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AN ANALYSIS OF STOCK MARKET VOLATILITY

*Prashant Joshi

Abstract

The ups and downs of the financial markets are always in the news. After all, there's plenty to report. Wide price fluctuations are a daily occurrence on the world's stock markets as investors react to economic, business, and political events. Of late, the markets have been showing extremely erratic movements, which are in no way in tandem with the information that is fed to the markets. Thus chaos prevails in the markets with investor optimism at unexpected levels. Irrational exuberance has substituted financial prudence. Has the stock market volatility increased? Why is this volatility so pronounced? In this paper we try to analyze these questions in the context of Indian stock markets. The study analyses and estimates the volatility. The study reports an evidence of time varying volatility which exhibits volatility clustering. The return series analysis suggest that weekly returns are not normally distributed as confirmed by various statistical measures like kurtosis, skewness and jerque bera statistics. Using Box Jenkins Methodology, the study suggests that AR (3) model fits the data well. The study found out that the irrational behavior of the market made the year 1992 as the year of highest volatility in the History of Indian Stock Market followed by the year 2000.

INTRODUCTION :

Economic growth is essential for improving 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 healthy investment climate. In a situation of financial stability, financial institutions and markets are able to efficiently mobilize savings, provide liquidity and allocate investment. The growing role of the financial sector in the efficient allocation of resources at appropriate prices could significantly enhance the efficiency with which our economies function. If financial markets work well, they will direct resources to their most productive uses. Risks will be more accurately priced and will be borne by those who have appetite for absorbing risks. Real economic activity with higher investments, in both quantity as well as quality, would result in growth with macroeconomic stability and fewer financial uncertainties. A stable financial system facilitates efficient transmission of monetary policy initiatives.

A number of developments in recent years have combined to put the issue of financial stability at the top of the agenda. The growth in the volume of financial transactions and the increasing integration of capital markets have made institutions in the financial sector more interdependent and exposed to risk. Financial stability applies to both markets and institutions. Stability in the financial markets means the absence of price movements that cause wider economic damage. Prices can and should move to reflect changes in economic fundamentals. It is only when prices in financial markets move by amounts that are much

* **Professor, C. K. Pithawalla Inst. of Management, Surat. Email: drsnehalmistry@email.com**

greater than can be accounted for by fundamentals, and do so in a way that has damaging economic consequences, that one is justified in talking about "instability" or "crisis" in the financial system. Any price movements (Price Volatility) that exceed what can be justified on grounds of changing fundamentals have potential to result in misallocation of resources. Sustained price volatility that generates uncertainty hampers economic performance through discouraging the mobilization and allocation of savings through the financial system. So, stability is essential prerequisite for economic prosperity. Higher volatility obstructs investment to direct in productive economic activities and dampens investors' confidence. So, it is interesting to study nature and characteristic of volatility and its impact.

The Indian stock market is represented by two most prominent stock indices, i.e. Bombay Stock Exchange's (BSE) Sensitive Index (Sensex) and NSE's S&P CNX Nifty. The Sensex is generally considered to be the bellwether of the Indian Stock Market. It is the older and the more often quoted index. However of late with the growing popularity of the NSE, due to its more transparent trading mechanism and lower trading cost, NSE has become to be considered as an important and broader-based market index. As per SEBI's Annual report of 2005-06, the BSE and NSE together account for more than 90 percent of the total business transacted on all stock exchanges of the country. More than 9000 companies are listed on BSE and 1000 on NSE. Additionally, according to the data available on the respective stock exchange web sites (www.bse-india.com and www.nseindia.com), a major portion around 95% of the total market turnover of the respective stock exchanges is accounted for by the index (Sensex and Nifty). They are considered to be the barometer of the Indian Economy. Before 1992, the three principal Acts governing the securities market were : (a) the Capital Issue(Control) Act,1947, which restricted issuer access to the capital market (b) the Companies Act, 1956, which sets out code of conduct for the corporate sector in relation to issue, allotment and transfer of securities and disclosures to be made in public issues; and (c) the Securities Contracts (Regulation) Act,1956 which provides for regulation of transactions in securities through control over stock exchanges. After liberalization, many regulatory and policy measures have been taken for development of capital market. SEBI was enacted in the year 1992 to develop and protect interests of investors. Foreign investment was not welcome into India before 1991. The policy framework was liberalized for FII. All the measures aimed at making stock market more transparent and efficient. The positive measures and sound economic fundamentals attracted many investors (domestic and foreign) to participate in economic activities in the nation. Stock markets also responded positively. Major stock indices took upward trend immediately after liberalization measures taken by the Government of India. Investors were benefited. But after the Harsad Mehta scam, BSE stock market plunge in the year 1992 to more than 300 points. It had created havoc in minds of Investors. They were bereft of their savings. It made the investment in stock market risky proposition. It increased uncertainty and reduced savings. Stock returns are also affected by changes in Macro economic factors like GDP, FII investment, Inflations etc which also cause the stock price to move up or down(Basabi Bhattacharya and Mukharajee). These stock price movements technically known as volatility. It is randomness or variability of asset price around their mean value.

