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STOCK MARKET VOLATILITY DURING POST RECESSION – A STUDY ON EXTREME VOLATILITY ESTIMATORS

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Abstract

Volatility is the measure of risk associated with the financial instruments. Volatility of a financial instrument can be understood either by using historical volatility measures or by using implied volatility measures. In the present study NSE-NIFTY listed stocks are selected for the purpose of understanding the volatility of select stocks in the post-recession period, using historical volatility estimators. Nearly 25 stocks are selected from NSE-NIFTY on a random basis for a period of five years i.e. 2009-2014 on a daily basis. Historical volatility levels of these companies are computed using classical, range-based and drift independent volatility measures. The volatility was analyzed using extreme value volatility estimators namely, Garman Klass estimator, the Parkinson estimator, the Rogers Satchell estimator and the Yang and Zhang estimator. One of the major finding in the study that recession affected the financial markets in the year 2008, but more deviations in the stock prices are observed in the year 2010, during recovery stage of recession, it may be due to the ambiguity presented in the financial markets across the world. The study also observed that stocks like Bharati Airtel, HCL Technologies, Ruchi Soya Industries, Reliance Communication and Union Bank of India exhibited high volatility during the study period, whereas the stocks like TCS, Infosys and HDFC are stagnant during the study period.

Keywords: *Volatility, NSE-NIFTY*

Introduction

Volatility as a measure of risk associated with an asset and is a matter of great concern for researchers, industry experts, financial institutions, domestic and foreign institutional investors

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and retail investors alike. Studying volatility in capital markets often raises issues related to public policies about the stability of financial markets and the economy as a whole.

Investors in the market make their decisions based on their perceptions of the distribution of future stock returns; therefore, knowledge about future volatility has enormous influence on investment behavior. Forecasting stock volatility is also a key aspect in determining pricing in the market. Security analysis is built around the idea that investors are concerned with two principal properties inherent in securities- the return that can be expected from holding a security, and the risk that is associated with that particular security.

Volatility, which is a measure of risk, was studied through extreme value volatility estimators. The extreme value volatility estimators take into account the highest and lowest prices observed during the day besides opening and closing prices. The study was done from 2009 to 2014 for 25 select companies from various sectors

Review of Literature

Raju and Ghosh (2004) in their research paper titled as" Stock Market Volatility- An International Comparison", studied the volatility of 20 stock indices of various countries for a period of 24 years (1980-2013) by using extreme volatility estimators. The study segregated the research into developed and developing markets and concluded that developed (mature) markets provided long period of time high return with low volatility and developing (emerging) economies exhibited low returns during the study period.

Sato and Kunitomo (2008) in their research paper titled as : A Robust Estimation of Realized Volatility and Covariance with Micro-Market Adjustments and Round-Off Errors", studied the realized volatility and covariance by using high frequency data and proposed and studied a method in their research paper i.e. Separating Information and Maximum Likelihood (SIML) Method, in the micro-market noises. They studied the robustness of SIML method in estimating realized volatility and covariance. They conclude that SIML estimator has robustness properties.

Pandian and Jeyanthi (2009) studied "Stock Market Volatility in Indian Stock Exchanges", during bull and bear phases of the market. They selected Nifty and Sensex indices for the study form 1998 to 2008 and calculated inert day and intraday volatility, Parkinson and Garman Klass Estimators are used in the study to understand the volatility during the study period. They concluded that during the bull phases earned decent returns and the bear phases incurred loss. Bull phase volatilities are lower than the bear phase volatilities, due to quick consolidation in the markets.

Duque .J. & Paxson .A. study on "Empirical Evidence on Volatility Estimators", made a comparison among the estimators of historical and implied volatility estimators. The main objective of this paper is to understand the quality of the estimators used in various

research studies. They concluded that in the among the extreme volatility estimators, Garman-Klass estimator are systematically higher than the other estimators.

Contemporary Literature in the field of volatility poignant in the direction of examining the volatility behavior in different asset classes on individual basis using High Frequency Data (HFD), Stylized facts analysis, Algo trading patterns etc.,

Hans & Timo (2004) study on Stylized Facts of Financial Time Series and usage of three popular models of volatility like GARCH, EGARCH and Autoregressive Stochastic Volatility models and their ability in reproducing properties of stylized facts. The study investigated first order models and revealed that there exists presence of stylized facts in the data.

Wang and Roberts (2005) examined realized volatility in the agricultural futures market by collecting the high frequency data on soybean future contracts and grain future contracts form CBOT. The study covers a period of 10 years from 1990 to 1999. The study used econometric models like ARCH, ABDL, ABDE, ARFIMA etc. The study concluded that realized volatility based on 5 minutes returns largely corresponds to the findings of the existing literature. The findings of the study indicate that three volatility measures confirm the Mixture of Distributions Hypothesis (MDH) (Clark, 1973).

