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The financial crisis of 2008 and stock market volatility – analysis and impact on emerging economies pre and post crisis

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Abstract: Stock market volatility plays a very important role in making or marring the fortunes of investors. The study of volatility becomes more important during extreme conditions such as financial crisis. This paper through GARCH, TGARCH and EGARCH models analyses and compares the volatility before and after the financial crisis of 2008. The study has been conducted on the emerging economies and comes out with quite interesting results. It concludes that the impact of the crisis on the volatility and leverage effect has been significant on the stock markets of different nations but the direction of the impact has been mixed.

Keywords: volatility; GARCH; asymmetry; risk; financial crisis.

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Biographical notes: Shailesh Rastogi is an Associate Professor in finance area at Thiagarajar School of Management, Madurai. He is keenly interested in quantitative aspects in finance. His areas of interests for research are behavioural finance, primary market, capital structure, time series modelling and volatility models. He has also conducted several MDP and FDP programmes in the field of data analysis including in the area of time series econometrics. He has been instrumental in conducting many sponsored research projects as well.

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1 Introduction

The stock market of a nation is a barometer of the nation's capital market. The impact upon the volatility of stock market is a good indicator of the ability of the stock market to withstand a financial crisis. Studying the impact upon volatility of the stock markets of

the emerging economies provides a comparative picture of the stock markets. The result of this study can be used by policymakers in designing the bilateral trade or business among the countries. The practitioners can also use the study to take a call as well as to make future decisions of doing business with other countries. Stability of the market of a country, in terms of managing the financial hiccups is a good parameter for deciding to do business with a particular nation. Deliberating and providing such inputs were the main motivations for conducting this study.

The maximum impact of the financial crisis is felt on the stock market volatility. Financial literature is full of studies on the impact of financial crisis on volatility. In the present study, the global financial crisis of 2008 has been undertaken. Though it seems that the financial crisis of 2008 is unique in terms of its intensity, but by looking at the history, it is found that the great depression of 1930s was of the same magnitude (Spiegel, 2011). Demyanyk and Van Hermert (2011) elaborated that prolonged deterioration of loan quality followed by initial rise and then fall in lending coupled with unsustainable growth were the main causes of the global financial crisis of 2008. International Monetary Fund (2009) opined that the financial crisis of 2008 started with the subprime mortgage crisis and gradually spread all over the world. Toman (2012) proposed that on the issue of reason for financial crisis of 2008 the world is divided into two-school of thoughts. One school of thought says that fair value accounting (FVA) is to be blamed for the world financial crisis of 2008 and the other says that FVA is good and cannot be held accountable for the crisis. Regardless of the literature supporting the former cause or the latter, this paper studies the impact of the financial crisis of 2008 on the volatility of the stock market of the emerging economies.

The role and importance of volatility in studying finance and financial markets have been argued by Poon and Granger (2003), and Raja and Selvam (2011), which is also supported by other studies (Angabini and Wasiuzzaman, 2011; Balasubramanyan and Premaratne, 2003; Bollerslev et al., 1992). Earlier volatility was assumed to be constant. However, with time as more research was done, it was found that volatility varies with time (Kovačić, 2008). Volatility is sometimes understood as a risk. But volatility and risk are not one and the same. Risk is associated with undesirable or unwanted results whereas volatility may be due to positive changes or not necessarily due to negative reasons (Poon, 2005). Earlier it was enough to know the mean return but now without a measure of volatility, description of a financial market is incomplete. After the financial crisis of 1987, the focus shifted towards the study of volatility (Brailsford and Faff, 1996).Volatility has its own significance in the financial world. It is studied in finance for various purposes. Important among them are to assess risk, to assess how volatility is impacting the overall economy, to be used as an input in the derivative pricing and for forecasting financial return series (Karmakar, 2005a). Information on volatility is also required for pricing of financial assets, selection of securities for the portfolio construction and management, and to assess the risk present in the stock market (Foucault et al., 2011). If volatility undergoes any change, it immediately impacts the economy as well as the investors. In this study, the stock markets of the selected emerging economies have been taken. The volatility of the stock markets of selected nations has been studied and compared during the period before and after the financial crisis of 2008. This paper provides good insight into the ability of stock market of selected nations to withstand a crisis in terms of volatility and its impact on the stock market. The first objective of the study is to carry out a comparative study of the behaviour of volatility before and after the world financial crisis of 2008 on the stock markets of emerging economies. The

second objective is to determine the asymmetric behaviour or leverage effect of stock market return series of the emerging economies. The third objective is to study the impact of the crisis on the leverage effect of stock market return of the emerging economies.

