz criterion	-5.092768
Log likelihood	2528.719	Hannan-Quinn criter.	-5.101974
F-statistic	2.646822	Durbin-Watson stat	1.999698
Prob(F-statistic)	0.071380		

Table 7: Autocorrelation BSE SENSEX

Hypothesis

Ho: There is no Serial correlation

Ha: There is serial correlation

From the above table, we fail to reject the null hypothesis that there is serial correlation or in other words there is no autocorrelation in the series as the p value is more than 0.05. Thus, after this test we can conclude that the series is not affected by its historical data.

GARCH (2,1)

Dependent Variable: BSE_LOG

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 03/19/14 Time: 21:57

Sample (adjusted): 4/02/2008 3/30/2012

Included observations: 989 after adjustments

Convergence achieved after 23 iterations

Presample variance: backcast (parameter = 0.7)

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-2)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
DATE	-8.44E-09	4.48E-09	-1.882791	0.0597
CLOSE	3.92E-07	1.90E-07	2.063720	0.0390
	Variance Equation			
C	2.58E-06	1.06E-06	2.436398	0.0148
RESID(-1)^2	0.068854	0.037963	1.813712	0.0697
RESID(-2)^2	0.031687	0.043843	0.722738	0.4698
GARCH(-1)	0.895325	0.017610	50.84135	0.0000
R-squared	0.001346	Mean dependent var		0.000109
Adjusted R-squared	0.000334	S.D. dependent var		0.018824
S.E. of regression	0.018821	Akaike info criterion		-5.485782
Sum squared resid	0.349636	Schwarz criterion		-5.456075
Log likelihood	2718.719	Hannan-Quinn criter.		-5.474486
Durbin-Watson stat	1.866559			

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Interpretation

In the above table, RESID (-1)^2 represents ARCH and GARCH is represented by GARCH(-1). The p value (probability) of the ARCH 1 is found to be 0.0697, whereas ARCH 2 is 0.4698 and GARCH is also 0.00 which is less than 0.05 meaning that ARCH 1 effects is not note worthy and ARCH 2 effects is also not significant but the GARCH effects are noteworthy. The table also suggests that the coefficients α1 (0.068854) for ARCH 1 is not statistically significant, α2 (0.031687) for ARCH 2 is not statistically significant and β1 (0.895325) is statistically significant and is within parametric restriction for all the period under the study, thus implying a greater impact of shocks (or news) on volatility. A significant ARCH coefficient α1 indicates a larger degree of shocks on day t-1 which leads to large (conditional) variance on day t news which has a greater impact on price changes which suggest that the impact of yesterday's news on today's volatility. α1 is the "news" component that explains that recent and internal news and the GARCH coefficient β1 measures the impact of "old news" and external news. Thus we can conclude that latest and internal news has less impact on the stock price than old and external news. The average volatility per day witnessed for the period was 34%.

Conditional variance

Figure 7: Residual BSE SENSEX

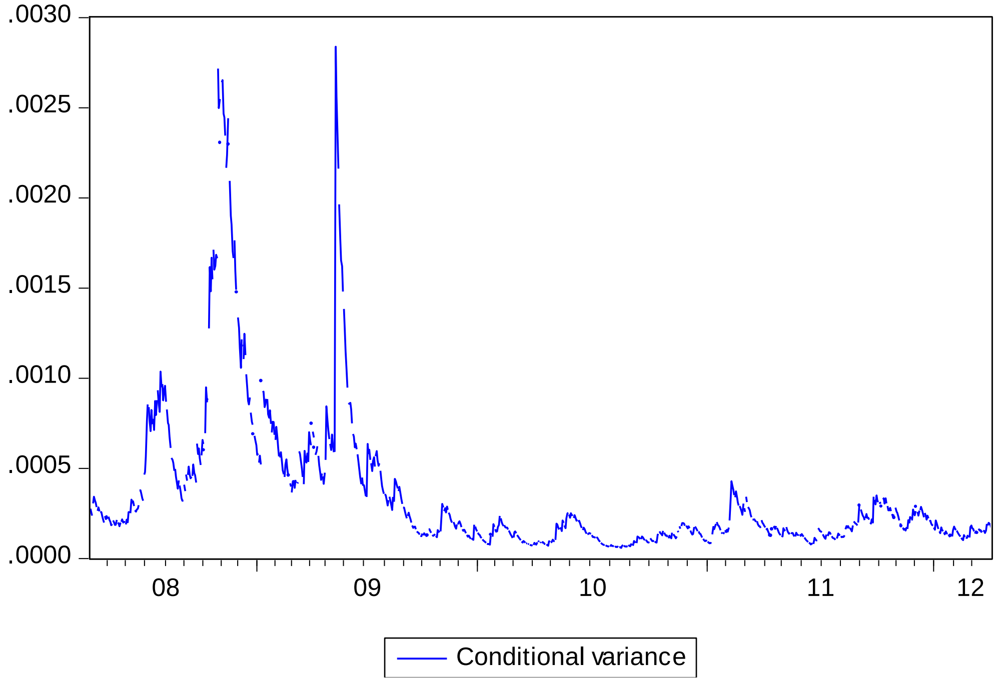

Figure 8: Conditional Variance BSE SENSEX

Interpretation

From the above two figures we can see that there was high volatility in the CNX Nifty Index from 2008 to 2009 for a prolonged period followed by low volatility for a prolonged period

Conclusion

The stock indices CNX Nifty and SENSEX faced huge volatility from the period 2008 to 2009.CNX Nifty and BSE SENSEX witnessed 39% and 34% average per day volatility. It was followed by low volatility since then. It was tested that the financial time series was not normally distributed. It was also tested that financial time series was not auto correlated. Further testing also showed that the financial time series was not stationary lastly, it was seen that the financial time series was heteroskedatic in nature. The study has not undertaken calculation of intraday volatility by using high frequency daily data. Asymptotic coefficient is not considered as EGARCH and TARCH model is not incorporated in the study.

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