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Stock return, volatility in an emerging market: The Indian case

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Abstract
This paper investigated the relationship between stock returns and volatility in India using the E-GARCH-in-mean model in light of banking reforms, insurance reform, the stock market crash, and the global financial crisis. Using daily returns over the period of 4 January 2004 to January 4, 2009, Volatility persistence, asymmetric properties, and risk-return relationship are investigated for the Indian stock market. The result also shows that volatility is persistent and there is a leverage effect supporting the work of Nelson (1991). The study found little evidence of the relationship between stock returns and risk as measured by its own volatility. The study found a positive but insignificant relationship between stock return and risk. The result shows that banking reform and stock market crash negatively impact stock returns while insurance reform and the global financial crisis have no impact on stock returns. The stock market volatility is also found to have accounted for the sudden change in variance.

Keywords: Stock market, financial reforms, volatility persistence, E-GARCH in mean, risk-return trade-off

Introduction

Recently, the volatility of the stock market return on the Indian Stock Market has been of concern to investors, analysts, brokers, dealers and regulators. Stock return volatility which represents the variability of stock price changes could be perceived as a measure of risk. The understanding of the volatility in a stock market will be useful in the determination of the cost of capital and in the evaluation of asset allocation decisions. Policy makers therefore rely on market estimates of volatility as a barometer of the vulnerability of financial markets. However, the existence of excessive volatility, or "noise," in the stock market undermines the usefulness of stock prices as a "signal" about the true intrinsic value of a firm, a concept that is core to the paradigm of the informational efficiency of markets (Karolyi, 2001) [22].

The traditional measure of volatility as represented by variance or standard deviation is unconditional and does not recognize that there are interesting patterns in asset volatility; e.g., time-varying and clustering properties. Researchers have introduced various models to explain and predict these patterns in volatility. Engle (1982) [14] introduced the autoregressive conditional heteroskedasticity (ARCH) to model volatility. Engle (1982) [14] modeled the heteroskedasticity by relating the conditional variance of the disturbance term to the linear combination of the squared disturbances in the recent past. Bollerslev (1986) [7] generalized the ARCH model by modeling the conditional variance to depend on its lagged values as well as squared lagged values of disturbance, which is called generalized autoregressive conditional heteroskedasticity (GARCH). Some of the models include IGARCH originally proposed by Engle and Bollerslev (1986) [7], GARCH-in-Mean (GARCH-M) model introduced by Engle, Lilien and Robins (1987) [16], the standard deviation GARCH model introduced by Taylor (1986) [36] and Schwert (1989) [35], the EGARCH or Exponential GARCH model proposed by Nelson (1991) [30], TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) [38] and Glosten, Jaganathan, and Runkle (1993) [18], the Power ARCH model generalized by Ding,. Zhuanxin, C. W. J. Granger, and R. F. Engle (1993) [13] among others.

If investors are risk averse, theory predicts a positive relationship should exist between stock return and volatility (Leon, 2007) [29]. If there is a high volatility in a stock market, the investors should be compensated in form of higher risk premium.

The GARCH-in-Mean (GARCH-M) model introduced by Engle, Lilien and Robins (1987) [16] has been used by various researchers to examine the relationship between stock return and volatility See French, Schwert and Stambaugh, 1987 [17]; Chou, 1988 [11]; Baillie and DeGennaro, 1990 [4]; Nelson, 1991 [30]; Glosten *et al*., 1993 [18], Léon, 2007 [29] among others. Mixed results were found by various authors. Some found the relation between the risk and return to be positive (French, Schwert and Stambaugh, 1987; Chou, 1988; among others) [17, 11] while some others found it negative (Nelson, 1991; Glosten *et al*., 1993 among others) [30, 18]. Little or no work has been done on modeling stock returns volatility in Indian particularly using GARCH models. This paper attempts to fill this gap.

Literature Review

The introduction of autoregressive conditional heteroskedasticity (ARCH) model by Engle (1982) [14] as generalized (GARCH) by Bollerslev (1986) [7] has led to the development of various models to model financial market volatility. Some of the models include IGARCH originally proposed by Engle and Bollerslev (1986) [7], GARCH-in-Mean (GARCH-M) model introduced by Engle, Lilien and Robins (1987) [16], the standard deviation GARCH model introduced by Taylor (1986) [36] and Schwert (1989) [35], the EGARCH or Exponential GARCH model proposed by Nelson (1991) [30], TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) [38] and Glosten, Jaganathan, and Runkle (1993) [18], the Power ARCH model generalised by Ding,. Zhuanxin, C. W. J. Granger, and R. F. Engle (1993) [13] among others.

Engle, Lilien and Robins (1987) [16] introduced the GARCH-in-Mean to examine relation between stock return and volatility to enable risk-return tradeoff to be measured. Since the work of Engle, Lilien and Robins (1987) [16], various studies have been done using the GARCH-in-Mean to explain the relation between risk and return. However, there is mixed evidence on the nature of this relationship. It has been found to be positive as well as negative (Kumar and Singh, 2008) [27]. French, Schwert and Stambaugh (1987) used daily and monthly returns on the NYSE stock index to investigate the relation between risk and return. They find evidence that expected market risk premium is positively related to predictable volatility of stock returns. Chou (1988) [11] and Baillie and DeGennaro (1990) [4] also found a positive relation between the predictable components of stock returns and volatility. Glosten *et al*. (1993) [18] use data on the NYSE over April 1851 to December 1989, and find negative relationship between expected stock market return and volatility. However, Glosten LR, Jagannathan R, Runkle DE (1993) [18] used the data on the New York Stock Exchange to find negative relationship between expected stock market return and volatility. Bekaert and Wu (2000) [6] reported asymmetric volatility in the stock market and negative correlation between return and conditional volatility.