This paper has been further arranged into four more sections. The following section discusses the previous studies done in this field. Section 3 describes data and research methodology used in the study to serve the objectives of this paper. Section 4 deals with results and Section 5 deals with discussions and conclusion of this study.

2 Review of literature

The previous research on the topic can be divided into four streams. The first stream is on the stock market volatility related issues. Second stream comprises research on volatility and emerging economies. The third stream is on the volatility of the stock market due to financial crisis other than financial crisis of 2008. The fourth stream is related with the impact on stock market volatility due to financial crisis of 2008.

The first stream of research is on the stock market volatility related issues. Zhang and Li (2008) proposed that in the initial periods of Chinese stock market the asymmetry was not found but later on as the stock market became developed, the asymmetry was found in the market. Phichhang and Hengshan (2010) examined the volatility of stock exchanges using GARCH, EGARCH and TGARCH models, where classical models have been clubbed with least square support vector machine (LSSVM) method. It was argued that the new hybrid models provide improved forecasting results as compared to the classical volatility models. Tripathy (2010) proposed that the news regarding trading volume can be a useful input in forecasting the volatility. This paper also opined that asymmetric models capture the volatility better than their symmetric counterpart models. Byström (2011) provided the impact of news on volatility of stock exchanges across the globe including Chinese Stock Market. It has been found that the link between quantity of news and impact on the volatility has been strongly present for the world but weak for the Chinese stock market. Foucault et al. (2011) argued that retail investors' trading activities affect volatility. The actions of the retail investors cause short-term fluctuations in prices and returns. A crisis, which is reflected in media, affects the trading activities of retail investors which eventually affect stock volatility. Malik (2011) examined the impact of good news on stock market volatility. Literature supports the impact of the negative news on the stock volatility using leverage argument, but Malik (2011) argued that good news also impacts stock volatility and reduces volatility significantly. The symmetric model of GARCH to measure the volatility has also been used for studying the impact on the stock return volatility due to introduction of electronic trading (Al-Khouri and Al-Ghazawi, 2008). Rastogi and Srivastava (2011) examined the comparative volatility of stock market return series of the US and Indian markets. Debasish (2008) and Onour (2008) have also done studies on stock market volatility.

The second set of research is on the study of volatility and emerging economies. Carrasco and Williams (2012) argued that the emerging economies bounced back quickly from financial crisis of 2008. Varma (2009) opined that the Indian financial market had limited exposure to the assets which were part of the financial crisis of 2008. Varma (2009) emphasised that the cause of the financial crisis of 2008 was not financial innovation but lack of reforms in the bond and securitisation market. Financial literature

supports as well as criticises the notion that developed economies were most affected by the world crisis of 2008 and emerging economies were relatively less impacted. It was also much debated whether those emerging economies which were affected by the financial crisis of 2008 resumed normalcy more quickly as compared to developed economies or not (Dullien et al., 2010). The less impact assumption of the emerging economies has also been discussed and supported by International Monetary Fund (2009). Nartea et al. (2011) examined the volatility on five ASEAN markets (Malaysia, Singapore, Thailand, Indonesia and the Philippines) and put forth the finding that results generated in the developed stock markets cannot be generalised for the emerging economies. It was found that there exists a positive association between volatility and market returns in the stock market of emerging economies.

The third set of research is based on the impact of the volatility on the stock market returns due to financial crisis other than that of 2008. There is widespread evidence in financial literature of the instances that the financial crisis and volatility have been associated. Wu (2001) introduced that asymmetric volatility has been seen more clearly during a financial crisis, which is not prominent during periods of equilibrium. Schwert (1990) found that the volatility increased during and after the crisis of 1987 crash of the US stock markets but the volatility came back to normalcy faster than what had happened earlier. Aggarwal et al. (1999) proposed that the causes of impact on the stock market volatility of emerging and developed economies during 1985 to 1995 were mainly local causes except the October 1987 US stock market crash, which had impacted several economies undertaken for the study. Cuñado et al. (2009) examined the impact of IT bubble on the US stock markets and provided the evidence of long memory features during both periods (before as well as after the IT bubble).

