Volatility Swings in Indian Equity Market through Generalized Autoregressive Conditional Heteroskedasticity Model

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ABSTRACT

The present study has made an attempt to highlight the conditional volatility of Indian stock market during last decade. As the Indian stock market has come to a more advanced stage now and it is offering various financial instruments catering the needs of various segments of individual and institutional investors therefore a study focusing on the current state of volatility can be fruitful to all concerned parties. The present study is focused to examine the time varying volatility of Indian stock market specifically in equity market and has considered daily observations of closing value of BSE Sensex index of Bombay Stock Exchange for the period of 1st January 2001 to 30th November 2012. Various econometric tools like unit root, Q statistic, ARCH-LM test and GARCH have been used to study the volatility shifts in the Indian equity market. The equity index of Indian stock market has shown that the magnitude of á is lesser than magnitude of â during various time segments considered in the study which shows that there is more impact of past volatility on the current volatility in comparison to impact of past shocks/news on the conditional volatility in daily return series of the stock index.

Key Words: *GARCH, Indian Stock Market, Time Varying Volatility.*

I. Introduction

The swift changes in equity stock prices in recent times have arouse the interest of individual and institutional investors to understand the volatility shifts prior to taking any investment decision. The recent fall of European sovereigns and major financial institutions in US has strongly shaken the faith of investors even in the fastest growing economies also. Various volatility indicators are also developed, viz., Nasdaq Volatility Index (VXN) and S&P 500 Volatility Index (VIX), which gives a broader look at the volatility of US stock market. But these volatility indicators may not serve the purpose of all the investors and every investor has its own risk bearing capacity. Therefore understanding the volatility shifts of a stock market is necessary to understand so that the investors could set a benchmark of risk return trade off criteria before investing in stock market products. The present paper is focused to study the volatility shifts in equity market in India. The frequent occurrence of financial crisis in world economy has made it essential to keep an eye on the changing patterns in the stock market performance in India. The shaken performance of Indian stock market is the result of stock market liberalization regime. The general meaning of volatility is measuring variability in the stock prices which simultaneously measures the unpredictability and uncertainty in the price movement. Higher level of volatility indicates the higher level of risk involved in investment in a particular stock or stock market and hence the higher level of expectations of more returns. A more than desired level of volatility in the market may distort its routine functioning as it will not be able to fetch the confidence of the investors. The use of standard deviation and beta measures to determine the volatility of a stock are counted as traditional methods only as these measures are not capable to show the conditional volatility based on historical prices. But no doubt that for primary evidences these basic statistical tools still have relevance to the investors and used frequently by them. The investors use these basic statistical tools to examine volatility of various financial instruments like individual stocks, portfolios, interest rate etc. A stock having more standard deviation coefficient than standard deviation of a market proxy is considered as more volatile.

These traditional measures are not able to examine the volatility clustering in the stock prices which results in frequent and large clustering in stock prices. To examine such time varying volatility, various stochastic processes and heteroskedastic models are used. Among various models in this category, the most popular models are based on ARCH and GARCH models.

Engle in 1982 introduced ARCH (Autoregressive Conditional Heteroskedasticity) model. Later in 1986, Bollerslev generalized the ARCH model popularly known as GARCH model by using lagged values of conditional variance and lagged values of squared disturbance of the series. After the decisive work of Engle (1982) and Bollerslev (1986), much of the empirical research works have used these models and extensions of these models in their research works (see, for example, French, Schwert