The study of financial assets volatility is important to academics, policy makers, and financial markets participants for several reasons. Over the last two decades, considerable attention has been paid to estimating and predicting aggregate stock market volatility. Stock market prices are known to vary, indeed this leads to presumed capital gains and is one of the prime reasons for the attraction of equities as an investment for most investors. Reduction of volatility in a

stock market is seen to be an indicator of increased development and efficiency in financial markets in general and stock market in particular.

Share Price Volatility:

The efficient market theory argued that all share price movements must be interpretable by the flow of information about economic fundamentals. If the share prices changes in response to fundamental economic factors or because of information and expectation about them, prices will be in "equilibrium" {Roy 2001}. Markets with severe price swings can be hardly explained by fundamental economic factors.

Volatility of a stock measures the frequency with which changes in its market price take place over a period of time. If a stock is highly volatile, that is, if there are large fluctuations in its prices, risk averse investors might avoid participating in the market. On the other hand, if prices are often swayed by "animal spirits", a big rise and fall in share prices may make investors anxious about the prospects of their investment.
As a concept, volatility is simple and intuitive. It measures the variability or dispersion about a central tendency. It is a measure of how far the current price of an asset deviates from its average past price. The greater this deviation, the greater is the volatility. The magnitude of asset price deviation is commonly measured in terms of standard deviation.

The study aims at measuring and analyzing the volatility of weekly stock return in the Indian Stock markets mainly BSE over the period from January 1991 to April 2006. We focus our attention on the following questions. First, does stock market volatility change over time? If so, are volatility changes predictable or modeled over time?. Third, has volatility increased over the period? If so, what is the reason for higher volatility?

With these objectives, we have measured volatility of daily stock returns in the Indian Stock Market-BSE weekly return series. The study reports an evidence of time varying volatility which exhibits volatility clustering. The return series analysis suggest that weekly returns are not normally distributed as confirmed by various statistical measures like kurtosis, skewness and jerque bera statistics. The study found out that the most volatile year in the history of India Stock Market is the year 1992 followed by the year 2000. Using Box Jenkins Methodology, the study suggests that AR(3) model fits the data well.

We proceed in steps. First, we talk about measures of volatility. Then we discuss the data series and characteristics. Then after we estimate model of data series applying Box Jenkins Methodology to BSE which explains the data series. Finally, we summarize and conclude the study.

Volatility and its measurement:

Volatility is the most basic statistical measure of risk. It can be used to measure the market risk of a single instrument or an entire portfolio of instruments. It can be defined as variability or randomness of asset prices. Theoretically change in the volatility of either future cash flows or discount rates causes a change in the volatility of share prices. The most commonly used statistical measure of volatility is the standard deviation of return. The

standard deviation measures the dispersion of return or the degree to which it varies from period to period, the period being a month, day and even hour or minute.

Stock returns are characterized by their statistical distributions. The fluctuations in stock prices lead to a sharp changes in volatility. To measure how much volatility changed during the period under study, the following method of estimating inter-day stock market volatility is used here. These measures are suggested in a recent SEBI publication on volatility by Raju and Ghosh (2004). The formula measures inter-day volatility by computing standard deviation of daily returns on stock prices. In this method, the formula used for calculating volatility is

$$\sigma = \sqrt{(1/n-1)\sum_{t=1}^{n}(r_t - r^{-})^2}$$

where $r_t=\ln(I_t/I_{t-1})$

I_t is the closing value of the stock market index at time t,

ln is natural logarithm.