The fourth set of research is based on the impact of volatility on the stock market return due to financial crisis of 2008. Global financial crisis of 2008 has impacted financial markets and financial institutions significantly all over the world (Angabini and Wasiuzzaman, 2011). Many studies have been conducted on the impact of the world financial crisis of 2008 on stock market volatility. It has been argued in these research papers that the stock market volatility has significantly changed post financial crisis of 2008 (Varma, 2009; Ramlall, 2009, 2010; Karunanayake et al., 2010). Goudarzi and Ramanarayanan (2011) proposed a study on the Indian stock market on BSE 500 return data using EGARCH and TGARCH methods during the financial crisis of 2008 to 2009 and found significant presence of leverage effect in the market. Roquete et al. (2012) examined the impact on the diversification due to financial crisis on the Brazilian stock market and the crisis selected for the study was Russian financial crisis of 1998 and financial crisis of 2008. It was found that there is no loss of diversification benefit due to Russian financial crisis but there were losses of diversification benefit due to financial crisis of 2008. Narayan and Islam (2012) proposed that the impact of the world financial crisis of 2008 has been same on the persistence in the stock market return of all the emerging and developed economies undertaken for the study but the leverage impact intensified in the emerging economies during the crisis as compared to developed economies. Kassim et al. (2011) have explained the impact of 2008 financial crisis on Malaysian stock market. Bagchi and Ryu (2011) have done a study on the US, Korean and Japanese stock markets due to the financial crisis of 2008.

Referring to the review of literature, the following hypotheses have been framed for this study. The first null hypothesis is that there has been no change in volatility in the

stock markets after the financial crisis of 2008. The second null hypothesis is that there is no leverage effect in the return series of stock indices. The third null hypothesis is that there has been no change in the leverage effect due to the financial crisis of 2008.

3 Data and methodology

3.1 Data

Many studies have been done for the developed economies and very few have been done for emerging economies. After having decided to fill the gap, by doing this study only on emerging economies, the obvious issue was of deciding on the emerging economies for the study. In this paper, ten nations (economies) have been selected for the study. The selection of the nations was based mainly on economic growth (measured by the GDP growth rates). The following table (Table 1) illustrates the main criteria along with other economic parameters for the selection (Rastogi, 2013). But availability of the clear data was also one of the important reasons for the final selection of the ten nations for the study. The selection of nations was taken from Rastogi (2013) with some modifications.

Table 1 Criteria for selection of the nations in the study

SN	*Criteria*
1	GDP (Growth rate in %)
2	Inflation (Consumer price; % change)
3	Unemployment (% of Total labour force)
4	Government Finances (Gross debt as % of GDP)
5	Current Account Balance (% of GDP)
6	FDI Inflow in the Country (Millions of $)

Source: Author's analysis and Rastogi (2013)

Data for the study has been collected from websites of the concerned stock markets and the Yahoo-finance website (http://www.yahoo/financeere). Following is the list of stock indices taken for the various nations (Table 2).

Daily stock prices have been taken from all the ten indices. There are 2,703 observations altogether from March 2000 to May 2011. Some observations have been deleted to bring synchronisation in all the ten datasets of ten indices as there were some deviations in the dates of functioning of respective stock exchanges. These datasets have been divided into two parts. The first part of data pertains to the period March 2000 to December 2007 and the second part of the data pertains to the period January 2008 to May 2011. Dullien et al. (2010) and International Monetary Fund (2009) have argued that the commencement of the financial crisis of 2008 can be taken from January 2008. Following the literature, the same has been done in this study. Further, the price datasets have been converted into return series using natural log of the relative prices for all the ten indices in both the periods.

Table 2 Selected nations' stock indices

S no.	*Name*	*Stock exchange*
1	Singapore	Singapore Exchange (SGX)
2	Taiwan	Taiwan Stock Exchange
3	India	Bombay Stock Exchange (BSE)
4	China	Shanghai Stock Exchange
5	Argentina	Buenos Aires Stock Exchange
6	Brazil	BM&F Bovespa
7	Malaysia	Kuala Lumpur Stock Exchange
8	Hong Kong	Hong Kong Stock Exchange
9	Korea	Korea Stock Exchange
10	Indonesia	Indonesian Stock Exchange

Source: Author's own analysis and Rastogi (2013)