Soren Konigkramer (2014) thesis titled "Realized Volatility Estimators", examined three categories of estimator's viz., historical, high frequency and implied volatility. The study investigated as what is the best realized volatility estimator for historical asset returns? And in a Monte Carlo Simulation setup which Realized Estimator will generate the best results? Is the findings of study supports the stylized facts proposed by Rama Cont (2001). Study compared the results of historical as well as Monte Carlo simulation. For daily observations, sum of squared returns evolved as best estimator and VIX is over estimating the volatility in the asset classes and markets. Low frequency data (weekly/ monthly/data) performed very poorly, whereas five minute data resulted slightly better estimates.

Research Gap

In the financial sector, there are very few studies on Integrated Volatility (IV) or latent volatility and is not completely observable in many areas of research (Medeiros, 2008). Realized Volatility is consistent estimator of Integrated Volatility (Anderson et.al 2001). Majority of the studies are in the direction of examining the implied volatility and modeling and forecasting of such volatility using ARCH and GARCH (Symmetric and Asymmetric models) family tests. But there are few studies are dedicated to understand the role of realized volatility estimators in capturing the volatility of securities. This study will cover the both intraday and inter day volatility estimators.

Objective of the Study

The Primary objective of this study is to understand the volatility behavior of select stocks using extreme volatility estimators' viz., Classical Volatility Measures (Close-Close Standard Deviation, Open-Open Standard Deviation), Range Based Volatility measures (Parkinson Estimator and Garman Klass Estimator) and Drift Independent Volatility Measures (Roger-Satchell's Estimator, Yang-Zhang's drift independent).

Database

The classical estimator was calculated using

i. The daily close prices of 25 companies for a period of 5 years from August 7, 2009 to August 6, 2014, totaling 1298 trading days.

ii. The daily open prices of 25 companies for a period of 5 years from August 7, 2009 to August 6, 2014 totaling 1298 trading days.

The range-based and drift-independent volatility estimators were calculated using the daily open, high, low and close prices of 25 companies for a period of years from August 7, 2009 to August 6, 2014 totaling 1298 trading days.

The daily open, high, low and close prices of 25 companies were obtained from trading websites, ignoring the days when there was no trading. The price changes were calculated from the last day the market was open.

Methodology

The study used historical volatility estimators to measure the volatility on the select stocks. These estimators are different variants of standard deviation. The methodology for estimation of such volatility is presented in the following discussions. First section of the methodology will discuss the theoretical framework of each estimator and the second section of the methodology presents the discussion on analysis and interpretation of results.

Theoritical Framework of Volatility Estimators

This section broadly divides the volatility estimators as intraday and interday volatility estimators, including drift independent estimators also.

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.

Close to Close Volatility

For computing close to close volatility, the closing values of the both the markets are taken. Close to close volatility (standard estimation volatility) is measured with the following formula—

$$\sigma = \sqrt{\frac{1}{n-1}\Sigma(rt-r)^2}$$

Where

n = The number of trading days

r_t = Close to Close return (in natural log)

r = Average of the close to close return

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.

It is computed as—

$$\sigma = \sqrt{\frac{1}{n-1}\Sigma(rt-r)^2}$$

Where

n = The number of trading days

r_t = Open to open return (in natural log)

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.

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.

Parkinson Model

The Parkinson (1980) estimator efficiency intuitively comes from the fact that the price range of intraday gives more information regarding the future volatility than two arbitrary points in this series (the closing prices). Assuming that the asset price follows a simple diffusion model without a drift term, his estimator σ_p^2 can be written:

$$\sigma_p^2 = k(\frac{1}{n}\Sigma \log(H_t/L_t)^2$$

Where

σ = High–Low volatility

k = 0.601

H_t = High price on the day

L_t = Low price on the day

n = Number of trading days

Garman and Klass Model

Garman and Klass (1980) propose several volatility estimators based on the knowledge of the opening, closing, highest and lowest prices. Like Parkinson (1980), they assume the same diffusion process and propose their estimator σ_{GK}^2 . 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.

$$\sigma_{GK}^2 = \frac{1}{n}\sum\left((1/2)[\log H_2/L_2]^2 - [2\log 2 - 1][\log(C_t/O_t)]^2\right)$$

Where

Ht = High price on the day

Lt = Low price on the day

Ct = Closing price on the day

Ot = Opening price on the day

n = Number of trading days

ó = Intra-day volatility for the period

Since the price path cannot be monitored when markets are closed, however, Wiggins (1991) finds that the both Parkinson estimator and Garman-Klass estimator are still biased downward compared to the traditional estimator, because the observed highs and lows are smaller than the actual highs and lows. Garman and Klass (1980) and Grammatikos and Saunders (1986), nevertheless, estimate the potential bias using simulation analysis and show that the bias decreases with an increasing number of transaction. Therefore, it is relatively easy to adjust the estimates of daily variances to eliminate the source of bias.