Data Set and its Properties

Data description

Weekly sensex data are used for estimation of volatility. Data on a weekly basis are taken from the CMIE Prowess and Business Beacon Online data base for the period from Jan 1991 to April 2006.

The raw data are presented in **Figure 1**, where prices are shown on the left axis. The price curve shows what has happened to the BSE Sensex from 1st January1990 to 29th April 2006.

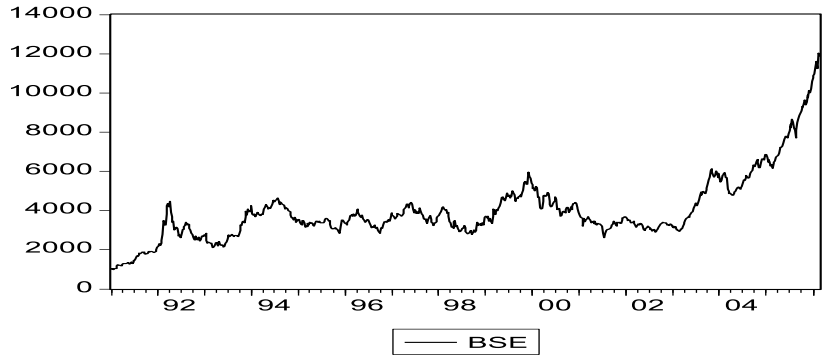

Figure 1: BSE Weekly Price from January 1991 to April 2006.

Bidding farewell to the "control regime", the Indian Economy gradually entered into the era of liberalization from the early 1980s. In response to the liberalization, the stock market started booming. It gained momentum since 1990. After the presentation of Union Budget of 1992-93, there was a miracle in Indian Stock Market. Share Prices shot up almost vertically till April and thereafter, slide down sharply in May 1992(Harsad Mehta Scam), the downward journey continued up to 1993. In the following period, the share price gyrated up and down very much.

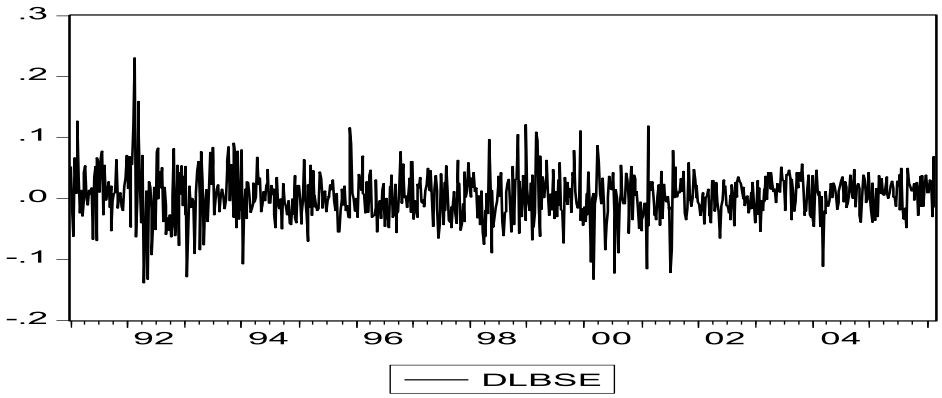

Figure 2: Daily return series

The daily return series is shown in **figure 2.** This shows the daily price change on right axis. This return series seems mean reverting. It is revolved round zero throughout the sample period even though the prices are sometimes increasing and decreasing. The dramatic event was the crash of 1992, where return declines heavily and there is a partial recovery thereafter. It is very obvious that the amplitude of return is changing. The magnitude of return is sometimes large and sometimes small which is known as volatility clustering. There is however another interesting feature in the graphs. It is clear that the volatility is higher when prices are falling (around 1992 in Fig.2). It means that negative returns are more likely to be associated with greater volatility than positive returns. This is asymmetric volatility effect that Nelson described with his EGARCH model.