There are other studies on the relation between stock return and risk using other framework ther than GARCH-in-Mean model., Campbell (1987) [10] used an instrumental variables specification for conditional moments and finds negative risk- return tradeoff Pagan and Hong (1991) [32] used non-parametric techniques and find a weak negative relationship between risk and return. Harrison and Zhang (1999) find that the relationship between risk and return is significantly positive at longer horizons. Few studies have been done on stock market volatility in emerging markets. Leon (2007) [29] investigated the relationship between expected stock market returns and volatility in the regional stock market of the West African Economic and Monetary Union called the BRVM. Using weekly data over the period 4 January 1999 to 29 July 2005, he found that expected stock return has a positive but not statistically significant relationship with expected volatility. He also found that volatility is higher during market booms than when market declines. Aggarwal, Inclan and Leal (1999) [1] analyze volatility in emerging stock markets during 1985-95. They identify the points of sudden changes in the variance of returns and examine the nature of events that cause large shifts in stock return volatility in these economies. Aggarwal *et al* find that mostly local events cause jumps in the stock market volatility of the emerging markets. Kim and Singal (1997) [26] and De Santis and Imorohoroglu (1997) [12] study the behavior of stock prices following the opening of a stock market to foreigners or large foreign inflows. They find that there is no systematic effect of liberalization on stock market volatility. Hussain and Uppal (1999) [19] examines stock returns volatility in the Pakistani equity market. He finds a strong evidence of persistence in variance in returns implying that shocks to volatility continue for a long period. However, after accounting for the structural shift due to opening of the market, the persistence was found to decline significantly. Batra (2004) [5] examines the time variation in volatility in the Indian stock market during 1979-2003. He finds that the period around the BOP crisis and the subsequent initiation of economic reforms in India is the most volatile period in the stock market. Sudden shifts in stock return volatility in India are more likely to be a consequence of major policy changes and any further incremental policy changes may have only a benign influence on stock return volatility.

Methodology

The Data

The time series data used in this analysis consists of daily Indian Stock Exchange index from January 2, 2004 to January 16, 2009 obtained from the Indian Stock Exchange. In this study, stock return is defined as:

$$R_t = \log\left(\frac{NSI_t}{NSI_{t-1}}\right)$$

Rt represent stock return at time t

NSIt mean Nigerian Stock Exchange index at time t

NSIt-1 represent Nigerian Stock Exchange index at time t-1.

The R_t of Equation (1) will be used in investigating the volatility of stocketurns in Indian over the period, January 2, 2004 to January 16, 2009. On July 4, 2004, the Central Bank of Indian, with a view to strengthening the Indian banking industry, announced a new capital requirement for banks operating in Indian. The new capitalization of Indian banks was increased to N25 billion. Furthermore, on September 5, 2005, the Federal Government of Indian announced the recapitalization of Insurance and Reinsurance companies as N2 billion for life insurance companies, N3 billion for non-life operators, N5 billion for composite insurance companies and N10 billion for re-insurers (NAICOM, 2008). The recapitalization of the banking industry and the Insurance industry boosted the number of securities on Indian Stock Market increasing public awareness and confidence about the Stock market. This paper will investigate the impact of the banking reform (BR) and insurance reform (ISR) on the stock market volatility. To account for the banking reform in this paper, a dummy variable is set equal to 0 for the period before July 4, 2004 and 1 thereafter. To account for the insurance reform in this paper, a dummy variable is set equal to 0 for the period before September 5, 2005 and 1 thereafter.

Since April 1, 2008, stock prices on the Indian Stock Market has been declining. The stock index fell from 63016.56 on April 1, 2008 to 27108.4 on January 16, 2009. To investigate the impact of this stock market crash on stock market volatility, results will be presented separately for the period before the stock market crash (January 2, 2004-March 31, 2008) and after the stock market crash (April 1, 2008 – January 16, 2009). To account for the stock market crash (SMC) in this paper, a dummy variable is set equal to 0 for the period before April 1, 2008 and 1 thereafter.

The global financial crisis of 2008, an ongoing major financial crisis, was triggered by the subprime mortgage crisis in the United States which became prominently visible in September 2008 with the failure, merger, or conservatorship of several large United States-based financial firms exposed to packaged subprime loans and credit default swaps issued to insure these loans and their issuers (Wikipedia, 2009) [37]. On September 7, 2008, the United States government took over two United States Government sponsored enterprises Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation) into conservatorship run by the United States Federal Housing Finance Agency. The two enterprises as at then owned or guaranteed about half of the U.S.'s $12 trillion mortgage market. This causes panic because almost every home mortgage lender and Wall Street bank relied on them to facilitate the mortgage market and investors worldwide owned $5.2 trillion of debt securities backed by them (Wikipedia, 2009) [37]. Later in that month Lehman Brothers and several other financial institutions failed in the United States. This crisis rapidly evolved to global crisis. In this study, September 7, 2008 is taken as the date of commencement of the global financial crisis. To investigate the impact of the global financial crisis on stock market volatility, results will be presented separately for the period before the global financial crisis (January 2, 2004-September 6, 2008) and the global financial crisis period (September 7, 2008 – January 16, 2009). To account for global financial crisis (GFC) in this paper, a dummy variable is set equal to 0 for the period before September 7, 2008 and 1 thereafter.

Properties of the data

The summary statistics of the stock returns return series is given in Table 3. The mean return or the full sample, Pre-Stock Market Crash period, Pre-Global Financial Crisis period, Stock Market Crash period and Global Financial Crisis period are 0.0002, 0.0011, 0.0008, -0.0042 and -0.007 respectively while their standard deviations are 0.0934, 0.1017, 0.0967, 0.0168 and 0.0151 respectively. The mean return appears to be negative during Stock market crash period and global financial crisis period showing that, on average, investors sustain losses during these periods. The standard deviation appears to be lower during Stock market crash period and global financial crisis periods since returns are lower possibly reflecting positive relation between risk and return.

