Abstract
The recession is believed to happen when Gross Domestic Product (GDP) drops for two consecutive quarters and when unemployment rises by 1.5 percent or more in a year. The economic recession that happened in 2008 had a significant impact on the well-being of a larger section of certain population across many countries. The effects of this on the US economy were evident in the early results from 2009 with the decline in agricultural export, real estate bubble, increase in unemployment rate etc. The influence of this economic recession was visible in the Indian stock market also because of the co integration and internationalization of the Indian stock market with other foreign markets and economy. This paper has measured the volatility of Indian stock market during the period of 2005 to 2012. The data related to the stocks and the index return is collected from the BSE & NSE and authors own calculation is used to measure the volatility using models like Parkinson Model, Garman & Klass Model, and Intra & Inter day volatility. It has been observed that returns were mostly negative in both the market indexes during the recession period with the higher volatility when the market was falling and vice versa.

Keywords
Economic Recession, Daily Return, Stock Market, Volatility

I. Introduction
During the past few years Indian Capital Market has undergone metamorphic reforms. Every segment of Indian Capital Market viz. primary and secondary markets, derivatives, institutional investment and market intermediation has experienced impact of these changes. Our market, today, is being recognized as one of the most transparent, efficient and clean markets. Several techniques / instruments are used by academicians, policy makers, practitioners and investors to test the extent of efficiency of the market.

In this research paper, an attempt has been made to analyze distributional characteristics of stock indices in India. Return (Mean), Volatility (Standard Deviation), open to open volatility, close to close volatility, high to low volatility, open to close volatility computed for various indices for different lengths of periods. These, known as first, second, third and fourth order moments of a distribution respectively, provide a picture of Indian stock price movements.

In the recent past there have been perceptions that volatility in the market has gone up; Inter and Intra-day volatility. News items and some clinical research papers also provided figures to evidence this argument. SEBI undertook a comprehensive and deep analysis of volatility by using several statistical techniques to measure and analyze it. The results show that the volatility has not gone up much in the recent past as it has been perceived. Indian stock market provides a very high rate of return and comparatively moderate volatility. Efficiency of Indian market appear to have improved in the past few years owing to contraction in settlement cycles, introduction of derivative products, improvement in corporate governance practices etc.. Stock market returns exhibit informational efficiency and approximates to normal distribution.

Volatility is an important phenomenon in markets in general and security markets in particular. Modeling stock market volatility has been the subject of empirical and theoretical investigation by both academicians and practitioners. As a concept, volatility is simple and intuitive. It measures the variability or dispersion about a central tendency. To be more meaningful, it is a measure of how far the current price of an asset deviates from its average past prices. Greater the deviation, greater is the volatility & greater is the risk.

At a more fundamental level, volatility can indicate the strength or conviction behind a price movement. In other words, it measures how for the current price of an asset deviates from its average past values. The study of volatility becomes more important due to the growing linkages of national markets in currency commodity and stock with rest of the world markets and existence of common players have given volatility a new property- that of its speedy transmissibility across markets.

II. Meaning and Concept of Volatility
A. The Statistical Nature of Volatility

Black & Scholes assumed that financial asset prices are random variables that are log normally distributed. Therefore, returns to financial assets, the relative price changes are usually measured by taking the differences between the logarithmic prices. These differences (the so-called log-relatives) are normally distributed. Financial assets, the relative price changes are usually measured by log normally distributed. Therefore, returns to financial assets, the relative price changes are usually measured by the equation

$$\ln(S_t) - \ln(S_{t-1}) = \ln\left(\frac{S_t}{S_{t-1}}\right)$$

Fig. 1:

What does this all means in practise? Stock prices are usually observed at fixed intervals of time (daily, weekly or monthly) and we then have a time series of data. The log relative returns are mathematically defined by the equation

$$u_i = \ln(S_i) - \ln(S_{i-1}) = \ln\left(\frac{S_i}{S_{i-1}}\right)$$

Where $i$ is the stock price at the end of the $i$th interval and $\ln(\cdot)$ is the natural logarithmic function. We also assume that there are $n$ stock prices in our sample. Volatility is defined as the variation or dispersion or deviation of an asset’s returns from their mean. In
Fig. 1 we show two normal curves. Both have the same mean but the dotted line shows a greater dispersion than the continuous line. These two curves also illustrate that volatility indicates the range of a return’s movement. Large values of volatility mean that returns fluctuate in a wide range – large risk. The most – common measure of dispersion is the standard deviation of a random variable.