Return Analysis

We now show some of the statistics that shows the stylized facts : fat tails and volatility clustering. Some of the features of returns are shown in Table 1. The mean is close to zero. The standard deviation is 0.039 in the fifteen years. The returns are positively skewed for the period 1991-2006.

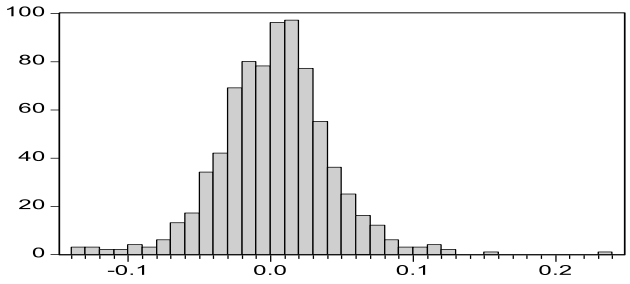

Chart 1

Series: DLBSE	
Sample 1/12/1991 2/25/2006	
Observations 790	
Mean	0.003152
Median	0.002985
Maximum	0.230007
Minimum	-0.138966
Std. Dev.	0.039132
Skewness	0.141937
Kurtosis	5.491595
Jarque-Bera	207.0007
Probability	0.000000

Table 1: Return Statistics

The most important feature is kurtosis, which measures the magnitude of extremes. The return curve is a peaked curve called as leptokurtic. The kurtosis is high(+5.49). The results thus suggest that the return series have fatter tails than the normal distribution. That is, the probability of extreme returns that has been observed empirically is higher than the probability of extreme returns under normal distribution. This feature is referred to as lepto kurtosis. The daily returns are thus not normally distributed- a conclusion that is confirmed by the Jarque-Bera test for the period.

Volatility clustering will show up a significant auto-correlation in squared returns. Table 2 shows the plots of squared returns for the period. The autocorrelations are positive, which is unlikely to occur by chance.

Table:2 Squared returns Autocorrelations (1991-2006)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.191	0.191	28.705	0.000
.|. |	.|. |	2	0.051	0.015	30.782	0.000
.|** |	.|* |	3	0.198	0.193	61.929	0.000
.|* |	.|* |	4	0.179	0.115	87.324	0.000
.|* |	.|. |	5	0.091	0.038	93.853	0.000
.|. |	.|. |	6	0.022	-0.038	94.242	0.000
.|* |	.|. |	7	0.102	0.057	102.56	0.000
.|** |	.|* |	8	0.210	0.158	137.67	0.000
.|* |	.|. |	9	0.087	0.022	143.76	0.000
.|* |	.|. |	10	0.066	0.029	147.23	0.000

A Model Of The Stock Price Index-BSE

It is useful to illustrate the **Box-Jenkins** modeling procure by estimating a weekly model of the BSE index. Figure 1 reveals that there is little point in modeling the series as being stationary, there is decidedly positive trend or drift throughout the period. The first difference of the series seems to have a constant mean (figure 2). The first difference of the logarithm(Denoted by dlbse) is more likely candidates for covariance stationary. As the ADF(Augmented Dickey Fuller Test) statistics confirms the finding as its calculated value is exceeding critical values as shown below:

Table 3:dlbse's ADF Statistics for unit root

ADF Test Statistic	**-19.01321**	**1% Critical Value***	**-3.4413**
		5% Critical Value	**-2.8656**
		10% Critical Value	**-2.5689**
***MacKinnon critical values for rejection of hypothesis of a unit root.**			

Examination of Autocorrelation(ACF) and Partial autocorrelation functions(PACF) of BSE

1. The ACF and PACF converge to zero quickly. We do not want to over difference the data and try to model the lnse(-1) sequence.
2. The ACF does not decay geometrically. Thus the ACF is suggestive of an AR process or process with both autoregressive and moving average components.
3. Since the BSE time series are not stationary (AS can be seen from ADF test whose value turns out to be -1.0852 which is lower than 1%, 5% and even 10% critical values), we have to make it stationary before we apply the Box-Jenkins methodology. In the following figure we plotted the first differences of BSE. We do not observe any trend in this series, perhaps suggesting that the first-differenced BSE time series is stationary.(Table3)
4. A normal application of the ADF test shows that that is indeed the case. .(Table3)
5. We can also see this visually from the estimated ACF and PACF. ACF at lags 1 and 3 seem statistically different from zero.

