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A study of Indian stock market volatility and economic indicators using ARCH model

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Abstract
The present paper studies estimating the volatility of the BSE index and economic indicators using ARCH (1,1) model. The Quarterly Data utilized in the study of BSE index return and selected economic indicators like Money Supply (M3), Exchange Rate, Foreign Institutional Investors (FII), Gross Domestic Product (GDP), Export of goods & services, And Import of goods & services dated from 1st-Jan-2001 to 31st-Dec-2018. The following time span used to identify the volatility of stock market before recession and after recession period and to evaluate the relationship between Indian Stock Market volatility and selected macroeconomic indicators. It confirmed that the BSE index and economic indicators are having highly positive correlation among the studied period. The model helps investor to identify that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period due to changes take place in selected economic indicators (Fundamentals).

Keywords: BSE, arch, FII, GDP, volatility, money supply (m3), export of goods & services, and import of goods & services

1. Introduction
Volatility can be refers as an statistical measure of dispersion of returns for a given particular security or market index. It can either be measured by using the standard deviation or variance between returns whether they are from that same security or market index. Commonly, it is said that the higher the volatility, the riskier the security and vice versa. The economic indicators play a crucial role in volatility of BSE because the changes take place in the percentage of Economic Indicators. The selected economic indicators are directly related or we can say that it influences to BSE Index volatility. Autoregressive conditional heteroskedasticity (ARCH) is a time-series statistical model used to analyses the effects left unexplained by econometric models. In particular these models, the error term is the residual result left unexplained by the model. This is known as "homoskedasticity." ARCH models are commonly employed in modeling financial time series that exhibit time-varying volatility and volatility clustering, that it's time periods of swings interspersed with periods of relative calm. ARCH-type models are sometimes considered to be in the family of stochastic volatility models, although this is strictly incorrect since at time t the volatility is completely pre-determined (deterministic) given previous values. With the help of the following indicators, this paper tries to evaluate that whether the selected indicators are having certain relationship among the BSE SENSEX (Index) Volatility.
The conditional mean equation and variance equation for an ARCH (1,1) model is given as:
$yt = \boldsymbol{\beta 1} + \boldsymbol{\beta 2 x 2 t} + \boldsymbol{\beta 3 x 3 t} + \boldsymbol{\beta 4 x 4 t} + \mu \boldsymbol{t}$ $\mu t \sim$ N (0,2) (1)
$\sigma t2 = \beta 0 + \sum \beta i q i = 1\ \mu t - i\ 2$
(1b) where $\beta 0 > 0$; $\beta i > 0$; $\forall$ i = 1, …, q
Where μt is the error generated from the mean equation at time t. and $\sigma t2$ is the conditional variance equation

2. Review of literature
Mohammad Irshad VK and George Varghese have conducted a nature of volatility in Indian stock market. The main purpose of study was to characterize the time varying volatility of Indian stock market in long run by concentrating on aspects time varying volatility, predictability volatility, and asymmetric nature of volatility towards negative and positive shocks for a period of 20 years from 1994 to 2014. The study was made using advanced econometric models like ARCH and simple standards deviation models. The data was based on secondary data which was extracted from the database of NSE website. The study concluded that the magnitude of volatility was found to fluctuate between periods and shows a repeating trend over a time.
Prof. Pushpa M. Savadatti has conducted a research by analyzing the volatility in daily returns series of BSE all cap indexes. The objective of this study was to analyses the pattern of BSE to help investors. The secondary data is used in this study which collected from BSE website covering period from 16th September 2005 to 9th March 2018 (excluding public holidays). The study was conducted by using symmetric and asymmetric GARCH models. The study has concluded that volatility in stock market are helpful for investors as well as it revealed that daily return series of BSE all cap index do not exhibit normality and having existence of leverage effect in daily return series of BSE all cap index.
Li Liu and Tao Zhang have conducted a research to investigate the predictability of economic policy uncertainty (EPU) to stock market volatility. The main purpose of this study was to examine the ability of EPU to predict the realised volatility. The secondary data is used in this study which extracted from the Journal of Business Management, Reports of Ministry of Commerce and Industry. The study

Was analyzed by using the heterogeneous autoregressive model (GARCH model). The study has concluded that EPU exhibits significantly predictive power of market volatility which is robust to the specifications of volatility predictive models.