Several factors lie behind the volatility. One of them is the leverage. Leverage has an impact on the volatility. Financial and operating leverage affects the volatility of returns to common stocks. Consider a simple example of an all equity or unlevered firm. The standard deviation of its stock returns simply equals the standard deviation of return to its assets. Now suppose, that the firm issues debt to buy back half of its stock. The volatility of its stock returns will increase, because the stock holders still has to bear most of the risk of the assets, but the value of their investment is only half as large. Thus by increasing financial leverage, the firm has increased the volatility of its stock return.

A similar case can be made for a firm that has large fixed costs. Large amount of operating leverage will make the value of the firm more sensitive to economic condition. If demand falls of unexpectedly a profit of the firm with large fixed cost will fall more than the profits of the firm that avoids large capital investments or long term supply contracts. Firms with large fixed cost will thus have higher stock return volatility.

III. Review of Literature on Market Volatility

To many among the general public, the term volatility is simply synonymous with risk: in their view high volatility is to be despised, because it means that security values are not dependable and the capital markets are not functioning as well as they should. Merton Miller (1991), the winner of the 1990 Nobel Prize in Economics wrote in his book ‘Financial Innovation and Stock Market Volatility’... “By volatility public seems to mean days when large market movements, particularly down moves, occur. These precipitous market wide price drops cannot always traced to a specific news event. Nor should this lack of smoking gun be seen as in any way anomalous in market for assets like common stock whose value depends on subjective judgment about cash flow and resale prices in highly uncertain future. The public takes a more deterministic view of stock prices; if the market crashes, there must be a specific reason”.

IV. Volatility, Crises and Recession

The stock market ‘crash’ in October 1987 raised considerable concern about the stability of financial institutions and the future of the economy. Not only did broad indexes of stock prices around the world fall about 20 percent on October 19, but for many weeks afterward stock volatility remained at very high levels. As we now know, United States financial institutions survived with very few problems (perhaps due to the calm reaction of government and private institutions).

There has been a plethora of research trying to explain the October 1987 crash, including reports from several government and financial industry-sponsored commissions. This paper documented the relations between business cycles, financial crises and stock volatility in the U.S. from 1884 through 1987. This period covers the entire history of the United States as an industrialized economy.

Thus, it provides an exhaustive record of the evidence available to judge whether the October 1987 crash was anomalous. The evidence shows that stock volatility increases after stock prices fall, it increases during recessions, and it increases around major financial crises.

There are several theories about the relation between stock volatility and macroeconomic behavior. The most controversial, advocated by Shiller [1981a, b, 1984] and Summers [1986], is that random or sociological factors have large effects on stock volatility, from this perspective, stock volatility has adverse effects on the economy when rational investors bear unnecessary risk. It is not clear how stock volatility would affect other macroeconomic variables, it is also unclear, and however, why such sociological behaviors would only affect financial asset markets and not capital, labor, or consumption goods markets. Schwert (1988) concludes that stock return volatility increased too much during the Great Depression to be explained by increases in the volatility of variables that reflect future cash flows. Wei and Zhang (2006) the volatility of stock returns is negatively related to the profitability of the company and positively related to the uncertainty on firm profitability. Bernstein [1983] argues that financial crises cause economic losses that exacerbate recessions. In essence, there is large bankruptcy costs associated with failures of financial institutions. It is not possible to eliminate these costs because of the asymmetry of information between banks and depositors about the quality of the bank’s loan portfolio (also see Diamond and Dybvig [1983]). Thus, financial crises would lead to high stock volatility because the chance of large permanent losses increases. Of course, exogeneous stock volatility could increase the likelihood of a financial crisis. Nevertheless, crises would induce further volatility because of the associated bankruptcy costs.