The skewness for the full sample, Pre-Stock Market Crash period, Pre-Global Financial Crisis period, Stock Market Crash period and Global Financial Crisis period are -0.0292, -0.0524, -0.0445, 0.8302 and -0.3431 respectively. This shows that the distribution, on average, is negatively skewed relative to the normal distribution (0 for the normal distribution). This is an indication of a non-symmetric series. The kurtosis for full sample, Pre-Stock Market Crash, Pre-Global Financial Crisis, Stock market crash period and Global Financial Crisis are very much larger than 3, the kurtosis for a normal distribution. Skewness indicates non-normality, while the relatively large kurtosis suggests that distribution of the return series is leptokurtic, signaling the necessity of a peaked distribution to describe this series. This suggests that for the stock returns return series, large market surprises of either sign are more likely to be observed, at least unconditionally. The Ljung-Box test Q statistics for the full sample, Pre-Stock Market Crash, Pre-Global Financial Crisis, Stock market crash and Global Financial Crisis periods are all significant at the 5% for all reported lags confirming the presence of autocorrelation in the stock returns return series. Jarque- Bera normality test rejects the hypothesis of normality for the full sample, Pre-Stock Market Crash, Pre-Global Financial Crisis, Stock market crash and Global Financial Crisis periods. Figures 2, 3, 4, 5 and 6 shows the quantile-quantile plots of the stock returns for the for the full sample, Pre-Stock Market Crash, Pre-Global Financial Crisis, Stock market crash period and Global Financial Crisis periods. Figures 2, 3, 4, 5 and 6 clearly show that the distribution of the stock returns return series show a strong departure from normality.

The Ljung-Box test Q^2 statistics for the full sample, Pre-Stock Market Crash, Pre- Global Financial Crisis, Stock market crash period and Global Financial Crisis periods are all significant at the 5% for all reported lags confirming the presence of heteroscedasticity in the stock returns return series. Table 4 shows the results of unit root test for the stock returns return series. The Augmented Dickey-Fuller test and Phillips-Perron test statistics for the stock returns return series are less than their critical values at the 1%, 5% and 10% level. This shows that the stock returns return series has no unit root. Thus, there is no need to difference the data.

In summary, the analysis of the stock returns return indicates that the empirical distribution of returns in the foreign stock returns market is non-normal, with very thick tails for the full sample and the two sub periods (Fixed rate and managed floating rate regimes). The leptokurtosis reflects the fact that the market is characterized by very frequent medium or large changes. These changes occur with greater frequency than what is predicted by the normal distribution. The empirical distribution confirms the presence of a non-constant variance or volatility clustering.

Table 1: Summary Statistics and Autocorrelation of the Raw Stock returns Return Series over the period, January 2, 2004 – January 16, 2009

	Full Sample	Pre-Stock Market Crash	Pre-Global Financial Crisis	Stock Market Crash	Global Financial Crisis
Summary Statistics					
Mean	0.0002	0.0011	0.0008	-0.0042	-0.0070
Median	-0.0000	-0.0000	-0.0000	-0.0052	-0.0055
Maximum	2.3040	2.3040	2.3040	0.0707	0.0224
Minimum	-2.3053	-2.3053	-2.3053	-0.0566	-0.0566
Std. Dev.	0.0934	0.1017	0.0967	0.0168	0.0151
Skewness	-0.0292	-0.0524	-0.0445	0.8302	-0.3431
Kurtosis	601.6833	510.5658	562.3465	6.519327	3.4932
Jarque-Bera	18458718	11131463	14991614	125.5572	2.5593
Probability	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*
Observations	1236	1037	1150	199	86
Ljung-Box Q Statistics					
Q(1)	294.2400	251.71600	276.8800	15.218	38.0790
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*
Q(2)	294.2500	251.7200	276.8900	40.811	62.7420
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*
Q(3)	294.3700	251.8200	277.0000	59.388	113.1200
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*
Q(4)	294.4900	251.9200	277.1200	72.082	122.3400
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*
Ljung-Box Q^2 Statistics					
Q(1)	308.2200	258.4800	286.7200	21.6090	5.4646
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0190)*
Q(2)	308.2300	258.5000	286.7400	26.3030	17.0660
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.0090)*
Q(3)	308.2500	258.5200	286.7600	28.1330	20.2860
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0050)*	(0.0620)
Q(4)	308.2800	258.5500	286.7900	48.5510	22.7050
	(0.0000)*	(0.0000)*	(0.0000)*	(0.0000)*	(0.3040)

Notes: p values are in parentheses. * indicates significance at the 5% level

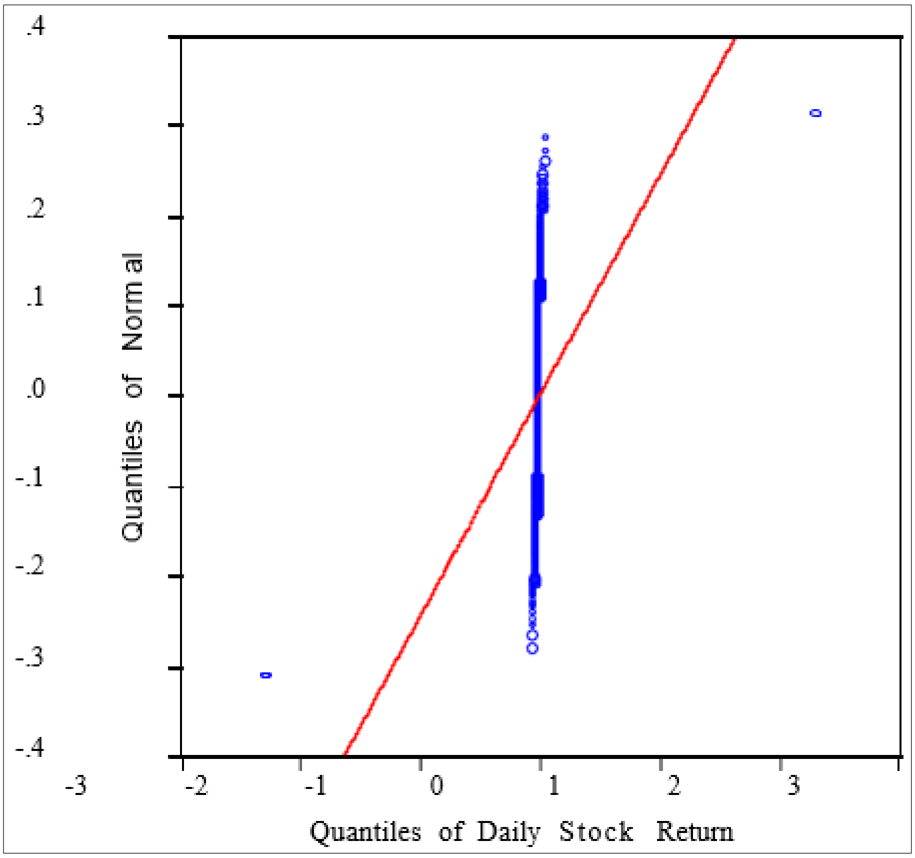

Fig 1: Quantile-Quantile Plot of Stock returns Return Series Based on the Full Sample (January 2, 2004 – January 16, 2009)

