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AN ENQUIRY INTO STABILITY AND EFFICIENCY IN INDIAN STOCK MARKET DURING POST REFORMS PERIOD

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Abstract: Stock market stability and efficiency play an important role to the investors as well as regulatory authorities. This study investigates the impact of recent financial crisis on the Indian stock market in the context of its efficiency and stability during post reforms era. In other words, this paper examines the weak form of efficiency of the Indian stock markets and also identifies the stability of stock market by measuring volatility centering the period of recently held global financial crises using daily returns of 2 major indices of BSE (Sensex), NSE (Nifty50) and 5 sectoral indices of NSE. We have applied break-point test, unit root test, auto-correlation test, runs test, volatility clustering test using GARCH (1,1) and EGARCH (1,1) models during the period of Jan 1996 to September 2022. The findings of the paper evidence the weak form of pricing inefficiency of the Indian stock market and also high persistence of volatility clustering in the stock returns indicating that the stock market is neither efficient nor stable over time (volatility is changing). Indian stock market becomes relatively stable after 2007-08 financial crisis. The outcomes of the paper help generate an intense hint to the investors and policy makers while making their decisions.

Keywords: Efficient Market Hypothesis (EMH), Random Walk Model, structural break, stability of Indian stock market, global financial crisis, EGARCH

JEL classification: G14, G01, G15

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1. INTRODUCTION

Stock market development induces economic growth when it is efficient and stable. In other words, stock market stability and efficiency play an important role to the investors and regulatory authorities in making useful decisions for the overall development of the economy. Efficient and stable stock market influences the investment decision of investors. In an efficient stock market trading remains friction free. Relevant information is accessible to all and that is quickly impounded within the stock prices in which jump (not slow) response is observed here.With efficient pricing mechanism, savings and investment of an economy are allocated in an efficient manner. In case of efficient market there will be no undervalued or overvalued securities in the long run. So, there is no scope of profitable trading activities consistently and continuously, i.e., returns from securities, following sub-martingale stochastic process,do not remain consistently higher or lower than their respective expected returns for given risks. All assets offer optimal reward to risk. If the markets are not efficient, excess returns can be made by correctly picking the winners. Likewise, an unstable market becomes excessively speculative, thus be distorting for efficient allocation of resources.

The term market efficiency was first coined by Eugene Fama in 1970 and he used three different forms of efficiency, *viz* weak, semi-strong and strong forms of efficient market hypothesis.In the weak form of pricing efficiency, it is argued that future stock price cannot be predicted by using its past prices or historical price series, i.e. past price information cannot be used to earn superior returns from stock trading. In other forms of pricing efficiency other sets of information are used and even by increasing base of information investors are unable to achieve a competitive advantage over others in investing process through acquiring any particular relevant information.

Efficiency of an emerging market is more important especially in case of integration with more developed markets and also for cross border capital movements. Again, stability of any stock market is also important to make market more liquid, i.e., as stability increases over time liquidity also increases putting, however, restriction on excessively speculative activities. Stock price behavior has drawn interest to the researchers, economists and investors because this helps in capital formation, wealth distribution and also has implications on investors' rationality. In the last three decades, several developing countries have initiated reforms process to open their economies (termed as emerging economies) and to make their capital markets (known as emerging markets)

comparable with the developed counterparts which are mostly efficient and stable. Among these India has started its reforms process since 1990-'91 and has received its more than fair share of foreign investment inflows. This also happened because of Asian crisis which affected all the fast-developing East Asian tigers vigorously. At that time India maintained its high economic growth with stability (Gupta and Basu, 2005), that established the ground for enquiring present state of its stock market efficiency and stability.

Here we would also like to investigate the impact of recent financial crisis on the Indian stock market during post reforms era. Financial crisis is a state when the values of financial assets or institutions fall rapidly which is associated with a run on the banks. In this situation, the investors sale their assets and customers withdraw their money from savings expecting that the value of those assets will drop. There were actually two financial crises after reforms; one was in 2001 (known as bursting of dot-com bubble) and another was in the end of 2007 and beginning of 2008 (coined as bursting of real estate bubble or financial meltdown). Between these two crises latter one was stronger in its width and breadth compared to the former. During the time periods of financial meltdown there was wide spread destruction to the financial markets around the world. There was a doldrum in the global stock market scenario with liquidity short fall in US banking system and also fall in stock prices because of collapsing of many investment bankers and companies like Lehman Brothers, Merill Lynch etc. The stock markets suffered huge losses around the world. At this critical stage it is necessary to examine the efficiency level and the stability of the Indian Stock Market to establish its long-term role in development process.

The rest of the paper divided into four parts as follows: Literature Survey, Data and Methodology, Empirical findings and Conclusion.

2. LITERATURE SURVEY

On the question of stability and efficiency, various researchers have given their different findings and opinions on worldwide different stock markets. The findings were not similar, rather, often, contradictory. Here we consider only those studies which are made on the basis of weak form of market efficiency on the Indian stock market and also on the measures of volatility of the Indian Stock Market.

According to literature the first study on efficiency was made by Krishna Rao and Mukherjee in 1971. They tested the independence of price change