CH Shankar and K. Ramlu has conducted an research between volatility and correlation of stock indices on Indian stock market during the period of 1st January 2005 to 31st March 2012. The objective of this study is to examine the relationship between volatility and stock indices on Indian stock. The secondary Data is utilized in this study which collected from the Bombay Stock Exchange (BSE) and Other Internet/ Web sources. The VAR model is been used to conducted this study. The study concluded that IT and Tech Industry are high positive correlation and Auto & Metal, Bank & Oil and Gas, Bank & Tech, Oil and Gas & Tech Industries have a positive correlation on the basis of last 7 years daily returns.

Onoh, John Okey and Obioma James has conducted an study on monthly stock returns and volatility in Nigeria from the period of January 1998 to December 2009 (144 Months). the objective behind the study was to examine the impact on stock market returns of liquidity and volatility in the Nigerian Stock Market. The ARCH and GARCH model is utilized in this study. The study based on Secondary Data which collected from Nigerian Stock Market. The study concluded that volatile nature of emerging markets and provides clear evidence of time varying risk in the emerging stock market of NSE.

3. Need for the study

- Indian stock market is primarily place where any Indian companies get listed to issue the share and raise the funds. India is being a country with more and active stock trading volume in Asia. Therefore, all time the performance and condition of Indian stock market plays a vital as well as important role for the other nations too. Majorly economic variables being the strongest factors behind affecting the stock market performance so, the current study try to analyze the volatility of Indian stock market and economic indicators.
- The analysis mainly studies the BSE Sensex volatility of before as well as after recession period with the help of ARCH Model.
- To find that changes in Economic Indicators being reason of BSE Sensex Volatility

4. Objectives of the study

- The primary objective is to analyses the volatility of stock market before Recession and after recession period.
- The secondary objective which is to evaluate the relationship between stock market volatility and selected Macroeconomics Indicators

5. Sampling Design

In the following study the research design used is casual design and descriptive design. The Casual design is used in order to measure the volatility of stock market before and after recession according with changes in economic fundamentals. The Descriptive design is used to obtain about the changes in volatility of Indian stock market in respect to a selected number of economic variables. Data had been collected from secondary sources, the BSE Index and selected economic indicators had been collected from Bombay Stock Exchange official websites (https://www.bseindia.com/) and RBI official websites (https://www.bseindia.com/)

6. Tools used in this research to find out objectives:

1. For Log Value, Log = LN (Q1/Q2) *100
2. For Log Volatility, LOGV = (STDEV (Q1:Q3) *SQRT (70))
3. Correlation is calculated as per excel formulae.
4. The conditional mean equation and variance equation for an ARCH (1,1) model is given as:

$$yt = \boldsymbol{\beta 1} + \boldsymbol{\beta 2 x 2 t} + \boldsymbol{\beta 3 x 3 t} + \boldsymbol{\beta 4 x 4 t} + \mu \boldsymbol{t}\ \mu t \sim N(0,2) \quad (1)$$

7. Limitations of the study

1. The study has limitation that it amid the data constraints, it could not account for the impact of recent macroeconomic indicators which are associated with key major reforms such as demonetization and GST (Good and Service Tax) Launched in past couple of years.
2. The study comprises of ARCH (1, 1) Model while there are different ARCH Family model which can be utilized.
3. The determinants for sector- specific volatility are being beyond the scope of the present study. However the same path can be used for the scope of future research.

8. Data Analysis and Interpretation

In order to fulfill the research objective first of all need to evaluated the Descriptive Statistics

Table 1: showing for Descriptive Statistics

Particulars	BSE logv	ER logv	M3 logv	FII logv	GDP logv	EXP logv	IM logv
Mean	0.62	0.22	0.16	12.51	0.61	0.6	0.46
Standard Deviation	0.5	0.19	0.1	9.13	0.28	0.39	0.25
Kurtosis	8.46	2.73	0.68	1.73	-0.92	0.08	0.16
Skewness	2.33	1.55	0.8	1.44	-0.33	0.69	0.52

Interpretation

The above table interpret that among all variables FII is having the highest standard deviation 9.125819% which is followed other variables like; BSE SENSEX, Export Rate, GDP, Import Rate, Exchange Rate, Money Supply (M3) having standard deviation of 0.499750%, 0.390%, 0.28482%, 0.255%, 0.19136%, 0.10121% respectively while, FII has maximum percentage mean 12.51% which is followed by rest all indicators BSE, GDP, Export Rate, Import Rate, Exchange Rate, Money Supply (M3) having the following mean rates 0.625%, 0.6101%, 0.598%,0.462%, 0.2159%, 0.1569% respectively. BSE is having higher percentage of kurtosis 8.460% while GDP is in negative -0.9177% as per kurtosis is concerned. Skewness is high of BSE and negative in GDP 2.327% and -0.9177% respectively.