3.2 Methodology

A financial time series has three characteristics different from a normal time series. These are leptokurtic distribution, volatility clustering and leverage effect. These features of financial time series differentiate the study of the returns of financial assets from the returns of other asset classes (Brooks, 2002; Mandelbrot, 1963). The leverage effect or the asymmetric nature of the financial time series gets accentuated more during a crisis (Wu, 2001). Therefore, volatility cannot be modelled in the normal way for a financial time series. Hence, to model such time series, time varying volatility models are required. Engle (1982) proposed for the first time to incorporate the time varying nature of volatility using ARCH process. GARCH models were developed by Bollerslev (1986) to overcome the lacunas of ARCH models. Brailsford and Faff (1996) have enumerated the following volatility forecasting models after many investigations. These are random walk model, historical mean model, moving average model, exponential smoothing model, exponential weighted moving average (EWMA) model, regression models and ARCH/GARCH family of models. The study was done on Australian stock market data and a comparative analysis is presented in their paper. ARCH/GARCH family of models along with the regression models have given superior results over all other models. This is the reason that the most sought after models for modelling volatility of financial time series data are the ARCH/GARCH family of models. The ARCH/GARCH family of models uses advanced methods to forecast volatility which are better than traditional measure of volatility. The work of Engle (1982) was improved upon by Bollerslev (1986) and Taylor (1986) to overcome some of the limitations of ARCH models, such as overfitting and breach of non-negativity constraint, etc. GARCH models have been found to be more flexible and parsimonious over ARCH models (Bollerslev, 1986). After formulating GARCH models, Tim Bollerslev explained the utility of ARCH/GARCH family of models in modelling financial data especially time series volatility of high frequency data (Bollerslev et al., 1992). Many researchers have also found GARCH family of models to outperform the other models. Different researchers used different markets and methods to communicate the same thing in their research. Akgiray (1989), Pagan and Schwert (1990), Brailsford and Faff (1996) and Brooks (1998) have given

their views on the US-based data. Corhay and Rad (1994) examined Europe-based data and Anderson and Bollerslev (1998) have studied data based on Asian countries. In the Indian context, Kumar (2006) has carried out a study on both stock market and forex markets. It has been found that GARCH family of models gives superior results. In stock markets, GARCH (4, 1) models along with EWMA methods were found to give best results and GARCH (5, 1) were found to give better results in the forex markets than the other models considered in the study. All the researchers found that GARCH family of models provides more accurate forecast of volatility of returns of the financial assets. The simplest but often useful GARCH process is the GARCH (1, 1) process which is also called the generic or plain vanilla GARCH model. We have used GARCH (1, 1) model in our study because of its simplicity. Karmakar (2005b) has suggested to use GARCH (1, 1) to capture conditional volatility of stock returns. GARCH (1,1) model does not take care of leverage effect and sometimes violation of non-negativity constraint is also found. Despite the shortcomings GARCH (1, 1) model is found to be excellent for a wide range of financial data (Bollerslev et al., 1992) and this suits well for our purpose of comparing conditional volatility during both the periods taken for this study in non-asymmetric situation.

The specification of GARCH model is as follows (Brooks, 2002):

$$y_t = \beta_0 + \varepsilon_t \tag{1}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \tag{1a}$$

where y_t is conditional mean and h_t is conditional variance. ε_t is the error term of the mean equation. 'p' and 'q' are the lag of the residual (error) term and conditional variance terms in the conditional variance equation. In their specifications the optimum number of lag order (values of 'p' and 'q' are decided with the help of AIC and SIC criteria (Brooks, 2002). In GARCH (1, 1) model where $p = 1$ and $q = 1$, where the equation [1(a)] gets transformed into equation (2).

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{2}$$

'α' and 'β' are coefficients of ARCH and GARCH terms respectively in equations (1) and (2). In equations (1) and (2) 'α_0'and 'β_0'are the constant term. Here, 'α' estimates the response to shock and 'β' measures the time it takes for any change to die out. Higher α means more responsive to new information and higher β means more time for the change to die out. The ($\alpha + \beta$) gives a measure of persistence of the concerned time series. Higher value of the ($\alpha + \beta$) indicates more persistence in volatility and it should tend towards one which is an extreme case of persistence (Karmakar, 2005b).

Out of the three special features of financial time series data mentioned (leptokurtic distribution, volatility clustering and leverage effect) the leptokurtic and volatility clustering nature of financial return data have been captured by GARCH models but asymmetric behaviour is not captured. To incorporate the asymmetric nature of the financial time series, asymmetric predictable volatility has been discovered by Black (1976) and later on confirmed by French et al. (1987), Schwert (1990) and Nelson (1991). To address the asymmetric issue Nelson (1991), Zakoian (1991) and Glosten et al. (1993) proposed EGARCH, TARCH and GJR (proposed by Glosten et al., 1993) models, respectively. Zakoian (1991) first proposed the TGARCH model and later on

similar GJR model was proposed by Glosten et al. (1993). Rabemananjara and Zakoian (1993) have relaxed assumptions proposed by Zakoian (1991) in his paper on the TGARCH model which reinforces the asymmetric behaviour of the stock markets. French stock market was used to make the point in their work. Engle and Ng (1993) have studied the impact on the stock market return volatility. It was tested on Japanese data from 1980 to 1988 and it was found that to capture the asymmetry due to the news, EGARCH and TGARCH models were appropriate. Therefore, to incorporate the leverage effect in the analysis of the time series data in this study both the popular models have been used. Both the models are fully equipped to take care of the asymmetrical effect in the analysis. There are several studies to determine which model is better to study the asymmetric nature of financial time series data. Engle and Ng (1993) have found that GJR or TGARCH models are the best parametric models whereas EGARCH also captures the asymmetric behaviour and variability determined by EGARCH is considerably high. Mukherjee et al. (2011) have also found that EGARCH models are better than TGARCH using the data of Bombay Stock Exchange (BSE) Sensex.