Rogers and Satchell

Parkinson (1980) and Garman and Klass (1980) estimators implicitly assume that log-price follows a geometric Brownian motion with *no* drift term, further refinements are given by Rogers and Satchell (1991) and Kunitomo (1992). Rogers and Satchell (1991) add a drift term in the stochastic process that can be incorporated into a volatility estimator using only daily opening, highest, lowest, and closing prices. Their estimator can be written as

$$\sigma_{RS}^2 = \frac{1}{N}\sum_{n=t-N}^{t} \ln\left(\frac{H_n}{O_n}\right)\left[\ln\left(\frac{H_n}{O_n}\right) - \ln\left(\frac{C_n}{O_n}\right)\right] + \ln\left(\frac{L_n}{O_n}\right)\left[\ln\left(\frac{L_n}{O_n}\right) - \ln\left(\frac{C_n}{O_n}\right)\right]$$

Rogers, Satchell,and Yoon (1994) report that the Rogers-Satchell estimator yields theoretical efficiency gains compared to the Garman-Klass estimator. They also report that the Rogers-Satchell estimator appears to perform well with changing drift and as few as 30 daily observations.

Yang and Zhang

Yang and Zhang (2000) make further refinements by deriving a price range estimator that is unbiased, independent of any drift, and consistent in the presence of opening price jumps. Their estimator σ_{YZ}^2 thus can be written as

$$\sigma_{YZ}^2 = \frac{1}{N-1}\sum_{n=t-N}^{t}\left[\ln\left(\frac{O_n}{C_{n-1}}\right) - \overline{\ln\left(\frac{O_n}{C_{n-1}}\right)}\right] + \frac{k}{N-1}\sum_{n=t-N}^{t}\left[\ln\left(\frac{O_n}{C_{n-1}}\right) - \overline{\ln\left(\frac{O_n}{C_{n-1}}\right)}\right]$$

$$+(1-k)\sigma_{RS}^2$$

Where $k = \dfrac{0.34}{1.34 + \dfrac{N+1}{N-1}}$

The symbol $\overline{X}$ is the unconditional mean of X and σ_{RS}^2 is the Rogers-Satchell estimator. The Yang-Zhang estimator is simply the sum of the estimated overnight variance, the estimated opening market variance, and the Rogers and Satchell (1991) drift independent estimator. The resulting estimator therefore explicitly incorporates a term for the closed market variance.

Annual Average Returns

Daily stock returns are calculated by the log difference change in the price, using the following formula where denotes logarithmic return on day r(t), I(t) denotes Index price on day t and ln is the natural log

$r(t)=\ln(I(t)/I(t-1))$

The average annual returns are calculated for the selected stocks and results are presented in table 1. It can be observed that majority of the stocks during the study period exhibited positive returns after recovery from financial crisis 2008, except for the year 2011; almost all the selected stocks generated negative returns to investors due to Sharpe changes in the financial and economic conditions of the economy.

Classical Volatility

The classical volatility estimators are calculated by using close- close volatility and open-open volatility of select stocks in the study. Volatility of stocks is measured by using standard deviation. Table 2 presents the close-to-close volatility of select stocks and it can

Table 1 : Average Annual Returns

Companies	2009	2010	2011	2012	2013	2014	AVEARAGE
INDIAN OIL	-0.00565	0.0004	-0.00121	0.00022	-0.0009	0.00279	-0.00073
BPCL	0.00196	0.00016	-0.00126	-0.00113	-0.00007	0.00331	0.000495
SBI	0.00247	0.00087	-0.00223	0.00148	-0.00116	-0.00062	0.000135
ONGC	0.00038	0.00029	-0.00365	0.00017	0.00031	0.00202	-0.00008
COAL INDIA	NA	-0.00218	-0.0002	0.00061	-0.0008	0.00139	-0.00024
BHARTI AIRTEL	-0.0015	0.0003	-0.00014	-0.00029	0.00012	0.00069	-0.00014
ICICI BANK	0.00172	0.00104	-0.00202	0.002	-0.00029	0.00173	0.000697
MAHINDRA & MAHINDRA	0.00043	0.00162	0.00094	0.00075	0.00129	0.00065	0.000947
MRPL	-0.00061	-0.00025	-0.00139	0.00062	-0.00138	0.00043	-0.00043
TCS	0.0037	0.00167	0.00001	0.0003	0.00213	0.0009	0.001452
GAIL	0.00255	0.00087	-0.00116	-0.0003	-0.00016	0.00091	0.000452
WIPRO	0.003	-0.00126	-0.00087	-0.00006	0.00135	-0.00045	0.000285
INFOSYS	0.00235	0.00111	-0.00089	-0.00067	0.00157	-0.00109	0.000397
JSW STEEL	0.00366	0.00058	-0.00336	0.00181	0.00087	0.00093	0.000748
HDFC	0.00197	0.00128	-0.00685	0.00177	-0.00007	0.00188	-3.3E-06
RUCHI SOYA IND.	0.00413	0.00101	-0.001	-0.00141	-0.00199	0.00044	0.000197
AXIS	0.00188	0.00127	-0.00208	0.00197	-0.00016	0.00292	0.000967
TATA POWER	0.00113	-0.00006	-0.01106	0.00089	-0.0007	-0.0025	-0.00205
HERO MOTO CORP	0.0015	0.00059	0.00024	-0.00039	0.00033	0.00147	0.000623
UNION BANK	0.00138	0.00106	-0.00283	0.00182	-0.00288	0.00278	0.000222
ADITYA BIRLA NUVO. LTD.	-0.00005	-0.00015	-0.00048	0.0015	0.00049	0.0011	0.000402
HCL TECHNOLOGIES	0.00401	0.00079	-0.00067	0.0018	0.00275	0.00128	0.00166
RELIANCE COMMUNICATION	-0.00375	-0.00069	-0.00293	0.00021	0.00217	-0.0012	-0.00103
ULTRATECH	0.00164	0.00066	0.00029	0.00205	-0.00048	0.00233	0.001082
IDBI BANK	0.00281	0.00098	-0.00298	0.00136	-0.00198	0.00158	0.000295