Stationary test result for Bombay stock exchange index (BSE Sensex) and selected economic indicators

From ADF-unit root test can conclude that the data of Bombay Stock Exchange Index (BSE SENSEX) are stationary as the P-value of Exchange Rate (0.0037) is less than the significance level (0.05) and also its t-statistic value

(-3.870876) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From the ADF-unit root test can conclude that the data of Exchange Rate are stationary as the P-value of Exchange Rate (0.0000) is less than the significance level (0.05) and also its t-statistic value (-8.364991) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From the ADF-unit root test can conclude that the data of Export Rate of goods and services are stationary as the P-value of Exchange Rate (0.0000) is less than the significance level (0.05) and also its t-statistic value (-8.143619) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From ADF-unit root test can conclude that the data of Foreign Institutional Investor (FII) are stationary as the P-value of Exchange Rate (0.0000) is less than the significance level (0.05) and also its t-statistic value (-8.510830) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From the ADF-unit root test can conclude that the data of Import Rate of Goods and Services are stationary as the P-value of Exchange Rate (0.0021) is less than the significance level (0.05) and also its t-statistic value (-4.057409) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From the ADF-unit root test can conclude that the data of Gross Domestic Product (GDP) are stationary as the P-value of Exchange Rate (0.0001) is less than the significance level (0.05) and also its t-statistic value (-5.108115) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further tests.

From the ADF-unit root test can conclude that the data of Money Supply (M3) are stationary as the P-value of Exchange Rate (0.0047) is less than the significance level (0.05) and also its t-statistic value (-3.791063) is greater than the critical values. Therefore, null hypothesis is failed to accept and the data can be used for the further test.

Table 2: showing for Correlation between BSE SENSEX and Selected Economic Indicators

Variables	BSE SENSEX	Exchange Rate	FII	Money Supply	GDP	Export Rate	Import Rate
BSE SENSEX	1						
Exchange Rate	0.77	1					
FII	0.148	0.005	1				
Money Supply	0.956	0.897	0.111	1			
GDP	0.947	0.908	0.09	0.995	1		
Export Rate	0.943	0.846	0.122	0.978	0.973	1	
Import Rate	0.934	0.803	0.146	0.964	0.954	0.992	1

Interpretation

The following table shows the relationship between BSE and Economic Variables. BSE SENSEX and Exchange Rate is 0.7696, BSE SENSEX and FII having positive relationship but in low proportion 0.148, BSE SENSEX and Money Supply (M3) is 0.956, BSE SENSEX and Gross Domestic Product (GDP) is 0.947, BSE SENSEX and Export of goods & Services is 0.943, BSE SENSEX and Import of goods & Services is 0.934, which means all indicators are highly positive Correlated with BSE Sensex and we can conclude that all indicators are the one of the reasons for BSE volatility highly in nature.

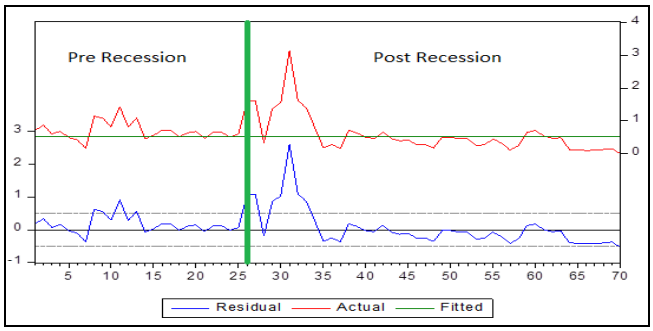

Fig 1: BSE SENSEX

Arch Model

After ensuring the non-existence of unit root in time series data, it should be further investigated whether the data is found with ARCH effect. The ARCH effect means Periods of low volatility tend to be followed by periods of low volatility for a prolonged period. Again, periods of high volatility is followed by periods of high volatility for a prolonged period.