of the Indian aluminum companies shares taking fifteen years data and found the randomness of price movements. After that Ray (1976) examined daily return of seven indices during 1996 to 1972 and ended with mixed result of the randomness nature of seven companies. Next Sharma and Kennedy (1977) examined the pattern of stock indices of London, New York and Bombay stock exchanges during the period 1963-1973 usingRuns test and spectral analysis. They found that all the stock markets were following random walk and they concluded that the Bombay Stock Exchange (BSE) was equivalent to the advanced industrialized countries' markets. Vaidyanathan and Gali (1994) examined the weak form of efficiency in the Indian capital market based on daily closing prices of ten shares traded on the BSE during four different periods of time. They used Runs tests, Serial Correlation Test, Filter Rule Test for the analysis and found that all three tests supported the weak form of efficiency. Belgaumi (1995) also analyzed the weak form of efficient market hypothesis in the Indian stock market. This paper examined the share price movements over short period such as week for the April 1991 to March 1992 using Random Walk Model, Runs test and Serial Correlation test on individual weekly share price series of selected companies collected from Economic Times All India Index of ordinary shares, with the base year 1985 = 100. He ended with the conclusion that the pattern of share prices over a short period did not follow any particular pattern. Sharma and Mahendru (2009) tried to examine the validity of the EMH on the Indian securities market by taking eleven securities of BSE over the period 30 June 2007 to 27 Oct 2007. From the findings of the study it was concluded that there was very modest effect of past stock prices on future prices. So, investors were unable to make profit by using the share price trend which followed random walk model.Lasrado and Rao (2010) studied the informational efficiency in its weak form for the Indian stock market in the liberalization era (1995 to 2005) on the basis of four major stock price indices, namely, Sensex, Nifty, S&PCNX 500 and BSE 100. The findings indicated that the Indian stock market was informationally efficient in the weak form.

The findings of Kulkarni (1978),Gupta and Basu (2007), Khan et.al. (2011), Sharma and Seth (2011), Rehman *et. al.* (2012), Poshakwale (1996), contradict thesaid studies. Kulkarni (1978) studied on the weekly data of RBI of stock price indices for Calcutta, Delhi, Madras, Bombay and Ahmedabad stock exchanges and also studied on the monthly indices data of six different industries by using spectral methods and observed a repeated cycle of four weeks for weekly data and there was seasonality in case of monthly stock prices

of the indices. The findings of this study rejected the randomness in changes of price, i.e., stock prices did not follow random walk. Poshakwale (1996) also attempted to test the weak form of efficiency and also the day of the week effect on the BSE using BSE national index data during the period 1987-1994. The findings indicated non-random nature of the series i.e., there was violation of the weak form of efficiency in the BSE.Gupta and Basu (2007) tested the weak form of efficiency in the framework of random walk hypothesis for India during 1991-2006. This study suggested that the series did not follow Random walk model and there was significant autocorrelation in both the BSE and NSE markets which suggested that there were increased movements of investments across international boundaries stating integration of world economies. Khan *et.al.* (2011) also examined the efficiency of the Indian Stock Market on daily closing values of NSE and BSE during the period 2000 to 2011 using Runs test and wrapped up the study with the non-randomness nature of Indian stock market.Sharma and Seth (2011) also did the same thing, during the study period 01.11.2000 to 31.10.2010 and found same result like khan *et. al.* Rehman *et. al.* (2012) examined the weak form of efficiency of South Asian Stock markets, during the period 1998 to 2011 by applying autocorrelation Test, Q Statistics and Unit Root Test. The findings of the study conclude that only Colombo Stock Exchange is weak form efficient but Karachi and BSE are weak form inefficient.

Next, we briefly survey some literature on measures of volatility. First of all,Karmakar (2005) estimated conditional volatility of Indian stock market with the help of S&P CNX Nifty and BSE Sensex by applying GARCH (1,1) model. This paper gave strong evidence of volatility clustering and persistence of volatility on these two indices and time varying volatility was also observed. Ahmad et.al. (2006) attempted to seek evidence for the weak form of efficient market hypothesis (EMH) using daily stock indices of Nifty of NSE and Sensex of BSE during the period 1999-2004. This paper found, Nifty and Sensex stock indices did not follow random walk and both the markets had high and increasing volatility. These findings suggested immediate dissemination of information on foreign institutional investor trades and there should be improvement in free float of equity to move towards efficiency. Banerjee and Sarkar (2006) examined daily volatility of Nifty index return on five-minute interval intraday data by applying realized volatility measure. The results showed positive and direct relation between the volume of trade and volatility of stock market return. In the study it was also found that the level of FII

(Foreign Institutional Investors) trade didn't have any effect on volatility. Jana and Meher (2012) attempted to investigate the weak form of efficiency in the Indian stock market for the period from 2006 to 2011 by applying Runs test, GARCH Test and Serial correlation test on daily closing price of four indices of BSE (Sensex, BSE 100, BSE 200 and BSE 500) and also four indices of NSE (S&PCNX Nifty, CNX 100, CNX 200 and S&PCNX 500). From their findings it can be said that the return data are non-random and persistent in nature with volatility clustering. Bhowmik (2013) tested the effect of political instability on Indian stock market and measured multidimensional framework of stock market volatility. An inverse relation of volatility with growth rate and international trade was found i.e., high volatility reduced growth rate as well as volume of trade but rise in volatility increased the current account and capital account deficit. Tanty *et. al.* (2016) examined the relation between return and volatility, persistence of volatility clustering and also leverage effect on NSE and BSE during the period of study 1990-2016 by applying ARCH and GARCH model. This study found an evidence of high persistence of volatility clustering on both BSE and NSE and volatility was predictable. Yadav (2017) studied the volatility of the Indian stock market in the context of three basic stock markets namely, BSE, NSE and CSE (Calcutta Stock exchange) to examine the past, present and future characteristics of the stock market. In general, it was observed that the extent of Bull phase was longer than Bear and the volatility was also high in Bull phase. But after liberalization volatility declined for both Bull and Bear phase.

From the past researches it is observed that the studies provide conflicting and contradictory results upon the nature of the Indian stock market. So, it is difficult to conclude any general comment on the status of the stock market of our country from the past studies. That's why the emerging stock market of India draws special attention and motivation of the researchers.

3. DATA AND METHODOLOGY

The Indian stock market started its journey in 1875 in Mumbai. In 1992 SEBI (Security Exchange Board of India) was established to regulate and reform the Indian Stock Market. Bombay Stock Exchange (BSE) played a dominant role in the Indian Stock Market up to late 1990s. NSE (National Stock Exchange) was set up in 1992 (and started its functioning from 1994) with a new institutional structure through a combination of new technology and efficient market network. Due to the Government support and wide network system

NSE is more accessible to domestic and foreign investors. The liquidity and accessibility of the NSE market are the main factors for generating impact on the market efficiency. Here we consider both BSE and NSE as a representation of the Indian stock market.