The TGARCH model is a simple broadening of the GARCH model or the GARCH conditional variance equation (2). In conditional variance equation [equation (2)], an additional term has been included which incorporates the asymmetrical features of financial time series data. The TGARCH conditional variance equation is as follows (Enders, 2004):

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \lambda \varepsilon_{t-1}^2 d_{t-1} \tag{3}$$

where d_{t-1} is a dummy variable that is equal to 1, if $\varepsilon_{t-1} < 0$ and is equal to zero if $\varepsilon_{t-1} \geq 0$. Dummy variable is a variable which takes either zero value or 1 value. It signifies presence or absence of some attribute. If the coefficient of dummy variable (λ) happens to be statistically significant, it means that the leverage effect is present. The λ should be greater than zero and the condition for non-negativity will be $\alpha_0 \geq 0$, $\alpha_1 \geq 0$, $\beta \geq 0$ and $\alpha_1 + \lambda \geq 0$.

The problem of non-negativity associated with the condition which was initially imposed on GARCH model, still remains despite the fact that asymmetric behaviour is modelled in TGARCH models. This implies that all the estimated coefficients should be positive. Nelson (1991) proposed EGARCH (exponential GARCH) model as an improvement over GARCH/TGARCH models. By its very nature the EGARCH specification does not need a non-negativity constraint [equation (4)] (Brooks, 2002).

$$\ln(h_t) = \alpha_0 + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \beta \ln(h_{t-1}) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \tag{4}$$

Here h_t is conditional variance, ε is the error term and α_0, α, β, γ are coefficients. The presence of leverage effect in the time series data is indicated by the significance value of γ.

All the three tests being used in the study are meant to study the volatility and would be able to serve the objective of (GRACH, TGARCH and EGARCH) comparing volatility in periods before and after the 2008 financial crisis.

4 Results

Table 3 reports the descriptive statistics of all the return series of all the ten indices taken for both the periods. The mean return has been decreased in all the ten indices from period one to period two. The fall is ranging from 16% to 126% in the case of Argentina and Indonesia respectively. In terms of variances, there is an increase in the variance from period one to period two in all the indices except Argentina, Taiwan and Korea. In the case of Argentina, no change in variance has been reported. In case of Taiwan and Korea, variances have decreased, though marginally. The highest increase in the variance has been found in Malaysia (255%) and highest fall is for Taiwan (2%). Therefore, for variances it can be interpreted that variance has either increased or did not change. In terms of normalcy, all the return series in both the time periods are normally distributed except Singapore for period one. No significant change has been reported for skewness and kurtosis from period one to period two in all the ten indices undertaken for the study.

Table 3 Description of all the ten daily return series

	Mean	*Variance*	*Skewness*	*Kurtosis*	*JB* Statistics*
	Period one from March 2000 to December 2007				
Singapore	0.000287	0.00012	−0.30503	6.421852	937.3027#
Taiwan	−0.000012	0.000244	−0.23255	5.704095	584.7094
India	0.000768	0.000213	-0.6235	7.532142	1,716.07
China	0.000532	0.000195	0.036146	8.868195	2,674.913
Argentina	0.000699	0.000472	0.157243	8.021326	1,965.946
Brazil	0.000651	0.000319	−0.22677	3.776102	62.75667
Malaysia	0.000306	0.000077	−0.63982	8.901625	2,832.244
Hong Kong	0.000274	0.000163	−0.20414	5.86855	652.0331
Korea	0.000361	0.000294	−0.48885	6.534294	1,044.394
Indonesia	0.000848	0.000199	−0.75204	8.489687	2,516.318
	Period two from January 2008 to May 2011				
Singapore	−0.00015	0.000257	−0.2786	7.929046	857.1077
Taiwan	0.000143	0.000239	−0.18261	5.179334	170.087
India	−0.00014	0.000431	0.276405	9.33224	1,407.366
China	−0.00072	0.00045	−0.17195	4.947666	136.2565
Argentina	0.000584	0.00047	−0.60472	8.356838	1,050.52
Brazil	0.000173	0.000491	0.133459	9.40265	1,430.437
Malaysia	0.000139	0.000274	−0.02572	77.42229	192,930.7
Hong Kong	−0.00018	0.000481	0.155592	9.446691	1,451.04
Korea	0.000278	0.000288	−0.55054	11.01901	2,282.175
Indonesia	0.000287	0.000288	−0.79234	11.35048	2,516.418

Notes: #Null of normalcy has been rejected at 5% level of significance.
*Jarque Bera test of normalcy (null of normalcy).