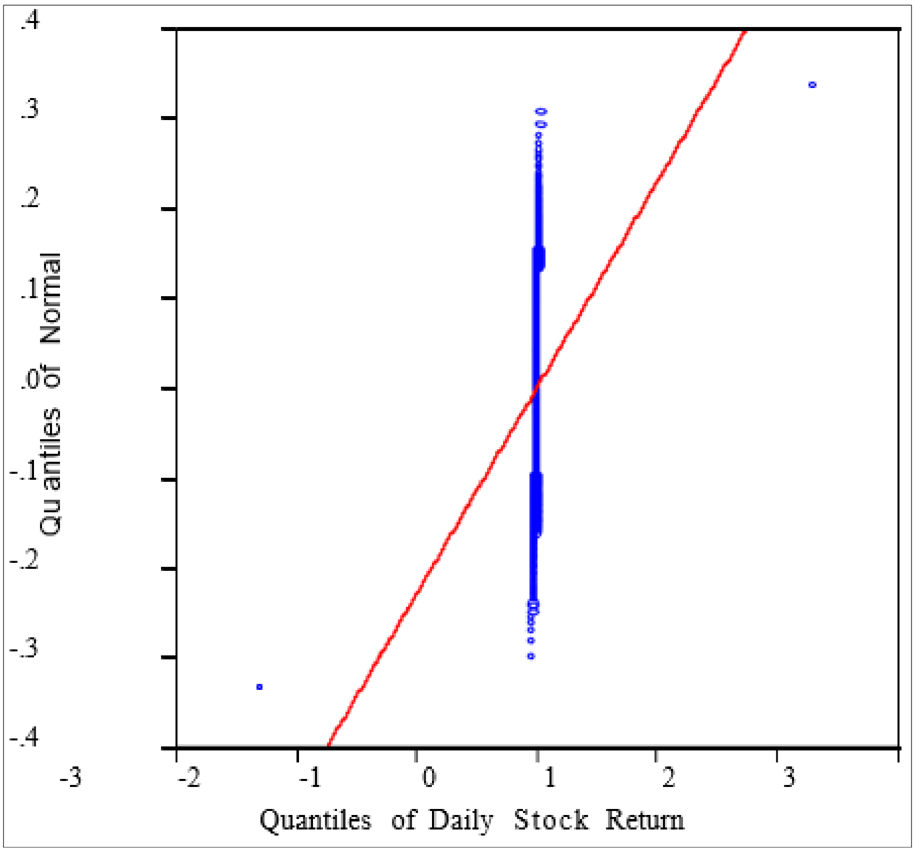

Fig 2: Quantile-Quantile Plot of Stock returns Return Series Based on the Data before the Inception of Stock Market Crash in Indian

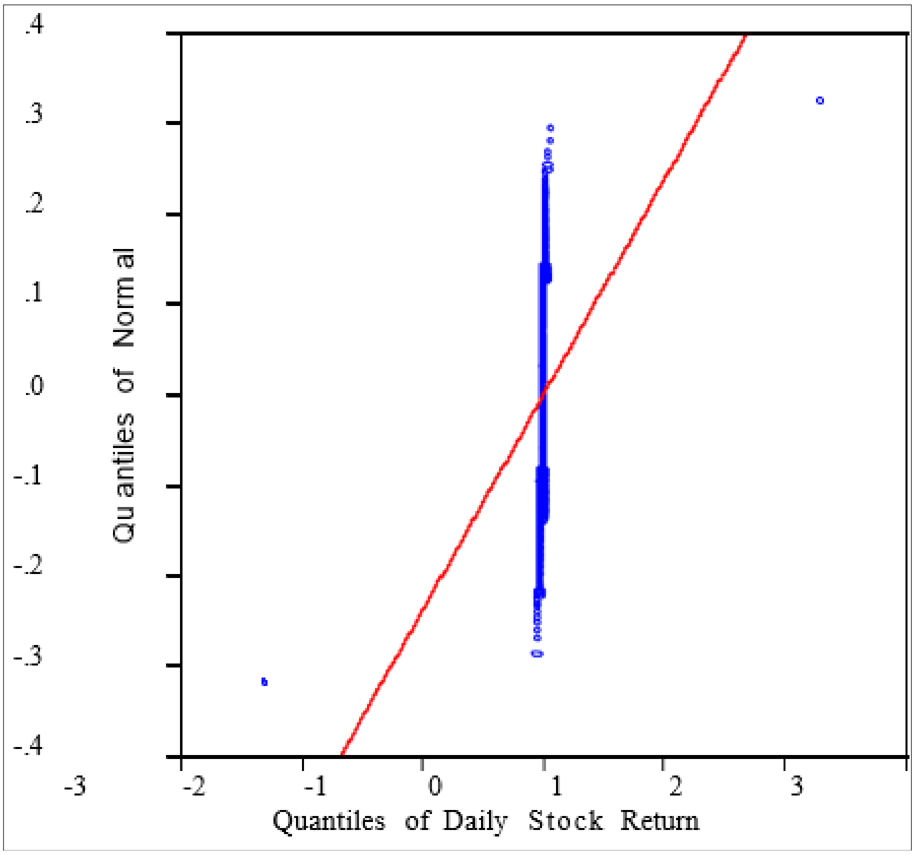

Fig 4: Quantile-Quantile Plot of Stock returns Return Series Based on the Data before the Inception of Global Financial Crisis and Response