Stock market volatility may impair the smooth functioning of the financial system and adversely affect the economic performance of a country. One of the ways of slowing down the economic progress is the effect on consumer spending due to volatility in the stock market (Campbell, 1996; Starr-McCluer, 1998; Ludvigson and Steineld, 1999 and Poterba, 2000). The volatility impacts the consumer spending through wealth effect. The increase in stock market will drive up the consumer spending as the investor will make money in the same way if it falls consumer spending will decline.

V. Methodology

The study begins by measuring volatility from different angles. Literature is available on the calculation of different types of volatility. The study is based on BSE Sensex and NSE Nifty index figures which will represent the Indian stock market. Data is collected from BSE and NSE for calculating return and volatility. BSE index is a basket of 30 shares constituting stocks representing a sample of large, fundamentally strong and across key important sectors companies. Due to its wide acceptance amongst the Indian investors, sensex is regarded the pulse of the Indian stock market. Nifty is a well diversified 50 stock index accounting for 24 sectors of the economy. Hence these two indices were taken for the study.

Data is taken for a period of 8 years from 2005 to 2012. The different measure of volatility is discussed henceforth. One of the best measures of volatility is the variance, or the standard deviation of expected returns or the actual returns, it is a statistical measure of the dispersion of returns around the expected (actual) returns whereby a larger variance or standard deviation indicates greater dispersion all other factors being equal. The more dispersed the expected or actual returns the greater the uncertainty of that stock. Other measures of volatility like Parkinson Model and Garman & Klass Model will also be calculated. Descriptive statistics will also be used to understand the volatility and return.
Calculation of Return
Return is calculated using logarithmic method as follows.

\[ r_t = ((\log p(t) - \log p(t-1)) \times 100 \]

where
- \( r_t \) = Market return at the period \( t \)
- \( p_t \) = Price index at day \( t \)
- \( p_{t-1} \) = Price index at day \( t-1 \)
- \( \log \) = Natural log

A. Historical Volatility
The historical volatility is the volatility of a series of stock prices where we look back over the historical price path of the particular stock. We previously mentioned that the most common measure of dispersion is the standard deviation. The historical volatility estimate is thus given by

\[ \sigma = \sqrt{\frac{1}{n-1} \sum_{t=1}^{n} (u_t - \mu)^2} \]

B. Inter–day Volatility
The variation in share price return between the two trading days is called inter–day volatility. Inter–day volatility is computed by close to close and open to open value of any index level on a daily basis. Standard deviation is used to calculate inter–day volatility. The inter–day volatility is calculated by close to close and open to open volatility method.

C. Close to Close Volatility
For computing close to close volatility, the closing values of the Nifty and Sensex are taken. Close to close volatility (standard estimation volatility) is measured with the following formula.

\[ \sigma = \sqrt{(1/n - 1) \sum \frac{(r_t - \bar{r})^2}{n}} \]

Where
- \( n \) = The number of trading days
- \( r_t \) = Close to close return (in natural log)
- \( \bar{r} \) = Average of the close to close return

D. Open to Open Volatility
Open to open volatility is considered necessary for many market participants because opening prices of shares and the index value reflect any positive or negative information that arrives after the close of the market and before the start of the next day’s trading. The following formula is used to calculate open-to-open volatility:

\[ \sigma = \sqrt{(1/n - 1) \sum \frac{(r_t - \bar{r})^2}{n}} \]

Where
- \( n \) = The number of trading days
- \( r_t \) = Open to open return (in natural log)
- \( \bar{r} \) = Average of the open to open return

Inter–day volatility takes into account only close to close and open to open index value and it is measured by standard deviation of returns.

E. Intra–day Volatility
The variation in share price return within the trading day is called intra–day volatility. It indicates how the indices and shares behave in a particular day. Intra–day volatility is calculated with the help of Parkinson Model and Garman and Klass model.

F. Parkinson Model
We use Parkinson’s (1980) model, which uses intra–day highs and lows, for estimation of intraday volatility. Since, most asset pricing models are based on continuous time the extreme value estimators are more efficient. We use the following Parkinson model to estimate intra-day volatility. This volatility measure is referred to as high-low volatility. In my paper usage of factor 0.601 scales down volatility although, statistically, it is correct.