In the early 1980's there was no index to measure the trends of stock prices. BSE came out with the Sensex bundling 30 stocks in 1986 with base year 1978-'79. The NSE launched the S&P CNX Nifty in 1996 based on 50 stocks; later on, NSE sectoral indices came into the market for better assessments of individual sectors. Both BSE and NSE over time have changed the constitutes of the indices to reflect broad based liquidity and market capitalization and they occupy jointly a major portion of the Indian stock trading. Here we consider daily closing index values of Nifty50 from NSE and SENSEX-30 from BSE and also take four sectoral indices (namely, NIFTY IT, NIFTY BANK, NIFTY FMCG, NIFTY ENERGY& NIFTY PHARMA) of NSE for the study period of 03 Jan 1996 to 31 Oct 2022 as per availability of the data.We calculate the daily compounded logarithmic returns for the analysis.

$$R_t = \ln(p_t)-\ln(p_{t-1}) \quad (1)$$

Where, R_t is return of the Index at time t and P_t is closing value of the Index at time t.

The detailed source of data and their study period according to availability are given in Table 1.

Table 1: Data Base of the Study

NAME	*STUDY PERIOD*	*SOURCE*	*NO OF OBSERVATIONS*
NIFTY50	1/03/1996-10/31/2022	www.nseindia.com	6571
SENSEX	1/03/1996-10/31/2022	www.nseindia.com	6571
NIFTY IT	1/03/1996-10/31/2022	www.nseindia.com	6571
NIFTY FMCG	1/03/1996-10/31/2022	www.nseindia.com	6571
NIFTY BANK	1/04/2000-10/31/2022	www.nseindia.com	5610
NIFTY ENERGY	1/02/2004-10/31/2022	www.nseindia.com	5360
NIFTY PHARMA	1/02/2004-10/31/2022	www.nseindia.com	5360

In weak form of EMH we test two things: first, whetherstock prices follow random walk and second, whether changes in price are independent, i.e., whether historical price changes cannot be used to predict future price.

Unit Root Test is popularly used to test the stationarity of time series data. If Y_t follows a random walk model [I.e., I(1)] then ΔY_t must be stationary. A series is said to be weak stationary if its mean and variance are constant over time and the covariance between two periods depends not on time but on the length of lag between the two time periods. Stationary time series data refers to integrated of order zero, i.e., I (0). If return data is found to be I(0), efficiency condition is fulfilled. Thus, the first condition of efficiency is fulfilled.

Stationarity condition is tested by Perron break point unit root test because our data contain most probably breaks with two financial crises. This tests use the null hypothesis as the series contains unit root. If the series is found to be non-stationary at level and stationary first difference then the market is said to be efficient. Apart from unit root tests there are several other tests for testing of market efficiency. To test weak form of market efficiency we also check whether return distribution is normal or not by Jarque - Bera (JB)test.

If the value of probability for significance is greater than 5% level, we accept the null hypothesis, i.e. the market is said to be efficient in weak form.

The second test of market efficiency is known as autocorrelation test.

Using autocorrelation coefficients, we can test whether share prices are dependent or not.

Test statistic for k^{th} order autocorrelation is:

$$t_0 = \frac{r_k\sqrt{n-k}}{\sqrt{1-r_k^2}} \sim t_{(n-k)} \tag{2}$$

Where n= total number of observations. H_0: $\rho_k = 0$

Now, if the calculated value of $|t_0|$ is less than the table value ($t_{\alpha/2,(n-k)}$) then we accept the null hypothesis.

One may face problem in autocorrelation. If there are number of autocorrelation coefficients and their tests do not generate same results, one may face problem to derive overall conclusion. To resolve this problem there is Q statistic to test the group of autocorrelation coefficients jointly. There are three types of Q statistic, namely Q of Ljung Box, Box-Pierce and Hull.

Here we use most popular Q statistic ofLjung-Box (1978):

$$Q_{LB} = n(n+2)\Sigma_{i=1}^{m}\frac{r_i^2}{n-i} \sim \chi_m^2 \tag{3}$$

Under H_0 : $r_1 = r_2 = \ldots\ldots\ldots = r_i = 0$ where $Q \sim \chi^2_m$ distribution with m degrees of freedom.

The high sample autocorrelation leads to large Q. If the calculated value of Q exceeds the table value of appropriate $\chi^2_{\alpha,m}$, then we reject the null hypothesis, i.e., at least one autocorrelation is not zero. So, market is inefficient.

Next, we apply Run test which is a nonparametric test. 'Run' is a sequence of same observations preceded by and/or followed by other type of observations or no observation. Using Run test one can examine whether the distribution is random or not. Too many runs or too few runs imply that distribution is non-random. For the share price data, we calculate the first differences and then take '+' or '-'signs into account to calculate runs (ignoring zero values). Let 'R' be the total runs, 'n_1' be the no. of '+' signs, 'n_2' be the no. of '-' signs and n= n_1+ n_2 (ignoring zero values).

Then the test statistic is:

$$\frac{R-E(R)}{\sqrt{var(R)}} \tag{4}$$

which approximately follows standard normal distribution.

$$\text{Here E(R)} = \frac{2n_1n_2}{n_1+n_2}+1 \text{ and VAR (R)} = \frac{2n_1n_2(2n_1n_2-n)}{n^2(n-1)}$$

Null hypothesis (H_0): Distribution is random.

If the calculated value of the test statistic lies within ± 1.96 at 5% level of significance, we accept the null hypothesis, i.e. the market is said to be efficient.

In the study we also use the estimation of volatility model, from which both stability and efficiency can be measured. An observable pattern (say clustering effect) in variances of log return series signifies the existence of market inefficiency.Further significant change, if any, in variances of log return series over time evidences instability in the market.