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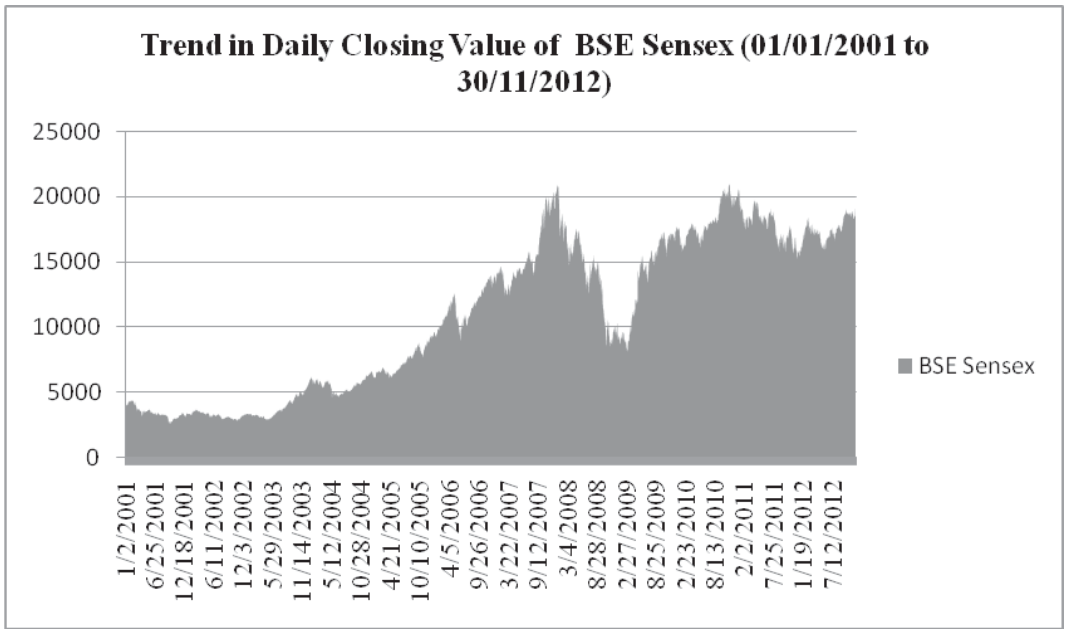
and Stambaugh 1987; Akgiray, 1989; Connolly, 1989; Ballie and De Gennaro, 1990; Lamoureux and Lastrapes, 1990; Corhay and Tourani, 1994; Geyer, 1994; Nicholls and Tonuri, 1995; Booth, Martikainen and Tse, 1997; De Lima, 1998; and Sakata and White, 1998).

The persistence of volatility is not only dependent upon the turmoil global financial environment but several instances have also reported that introduction and development of derivative market has also an impact on the spikes in the stock index return series. Kumar S., Mohan, G. and Pappu S. (2002) examined the volatility in the Indian stock market after the introduction of future trading. Their study documented that the volatility in the individual stock prices was slightly increased and it was more dependent on the current news instead of volatility in the past. The past events also resulted in present volatility popularly known as conditional volatility. Choudhary (1996), De Santis (1997), and Lee et al. (2001) conducted studies on stock market volatility of various emerging markets and their findings indicated that there was positive but insignificant impact of conditional variance of stock returns on their volatility. Similarly the trading volume also determines the level of liquidity in the market which can further bang on the volatility patterns in a stock market. There are various models to determine the level of volatility. The risk assessment is crucial for fund managers to draw their future strategies for risk management.

The present study has made an attempt to highlight the conditional volatility of Indian stock market during the last decade. As the Indian stock market has come to a more advanced stage now and it is offering various financial instruments catering the needs of various segments of individual and institutional investors therefore a study focusing on the current state of volatility can be fruitful to all concerned parties. Like all world economies, the Indian economy has also been impacted by the recent inopportune behavior of the strongest financial systems of the world. Although the Indian stock market has been able to stand in this challenging environment but the anticipated growth rate does not seem meeting the expectations of the investors. The history of equity market in India has seen various turmoil phases which were full of domestic scams and other irregularities resulting in a volatile environment. Various studies in the past have documented the evidences of persistence of volatility shifts in Indian stock market. The following figure has shown the movements in the closing prices of BSE Sensex during last decade.

Figure I



Some more studies have been discussed hereunder citing the findings of volatility in various stock markets around the world. Kaur (2004) investigates the nature and characteristics of stock market volatility in India from January 1993 through March 2003 and examined daily closing observation of Sensex and Nifty, and S&P 500 by using ARCH and GARCH models. The study concluded that there is mixed evidence of return and volatility spillover between the US and the Indian markets. Batra (2004) studied stock market volatility in India during post liberalization era. He documented that structural breaks in the volatility of stock market are more likely to be the consequence of macro policy reforms taken by government and the bullish phase after the liberalization reforms were found longer and stable. Further Raju et al. (2004) examined volatility of international stock markets. Their study documented that volatility in Indian stock market was comparatively lesser than other stock markets of the world. Their study further reported that the information efficiency in Indian stock market has increased over time and even the intraday volatility is also under control.