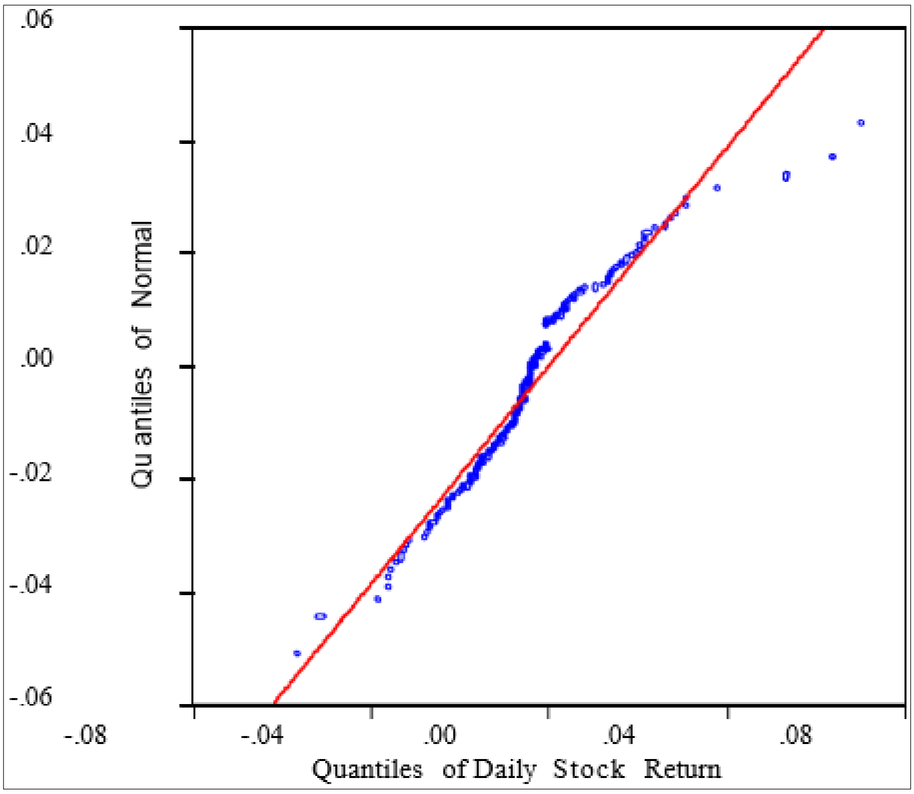

Fig 5: Quantile-Quantile Plot of Stock returns Return Series Based on the Data after the Inception of Stock Market Crash in Indian

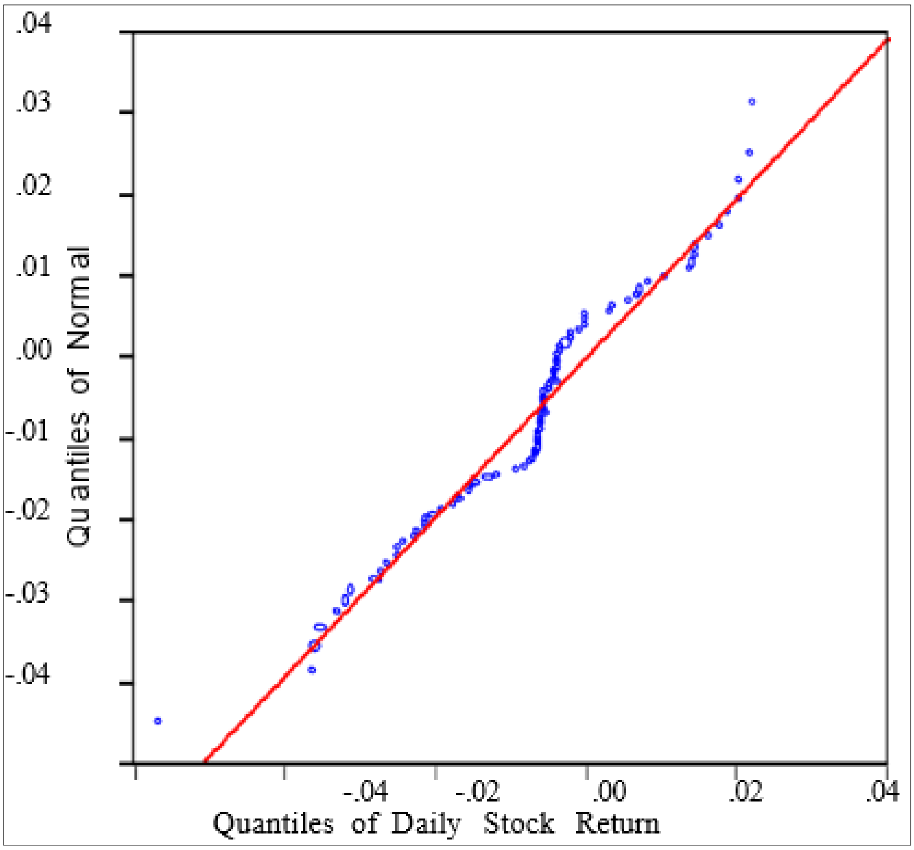

Fig 6: Quantile-Quantile Plot of Stock returns Return Series Based on the Data after the Inception of Global Financial Crisis and Response

Table 2: Unit Root Test of the Stock returns Return Series over the period, January 2, 2004 – January 16, 2009

	Augmented Dickey-Fuller test					Phillips-Perron test		
	Statistic Critical Values (%)				Statistic	Critical Values (%)		
		1% level	5% level	10% level		1% level	5% level	10% level
Full Sample	-22.141	-2.567	-1.941	-1.617	-107.634	-2.567	-1.941	-1.617
Pre-Stock Market Crash	-19.323	-2.567	-1.941	-1.616	-123.467	-2.567	-1.941	-1.616
Pre-Global Financial Crisis	-20.038	-2.567	-1.941	\ -1.617	-125.950	-2.567	-1.941	-1.617
Stock Market Crash	-6.705	-2.577	-1.942	-1.616	-10.509	-2.577	-1.942	-1.616
Post-Global Financial Crisis	-3.723	-2.592	-1.945	-1.614	-3.763	-2.592	-1.945	-1.614