Volatility or uncertainty of security may change over time depending on the conditioning set of information. This volatility can be measured by GARCH-M (Generalized Auto Regressive Conditional Heteroscedasticity) proposed by BOLLERSELV (1986) this model allow the conditional mean to depend on its own conditional variance.

In the GARCH-M (1, 1) the mean equation is:

$$\mu_t = C + \psi\sigma_t^2 + \in_t \tag{5}$$

and the variance equation is: $\sigma_t^2 = \alpha_0 + \alpha_1 \in_{t-1}^2 + \beta_1\sigma_{t-1}^2$ (6)

Where, $\in_t / \psi_{t-1} \sim N(0,t^2)$ *and* $\alpha_0 > 0, \alpha_1 \geq 0, \beta_1 \geq 0$ *and* $var\left(\in_t / y_{t-1}\right) = \sigma_t^2$ (because variance cannot be negative). Moreover, if $\alpha_1 + \beta_1 < 1$, shock will

persist with short memory, i.e., weakly stationary, but if $\alpha_1 + \beta_1 \geq 1$, the shock will have long memory which indicates that the market is inefficient because of highly persistent volatility in the stock return. After estimating GARCH-M (1,1) model we do Engle and Ng test to determine whether there is sign bias or size bias, i.e., whether we should go for EGARCH or not.

For Engle and Ng test the model is

$$\widehat{u_t^2} = \varnothing_0 + \varnothing_1 S_{t-1}^{-} \widehat{u_{t-1}} + \varnothing_3 S_{t-1}^{+} \widehat{u_{t-1}} + v_t \tag{7}$$

Where $\widehat{u_t^2}$ denotes the squared residuals of a GARCH model, ϕ_0 is constant, S_{t-1}^{-} is a dummy variable that takes value 1 if $\widehat{u_{t-1}} < 0$ and zero otherwise, v_t is an error term and S_{t-1}^{+} is defined as $1\text{-}S_{t-1}^{-}$. If ϕ_1 is significant then there remains sign bias and if ϕ_2 or ϕ_3 is found to be significant then size bias also present.

In case of Exponential GARCH there is no parametric restrictions, which was developed by Nelson in 1993. When the stock price is more influenced by negative news compared to positive news, i.e., when there is asymmetric effect, one should apply EGARCH. To know the change of volatility over time due to adoption of particular policy or occurrence of particular event, one can use dummy variable in the variance equation; for EGARCH (1, 1) here the model is:

$$\ln(\sigma_t^2) = \omega + \beta \ln \sigma_{t-1}^2 + \gamma_1 \frac{\in_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left[\frac{|\in_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \lambda_1 D \tag{8}$$

where, D=0 in the pre-event period (before Global financial crisis) and D=1 in the post event period (after 2007-08 crisis). If λ_1 is found to be significantly negative (positive), the event has declining (increasing) effect on volatility instock return. Effect ofGood news: $\alpha + \gamma_0$ and effect of Bad news: $\alpha - \gamma_0$. If $\gamma_0 < 0$, effect of bad news is more pronounced than that of good news.

4. EMPIRICAL RESULTS

4.1. Breakpoint test

First of all, we check whether there is any structural break or not in the series under consideration.For this purpose, we use Quand- Andrews along with Bai Perron unknown (i.e., endogenous) break point(s) test which is also doubly checked by Chow exogenous break point(s) test. If we exclude 2007-08 financial crisis, we find one break date at the mid of 2003 and if we include 2007-08 crisis, we find two break dates; one is the aforementioned date and

another is at the January 2008 for some indices but for the others the break date was on September 2009 i.e., the breaks occurred at adjacent period not on the exact or same break dates of overall indices, probably because of defensive or aggressive nature of the sectoral indices or there may be a lag of passing the shock/information. The Chow test results are presented in Table 2; each being significant corroborates the existence of break points as suggested by endogenous tests.

Table 2: Estimated Results of Chow Test for Breakpoints in Sensex and Nifty

Null Hypothesis: No breaks at specified breakpoints				
Equation Sample: 1/03/1996 to 8/31/2020				
	Varying regressors	*BRAK DATE*	*F - statistic*	*Prob.*
NIFTY 50	DATE	1/09/2008	5.282809	0.0216**
	DATE	5/13/2003	4.021004	0.0450**
SENSEX	DATE	1/09/2008	5.452257	0.0196**
	DATE	5/13/2003	4.585291	0.0323**
NIFTY IT	DATE	3/04/2009	6.278345	0.0122**
	DATE	5/13/2003	4.720891	0.0089*
NIFTY FMCG	DATE	3/12/2009	3.253158	0.0713***
	DATE	4/25/2003	4.291540	0.0137**
NIFTY BANK	DATE	1/15/2008	4.034258	0.0446**
NIFTY ENERGY	DATE	1/09/2008	4.710733	0.0090*
NIFTY PHARMA	DATE	3/12/2009	5.571094	0.0183**

As per the break dates we divide our data into 2 segments: sample 1 refers the sub-period before 2008 financial crisis, sample 2 refers the sub-period after 2007-08 financial crisis as most of the cases we find one break date so we consider only global financial meltdown.

4.2. Unit root test

For examining stationarity of each series, we apply Perron break point unit root tests, the results of which are shown in Table 3. From estimated results it is noticed that the test statistics are highly significant, i.e., we can reject the null hypothesis of the presence of unit root in the return series concerned. So, returnseries being I(0), the original series of both Sensex and Nifty alongwithsectoral indices follow random walk model. Hence the Indian stock market is said to be weak form efficient according to unit rot tests.