In more recent studies the evidences are found in a blended form. Padhi (2006) used ARCH and GARCH models to explain the volatility of Indian stock market during 1990-2004. Her study documented similar trends in the volatility of indices and individual stocks of various industrial segments. Bansal and Pasricha (2009) examined the volatility shifts of Indian stock market by opening the stock market for Foreign Institutional Investors. But the volatility on Indian stock market was not found significantly related with the movements of FIIs even the evidences were reported other way and the market volatility was significantly reduced by opening doors to foreign institutional investors. Mukherjee, Paramita (2011) explored the relationship between volatility within not only the Indian equity market but also within other developed and emerging markets as well. Based on a daily data set for more than nine years (From 01 January, 1999 to 15 February, 2008), he estimated a joint Vector Auto Regression/Multivariate Generalized Autoregressive Conditional Heteroskedasticity (VARMGARCH) model and found that return volatility of the Indian market did not have an increasing or declining trend, but exhibited sudden sharp increases over the sample period. The conditional correlation of the Indian equity market return with all the other markets had increased over time in recent years.

The evidences of volatility are not found for Indian stock market but all major stock exchanges of the world have shown such evidences in the past. Moreover these evidences are not just for volatility in equity stock prices but such evidences are there for volatility in bond prices, foreign exchange rate, and interest rate and for other financial assets also. For other stock markets of the world, Hussain and Uppal (1999) document the evidences in favor of persistence in volatility of equity market of Pakistan. Their study further reported that there was decline in the volatility persistence after taking into consideration the structural shift occurring at the time of opening of the market. Lee et al. (2001) documented time varying volatility in four major stock markets of China. Lee and Ohk (1992), Kamara et al. (1992), Pok and Poshakwale (2004), Ryoo and Smith (2004) documented the impact of introduction of derivatives on various markets like Japan, Hong Kong, UK, USA, Malysian and Korean stock markets. Agrawal et al. (2003) documented that introduction of new technology by the firm has significant impact on the volatility of its stock prices as well as the positive abnormal returns of the firm also get increased with this real activity. In a more recent study by Kohers et al. (2005) documented that the volatility in many emerging markets of the world was steady during 1988-1996. But from 1997-2004, there was a noticeable increase in the volatility of various emerging markets and mean returns were also consistently lower during this period. In a more recent study by Mala and Reddy (2007), it was documented that interest rate changes considerably impacted the volatility of Fiji stock market. In their study they used multivariate GARCH model for a period of five years (2001 to 2005). Further, Meric et al. (2007) examined the volatility of Israeli and Egyptian stock market and documented relatively higher volatility at Egyptian stock market. Whaley (2009) conducted a study on the relationship of volatility index and stock markets of US. The findings of the study documented that the volatility index was in a better position to explain the market fluctuations rather than studying the changes in the performance of S&P 500 index portfolio.

As evidenced through past findings that numerous factors are responsible for volatility shifts in a stock market behavior therefore a consistent study examining the conditional volatility may be fruitful for the investors to strategize their investment decisions. The impact of various macro fundamentals has direct or indirect impact on the stock market behavior and therefore past performance of various macro fundamentals including the performance of capital market may have impact on the conditional volatility of the stock market. Therefore motivated by various instances of time varying volatility over major stock markets across the world, the present study has made an attempt to examine conditional volatility of Indian stock market.

II. Research Methodology

The present study has made an attempt to examine the persistence of time varying volatility on Indian stock market during various phases of the market. In order to examine the volatility, the sensitive index of Indian stock market, i.e., BSE Sensex has been examined. This market proxy represents 30 stocks having significant role in the Indian capital market in terms of their market cap as well as frequency of trading too. It covers a period more than a decade, i.e., 1st January, 2001 to 30 November, 2012. Daily observations of closing value of market proxy have been considered for all empirical tests. A total of 2952 daily observations have been taken for the study period. Therefore more than a decade period has been considered to make a comment about the persistence of conditional volatility of Indian stock market. The time period considered in the present study has been divided into various segments as Indian capital has implemented various reforms in order to liberalize it and make it compatible with global standards. As Indian market has seen various phases of bull and bear market phenomenon and recently impacted by financial crisis due to fall of Lehman Brothers and sovereign debt crisis in Euro Zone therefore the following segments have been made in the timeline of present study.

- *Bear Market Phenomenon, (01/2001-03/2003)*
- *Bull Market Phenomenon, (04/2003-08/01/2008)*
- *Era of Global Recession, (09/01/2008-02/2009)*
- *Market Recovery turning into bullish trend, (03/2009-Nov 2012)*

And to sum up all results, a comprehensive analysis based upon overall time period has also been made. All data has been obtained from official website of Bombay Stock Exchange, i.e., www.bseindia.com.