Source: Author's analysis

Table 4 Test of stationarity (Dickey Fuller Test)

Name of the country	*Level*		*First difference*	
	Period one from March 2000 to December 2007			
	*t-value**	*p-value*	*t-value*	*p-value*
Singapore	0.7273	0.9927	–23.3865	0.0000
Taiwan	–0.1.6449	0.4593	–41.9594	0.0000
India	2.8985	1.0000	–30.9004	0.0000
China	4.3824	1.0000	–18.2573	0.0000
Argentina	–0.4735	0.8938	–43.3108	0.0000
Brazil	0.8359	0.9747	–43.0052	0.0000
Malaysia	0.6816	0.9918	–35.3258	0.0000
Hong Kong	0.8514	0.9949	–19.5939	0.0000
Korea	–0.1701	0.9397	–23.9596	0.0000
Indonesia	0.9382	0.9960	–40.3527	0.0000
	Period two from January 2008 to May 2011			
	t-value	*p-value*	*t-value*	*p-value*
Singapore	1.5607	0.5023	–29.8023	0.0000
Taiwan	–0.9124	0.7845	–27.4155	0.0000
India	1.5518	0.5068	–27.1031	0.0000
China	–1.9521	0.3084	–28.9153	0.0000
Argentina	–0.1115	0.9463	–28.2329	0.0000
Brazil	–1.51123	0.5276	–29.7873	0.0000
Malaysia	–0.2924	0.9234	–26.7387	0.0000
Hong Kong	–2.1200	0.2369	–30.4362	0.0000
Korea	–0.8329	0.8088	–29.679	0.0000
Indonesia	–0.7112	0.8418	–26.2043	0.0000

Note: *The critical values of the augmented Dickey Fuller test are −2.8648 at 5% level of significance.

Source: Author's analysis

It was found that all the ten indices taken for the study are not stationary on the level but are stationary on the first differences. Therefore, we can say that the price series are not stationary but the return series are stationary. Therefore, further analysis has been carried out only on the return series, as being stationary is a necessary requirement for further analysis.

Having checked for stationarity the next step is to check the return series for ARCH effect before further analysis of volatility is done. We have used ARCH-LM test to check the presence of ARCH effect and reported in Table 5. It has been found in ARCH-LM tests that all the return series on the ten indices have time varying variances in both the periods undertaken for the study. This result endorses the need for ARCH-based models for further study. In this part of the analysis, plain vanilla GARCH (1, 1) model for the situation of symmetry and T-GARCH and EGARCH models for the situations of asymmetry have been used.

Table 5 ARCH-LM tests

	F test statistic	*p-value*	*F test statistic*	*p-value*
	Period one from March 2000 to December 2007		*Period two from January 2008 to May 2011*	
Singapore	20.7629	0.0000	22.3251	0.0000
Taiwan	22.5199	0.0000	15.5241	0.0000
India	41.7991	0.0000	9.4054	0.0000
China	6.9815	0.0000	5.7198	0.0000
Argentina	44.7184	0.0000	26.9255	0.0000
Brazil	7.2458	0.0000	46.6129	0.0000
Malaysia	27.9089	0.0000	52.5229	0.0000
Hong Kong	22.4569	0.0000	31.9343	0.0000
Korea	11.1115	0.0000	39.9343	0.0000
Indonesia	15.4431	0.0000	8.9303	0.0000

Source: Author's Analysis

Table 6 GARCH estimates and comparing of α and β

Name of the country	*Period one from March 2000 to December 2007*			*Period two from January 2008 to May 2011*			*Chang in* $(\alpha + \beta)$ *(%)*
	α*	β*	$(\alpha + \beta)$	*A*	*B*	$(\alpha + \beta)$	
Singapore	0.1061	0.8883	0.9944	0.1125	0.8865	0.9990	0.46
Taiwan	0.0671	0.9266	0.9937	0.0662	0.9263	0.9925	–0.12
India	0.1676	0.7689	0.9365	0.1321	0.8678	0.9999	6.77
China	0.0901	0.8938	0.9839	0.0635	0.9217	0.9852	–0.13
Argentina	0.0949	0.8796	0.9745	0.0995	0.8912	0.9907	1.67
Brazil	0.0514	0.9196	0.9710	0.0928	0.8916	0.9844	1.38
Malaysia	0.1422	0.8445	0.9867	0.1405	–0.0410[#]	0.0995	–90
Hong Kong	0.0542	0.9408	0.9950	0.1028	0.8916	0.9944	–0.06
Korea	0.0884	0.9073	0.9957	0.0757	0.9138	0.9895	–0.62
Indonesia	0.2056	0.6563	0.8619	0.1225	0.8346	0.9571	11.05

Notes: *α means ARCH term (coefficient of lagged squared error term) and β means GARCH term (coefficient of lagged variance term).
[#]Not significant at 5% level of significant.