Table 3: Unit root test

Break Date: 5/13/2003			*Break Date: 1/09/2008*		*Break Date: 3/12/2009*	
	t-Statistic	*Prob.*	*t-Statistic*	*Prob.*	*t-Statistic*	*Prob.*
SENSEX	-76.79021	< 0.01	-76.81796	< 0.01		
NIFTY 50	-76.75319	< 0.01	-18.568761	< 0.01		
NIFTY IT	-73.41309	< 0.01	**3/04/2009**		-73.48296	< 0.01
NIFTY ENERGY			-68.53095	< 0.01		
NIFTY BANK	**1/15/2008**		-52.58720	< 0.01		
NIFTY FMCG	-78.5310	< 0.01	**4/25/2003**		-78.48628	< 0.01
NIFTY PHARMA					-68.54083	< 0.01

4.3. Normality Test and Descriptive Statistics

Table 4 exhibits the descriptive statistics corresponding to the daily return series of the SENSEX, NIFTY50 along with all sectoral indices. The values of skewness and kurtosis are high implying thereby that the series are negatively skewed, i.e., investors enjoy frequent small gains with hardly any extreme losses. This also hints that investors may also face large negative return but it is less frequent than facing large positive return. Further, the leptokurtic distributions of both BSE and NSE disclose that the series are more peaked having fatter tails, which means it has greater risk of extreme outcomes than normal distribution. Jerque-Bera test statistic is also found to be significant in all cases, suggesting that the underlying distributions are not normal this result is plotted in Histogram for all indices in figure1 to figure 7.

If we consider restricted sample, i.e., in case of 1st sample period both SENSEXand Nifty50 have negative mean return andin case of NIFTY50 we observe positively skewed leptokurtic distribution.The standard deviation (s.d) of thetwo-return series depict that NIFTY50 is less volatile than Sensex in case of full sample but after 2001 financial crises volatility of NIFTY50 increases. If we compare among sectoral indices, it is found that NIFTY IT contains greater risk and NIFTY PHARMA has low risk, but if we consider the effect of before and after crisis, then all the markets over timeare found to be more stable with declining risks.

Table 4: Descriptive Statistics corresponding to Daily return of the Indices

	NIFTY50_RT	*NIFTY_IT_RT*	*SENSEX_RT*	*NIFTY_ FMCG_RT*	*NIFTY_ ENERGY_RT*	*NIFTY_ PHARMA_RT*	*NIFTY_ BANK_RT*
Mean	0.000466	0.000868	0.000461	0.000582	0.000613	0.000482	0.000654
Maximum	0.163343	0.145567	0.159900	0.083898	0.154433	0.111589	0.172394
Minimum	-0.139038	-0.221257	-0.141017	-0.123824	-0.150867	-0.093507	-0.183130
Std. Dev.	0.014887	0.021718	0.014991	0.014031	0.016190	0.012973	0.018801
Skewness	-0.296283	-0.346681	-0.296133	-0.171454	-0.497817	-0.278717	-0.341827
Kurtosis	11.56803	10.23489	10.67657	8.492936	11.63911	8.403393	10.32821
Jarque-Bera	20195.50	14462.89	16230.50	8293.131	16889.71	6589.984	12662.25
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	6571	6571	6571	6571	5360	5360	5610

Table 5: Results of Auto correlation coefficient and Q statistic for Nifty and Sensex

	1/03/1996 - 8/31/2020(FULL SAMPLE)													
	NIFTY 50		*SENSEX*		*NIFTY IT*		*NIFTY FMCG*		*NIFTY BANK*		*NIFTY ENERGY*		*NIFTY PHARMA*	
	A C	*Q-Stat*	*A C*	*Q-Stat*	*A C*	*Q-Stat*	*A C*	*Q-Stat*	*A C*	*Q-Stat*	*A C*	*Q-Stat*	*AC*	*Q-Stat*
1	0.055*	0.055*	0.054*	0.054*	0.098*	0.098*	0.032*	0.032*	0.099*	0.099*	0.068*	0.068*	0.066*	0.066*
2	-0.029*	-0.029*	-0.023*	-0.023*	0.008*	0.008*	-0.020*	-0.020*	-0.035*	-0.035*	-0.020*	-0.020*	0.013*	0.013*
3	-0.002*	-0.002*	-0.006*	-0.006*	0.004*	0.004*	-0.021*	-0.021*	-0.010*	-0.010*	-0.013*	-0.013*	0.015*	0.015*
4	0.007*	0.007*	0.006*	0.006*	0.012*	0.012*	0.015*	0.015*	-0.013*	-0.013*	-0.003*	-0.003*	0.016*	0.016*
5	0.010*	0.010*	-0.004*	-0.004*	0.012*	0.012*	-0.002*	-0.002*	-0.017*	-0.017*	0.004*	0.004*	0.002*	0.002*
6	-0.044*	-0.044*	-0.041*	-0.041*	-0.010*	-0.010*	-0.038*	-0.038*	-0.047*	-0.047*	-0.029*	-0.029*	-0.029*	-0.029*
7	0.024*	0.024*	0.029*	0.029*	-0.001*	-0.001*	0.009*	0.009*	0.023*	0.023*	0.032*	0.032*	0.012*	0.012*
8	0.012*	0.012*	0.014*	0.014*	0.038*	0.038*	-0.020*	-0.020*	0.009*	0.009*	0.018*	0.018*	0.003*	0.003*
9	0.029*	0.029*	0.034*	0.034*	0.029*	0.029*	0.020*	0.020*	0.040*	0.040*	0.015*	0.015*	0.008*	0.008*
10	0.034*	0.034*	0.023*	0.023*	0.052*	0.052*	0.010*	0.010*	0.038*	0.038*	0.021*	0.021*	0.006*	0.006*

[*Note:* * significant at 1%, ** significant at 5% and *** significant 10% level of significance]

4.4. Auto correlation (AC) test and Q-statistic

The autocorrelation and Ljung-Box Q statistic results are detailed in Table 5. Here we have taken a maximum of 10 lags for the test. If the probability value for any kth order autocorrelation is less than 5% (P< 0.05) then the null hypothesis of no autocorrelationis rejected. From the table it is observed thatautocorrelation coefficients forall the indices are highly significant in all lags in all cases.But some crucial differencesare eyed when we consider sub-sample data before 2001 crisisand after 2007-08 crisis.It is clear from the sub-sample results that both SENSEX and NIFTY50indices are not autocorrelated in some lags before 2001 crisis and again in case of NIFTY IT no autocorrelation is found after 2007-08 financial crisis. Therefore, the Indian stock markets are not certainly inefficient; especially whensub-samples are taken into consideration. So, broad outline of the results is that the Indian stock market is mostly not weak form efficient (as is also evident from Q statistic tests), i.e., here one can draw inference regarding future stock price activities by utilizing past data.