Source: Computed by author

be evident that average volatility is higher in case of Axis Bank 0.04 and Tata Power 0.03. During the study period select sample stocks exhibited volatility in the range of 0.01 to 0.02.

Second measure of classical volatility is estimating standard deviation of stocks by considering the opening prices as a basis. Table 3 presents the volatility in the form of Open-Open prices standard deviation. During the study period select sample stocks exhibited volatility in the range of 0.01 to 0.03, except AXIX Bank with a higher volatility of 0.05.

Table 2 : Close-Close Standard Deviation

STOCK	2009	2010	2011	2012	2013	2014	Average
INDIAN OIL	0.07314	0.01919	0.01686	0.0126	0.02168	0.0234	0.027812
BPCL	0.0201	0.02043	0.01914	0.04693	0.02458	0.02254	0.02562
SBI	0.00217	0.0191	0.02126	0.02003	0.0195	0.00907	0.015188
ONGC	0.01452	0.01543	0.0504	0.01461	0.02163	0.02227	0.023143
COAL INDIA		0.01733	0.02099	0.01462	0.01746	0.02363	0.018806
BHARTI AIRTEL	0.02881	0.02075	0.01849	0.02002	0.02274	0.01659	0.021233
ICICI BANK	0.02367	0.01935	0.02233	0.01823	0.02241	0.01768	0.020612
MAHINDRA & MAHINDRA	0.02834	0.02327	0.02309	0.01741	0.0139	0.01347	0.019913
MRPL	0.00203	0.02012	0.02355	0.02158	0.02295	0.01212	0.017058
TCS	0.01788	0.01665	0.01961	0.01588	0.01538	0.01655	0.016992
GAIL	0.00208	0.01357	0.01629	0.01662	0.017	0.00889	0.012408
WIPRO	0.0017	0.03648	0.01794	0.01499	0.0193	0.00849	0.016483
INFOSYS	0.00152	0.01407	0.0188	0.0169	0.02249	0.00998	0.01396
JSW STEEL	0.03342	0.02618	0.03072	0.02598	0.02482	0.0212	0.027053
HDFC	0.00132	0.01553	0.10337	0.0123	0.01821	0.00796	0.026448
RUCHI SOYA IND.	0.02873	0.03471	0.02055	0.01816	0.03247	0.02668	0.026883
AXIS BANK	0.02095	0.01832	0.02352	0.02139	0.02593	0.18363	0.048957
TATA POWER	0.00161	0.01479	0.14875	0.02063	0.02226	0.01259	0.036772
HERO MOTO CORP.	0.02005	0.0205	0.01931	0.01278	0.01694	0.01571	0.017548
UNION BANK	0.01907	0.01949	0.02367	0.02491	0.03265	0.03138	0.025195
ADITYA BIRLA NUVO. LTD.	0.02227	0.0193	0.01823	0.01793	0.01974	0.01839	0.01931
HCL TECHNOLOGIES	0.02696	0.02021	0.02235	0.01514	0.01806	0.01777	0.020082
RELIANCE COMMUNICATION	0.00284	0.02677	0.03316	0.02729	0.03615	0.01628	0.023748
ULTRATECH	0.02179	0.017	0.01614	0.01379	0.01815	0.01758	0.017408
IDBI BANK	0.02656	0.02284	0.02139	0.02078	0.02056	0.02693	0.023177