Notes: The appropriate lags are automatically selected employing Akaike information Criterion

Models Used In This Study

This study will attempt to model the volatility of daily stock returns return in Indian using the EGARCH-in-Mean model in the light of banking reforms, insurance reform, stock market crash and the global financial crisis. The mean and variance equations that will be used for the full sample, pre-stock market crash, pre-global financial crisis, stock market crash and global financial crisis periods are given as:

For the Full Sample, the mean and variance equations are given as:

$$R_t = b_0 + b_1R_{t-1} + b_2\sigma_t + b_3BR + b_4ISR + b_5SMC + b_6GFC + \varepsilon_t \quad (2)$$

$$\varepsilon_t / \phi_{t-1} \sim N(0, \sigma_t^2, v_t) \quad (3)$$

$$\log(\sigma_t^2) = \omega + \alpha\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right| + \beta_1 \log(\sigma_{t-1}^2) + \gamma\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| \quad (4)$$

where v_t is the degree of freedom

For the pre-stock market crash period, the mean equation (2) is modified as:

$$R_t = b_0 + b_1R_{t-1} + b_2\sigma_t + b_3BR + b_4ISR + \varepsilon_t \qquad \varepsilon_t / \phi_{t-1} \sim t(0, \sigma_t^2, v_t) \quad (5)$$

The variance equation of the pre-stock market crash period is the same as Equation (4).

For the Pre-global financial crisis, the mean equation (2) is given as:

$$R_t = b_0 + b_1R_{t-1} + b_2\sigma_t + b_3BR + b_4ISR + \varepsilon_t \qquad \varepsilon_t / \phi_{t-1} \sim t(0, \sigma_t^2, v_t) \quad (5)$$

The variance equation of the pre-stock market crash period is the same as Equation (4).

For the Pre-global financial crisis, the mean equation (2) is given as:

$$R_t = b_0 + b_1R_{t-1} + b_2\sigma_t + b_3BR + b_4ISR + b_5SMC + \varepsilon_t \qquad \varepsilon_t / \phi_{t-1} \sim t(0, \sigma_t^2, v_t) \quad (6)$$

The variance equation of the pre-global financial crisis period is the same as Equation (4).

For the stock market crash period, the mean equation (2) is given as:

$$R_t = b_0 + b_1R_{t-1} + b_2\sigma_t + b_6GFC + \varepsilon_t \qquad \varepsilon_t / \phi_{t-1} \sim t(0, \sigma_t^2, v_t) \quad (7)$$

The initial test of the variance equation of the stock market crash period using Equation (4) still gave the presence of ARCH in the variance equation. Thus, the variance equation of the stock market crash period is given as:

The initial test of the variance equation of the stock market crash period using Equation (4) still gave the presence of ARCH in the variance equation. Thus, the variance equation of the stock market crash period is given as:

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^{2} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} - \sqrt{\frac{2}{\pi}} \right| + \beta_1 \log(\sigma_{t-1}^2) + \gamma \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| \qquad (8)$$

The mean equation of the global financial crisis period is given as:

$$R_t = b_0 + b_1 R_{t-1} + b_2 \sigma_t \qquad \varepsilon_t / \phi_{t-1} \sim t(0, \sigma_t^2, v_t) \qquad (9)$$

The variance equation used in the global financial period that achieved convergence and absence of ARCH in the variance equation is given as:

$$\log(\sigma_t^2) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}} \right| + \sum_{j=1}^{2} \beta_j \log(\sigma_{t-j}) + \gamma \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| \qquad (10)$$

To account for the shift in variance as a result of the stock market crash and global financial crisis, the full sample is re-estimated with the mean equation (2) while the variance equation is augmented as follows:

$$\log(\sigma_t^2) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}} \right| + \beta_1 \log(\sigma_{t-1}^2) + \gamma \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \Theta_1 SMC + \Theta_2 GFC \qquad (11)$$

The volatility parameters to be estimated include ω, α, β and γ. As the stock returns return series shows a strong departure from normality, all the models will be estimated with Student t as the conditional distribution for errors. The estimation will be done in such a way as to achieve convergence.

The Results

The results of estimating the EGARCH-in-Mean models as stated in Section 4.3 for the full sample, pre-stock market crash, pre-global financial crisis, stock market crash and global financial crisis periods are presented in Tables 4. In the mean equation, b_1 (Coefficient of lag of stock returns) is significant in the full sample, all sub periods and the augmented model confirming the correctness of adding the variable to correct for autocorrelation in the stock return series. The mean equation further shows that b_2 (the coefficient of expected risk) is positive and insignificant in the full sample; all sub periods and the augmented model. This shows that there is little evidence on the statistical relationship between stock return and its own volatility. In other words, conditional standard deviation weakly predicts power for stock returns. The result is consistent with the work of French *et al.* (1987) [17], Baillie and DeGennaro (1990) [4], and Leon (2007) [29]. The coefficient b_3 (coefficient of the banking reform) in the mean equation is negative and statistically significant at the 5% level as reported in the full sample, pre-stock market crash, pre-global financial crisis and the augmented model. This implies that the new bank capital requirement announced in 2004 negatively impacts on stock returns. The result of Table 3 further shows that coefficient b_4 (Coefficient of the insurance reform) in the mean equation is statistically insignificant at the 5% level as reported in the full sample, pre-stock market crash, pre-global financial crisis and the augmented model. This implies that the new capital requirement of insurance companies announced in 2005 has no impact on stock returns. The coefficient b_5 (Coefficient of stock market crash) is negative and statistically significant at the 5% level in the full sample, pre-global financial crisis and the augmented model. This shows that the stock market crash since April 2008 negatively impacts on stock returns in Indian. The coefficient b_6 (Coefficient of global financial crisis) is statistically insignificant in the full sample, stock market crash period and the augmented model implying that the global financial crisis has no impact on stock returns in India.