Table 3: showing for BSE SENSEX on the basis of ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.52833	0.03563	14.8288	0
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.06285	0.00849	7.39913	0
RESID^2(-1)	0.92539	0.28677	3.2270	0.0013

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0013 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is influenced by the selected economic fundamentals. So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

Table 4: showing for BSE SENSEX and Exchange Rate on the basis of ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.51506	0.07248	7.10612	0
ER	0.04312	0.305233	0.141269	0.8877
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.06275	0.00887	7.07213	0
RESID^2(-1)	0.92987	0.29056	3.20024	0.0014

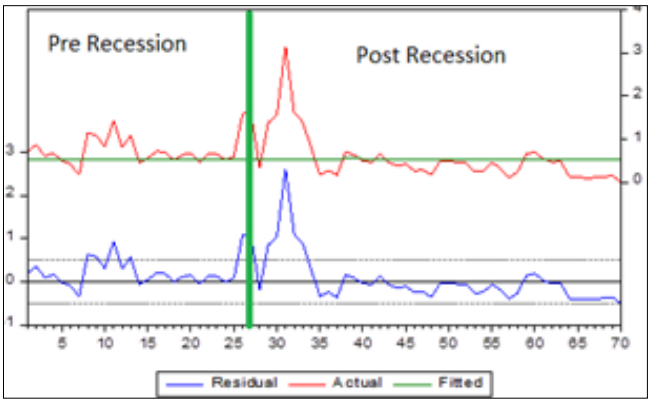

Fig 2: BSE Sensex and exchange rate

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0014 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is influenced by the changes taken place in the price of Exchange rates. So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

Table 5: showing for BSE SENSEX and Export Rate on the basis of ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.33278	0.03752	8.86881	0
ER	0.22646	0.059252	3.80457	0.0001
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.01466	0.00909	1.61245	0.1069
RESID^2(-1)	2.26946	0.48658	4.66414	0

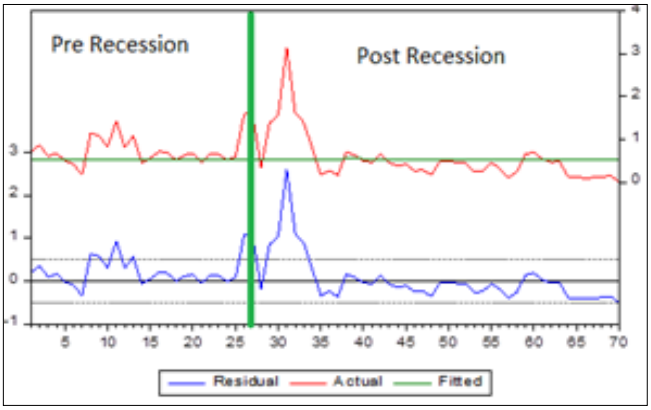

Fig 3: BSE Sensex and Export Rate

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.000 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is highly influenced by the changes taken place in the price of export rate of goods and services. So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

Table 6: showing for BSE SENSEX and FII on the basis of ARCH Model.

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.63389	0.07668	8.26658	0
FII	-0.0063	0.00558	-1.1295	0.2587
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.06327	0.00932	6.78943	0
RESID^2(-1)	0.89897	0.27366	3.28498	0.001

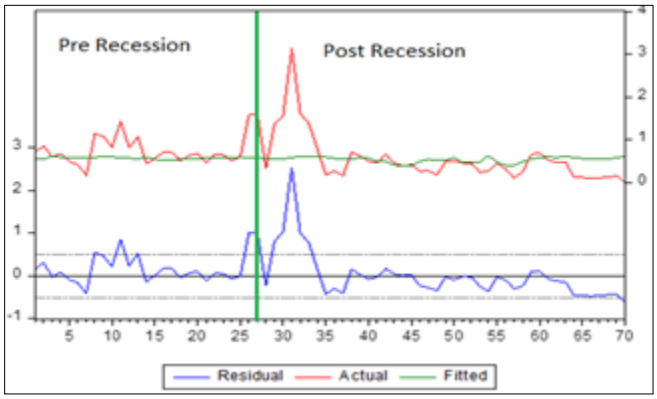

Fig 4: BSE Sensex and FII

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0010 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is influenced by the changes taken place in the price of Foreign Institutional Investors. So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

Table 7: showing for BSE Sensex and GDP on the basis of ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.2639	0.0448	5.89088	0
GDP	0.33319	0.06899	4.82987	0
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.02515	0.01444	1.74211	0.0815
RESID^2(-1)	1.71643	0.435	3.945883	0.001