Source: Computed by author

Table 3 : Open-Open Standard Deviation

STOCK	2009	2010	2011	2012	2013	2014	Average
INDIAN OIL	0.07303	0.0237	0.02158	0.02069	0.02504	0.02468	0.031453
BPCL	0.02418	0.02295	0.0195	0.04668	0.02548	0.02349	0.027047
SBI	0.00219	0.02223	0.0227	0.02188	0.02179	0.00942	0.016702
ONGC	0.01796	0.01736	0.04819	0.0161	0.02294	0.02294	0.024248
COAL INDIA		0.03199	0.02828	0.01437	0.01877	0.02367	0.023416
BHARTI AIRTEL	0.0312	0.02371	0.0198	0.02039	0.02457	0.01739	0.022843
ICICI BANK	0.06359	0.09796	0.10002	0.12419	0.093	0.12528	0.100673
MAHINDRA & MAHINDRA	0.02934	0.02317	0.02429	0.01686	0.01283	0.01269	0.019863
MRPL	0.00234	0.02247	0.03281	0.03203	0.02854	0.01414	0.022055
TCS	0.02212	0.01738	0.02112	0.01495	0.0165	0.0163	0.018062
GAIL	0.00252	0.02258	0.01818	0.01776	0.01815	0.00832	0.014585
WIPRO	0.00158	0.03366	0.01953	0.01504	0.01823	0.00946	0.01625
INFOSYS	0.00145	0.01444	0.02061	0.01607	0.01813	0.00931	0.013335
JSW STEEL	0.0319	0.02847	0.0328	0.02797	0.02581	0.02175	0.028117
HDFC	0.00161	0.02339	0.10309	0.01347	0.0181	0.00798	0.02794
RUCHI SOYA IND.	0.03038	0.03675	0.02357	0.02102	0.04107	0.03429	0.03118
AXIS	0.02263	0.02293	0.02327	0.02208	0.02813	0.18559	0.050772
TATA POWER	0.00164	0.01703	0.14497	0.02298	0.02445	0.01355	0.037437
HERO MOTO CORP.	0.02382	0.02075	0.02124	0.0138	0.01702	0.0179	0.019088
UNION BANK	0.0235	0.0255	0.02657	0.02976	0.03506	0.03337	0.02896
ADITYA BIRLA NUVO. LTD.	0.02628	0.02125	0.02149	0.02267	0.02172	0.01921	0.022103
HCL TECHNOLOGIES	0.03911	0.02191	0.02329	0.01594	0.01961	0.01874	0.0231
RELIANCE COMMUNICATION	0.00331	0.02893	0.03218	0.03015	0.03921	0.01569	0.024912
ULTRATECH	0.02608	0.02018	0.02086	0.02132	0.01829	0.01868	0.020902
IDBI BANK	0.02966	0.02366	0.02489	0.02385	0.02353	0.02854	0.025688

Source: Computed by author

Basic Volatility Estimators like Skewness and Kurtosis (higher order movements) are depicted in table 4. Kurtosis measures the peakness (or) flatness of the distribution of each stock in the sample. It can be observed in three forms viz., Mesokurtic, Leptokurtic and Platykurtic. Select sample stocks distributions may fall into any of these distributions.

Table 4 : Skewness and Kurtosis

STOCK	Skewness	Kurtosis
INDIAN OIL	2.209555	6.292307
BPCL	-0.08498	-1.25903
SBI	0.552517	0.165555
ONGC	0.863438	-0.96811
COAL INDIA	-0.059689	-0.725708
BHARTI AIRTEL	0.410292	0.09293
ICICI BANK	0.740311	0.691765
MAHINDRA & MAHINDRA	0.339935	-1.01492
MRPL	-0.45372	-0.59651
TCS	0.735824	-0.33944
GAIL	0.302762	-0.95878
WIPRO	0.931605	0.046142
INFOSYS	0.355841	-0.47186
JSW STEEL	0.362166	-0.92861
HDFC	0.640273	-1.31386
RUCHI SOYA IND.	-0.33924	-0.77242
AXIS	9.55272	96.25934
TATA POWER	0.348041	-1.8499
HERO MOTO CORP.	0.571071	0.838206
UNION BANK	0.008836	-0.63559
ADITYA BIRLA NUVO. LTD.	0.888326	0.178881
HCL TECHNOLOGIES	1.292833	0.374972
RELIANCE COMMUNICATION	1.061379	1.597906
ULTRATECH	0.49646	-0.7232
IDBI BANK	0.295114	-0.11414

Source: Computed by author

Skewness measures the degree of asymmetry of the distribution of stocks. Skewness can be examined in three different forms viz., normal skewness, positive skewness and negative skewness.

It is evident from table 4 that majority of the stocks have positive skewness i.e. long right tail with higher values in the distribution. Stocks like BPCL, Coal India Ltd, MRPL, and Ruchi Soya were negatively skewed i.e. long left tails with lower values. In case of Kurtosis stocks depicted negatively skewed distributions (platykurtic), whereas few select stocks exhibited positive kurtosis i.e. leptokurtic. However, the presences of excess kurtosis and the signs of skewness confirm the non-normality of the returns.