Further, instead of taking raw data based on daily closing value of market proxy, the present study has used daily return series of market proxy based on the log differenced series as under

$$R_t = Ln\left(\frac{C_t}{C_{t-1}}\right)$$

(where, R_t = Daily return of BSE Sensex, Ln = Natural Log, C_t = Closing Value of Market Proxy at time t, and C_{t-1} = Closing value of Market Proxy at time t-1.)

III. Statistical Analysis and Model Identification

Table I has shown the findings of descriptive statistics for overall period as well as for various sub periods considered in the study. There are positive mean returns reported by daily return series of sensitive index of Indian stock market over the study period. But the trend has not been found similar in case of various sub-periods considered in the study. The mean returns reported during first sub-period were negative as market was passing through bearish phase. But the maximum value of return during this phase indicates that there were certain instances during bear phase also when the market returns were positive. The overall distribution of returns was found negatively skewed and leptokurtic in nature. The second sub-period was a bullish market era and the features of the market return series also indicated various positive signals. The mean returns were highest (0.001608) during this phase and skewness and kurtosis coefficients supported diversion from the symmetrical distribution of the series. The global recession occurred after the collapse of biggest financial institutions of the world caused negativism in the performance of Indian stock market also. As given in the table below, during the third sub period of the study the mean returns were reported negative but these negative returns were higher than negative returns of bearish phase discussed in the first sub-period of the study. The last sub period is the duration when the Indian stock market entered into a phase of recovery and BSE Sensex reported positive mean returns. The distribution of mean return series was found positive in this phase which was an exception when compared with the other phases of the market. When analyzed on the basis of skewness and kurtosis coefficients the distribution of mean return series was found diverted from the perfect symmetrical distribution during all sub-periods and overall duration of the study. These results were further supported by Jarque-Bera statistics which supported less than normal distribution series of mean returns during all time segments at 1 per cent and 5 per cent levels of significance except in the case of third phase (only at 1 per cent level of significance). The volatility was also found almost similar in all phases of the market except for third phase (highest, 0.028425) which again showed the impact of global slow down on the Indian economy. Further tests to examine the volatility in the Indian stock market have been discussed through various tools discussed below.

Table I
Summary of Descriptive Statistics

	Overall Duration	First Sub-Period	Second Sub-Period	Third Sub-Period	Fourth Sub-Period
Mean	0.000532	-0.000498	0.001608	-0.003091	0.000873
Median	0.00116	0.000137	0.002563	-0.003125	0.000889
Maximum	0.1599	0.050765	0.079311	0.079005	0.1599
Minimum	-0.118092	-0.062205	-0.118092	-0.116044	-0.060084
Std. Dev.	0.016138	0.013936	0.014503	0.028425	0.014002
Skewness	-0.109486	-0.362525	-0.731253	-0.095981	1.670986
Kurtosis	10.25169	5.63004	9.069741	3.739738	21.4033
Jarque-Bera	6471.91	172.1149	1932.792	6.716714	13512.96
Probability	0	0	0	0.034792	0
Sum	1.571167	-0.276281	1.913234	-0.853194	0.809585
Sum Sq. Dev.	0.768327	0.107599	0.250105	0.222192	0.18154
Observations	2951	555	1190	276	927

Source: Secondary Data from 01/01/2001 to 30/11/2012

Before studying in detail about the volatility in the daily return series of BSE Sensex series it is mandatory to study whether the daily return series is serially correlated or not. The evidences of existence of serial correlation in the past values of a financial time series shows that the financial time series is not a stationary series. The present study has applied unit root test to examine the existence of unit root in the financial time series during various time segments. For this Augmented Dickey Fuller (ADF) test is applied (see Table II). Schewarz information criteria are used for auto selection of lag order size. The findings of ADF unit root test reject the null hypothesis that there is unit root in the daily return series of market proxy during all time segments.