Table 4: ACF and PACF of dlbse

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.060	0.060	2.8423	0.092
.|. |	.|. |	2	0.013	0.010	2.9797	0.225
.|* |	.|* |	3	0.083	0.081	8.3933	0.039
.|. |	.|. |	4	0.026	0.017	8.9377	0.063
.|. |	.|. |	5	-0.018	-0.022	9.1942	0.102
.|. |	.|. |	6	0.006	0.001	9.2187	0.162
.|. |	.|. |	7	0.020	0.017	9.5423	0.216

We can also decide statistical significance of the ACF at Lage by following the properties of normal distribution $\rho k \pm 1.96(\sqrt{n})$, where n= number of observations. But the interval (0.0133, 0.1523) at lag 3 does not include zero. So the lag 3 seem statistically different from zero.

6. Using Eviews, we obtain the following estimates:

DLBSE = 0.003204378148 + [AR(3)*0.08291187644]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0032043	0.00151520	2.11481144	0.034760
AR(3)	0.0829118	0.03554922	2.33231188258	0.019936

Some other stylized facts of volatility can be modeled using ARCH and GARCH kinds of models which here are left for further future research.

Diagnostic Checking

To know how the model is reasonable fit to data well, one simple diagnostic is to obtain residuals from the equation. The estimated ACF and PACF are shown in Figure below.

Table 4: ACF and PACF of residuals obtained from ARMA model

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.061	0.061	2.9211	0.075
.|. |	.|. |	2	0.014	0.010	3.0682	0.080
.|. |	.|. |	3	-0.002	-0.003	3.0702	0.215
.|. |	.|. |	4	0.026	0.026	3.6087	0.307
.|. |	.|. |	5	-0.018	-0.021	3.8625	0.425
.|. |	.|. |	6	-0.010	-0.009	3.9458	0.557
.|. |	.|. |	7	0.016	0.018	4.1503	0.656
.|. |	.|. |	8	0.024	0.021	4.6000	0.709
.|. |	.|. |	9	0.042	0.040	5.9824	0.649
.|. |	.|. |	10	0.013	0.008	6.1177	0.728
.|. |	.|. |	11	-0.026	-0.029	6.6403	0.759
.|. |	.|. |	12	-0.048	-0.046	8.4898	0.669
.|. |	.|. |	13	-0.055	-0.050	10.902	0.537
.|. |	.|. |	14	-0.001	0.008	10.902	0.619
.|. |	.|. |	15	-0.016	-0.013	11.103	0.678
.|. |	.|. |	16	-0.001	0.001	11.103	0.745
.|. |	.|. |	17	-0.015	-0.016	11.284	0.792
.|* |	.|* |	18	0.076	0.074	15.904	0.531
.|. |	.|. |	19	-0.020	-0.027	16.224	0.577
.|. |	.|. |	20	-0.003	0.003	16.230	0.642
.|. |	.|. |	21	0.030	0.038	16.939	0.657
.|* |	.|* |	22	0.096	0.093	24.348	0.277
.|. |	.|. |	23	0.004	-0.004	24.364	0.328
*|. |	*|. |	24	-0.075	-0.082	28.986	0.181

.|.	|	.|*	|	25	0.065	0.068	32.450	0.116
.|.	|	.|.	|	26	0.040	0.028	33.753	0.113
.|.	|	.|.	|	27	0.039	0.032	34.998	0.112
.|.	|	.|.	|	28	-0.004	-0.008	35.011	0.139
.|.	|	.|.	|	29	0.019	0.012	35.311	0.161

As this figure shows, none of the autocorrelations and partial autocorrelations is individually statistically significant. Nor is the sum of squared autocorrelations as shown by the Box-Pierce Q and Ljung-Box LB statistics, statistically significant.

In other words, the correlogram of both autocorrelations and partial correlations give the impression that residuals obtain from the above equation is purely white noise. Hence there is no need to look for another AR class of model.

Volatility Estimation and explanation

The section presents the results of the measurement of stock market volatility during the period of study. First, the volatility of weekly returns of BSE Sensex has been calculated over different observation period.