Range Based Volatility

In this section range based volatility estimators are discussed. These estimators measure the intra-day volatility (volatility within the trading day) of select stocks during the study period. These measures indicate the behavior of select stocks in a particular day. Intraday volatility is calculated with the help pf Parkinson Model and Garman Klass Model. Table 5 presents the results of Parkinson's Estimator and Table 6 depicts the results of Garman Klass Estimator.

Table 5 Parkinson's Estimator, shows that Bharti Airtel has been an exceptional company that had shown very high values throughout 2009-14. Though the estimator values for Bharti Airtel might be decreasing with time but still they are very high as compared to other companies. SBI had too showed very high values from 2009-13, but in 2014 its estimator value has drastically fallen.

Table 5 : Parkinson's Estimator

STOCK	2009	2010	2011	2012	2013	2014
INDIAN OIL	0.02135	0.02066	0.01915	0.01664	0.02236	0.0237
BPCL	0.02263	0.02147	0.02217	0.01865	0.02398	0.02343
SBI	0.10961	0.19205	0.25022	0.2699	0.22715	0.03224
ONGC	0.0211	0.01626	0.01946	0.01803	0.02154	0.02143
COAL INDIA		0.02597	0.02132	0.01733	0.01823	0.02088
BHARTI AIRTEL	0.26889	0.29325	0.31978	0.29847	0.38591	0.13271
ICICI BANK	0.02294	0.01987	0.01953	0.01848	0.01879	0.01744
MAHINDRA & MAHINDRA	0.02643	0.02178	0.02039	0.01525	0.01176	0.01122
MRPL	0.02316	0.02089	0.02616	0.0265	0.02734	0.01211
TCS	0.02028	0.01662	0.01808	0.01603	0.01507	0.01546
GAIL	0.02579	0.01788	0.01829	0.0193	0.01874	0.0102
WIPRO	0.01842	0.01735	0.02141	0.01876	0.01827	0.00955
INFOSYS	0.01528	0.01386	0.01561	0.01583	0.01328	0.00635
JSW STEEL	0.02869	0.02286	0.03096	0.0255	0.02533	0.02144
HDFC	0.01563	0.01666	0.01801	0.01588	0.01677	0.0081
RUCHI SOYA IND.	0.02874	0.03279	0.02838	0.02616	0.03348	0.03316
AXIS	0.02011	0.01913	0.02133	0.02031	0.02248	0.03246
TATA POWER	0.01882	0.01632	0.02122	0.0229	0.02164	0.01183
HERO MOTO CORP.	0.02059	0.0186	0.01937	0.01265	0.01741	0.01792
UNION BANK	0.02333	0.02218	0.02666	0.02814	0.03057	0.03175
ADITYA BIRLA NUVO. LTD.	0.02543	0.01981	0.02149	0.02048	0.02009	0.0196
HCL TECHNOLOGIES	0.03072	0.02154	0.02116	0.01653	0.01792	0.01761
RELIANCE COMMUNICATION	0.02977	0.02355	0.03091	0.02769	0.03451	0.01511
ULTRATECH	0.02506	0.02	0.02161	0.01951	0.01938	0.02007
IDBI BANK	0.02619	0.02159	0.02283	0.02209	0.02176	0.02619

Source: Computed by author

Apart from the above mentioned companies, HCL Technologies showed slightly high values in 2009. Similarly, Ruchi Soya Industries and Reliance Communication too showed high values in 2010 and 2011 respectively. In 2013, Union Bank and Reliance Communication were on peak and in 2014 it is Ruchi Soya Industries again. While other company's maintained almost low values throughout the study period.

Table 6 Garman-Klass estimator, shows that for many companies this estimator is higher like HCL Technologies, Bharti Airtel, Reliance Communication, JSW Steel and Mahindra and Mahindra in 2009 due to the effect of the 2008 financial crisis that struck the whole globe. Compared to 2009 not many companies have shown high volatility in 2010 except Coal India