Source: Author's Analysis

The estimates of GARCH (1, 1) model for both the periods have been reported in Table 6. All the GARCH models estimated for the ten indices in both the periods have significant coefficients at 5% level of significance except for Malaysia in the second period. Lagged variance term (GARCH term or β) is insignificant in Malaysia's second period of the study.

The responsiveness to news has been measured in GARCH (1, 1) model with the help of α [equation (2)]. It has been found that α value is significant in all the GARCH (1, 1) models. India, China, Malaysia, Korea and Indonesia have witnessed a fall in the

responsiveness to news from period one to period two. Highest fall has been reported in the case of Indonesia (40%). Other nations have seen an increase in responsiveness to news as their α values have increased.

The time taken by a time series to die out a change is being measured by β in GARCH (1, 1) model. In our study, the value of β is coming out to be significant in all the models measured in the study. In case of β also, India, China, Korea and Indonesia are showing an increase in the response time to have the changes die out. Singapore, Taiwan and Argentina have reported either no or very slight change in terms of their β values. In case of Brazil, Malaysia and Hong Kong a decrease in β value has been reported which implies that these nations will take less time to have the changes die out.

Table 7 Estimate of TGARCH and Interpretation

Name of the country	*Period one from March 2000 to December 2007*				*Period two from January 2008 to May 2011*				*Change in λ (%)*
	α	λ	β	$(\alpha + \lambda)$	α	λ	β	$(\alpha + \lambda)$	
Singapore	0.0426	0.1065	0.8924	0.1491	0.0372	0.1267	0.8973	0.164	18.97
Taiwan	0.0363	0.0618	0.9206	0.0981	0.010214#	0.07616	0.9430	0.087	23.24
India	0.0203	0.2691	0.7245	0.2894	0.059286	0.1285	0.8787	0.188	–52.25
China	0.0624	0.0440	0.9019	0.1064	0.02767	0.076155	0.9004	0.104	73.08
Argentina	0.0672	0.0581	0.8741	0.1253	0.07181	0.050994	0.8893	0.123	–12.23
Brazil	–0.0091#	0.1002	0.9151	0.0911	0.017285#	0.1515	0.8933	0.168	51.19
Malaysia	0.1055	0.0577	0.8519	0.1632	–0.1323	0.30038	0.8973	0.168	420.58
Hong Kong	0.0226	0.0597	0.9361	0.0823	0.02912#	0.1312	0.8931	0.160	119.76
Korea	0.0376	0.1109	0.8909	0.1485	–0.01911#	0.1544	0.9231	0.135	39.22
Indonesia	0.0472	0.2731	0.5953	0.3203	0.05548	0.131486	0.8352	0.187	–51.85

Note: # Not significant at 5% level of significance.

Source: Author's Analysis

Singapore, Taiwan, China, Hong Kong and Korea are having nominal or no change in their α plus β values. The α plus β value reflects the persistence of the time series. India, Argentina, Brazil and Indonesia have shown an increase in their persistence levels and maximum increase has been reported in Indonesia (11%). Malaysia has shown a decrease in the persistence level (90%).

It can be explained on the basis of results found in the GARCH model that the null of no change in the volatility has been rejected. There has been significant change in the volatility. But the direction of the change has been found to be bi-directional. In some cases it has increased and in some it has decreased.

Having estimated the GARCH (1, 1) model, the asymmetric models have been estimated separately for all the ten indices in both the time periods undertaken in the study. Table 7 has reported the estimates of TGARCH model. According to the equation (3), the presence of the leverage effect (asymmetric behaviour of the time series) is measured with the help of λ. In the analysis, it is found that the value of the λ is significant at 5% level of significance in all the ten indices in both the periods.

The value of λ has increased in Singapore, Taiwan, China, Brazil, Malaysia, Hong Kong and Korea. The maximum increase has been witnessed by Malaysia (420%).