Runs Test: Next, we apply the non-parametric Runtest for checking the randomnessnature of the stock market returns. Table 6 shows the results of Runs test. The value of z statistic conveys thedifference between actual and expected numberof runs. Here the test statistic is highly significant in all cases excepttwo, *viz* Nifty FMCG and NIFTY IT index returnswhich are, however, observed to be random after 2007-08 financial crisis. From the estimated results, therefore, it is clear that the Run test rejects the null hypothesis of randomnessdetecting that there remain systematic patterns in theindex return series.

Stability measure: Stability of any market can be assessed by measuring its volatility or uncertainty. In the study estimating volatility models this stability is captured. Here we first apply GARCH(1,1) model and also GARCH-M model for all but from the model it is also observed that the "Variance term is not statistically significant in the mean equation (except NIFTY-FMCG and NIFTY-ENERGY) but its inclusion substantially increases the significance of the GARCH term in the variance equation. NIFTY-FMCG and NIFTY-ENERGY whose estimated results are shown in Table 7. From the results it is noted that both ARCH ($\boldsymbol{\alpha_1}$) and GARCH ($\boldsymbol{\beta_1}$) parameters are significant with P values 0.0000 for all indices. Hence GARCH(1, 1) gives us good fit to the daily return series of all Indices except NIFTY FMCG, NIFTY PHARMA and NIFTY-ENERGY for this we estimate GARCH-M (2,1), GARCH (2,1) and GARCH-M (1,1).We also know that ($\boldsymbol{\alpha_{1+}\ \beta_1}$) represents the persistence

Table 6: Result of Runs test for all Indices

Run Test based on Median	*FULL SAMPLE*							*AFTER CRISIS*	
	SENSEX	*NIFTY50*	*NIFTY IT*	*NIFTY FMCG*	*NIFTY BANK*	*NIFTY ENERGY*	*NIFTY PHARMA*	*NIFTY IT*	***NIFTY FMCG***
Median value	.0009	.0008	.0008	.0006	.0008	.0008	.0008	.0008	.0009
Cases < Test Value	3285	3285	3285	3285	2805	2680	2680	1661	1661
Cases >= Test Value	3286	3286	3286	3286	2805	2680	2680	1662	1662
Total Cases	6571	6571	6571	6571	5610	5360	5360	3323	3323
Number of Runs	3074	3066	3126	3162	2657	2539	2492	1615	1669
Z	-5.243*	-5.441*	-3.960*	-3.072*	-3.979*	-3.880*	-5.164*	-1.648	.226
Run Test based on Mean									
Mean value	.000461	.000466	.000868	.000582	.000654	.000613	.000482	.000802	.000663
Cases < Test Value	3195	3199	3297	3295	2784	2646	2621	1663	1632
Cases >= Test Value	3376	3372	3274	3276	2826	2714	2739	1660	1691
Total Cases	6571	6571	6571	6571	5610	5360	5360	3323	3323
Number of Runs	3072	3060	3130	3164	2655	2541	2458	1615	1665
Z	-5.235*	-5.536*	-3.861*	-3.022*	-4.028*	-3.814*	-6.060*	-1.648	.105

[*Note:* * significant at 1% , ** significant at 5% and *** significant 10% level of significance]

Table 7: GARCH Model

	Full Sample 1/03/1996-8/31/2020						
	NIFTY50	*SENSEX*	*NIFTY BANK*	*NIFTY FMCG*	*NIFTY IT*	*NIFTY ENERGY*	*NIFTY PHARMA*
	GARCH(1,1)	*GARCH (1,1)*	***GARCH (1,1)***	***GARCH-M (2,1)***	***GARCH (1,1)***	***GARCH-M (1,1)***	***GARCH(2,1)***
(MEAN equation)	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient
ψ				3.43115*		2.793968**	
Coefficient in GARCH model (variance equation)							
α_0	2.56E-06*	2.31E-06*	3.72E-06*	4.15E-06*	9.55E-06*	6.18E-06*	4.23E-06*
α_1	0.108495*	0.105172*	0.090430*	0.168065*	0.122487*	0.101109*	0.159864*
α_2				-0.085315*			-0.097936*
β_1	0.885238*	0.889145*	0.901495*	0.897441*	0.859408*	0.875971*	0.912693*

[*Note:* * significant at 1% , ** significant at 5% and *** significant 10% level of significance]

of volatility in a model. From the estimated results it is revealed that the sum of the coefficients of the ARCH & GARCH parameters is close to one in each case which means that the conditional variance is highly persistent i.e.,each shock in the market has no short memory,i.e., markets may be termed asunstable or volatile in nature. Here also we plot the conditional variance of each set of return series and observe clustering volatility effect i.e., high return is followed by another high return and low return is followed by another low returnas evidenced from Figure 8 to Figure 14. Further anintimation of any new shock having long memory indicates that the market under consideration is inefficient.