Table 6 : Garman Klass Estimator

STOCK	2009	2010	2011	2012	2013	2014
INDIAN OIL	0.02526	0.02439	0.02263	0.01967	0.02642	0.02804
BPCL	0.02678	0.02538	0.02624	0.02206	0.02835	0.02772
SBI	0.02293	0.01951	0.02252	0.02283	0.02093	0.01021
ONGC	0.02502	0.01921	0.02302	0.02136	0.02547	0.02534
COAL INDIA		0.03056	0.02517	0.02054	0.0215	0.0246
BHARTI AIRTEL	0.03592	0.02377	0.02527	0.02402	0.02728	0.02071
ICICI BANK	0.02709	0.02347	0.02308	0.02186	0.0222	0.02062
MAHINDRA &MAHINDRA	0.03128	0.02576	0.02413	0.01803	0.01391	0.01327
MRPL	0.02741	0.0247	0.03089	0.03132	0.03233	0.01431
TCS	0.02396	0.01966	0.02137	0.01898	0.01778	0.01825
GAIL	0.03054	0.02112	0.02164	0.02286	0.02218	0.01209
WIPRO	0.02181	0.02052	0.02537	0.02225	0.02163	0.01129
INFOSYS	0.01807	0.01637	0.01843	0.01874	0.01569	0.00749
JSW STEEL	0.03389	0.02702	0.0366	0.03015	0.02994	0.02537
HDFC	0.01851	0.01964	0.0213	0.01881	0.01983	0.00957
RUCHI SOYA IND.	0.03399	0.03872	0.03364	0.031	0.03953	0.03922
AXIS	0.02379	0.02261	0.0252	0.024	0.02658	0.18303
TATA POWER	0.02231	0.01932	0.02509	0.02709	0.02557	0.01399
HERO MOTO CORP.	0.02433	0.02198	0.02288	0.01497	0.02059	0.02122
UNION BANK	0.0276	0.02623	0.03155	0.03325	0.03611	0.03754
ADITYA BIRLA NUVO. LTD.	0.03009	0.02344	0.02542	0.02421	0.02375	0.02318
HCL TECHNOLOGIES	0.03628	0.02548	0.02503	0.01957	0.02116	0.02081
RELIANCE COMMUNICATION	0.03511	0.02781	0.03652	0.03273	0.04076	0.01784
ULTRATECH	0.02965	0.02366	0.02556	0.02306	0.02291	0.02374
IDBI BANK	0.03094	0.02554	0.027	0.02611	0.02572	0.03094

Source: Computed by author

that went public in that year. In 2012, JSW Steel and Union Bank have shown increased volatility in shares. Companies like Reliance communication and Mangalore Refinery and Petrochemicals Limited have shown a consistent increase in volatility from 2009 to 2014, but in 2014 the volatility has come down drastically for both the companies which is a good indication.

Ruchi Soya Industries and Union bank has been continuously showing increased volatility from 2009 to 2013. But simultaneously companies like TCS, Infosys and HDFC has been consistently showing decreased volatility in share prices throughout the years from 2009 to 2014. This is a very good indication for the company. Axis Bank has shown a drastic increase in volatility in 2014 compared to its previous years.

Drift Independent Volatility Measures

In this section, drift independent volatility measures like Roger Satchell (1991& 1994) and Yang and Zhang (2000) estimations are analyzed. Roger Satchell estimator uses only high, low, close prices, but not open price. It attributes to no movement to overnight and is independent of any underlying drift. In case of Yang and Zhang estimator, it is volatility-squared estimator dealing with opening price jumps. It has smallest variance among all the estimators.

Table 7 Roger-Satchell's Estimator shows that SBI is the maiden company that has shown higher values throughout the study period from 2009-14. Its values were continuously increasing from 2009-12 but in the past 2 years they have slightly decreased. Other companies in the sample have very small values for this estimator.

Table 8 Yang-Zhang drift independent estimator shows that Indian Oil, HDFC Bank exhibiting high value for the years 2009 and 2011 respectively. SBI too showed high estimator value for the years 2010, 2011 and 2013. While companies like Axis Bank, IDBI Bank, UltraTech Cement showed stagnant values throughout the study period i.e 2009-14.

Policy Implications for the Study

This study will guide the policy makers in understanding the movement of asset returns viz., shares in the aftermath of recession and will help them in examining the behavior of volatility. This study mainly helps the policy makers in the selection of appropriate asset class and for formulation of portfolios with diversified asset class.

Limitations for the Study

The research study is not covering the areas like modeling and forecasting volatility for hedging options, risk management, derivative pricing and asset management etc., such financial applications (Taylor, 2013). This study is covering the process of identification and estimation

Table 7 : Roger-Satchell's Estimator

STOCK	2009	2010	2011	2012	2013	2014
INDIAN OIL	0.00051	0.00041	0.00038	0.00029	0.0005	0.00059
BPCL	0.00053	0.00048	0.00062	0.00038	0.0006	0.00058
SBI	0.03803	0.05762	0.07953	0.10549	0.0741	0.01173
ONGC	0.00064	0.00028	0.0004	0.00048	0.00048	0.00046
COAL INDIA		0.00052	0.00041	0.00043	0.00037	0.00042
BHARTI AIRTEL	0.00093	0.00037	0.00056	0.00051	0.00054	0.00032
ICICI BANK	0.00052	0.0004	0.00038	0.00046	0.00035	0.00033
MAHINDRA & MAHINDRA	0.00076	0.00049	0.00045	0.00024	0.00015	0.00013
MRPL	0.00064	0.00048	0.00065	0.00074	0.00083	0.00015
TCS	0.00043	0.00031	0.00034	0.00036	0.00021	0.00025
GAIL	0.00074	0.00031	0.00035	0.00052	0.00038	0.00012
WIPRO	0.0004	0.00031	0.00063	0.00055	0.00039	0.0001
INFOSYS	0.00026	0.00019	0.00024	0.00037	0.00017	0.00004
JSW STEEL	0.00078	0.00054	0.00099	0.00066	0.00065	0.00048
HDFC	0.00029	0.00023	0.00035	0.00038	0.00029	0.00007
RUCHI SOYA IND.	0.00084	0.00106	0.00105	0.0009	0.00113	0.00125
AXIS	0.00043	0.00038	0.00045	0.00044	0.00052	0.00088
TATA POWER	0.00042	0.0003	0.00046	0.00066	0.00046	0.00014
HERO MOTO CORP.	0.00044	0.00034	0.00037	0.00018	0.00033	0.00038
UNION BANK	0.00059	0.00055	0.00077	0.00082	0.00086	0.00108
ADITYA BIRLA NUVO. LTD.	0.00071	0.00043	0.00053	0.00044	0.00042	0.00041
HCL TECHNOLOGIES	0.00089	0.00049	0.0005	0.00032	0.0003	0.0003
RELIANCE COMMUNICATIO N	0.00081	0.00051	0.00093	0.00077	0.00108	0.00021
ULTRATECH	0.00072	0.00046	0.00061	0.00046	0.0004	0.00047
IDBI BANK	0.00065	0.00052	0.00054	0.00049	0.00049	0.00064