This can be interpreted as the asymmetric behaviour of the indices return series has increased after the financial crisis. Whereas a reverse pattern of fall in the value of λ has been found in India, Argentina and Indonesia (maximum fall is in India and Indonesia of 52.25% and 51.85%, respectively). This fall in the value of λ implies that the asymmetric nature has decreased only in these three nations due to financial crisis of 2008. The fall in the asymmetric behaviour due to financial crisis as severe as this is a different behaviour which may be studied separately and can be taken up as an area of future study.

Table 8 Estimate of EGARCH and interpretation

	Period one from March 2000 to December 2007		*Period two from January 2008 to May 2011*		*Change in the value of λ*
	*λ**	*p-value*	*λ**	*p-value*	*% change*
Singapore	–0.0791	0.000	–0.94300	0.000	1,092.16
Taiwan	–0.0612	0.000	–0.06147	0.000	0.44
India	–0.1569	0.000	–0.0972	0.000	–38.04
China	–0.0225	0.000	–0.0689	0.000	206.22
Argentina	–0.0304	0.000	–0.0500	0.000	64.47
Brazil	–0.0891	0.000	–0.1044	0.000	17.17
Malaysia	–0.0433	0.000	–0.1276	0.000	194.68
Hong Kong	–0.0425	0.000	0.0888	0.000	–308.94
Korea	–0.0888	0.000	–0.1115	0.000	25.56
Indonesia	–0.1359	0.000	0.1376	0.000	–201.25

Note: *λ is the coefficient that measures the leverage effect.

Source: Author's own analysis.

Having estimated the TGARCH model, the estimation of EGARCH model has been done on all the ten indices return data for both the periods. This has been reported in Table 8. In EGARCH model, significance value of γ implies the presence of asymmetric behaviour [equation (4)]. The value of γ is significant for all the ten time series in both the time periods studied in the paper. This means that asymmetry or leverage effect was present in all the 10 return series in both the time periods. The same results were also found in the TGARCH estimation of all the ten indices in both the periods. This is being corroborated by the results of the EGARCH estimation. The value of γ is negative in all the 10 return series of both the time periods [as expected by the equation specification of the EGARCH model in equation (4) (Brooks, 2002)]. But for Hong Kong stock market return series in the second time period (January 2008 to May 2011), the value of the γ coefficient, though significant, coming out to be non-negative. This implies that the behaviour of Hong Kong daily return series showed leverage effect; however, it also behaves irrationally.

The asymmetric measurement of γ has shown mixed results in terms of direction of change. For Singapore, Taiwan, China, Argentina, Brazil, Malaysia and Korea there is an increase in the asymmetric behaviour or leverage effect (value has been measured in absolute sense). The maximum increase in asymmetric behaviour has been reported for Singapore (1,092.16%) and minimum increase has been reported for Taiwan (0.44%) which can be considered as no change from period one to period two. India, Hong Kong and Indonesia have reported different results of decrease in the asymmetric behaviour

after the crisis. India and Indonesia have also reported the same behaviour in TGARCH estimation. The decrease in the asymmetric behaviour is 38% in case of India, 309% in case of Hong Kong and 201% in case of Indonesia. In TGARCH estimation, India and Indonesia both have reflected a 52% decrease in their asymmetric behaviour from period one to period two.

It can be explained on the basis of results reported for TGARCH and EGARCH models that the null of no leverage effect has also been rejected and the null of no change in leverage effect has also been rejected. Though, the direction of change increased in some cases and decreased in some.

5 Conclusions

It is concluded that there has been significant change in the volatility in the stock markets of the emerging economies due to the financial crisis of 2008. The change in volatility has been estimated with the help of two parameters. The first parameter is the responsiveness of the news on the volatility. The second parameter is the time it takes for the change to die out. It has been found that India, China, Korea, Indonesia and Malaysia have reported a significant fall in the responsiveness to the news due to the financial crisis of 2008. India, China, Korea and Indonesia have reported an increase in the time they take for the changes to die out. The direction of the change in volatility increased in some cases and decreased in some post financial crisis of 2008.

According to asymmetric models, TGARCH and EGARCH, it has been found in the study that the leverage effect was significantly present in all the ten indices undertaken for the study before as well as after the financial crisis of 2008. It was also concluded that India, Argentina, Hong Kong and Indonesia have reported a decrease in the leverage effect post financial crisis of 2008. For the other nations, indices have shown an increase in the leverage effect.

Owing to the financial crisis this tendency of decrease in responsiveness for news, increase in the duration for time a change to die out and decrease in leverage effect can be the topics for further study in the future especially for India and Indonesia. Besides that, the issue of capital flight in the aftermath of financial crisis of 2008 could have also been incorporated in the study which is one of the limitations of the paper. This can also lead to further study on the topic.

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