High–low volatility is calculated with the following formula

\[ \sigma = k \sqrt{\frac{1}{n} \sum \log(H_t / L_t)^2} \]

where
- \( H_t \) = High price on the day
- \( L_t \) = Low price on the day
- \( n \) = Number of trading days

G. Garman and Klass Model
The Garman and Klass model is used to calculate the open–close volatility. The formula for Garman and Klass model (1980) takes the following form.

\[ \sigma = \sqrt{\frac{1}{n} \sum (\frac{1}{2} \log(H_t / L_t)^2 - [2 \log(2) - 1] \log(C_t / O_t)^2]} \]

Where
- \( H_t \) = High price on the day
- \( L_t \) = Low price on the day
- \( C_t \) = Closing price on the day
- \( O_t \) = Opening price on the day
- \( n \) = Number of trading days

Volatility Difference in Opening and Closing Prices of BSE–SENSEX

<table>
<thead>
<tr>
<th>Year</th>
<th>Close to close Volatility (%)</th>
<th>Open to Close Volatility (%)</th>
<th>High - low Volatility (%)</th>
<th>Open to Open Volatility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>1.5231</td>
<td>0.5632</td>
<td>0.6412</td>
<td>2.1639</td>
</tr>
<tr>
<td>2006</td>
<td>1.7806</td>
<td>0.6406</td>
<td>0.7263</td>
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<tr>
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<td>0.664</td>
<td>2.2501</td>
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<tr>
<td>2008</td>
<td>2.3778</td>
<td>1.2078</td>
<td>1.9046</td>
<td>2.7832</td>
</tr>
<tr>
<td>2009</td>
<td>1.6987</td>
<td>1.0074</td>
<td>1.7103</td>
<td>2.236</td>
</tr>
<tr>
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<td>0.5541</td>
<td>1.9632</td>
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<tr>
<td>2011</td>
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<td>0.0635</td>
<td>0.6981</td>
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<tr>
<td>2012</td>
<td>1.0369</td>
<td>0.7852</td>
<td>0.4213</td>
<td>1.5478</td>
</tr>
</tbody>
</table>

Volatility Difference in Opening and Closing Prices of NSE–NIFTY

<table>
<thead>
<tr>
<th>Year</th>
<th>Close to close Volatility (%)</th>
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<td>0.4213</td>
<td>1.5478</td>
</tr>
</tbody>
</table>

H. Inter and Intra-Day Volatility
We have discussed inter-day volatility by computing close to close index level on daily basis. For many fund managers, investors, regulators and policy makers, in the recent times, intra-day volatility has assumed considerable significance because of its influence on the decision of the market participants and its impact on other instruments such as derivatives. Several metrics
are employed to estimate intra-day volatility:
1. Open-close index level
2. High low index level and
3. Open to open index levels
1. Open to close volatility provide information on change of the prices during the day. There is an elaborate literature to show that volatility is a function of length of time that means, longer the trading hours higher is the expected volatility. This is important mainly for India as the trading hours increased over a period of time. In the open-out-cry system, the market was open for about two hours. Later on number of trading hours was extended. With the implementation of computer screen based trading, number of trading hours have been enhanced. Now the market is open for almost 6 ½ hours. Therefore, one has to keep this in mind while interpreting the results.

2. High-low volatility conveys extreme movements and dispersion during the trade time. A very high high-low volatility is likely to scare investors and lead sometimes to panic conditions in the market place. Therefore, regulators, policy makers and SROs strive to implement policies that smoothen information flow and they also ensure certain measures which ensure bounded extremes with the help of circuit breakers, exposure limit, margin etc.
3. Open to open volatility is very important for several of the participants. High open to open volatility reveals informational asymmetry and also overflow of information. Any positive or negative information that comes after the close of the market and before the start of the next day’s trading, is expected to get reflected in the opening prices of shares and on the index. Significant economic and sociopolitical developments induce price movements and the extent of price movement depends on severity of information.