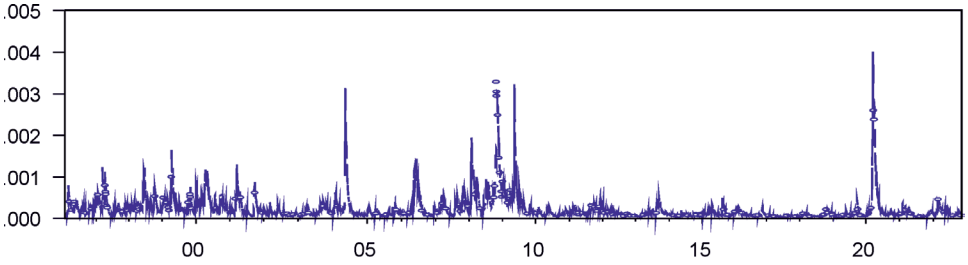

Figure 8: Conditional var of NIFTY50 Rt

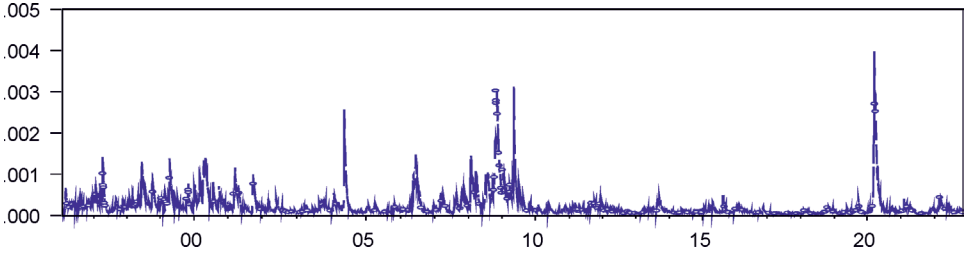

Figure 9: Conditional var of SENSEX Rt

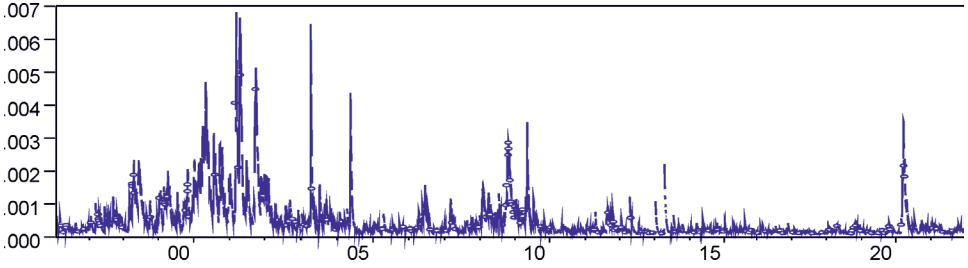

Figure 10: Conditional var of NIFTY IT Rt

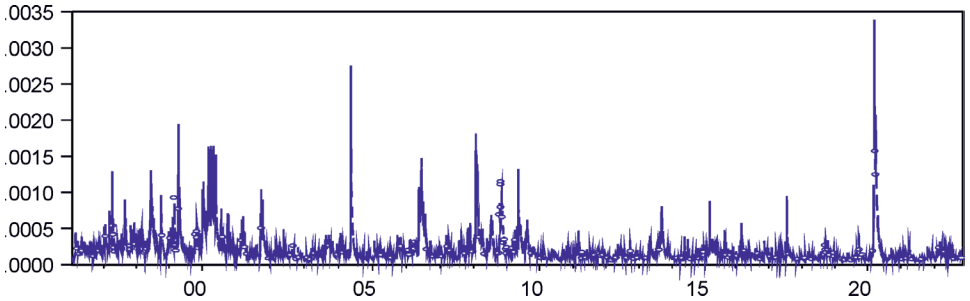

Figure 11: Conditional var of NIFTY FMCG Rt

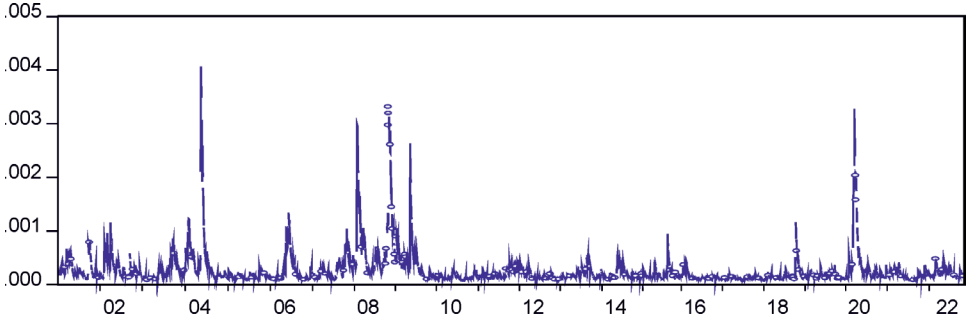

Figure 12: Conditional var NIFTY ENERGY Rt

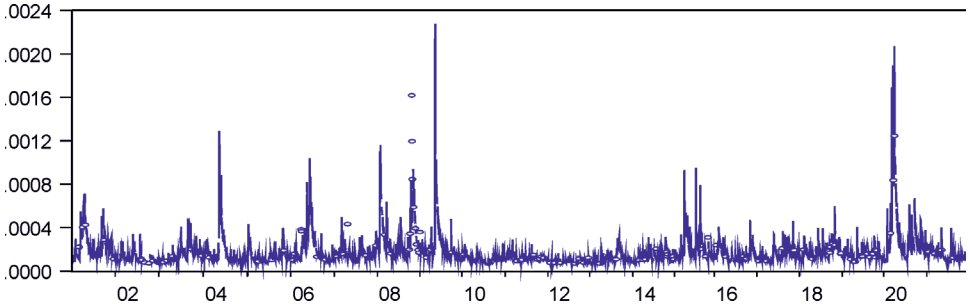

Figure 13: Conditional var of NIFTY PHARMA Rt

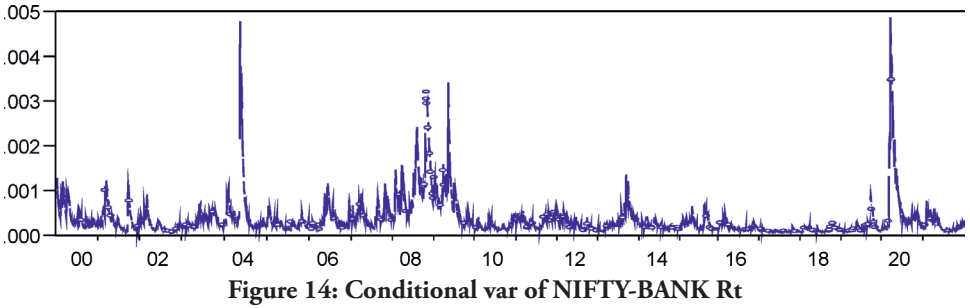

Figure 14: Conditional var of NIFTY-BANK Rt

Next, we apply Engle and Ng test to identify the persistence of sign or size bias in the volatility in the returns data. Table 8 displays the results of Engle and Ng test. Here we observe Φ_1 is insignificant in all cases except NIFTY-IT, NIFTY-BANK & NIFTY-ENERGY but Φ_2 **&** Φ_3 both are significant at 1% level of significance in casesfor all Indices; that means, size bias is present in all indices return but sign bias is present only in three sectoral indices. These observations establish the presence of asymmetric effect on volatility of all Index returns. So, for better modeling of stability measure we apply EGARCH model (shown in Table 9).

From Table 9 it is perceived that EGARCH (1,1,1) model fitted good in all cases except NIFTY-FMCG, NIFTY-PHARMA and NIFTY-ENERGYARCH. For NIFTY-FMCG & NIFTY-PHARMA EGARCH (2,1,1) gave best fit whereas, in case of NIFTY-ENERGY EGARCH (1,1,2) provided good estimation.The term (α) is significantly positive for all indices. Positive sign of α implies size of any shock has a significant impact on the volatility of the return series and there is a positiverelation between the past variance and current variance in absolute value; the bigger the volume of the shock to the variance, the higherthe volatility. GARCH term (β) is also found to be significantly positive which implies that past volatility helps to predict future volatility. Leverage term (γ) is significantly negative which implies that the sign of the shock has an impact on the volatility of the returns of the indices. The negative sign representing bad news leads to increase volatility more than the good news of the same size.Again, the coefficient of dummy variable (λ) is here found to be significantly negative in all cases except NIFTY-PHARMA implying thereby that after global financial crisis volatility in almost all segments (except NIFTY-PHARMA) of the Indian stock market reduces (i.e., becomes relatively stable) compared to the situation in the pre-crisis period.

5. CONCLUSION

The key objective of this paper is to know the state of efficiency and stability of the Indian stock market during post reforms period with its different sub-periods. From the study we observe mostly positive returns and the return distribution is negatively skewed with high peak (leptokurtic), i.e., a fat-tailed distribution. The weak form of stock market efficiency is checked by applyingconventional parametric and non-parametric tests, and also unit root test and test based on GARCH and GARCH-M model. It is evident from all these estimated test