Volatility of Weekly Returns in a year

An attempt has been made to measure volatility of weekly returns in a year. Table 5 summarizes the volatility of weekly returns.

Table 5

Yr	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Volatility(%)	3..89	7.22	4.53	3.45	2.87	3.66	3.22	3.85	4.43	4.76	4.20	2.40	2.55	2,82	2.52	2.72

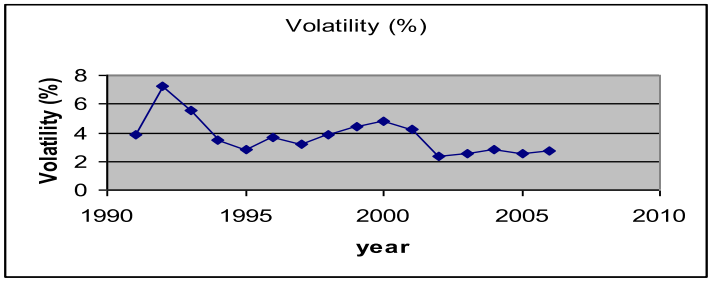

Figure 5 BSE Sensex : Volatility of Weekly Returns in a year(January 1991-April 2006)

Some interesting observation can be made from the data contained in the table 5. it is found that volatility varied across the years. 1992, 2000 and 2002 have been the most volatile years of all the

years. Volatility fell sharply in 1993 from the high of 1992. The years thereafter (1993-98) were comparatively calmer. Volatility looked up again since 1999-2000, with higher volatility in year 2000, signifying enhanced market activity.

What are the factors that contributed to the gradual rise of volatility in 1992? One of the explanations combines both fundamental factors and irrational behavior of investors. The initial boost up of share prices and fluctuations owed much to the strong fundamentals which were supplemented by a number of liberalization policies and procedure launched by government of India in July 1991. Prices started moving undeviatingly, fluctuations were high, and it culminated in a record high in March 1992, when the Indian Economy was in deep crisis. Harsad Mehta scam was detected during the period which had aggravated the situation and dampened the stock market. The social cost associated with the high volatility was heavy. Investors believed that the market became the breeding ground for the speculators and insiders. They had got deceived and lost confidence in the market. In many stock exchanges trading almost stopped. As reflected in the primary market, the fund mobilization through IPOs almost dried up. The situation continued till the recent past.

After the stable period of four years, the stock market again witnessed excessive fluctuation of share price (1999-2001). It needs to be remembered that in India, almost all previous experiences with high phases of stock market volatility have been associated with some sort of irregularities and corruption. As in April, 1999, BJP-led government lost the vote of confidence and the President dissolved the Lok Sabha. Thus uncertainty at the political front led to higher volatility. The SENSEX also affected by the global melt down of equities in the year 2000 as Technology dominated Asian markets following sharp fall in US market.

Only over the last two or three years, which were considered to be tranquil periods of volatility, market buoyancy has started again following the improved economic condition of the country. Very recently, FIIs have pushed in huge money into the market as they see bright prospects for the country. But the investment made by the FIIs is the hot money and excessive dependence on them poses a risk to the economy.

Conclusion and Summary

The study measures the volatility of weekly stock return in BSE over the period from 1991 to 2006. While studying the weekly logarithmic return series, we observed that the market is tranquil and volatile, volatile and calm. This is the effect we have termed as volatility clustering. There are indications of change in mood of the market. Volatility touched a record high in the year 1992, it surpassed all the previous record. Truly, higher price movement started in response to strong economic fundamentals, but the real cause higher volatility was also the series of scam unearthened in the Indian Stock Market. The irrational behavior of the market made the year 1992 as the year of highest volatility in the history of the Indian Stock Market. The violent fluctuations of 1992 were followed by a tranquil period of around four years, but the volatility again continued to increase till the end of the decade as series of securities scams were revealed in the Indian Stock Market. Genuine investors lost confidence and withdrew en massee. We also tried to model the daily return series using Box-Jenkins Methodology which is indicative of AR(3) series for weekly return. For the last two or three years, volatility has declined and this period is accompanied by increasing price rise, mainly fuelled by the investment made by the FIIs. The period of high and low volatility tend to cluster.

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