The tables below shows the monthly returns charts of both NSE and BSE Index.

<table>
<thead>
<tr>
<th>Monthly Return of Nifty</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
<th>Avg</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>-1.1</td>
<td>2.2</td>
<td>-3.2</td>
<td>-6.5</td>
<td>9.7</td>
<td>6.4</td>
<td>4.1</td>
<td>3.1</td>
<td>9.1</td>
<td>-8.9</td>
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<td>6.9</td>
<td>36.3</td>
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<td>10.7</td>
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<td>1.9</td>
<td>0.5</td>
<td>8.6</td>
<td>5.1</td>
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<td>39.8</td>
<td>3.02</td>
<td>6.08</td>
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<tr>
<td>2007</td>
<td>2.9</td>
<td>-8.3</td>
<td>2</td>
<td>7</td>
<td>5.1</td>
<td>0.5</td>
<td>4.9</td>
<td>-1.4</td>
<td>12.5</td>
<td>17.5</td>
<td>-2.3</td>
<td>6.5</td>
<td>54.8</td>
<td>3.91</td>
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<td>-3.9</td>
<td>9.3</td>
<td>15</td>
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<td>8.0</td>
<td>0.6</td>
<td>9.0</td>
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<td>0.6</td>
<td>11.6</td>
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<td>4.6</td>
<td>17.9</td>
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<td>2011</td>
<td>-10.20</td>
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<tr>
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<td>12.4</td>
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<td>0.95</td>
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Source: National Stock Exchange

<table>
<thead>
<tr>
<th>Monthly Return of Sensex</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>July</th>
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<th>Sep</th>
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<th>Avg</th>
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<tr>
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<td>47.8</td>
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<td>9.1</td>
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<td>8.0</td>
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<td>0.6</td>
<td>11.6</td>
<td>-0.2</td>
<td>-2.6</td>
<td>4.6</td>
<td>17.4</td>
<td>2.50</td>
<td>4.90</td>
</tr>
<tr>
<td>2011</td>
<td>-11.6</td>
<td>-2.8</td>
<td>9.1</td>
<td>-1.6</td>
<td>-3.3</td>
<td>1.7</td>
<td>-3.4</td>
<td>-7.4</td>
<td>-1.3</td>
<td>7.6</td>
<td>-9.8</td>
<td>-4.1</td>
<td>-24.6</td>
<td>-3.96</td>
<td>6.17</td>
</tr>
<tr>
<td>2012</td>
<td>11.6</td>
<td>3.3</td>
<td>-2</td>
<td>-0.5</td>
<td>-6.4</td>
<td>7.5</td>
<td>-1.1</td>
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<td>6.7</td>
<td>8.6</td>
<td>13.5</td>
<td>3.68</td>
<td>5.09</td>
</tr>
</tbody>
</table>

Source: Bombay Stock Exchange

The table of monthly returns of Nifty shown above gives a clear picture about the movement of the market during the recession. The year 2008 was the most affected with the lowest negative returns followed by 2011 which had the dollar falling nearly 16.6% and other macro economic variables pulling the market along with weak international markets. The standard deviation of the market
VI. Conclusion

This paper provides evidence on the behavior of stock prices and volatility during the period of pre and post recession period. After the study of the stock market volatility it has been concluded that the volatility during the phase of economic recession i.e. 2008 was high in the Indian market. The two indices taken for the study confirmed that there is relationship between the economic recession and stock market volatility. Whenever there is recession or financial crisis the stock market reacts negatively thus increasing the volatility. The reason for long term volatility during and after recession can be attributed to corporate leverage as at the time of economic recession the demand for the goods and services comes down thus increasing the fixed operation cost and putting pressure on the operating profits. The sentiment of the market remains negative with panic in minds of investors selling their shares which influence the volatility of the market to a great extent.

References


Mr. Sankharaj Roy is working as Faculty Member in ICFAI University Tripura since July 2008. He has completed his graduation in Commerce from University of Delhi and Master of Business Administration in Finance from SRM University, Chennai. He has a rich experience in teaching and is also engaged in research activities. His area of interest includes Corporate Finance, Microfinance and Banking.