Table II
Results of Augmented Dickey Fuller Unit Root Test

Time Segment	Co-efficient	Std. Error	t-statistic	Probability
Overall Duration	-0.925272	0.018366	-50.37978	0
First Sub-Period	-0.897271	0.042404	-21.15994	0
Second Sub-Period	-1.024436	0.039518	-25.92307	0
Third Sub-Period	-0.938585	0.060395	-15.54084	0
Fourth Sub-Period	-0.945648	0.032811	-28.82133	0
Test critical values:	1% level = -3.44275, 5% level = -2.8669			

Source: Secondary Data from 01/01/2001 to 30/11/2012

In addition to this, the findings of the Q statistic are used to study the remaining serial correlation in the mean equation and to check the specification of mean equation of model specified for the empirical study. The findings of Q-statistic displayed that at some lags, out of 16 lags selected in the study, the probability of Q statistic was found very low at 1 per cent level of significance (See Table III). And this phenomenon is more actual when Q statistic was applied on overall time period. Further the squared Q statistic has been used. This test is used to study the ARCH in the variance equation. Table IV has depicted the results of squared Q statistics. For a variance equation to be correct the squared Q statistic must not have all significant values. Table IV has supported these results.

Table III
Q Statistic of Residuals during Various Time Segments

Time Segment	Overall Duration		First Sub-Period		Second Sub-Period		Third Sub-Period		Fourth Sub-Period	
Lags	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.
1	23.521	0	8.0095	0.005	8.6978	0.003	1.0279	0.311	2.6408	0.104
2	23.522	0	8.0114	0.018	11.638	0.003	1.0288	0.598	3.5123	0.173
3	25.116	0	8.1614	0.043	12.82	0.005	1.063	0.786	3.6811	0.298
4	28.996	0	11.229	0.024	13.72	0.008	3.2463	0.517	4.7077	0.319
5	30.604	0	11.421	0.044	15.134	0.01	6.5066	0.26	5.5975	0.347
6	33.863	0	12.763	0.047	19.411	0.004	7.7299	0.259	5.6018	0.469
7	34.906	0	12.763	0.078	19.411	0.007	9.1608	0.241	5.846	0.558
8	36.028	0	13.063	0.11	19.552	0.012	12.536	0.129	5.9487	0.653
9	39.601	0	14.044	0.121	19.922	0.018	12.606	0.181	6.5119	0.688
10	40.859	0	15.372	0.119	20.791	0.023	12.674	0.242	7.5197	0.676
11	41.232	0	15.598	0.157	20.983	0.034	12.777	0.308	10.206	0.512
12	41.561	0	15.598	0.21	21.003	0.05	12.878	0.378	10.226	0.596
13	43.681	0	15.869	0.256	22.834	0.044	13.388	0.418	11.052	0.606
14	46.095	0	16.754	0.27	23.794	0.049	15.393	0.352	11.068	0.681
15	47.146	0	18.42	0.241	24.836	0.052	15.737	0.4	11.131	0.743
16	47.357	0	18.481	0.296	25.253	0.065	17.371	0.362	11.171	0.799

Source: Secondary Data from 01/01/2001 to 30/11/2012

Table IV
Q Statistic of Squared Residuals during Various Time Segments

Time Segment	First Sub-Period		Second Sub-Period		Third Sub-Period		Fourth Sub-Period		Overall Duration	
Lags	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.	Q-statistic	Prob.
1	0.1143	0.735	0.4857	0.577	0.0437	0.938	0.298	0.585	0.153	0.696
2	4.9314	0.089	0.8842	0.639	0.0482	0.797	0.6535	0.721	0.163	0.922
3	5.4416	0.142	3.3434	0.342	0.0903	0.991	0.7184	0.869	0.4529	0.929
4	5.7687	0.246	3.979	0.431	2.0687	0.723	0.9458	0.918	1.4315	0.839
5	6.2445	0.283	3.9876	0.571	2.1146	0.833	0.9991	0.963	1.8342	0.872
6	6.2496	0.396	4.7553	0.576	2.5505	0.863	1.0223	0.985	2.342	0.886
7	7.0384	0.425	7.5599	0.373	2.7685	0.906	1.0453	0.994	2.6842	0.913
8	7.7383	0.459	8.3913	0.396	3.0644	0.93	1.1729	0.997	4.0477	0.853
9	9.404	0.401	8.8536	0.451	3.4168	0.945	1.629	0.996	6.139	0.726
10	9.4644	0.489	10.963	0.36	4.291	0.933	2.5017	0.991	7.7367	0.655
11	9.5368	0.572	12.281	0.343	5.1373	0.924	2.5136	0.996	9.0502	0.617
12	10.118	0.606	14.561	0.266	5.1565	0.953	2.5179	0.998	10.153	0.603
13	10.327	0.667	29.481	0.006	7.839	0.854	3.0199	0.998	12.314	0.502
14	10.406	0.732	31.201	0.005	7.9525	0.892	3.497	0.998	12.336	0.579
15	11.529	0.714	31.319	0.008	8.3397	0.909	3.5974	0.999	12.337	0.653
16	12.179	0.732	31.328	0.012	8.8402	0.92	3.668	0.999	12.393	0.716