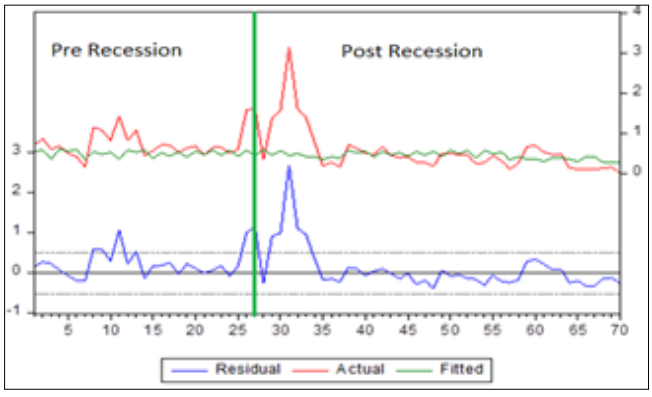

Fig 5: BSE Sensex and GDP

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0001 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is highly influenced by the changes taken place in the price of Gross Domestic Product (GDP). So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period

Table 8: showing for BSE SENSEX and Import Rate on the basis of ARCH Model**.**

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.30123	0.08644	3.48496	0.0005
IMPORT	0.57465	0.17374	3.30745	0.0009
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.05598	0.00893	6.26835	0
RESID^2(-1)	0.81082	0.2165	3.74519	0.0002

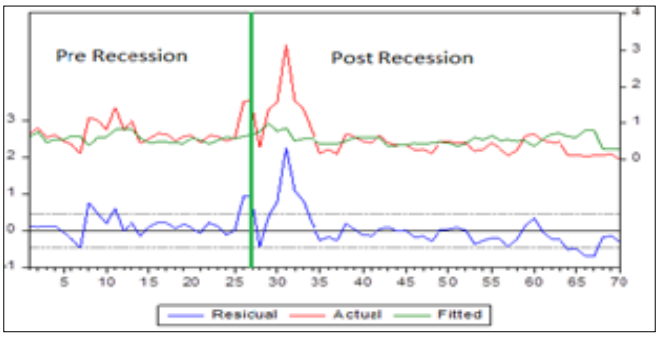

Fig 6: BSE Sensex and Import Rate

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0002 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is highly influenced by the changes taken place in the price of import rate of goods and services So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

Table 9: showing for BSE SENSEX and Money Supply on the basis of ARCH Model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.46327	0.08607	5.3826	0
Money supply	0.31737	0.48387	0.6559	0.5119
Variance Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.05588	0.0089	6.50509	0
RESID^2(-1)	1.02186	0.32719	3.12319	0.0018

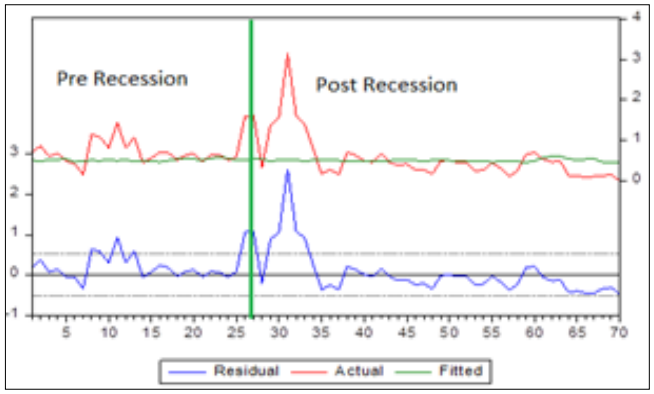

Fig 7: BSE Sensex and money supply

Interpretation

The outputs of ARCH model on BSE SENSEX benchmark indices show that the variance equation illustrates that RESID (-1) ^2 term is 0.0018 which is below the statistically significant at 5% which implies that the volatility of BSE SENSEX is highly influenced by the changes taken place in the price of money supply (M3) So, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period.

10. Conclusion

In this study, ARCH model is used to forecast the volatility of the stock indices, namely BSE SENSEX. ARCH (1) models are applied as benchmark models for this study. Regression and Correlation statistical tools are been used in this study. The Quarterly data from January 1, 2001 to December 2018 is used this study out which, The results of ARCH (1) Models on BSE SENSEX and selected economic variables series shows that in the variance equation the term, C and RESID (-1) ^ 2 are statistically significant which implies that the volatility of BSE SENSEX is influenced by the past square residual terms. The BSE SENSEX and all selected economic fundamentals are highly influenced by the changes taken place in the price of money supply (M3) FII, GDP, Export Rate of goods & Services, Import Rate of goods & Services so, it can be said that BSE SENSEX is highly volatility during the Post-recession period as compared to Pre-Recession period due to changes take place in selected economic indicators (Fundamentals).While it is proved that all economic indicators are having positive correlation with BSE SENSEX Volatility.

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