Source: Computed by author

of accurate estimators and using this estimator for a hedging problem. Moreover the study is not investigating the usage and application of "stylized facts" or "Stylized features". RamaCont. (2001) study on "Empirical Properties of Asset Returns: Stylized Facts and Statistical Issues", examines stylized fact as asymmetry of time scales: coarse-grained measures of volatility predict fine-scale volatility better than the other way round. In simple terms different asset classes will exhibit different properties from statistical point of view and exhibit random variations of asset prices do share some quite non trivial statistical properties. Such properties

Table 8 : Yang-Zhang Drift Independent

STOCK	2009	2010	2011	2012	2013	2014
INDIAN OIL	0.07488	0.02296	0.02246	0.02056	0.02451	0.02616
BPCL	0.02509	0.02349	0.02512	0.04811	0.02618	0.02523
SBI	0.04641	0.09994	0.10134	0.1150	0.09713	0.01333
ONGC	0.02503	0.0199	0.04865	0.02097	0.02388	0.0237
COAL INDIA		0.02214	0.02602	0.01965	0.02035	0.02347
BHARTI AIRTEL	0.03248	0.02239	0.02436	0.02264	0.02504	0.01887
ICICI BANK	0.02782	0.02492	0.02268	0.0212	0.02188	0.01931
MAHINDRA & MAHINDRA	0.03008	0.02464	0.02475	0.01785	0.01435	0.0134
MRPL	0.02613	0.02438	0.0308	0.03163	0.03269	0.01367
TCS	0.02382	0.01906	0.02112	0.01873	0.0162	0.01666
GAIL	0.02998	0.0221	0.0205	0.02249	0.02052	0.01093
WIPRO	0.0208	0.03642	0.02524	0.0220	0.02163	0.01021
INFOSYS	0.01775	0.01565	0.0197	0.02032	0.01815	0.00903
JSW STEEL	0.03093	0.0275	0.03243	0.02832	0.02671	0.0228
HDFC	0.01973	0.02175	0.10416	0.01802	0.01888	0.0088
RUCHI SOYA IND	0.03117	0.03716	0.03324	0.02972	0.03869	0.03891
AXIS	0.02363	0.02254	0.02401	0.0223	0.02594	0.02103
TATA POWER	0.02225	0.01979	0.14676	0.02606	0.02284	0.0137
HERO MOTO CORP.	0.02429	0.02031	0.02089	0.01485	0.01922	0.01946
UNION BANK	0.02523	0.02726	0.02989	0.03085	0.0319	0.0337
ADITYA BIRLA NUVO. LTD.	0.02938	0.02406	0.0258	0.02357	0.02202	0.02138
HCL TECHNOLOGIES	0.03633	0.02486	0.02481	0.01921	0.01915	0.0187
RELIANCE COMMUNICATION	0.03236	0.02771	0.0336	0.03007	0.03568	0.01522
ULTRATECH	0.02795	0.02299	0.02512	0.02383	0.0213	0.02156
IDBI BANK	0.02708	0.02508	0.0258	0.0239	0.02415	0.02729

Source: Computed by author

are common across different markets, instruments and time periods. The study conducted for blue chip companies and this may be further extended to mid cap companies and small cap companies to investigate their volatility in the post-recession.

Conclusion

The study mainly investigated the stock market volatility of select stocks during the post-recession scenario i.e.2009-14, for 1298 trading days across 25 select stocks from NSE-NIFTY. The study applied range based volatility estimators to examine the behavior stocks in the post-recession and concluded that higher volatility experienced during 2010 in the early

stages of recovery of the market and stocks like Bharati Airtel, HCL Technologies, Ruchi Soya Industries, Reliance Communications, Union Bank of India etc., depicted higher volatility. Index weightage stocks like TCS, Infosys, HDFC are stagnant during the period.

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