Source: Secondary Data from 01/01/2001 to 30/11/2012

Further in order to identify the ARCH effect in the standardized residuals, the ARCH-LM model has been used. The findings of ARCH-LM test have been given in Table V hereunder. The results documented by ARCH-LM test have not documented presence of autoregressive conditional Heteroskedasticity in the residuals. The ARCH test is a Lagrange Multiplier (LM) test for autoregressive conditional heteroskedasticity (ARCH) in the residuals (Eagle, 1982). This particular heteroskedasticity specification was motivated by the observation that in many financial time series, the magnitude of residuals appeared to be related to the magnitude of recent residuals. ARCH in itself does not invalidate standard LS inference. However, ignoring ARCH effects may result in loss of efficiency. The ARCH LM test statistic is computed from an auxiliary test regression. To test the null hypothesis that there is no ARCH up to order q in the residuals, we run the regression:

$$e_t^2 = b_0 + \left(\sum_{05}^{q} b_0 e_{t-0}^2 \right) + v_t$$

Table V
Results of ARCH-LM Test during Various Time Segments

Overall Duration	F-statistic	0.04995	Prob. F(1,2948)	0.8232
	Obs*R-squared	0.049983	Prob. Chi-Square(1)	0.8231
First Sub-Period	F-statistic	6.75E-05	Prob. F(1,552)	0.9934
	Obs*R-squared	6.77E-05	Prob. Chi-Square(1)	0.9934
Second Sub-Period	F-statistic	0.222899	Prob. F(1,1187)	0.6369
	Obs*R-squared	0.223233	Prob. Chi-Square(1)	0.6366
Third Sub-Period	F-statistic	0.585533	Prob. F(1,273)	0.4448
	Obs*R-squared	0.58856	Prob. Chi-Square(1)	0.443
Fourth Sub-Period	F-statistic	0.501339	Prob. F(1,924)	0.4791
	Obs*R-squared	0.502152	Prob. Chi-Square(1)	0.4786

Source: Secondary Data from 01/01/2001 to 30/11/2012

Therefore after conducting various preliminary tests, it was identified that the data series used in the present study is characterized by inter temporal dependence in its mean and variance and tend to depict volatility clustering in the daily return series of the market proxy. To be summarize, it was identified that the daily return series of market proxy of present study has documented the characteristics of unconditional distribution which is justifiable to the specification of GARCH model to study the persistence of volatility in the stock market. Moreover the findings of Q statistic based on residuals and squared residuals have verified that the mean and variance equations are correctly specified in GARCH (1, 1) model used in the current study as all coefficients of Q statistic are not significant in selected lag order size. The following mean and variance equations of simplest GARCH (1, 1) specification have been used in the present study :

In which the mean equation given in the above equation is written as a function of exogenous variables with an error term. Since σ_t^2 is the one-period ahead forecast variance based on the past information. It is called the conditional variance. The conditional variance equation specified in above is a function of three terms:

- A constant term: ω
- News about volatility from the previous period, measured as the lag of the squared residual from the mean equation: (the ARCH term).
- Last period's forcast variance:

The (1,1) in GARCH (1,1) refers to the presence of a first-order autoregressive GARCH term (the first term in parentheses) and a first-order moving average ARCH term (the second term in parentheses). An ordinary ARCH model is a special case of a GARCH specification in which there are no lagged variances in the conditional variance equation- i.e., a GARCH (0,1).