With the exception of global financial crisis period, the variance equation in Table 4 shows that the sum of α coefficients are positive and statistically significant in the full sample, all the sub periods and the augmented model. This confirms that the ARCH effects are very pronounced implying the presence of volatility clustering. Conditional volatility tends to rise (Fall) when the absolute value of the standardized residuals is larger (Smaller) (Leon, 2007) [29].

Table 4 shows that the β coefficients (The determinant of the degree of persistence) are statistically significant in the full sample, all the sub periods and the augmented model. The sum of the β coefficients in the full sample, pre-stock market crash period, pre-global financial crisis period, stock market crash period, global financial crisis period and the augmented model are 0.6994, 0.5972, 0.6205, 0.6947, 0.9735 and 0.6413 respectively. This appears to show that there is a high persistence in volatility as the sum of βs are, on average, close to 1 in the full sample, pre-stock market crash period, pre-global financial crisis period, stock market crash period, global financial crisis period and the augmented model. The volatility persistence is higher in the full sample compared to the pre-stock market crash period, pre-global financial crisis period and the stock market crash period. The volatility persistence is lowest in the pre-stock market crash period. This appears to indicate that the stock market crash since April 2008 accounts for the high volatility persistence in the Indian Stock Market. The high volatility persistence in the global financial crisis period shows that the stock market is more volatile during the global financial crisis period. The stock market crash and the global financial crisis could have accounted for sudden changes in variance. The augmented EGARCH-in-Mean model where the stock market crash and global financial crisis variables are added to variance equation indicates that Θ_1 (Coefficient of stock market crash) is statistically significant while Θ_2 is statistically insignificant. The volatility persistence in the augmented is also lower than that of the full sample. This appears to indicate that the stock market crash accounted for the sudden change in variance.

With the exception of global financial crisis period, Table 4 shows that the coefficients of γ, the asymmetry and leverage effects, are negative and statistically significant at the 5% level in the full sample, Pre-Stock Market Crash, Pre-Global Financial Crisis, Stock Market Crash and the augmented models. In the global financial crisis period, γ is positive and statistically significant. The predominance negatively significance of γ in the results, appears to show that the asymmetry and leverage effects are accepted in the full sample, all sub periods and the augmented model. The leverage effect is rejected for the global financial crisis period while asymmetry effect is accepted for this period.

The estimated coefficients of the degree of freedom, *v* are significant at the 5- percent level in full sample, all sub periods and the augmented model implying the appropriateness of student t distribution.

Table 3: Parameter Estimates of the EGARTCH-in-Mean Models January 2, 2004 – January 16, 2009

	Full Sample	**Pre-Stock Market Crash**	**Pre-Global Financial Crisis**	**Stock Market Crash**	**Global Financial Crisis**	**Augmented EGARCH with Full Sample**
	Mean Equation					
b_0	0.0001	0.0011	0.0007	-0.0018	-0.0009	0.0003
	0.0013	0.0018	0.0015	0.0010	(0.0003)*	0.0014
b_1	0.5291	0.4770	0.4821	0.6406	0.8521	0.5214
	(0.0228)*	(0.0265)*	(0.0246)*	(0.0491)*	(0.0473)*	(0.0234)*
b_2	0.1612	0.0900	0.1235	0.0277	0.0500	0.1624
	(0.1112)	(0.1986)	(0.1372	(0.0811)	(0.0499)	(0.1362)
b_3	-0.0019 (0.0007)*	-0.0021 (0.0007)*	-0.0021 (0.0007)*			-0.0019 (0.0007)*
b_4	0.0006	0.0007	0.0007			0.0006
	(0.0005)	(0.0005)	(0.0005)			(0.0004)
b_5	-0.0022 (0.0007)*		-0.0023 (0.0007)*			-0.0032 (0.0012)*
b_6	-0.0002			-0.0001		0.0002
	(0.0010)			(0.0008)		(0.0015)
	Variance Equation					
ω	-2.9811	-4.0154	-3.7199	-3.6718	-0.0457	-3.5729
	(0.4620)*	(0.6218)*	(0.5289)*	(1.0686)*	(0.1016)	(0.5273)*
α_1	0.2822	0.2091	0.2757	1.6859	-0.8225	0.2590
	(0.0432)*	(0.0489)*	(0.0441)*	(0.4961)*	(0.3519)*	(0.0441)*
α_2				-0.0652		
				(0.2751)		
γ	-0.2263	-0.1554	-0.2156	0.4176	-1.5132	-0.2034
	(0.0392)*	(0.0476)*	(0.0418)*	(0.2140)*	(0.4627)*	(0.0420)*
β_1	0.6994	0.5972	0.6205	0.6947	0.4633	0.6413
	(0.0485)*	(0.0638)*	(0.0559)*	(0.0997)*	(0.0069)*	(0.0546)*
β_2					0.5102 (0.0025)*	
Θ_1						0.3189 (0.0968)*
Θ_2						-0.1583
						(0.1187)
ν	3.1272	3.6814	3.1071	3.0040	2.2022	3.3030
	(0.1855)*	(0.2086)*	(0.1865)*	(0.8981)*	(0.1395)*	(0.1952)*
LL	4200.7820	3611.2710	3927.5100	629.5107	300.7290	4206.4150
Persistence	0.6994	0.5972	0.6205	0.6947	0.9735	0.6413
AIC	-6.7835	-6.9523	-6.8173	-6.2262	-6.7844	-6.7893
SC	-6.7337	-6.9045	-6.7689	-6.0607	-6.5275	-6.7313
HQC	-6.7647	-6.9342	-6.7990	-6.1593	-6.6810	-6.7675
N	1236	1037	1150	199	86	1236
EGARCH	EGARCH (1, 1)	EGARCH (1, 1	EGARCH (1, 1)	EGARCH (2, 1)	EGARCH (1, 2)	EGARCH (1, 1)