Table 8: ENGLE and NG test Results

	(NIFTY50)	*(SENSEX)*	*Nifty IT*	*NIFTY FMCG*	*Nifty BANK*	*NIFTY PHARMA*	*NIFTY ENERGY*
Coefficient OF model	*Value of coefficient*	*Value of coefficient*	*Value of coefficient*	*Value of coefficient*	*Value of coefficient*	*Value of coefficient*	*Value of coefficient*
Φ_0	7.17E-05*	6.72E-05*	2.65E-05	7.23E-05*	9.68E-05*	5.93E-05*	2.12E-05
Φ_1	-5.44E-06	7.48E-08	7.97E-05***	-1.53E-05	8.48E-05**	-1.34E-05	7.61E-05*
Φ_2	0.013163*	0.014376*	0.021672*	0.13171*	0.011661*	0.011802*	0.012312*
Φ_3	-0.016403*	-0.015944*	-0.033902*	-0.13574*	-0.020440*	-0.012906*	-0.022933*
SIC	-11.66713	-11.73023	-10.37931	-12.24474	-10.88733	-12060167	-11.36730

[*Note:* * significant at 1% , ** significant at 5% and *** significant 10% level of significance]

Table 9: Results of EGARCH Model (Full Sample Data)

	EGARCH (1,1,1)	*EGARCH (1,1,1)*	*EGARCH (1,1,1)*	*EGARCH (2,1,1)*	*EGARCH (1,1,1)*	*EGARCH (2,1,1)*	*EGARCH (1,1,2)*
	(NIFTY50)	*(SENSEX)*	*Nifty IT*	*NIFTY FMCG*	*Nifty BANK*	*NIFTY PHARMA*	*NIFTY ENERGY*
Coefficient OF model	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient	Value of coefficient
ω	-0.34120*	-0.364577*	-0.507383*	-0.445044*	-0.287794*	-0.379063*	-0.399282*
α_1	0.196883*	0.192835*	0.231560*	0.290204*	0.177199*	0.293701*	0.198815*
α_2				-0.119741*		-0.143586*	
γ_1	-0.091310*	-0.088449*	-0.034833*	-0.051999*	-0.060809*	-0.020252*	-0.088290*
γ_2							0.037402*
β	0.971846*	0.973898*	0.955709*	0.962663*	0.980722*	0.969848*	0.969606*
λ_1	-0.023403*	-0.021515*	-0.042198*	-0.018480*	-0.009485*	-0.000432	-0.017286*

[*Note:* * significant at 1% , ** significant at 5% and *** significant 10% level of significance]

results that the Indian stock market is inefficient in its weak form. For stability computation apart from GARCH we also applied exponential GARCH model. From the estimated EGARCH model and GARCH-M model it is clear that there was high persistence of volatility clustering in the returns of the stock markets and there was also leverage effect in the return volatility.Thus, the Indian stock market remains unstable. Moreover, bad news affects the market more than any good news. i.e., a fall in returns results in greater volatility than an increase in it of the same magnitude. But the Indian stock market becomes relatively stable after 2007-08 financial crisis. Thus, unlike most of earlier studies (and like a few past studies) as pointed out in literature survey, it can be concluded that the Indian stock market is neither efficient nor stable and investors and policy makers should take note of it while making their decisions but the risk averse investors can do their investment in the Indian stock market as the market is not so risky in the sense.

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