IV. Findings and Conclusion

The findings of GARCH (1,1,) model are given in Table VI. The findings of GARCH (1,1) model have reported positive α and β coefficients in the variance equation which is indicative of incidences of volatility shifts in the daily return series of BSE Sensex. The magnitude of á and β helps to understand the impact of past volatility on the present volatility and impact of past shocks or news on the conditional volatility. As shown in Table VI, the equity index of Indian stock market has shown that the magnitude of α is lesser than magnitude of β during various time segments considered in the study which shows that there is more impact of past volatility on the current volatility in comparison to impact of past shocks/news on the conditional volatility in daily return series of the stock index. The magnitude of α coefficient shows the impact of past news on the conditional volatility. As depicted in the Table VI the magnitude of α coefficient has declined over a period of time and its magnitude is lesser than the magnitude of β coefficient which reports that the lagged variance in stock index return series have reduced on the conditional volatility of equity index and eventually it has shifted to the unconditional volatility. In other words α coefficient shows the ARCH term and β coefficient is the GARCH term in σ_{t-1}^2 equation. Both α and β coefficients (i.e., lagged conditional variance and squared disturbance) were found statistically significant at 1 per cent and 5 per cent levels of significance which indicates that past news about the volatility in the stock market has some explanatory power to determine the current volatility. The significance of α coefficient indicates the impact of past good or bad news has same impact on the current volatility. In addition to this, the significance of β indicates the impact of volatility in preceding time period on the volatility in current time period. It implies that both past good and bad news and past volatility have an effect on the current investment decision of the investors.

Table VI
Findings of GARCH (1,1) Equation

Time Segments	Mean Equation				
	Variable	Coefficient	Std. Error	z-Statistic	Prob.
Overall Duration	θ	0.001127	0.000212	5.324839	0
First Sub-Period	θ	-3.96E-05	0.000508	-0.07811	0.9377
Second Sub-Period	θ	0.00222	0.000353	6.281579	0
Third Sub-Period	θ	-0.002083	0.001438	-1.44814	0.1476
Fourth Sub-Period	θ	0.000705	0.000375	1.877054	0.0605

	Variance Equation				
	Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
Overall Duration (Alternate Phases, 03/2001-10/2010)	ω	5.83E-06	8.19E-07	7.121231	0
	α	0.127831	0.009357	13.66189	0
	β	0.850987	0.010345	82.26141	0
First Sub-Period (Bear Phase, 03/2001-03/3003)	ω	1.56E-05	4.22E-06	3.703624	0.0002
	α	0.172981	0.033869	5.107328	0
	β	0.742811	0.048977	15.16661	0
Second Sub-Period (Bull Phase, 04/2003-08/01/2008)	ω	1.17E-05	2.26E-06	5.176788	0
	α	0.151305	0.017595	8.59943	0
	β	0.791361	0.024065	32.88489	0
Third Sub-Period (Global Recession, 09/01/2008-02/2009)	ω	3.29E-05	2.56E-05	1.285391	0.1987
	α	0.142919	0.053304	2.6812	0.0073
	β	0.818848	0.066534	12.30719	0
Fourth Sub-Period (Market Recovery/ Consolidation Phase, 03/2009-11/2012)	ω	1.52E-06	6.51E-07	2.325944	0.02
	α	0.055044	0.011203	4.91334	0
	β	0.935314	0.013114	71.32102	0

Source: Secondary Data from 01/01/2001 to 30/11/2012

The sum total of magnitude of α and β coefficients shows the volatility clustering. The total of these two coefficients measures the persistence of consistent volatility. As shown in the following section that α + β is very close to 1 during fourth sub-period and it indicates that the presence of ARCH and GARCH effects in the daily return series of stock index. The past volatility shifts have significant impact on the persistence of present volatility and moreover this tendency has been noticed significantly throughout the study period. But it is not found as greater than one which would have indicated an explosive persistence of conditional volatility.

$$\sigma_t^2 = \omega + \alpha \epsilon_{t-1}^2 - \beta \sigma_{t-1}^2$$

Table VII

Time Segment	**α + β**
Overall Duration	0.978818
First Sub-Period	0.915792
Second Sub-Period	0.942666
Third Sub-Period	0.961767
Fourth Sub-Period	0.990358

Source: Secondary Data from 01/01/2001 to 30/11/2012

Concisely, considering the evidences reported by various tests considered in the present paper it can be reported that there are consistent evidences of time varying volatility in Indian equity market. In such a volatile financial environment the investors must consider the historical significance of past volatility while taking any investment decision in Indian equity market. Moreover this can help investors to determine their return expectations from the equity market after examining the risk involved in it due to conditional volatility. A further study of existence of volatility in the derivative market can also help investors to understand whether the bid-ask spread in derivative market has helped to reduce this volatility clustering or not. Also if high frequency data is considered then the estimates of conditional volatility through GARCH model can support the findings of the present study.

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