Notes: Standard errors are in parentheses.
*indicates significant at the 5% level. LL, AIC, SC, HQC and N are the maximum log-likelihood, Akaike information Criterion, Schwarz Criterion, Hannan-Quinn criterion and Number of observations respectively

Table 4: Autocorrelation of Standardized Residuals, Autocorrelation of Squared Standardized Residuals and ARCH LM test of Order 4 for the EGARCH-in-Mean Models over the period January 2, 2004 – January

16, 2009						
Full Sample		Pre-Stock Market Crash	Pre-Global Financial Crisis	Stock Market Crash	Global Financial Crisis	Augmented EGARCH with Full Sample
Ljung-Box Q Statistics						
Q(1)	0.0035	0.0001	0.0009	0.3687	2.7308	0.0005
	(0.9530)	(0.991)	(0.9760)	(0.5440)	(0.0980)	(0.9830)
Q(2)	0.0550	0.0501	0.0500	9.5852	4.1797	0.0539
	(1.0000)	(1.0000)	(1.0000)	(0.1430)	(0.6520)	(1.0000)
Q(3)	0.3900	0.2996	0.3485	15.1030	8.2678	0.3764
	(1.0000)	(1.0000)	(1.0000)	(0.2360)	(0.7640)	(1.0000)
Q(4)	0.6585	0.5360	0.6223	18.1300	27.6310	0.6421
	(1.0000)	(1.0000)	(1.0000)	(0.5790)	(0.1180)	(1.0000)
Ljung-Box Q^2 Statistics						
Q(1)	0.0009	0.0010	0.0009	1.1846	0.0037	0.0008
	(0.9770)	(0.9750)	(0.9760)	(0.2760)	(0.9510)	(0.9770)
Q(2)	0.0052	0.0060	0.0055	4.8138	1.0862	0.0051
	(1.0000)	(1.0000)	(1.0000)	(0.5680)	(0.9820)	(1.0000)
Q(3)	0.0100	0.0117	0.0107	6.4056	1.8336	0.0099
	(1.0000)	(1.0000)	(1.0000)	(0.8940)	(1.0000)	(1.0000)
Q(4)	0.0168	0.0198	0.0180	18.0870	10.9080	0.0166
	(1.0000)	(1.0000)	(1.0000)	(0.5820)	(0.9490)	(1.0000)
ARCH LM						
F	0.0009	0.0010	0.0009	0.8620	0.1398	0.0008
	(1.0000)	(1.0000)	(1.0000)	(0.4878)	(0.9670)	(1.0000)
$N*R^2$	0.0009	0.0010	0.0009	0.8620	0.1398	0.0008
	(1.0000)	(1.0000)	(1.0000)	(0.4878)	(0.9670)	(1.0000)
Jarque-Berra	73148941	44263463	59318735	143	823	74003345
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: p values are in parentheses

Diagnostic checks

Table 5 shows the results of the diagnostic checks on the estimated EGARCH-in-mean-models for the full sample, all sub periods and the augmented model. Table 5 shows that the Ljung-Box Q-test statistics of the standardized residuals for the remaining serial correlation in the mean equation shows that autocorrelation of standardized residuals are statistically insignificant at the 5% level for the full sample, all sub periods and the augmented model confirming the absence of serial correlation in the standardized residuals. This shows that the mean equation are well specified. The Ljung-Box Q^2-statistics of the squared standardized residuals in Table 5 are all insignificant at the 5% level for the full sample, all sub periods and the augmented model confirming the absence of ARCH in the variance equation. The ARCH-LM test statistics in Table 5 for the full sample, all sub periods and the augmented model further showed that the standardized residuals did not exhibit additional ARCH effect. This shows that the variance equations are well specified in for the full sample, all sub periods and the augmented model. The Jarque-Bera statistics still shows that the standardized residuals are not normally distributed. In sum, all the models are adequate for forecasting purposes.

Conclusion

This paper investigated the relation between stock returns and volatility in Indian using E-GARCH-in-mean model in the light of banking reforms, insurance reform, stock market crash and the global financial crisis. Volatility persistence, asymmetric properties and risk-return relationship are investigated for the Indian Stock Market It is found that the Indian Stock Market, returns show persistence in the volatility and clustering and asymmetric properties. This is similar kind of result was found for other emerging market (Karmakar, 2005; Karmaka, 2006; Kaur, 2002; Kaur, 2004; Pandey, 2005; Leon, 2007; Kumar and Singh, 2008) [20, 21, 23, 24, 33, 29, 27]. The result also shows that volatility is persistent and there is leverage effect supporting the work of Nelson (1991) [30]. The study found that little evidence on the relationship between stock returns and risk as measured by its own volatility. The study found positive but insignificant relationship between stock return and risk. This positive relationship is consistent with most asset-pricing models which postulate a positive relationship between a stock portfolio's expected returns and volatility. However, in view of the insignificance relationship, the result is inconclusive as there might be need for research as to other risk measures.

The result shows the banking reform in July 2004 and stock market crash since April 2008 negatively impacts on stock return while insurance reform and the global financial crisis have no impact on stock return. The stock market crash of 2008 is found to have contributed to the high volatility persistence in the Indian Stock Market especially during the global financial crisis period. The stock market crash is also found to have accounted for the sudden change in variance.

It appears the stock market of emerging markets is integrated with the global financial market. It is suspected that the sub mortgage crisis in the United States which causes liquidity crisis could have put up pressure on foreign investors in the Indian and other emerging stock market to sell off their shares so as to provide the needed cash to address their financial problems. The continuous sale of shares by foreign investors causes the stock prices to fall in the Indian Stock Market. The fall in stock prices resulted in the loss of investor's confidence leading to further decline as many banks that granted credit facilities for stock trading recall their loans. Further research work needs to be done as to the causes of stock market crash in the Indian Stock Market. There is a need for regulators in the emerging markets to evolve policy towards the stability and restoration of investor's confidence in the Indian Stock Market. Governments should possibly aid the promotion of market makers towards warehousing shares and creating the market for securities trading.

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