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## Global Financial Crisis of 2007–08 and Volatility Spillover between the Stock Markets of India and US: A Comparison

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### A B S T R A C T

The recent global financial crisis of 2007-08 that had originated in the USA, rapidly invaded all over the world and adversely affected the real as well as the financial sectors of many economies. In this backdrop the present study dwells upon the nature of dynamic spillover effects within and across the stock markets of India and US. For this purpose, a sample consisting of the daily return data of BSE SENSEX for India and NASDAQ Composite for US from 2004 to 2013 has been constructed. To study the impact of the financial crisis on the chosen variables three subsamples have been considered, viz., Pre Crisis, In Crisis and Post Crisis. This study applies an EGARCH model to empirically estimate volatility of each return series under an Intra Country structure and a Diagonal VECH model to estimate the same under an Inter Country structure. The empirical findings are analysed and compared considering each market as well as country profile and different phases of the crisis. The study concludes that the financial crisis of 2007 - 08 affected the regular pattern of return and volatility spillover both within and across the markets. However, volatility spillover is found to be more vigorous compared to the return spillover as expected.

### Introduction

With the advent of globalization, financial markets worldwide have gradually become more interlinked enabling rapid transmission of market information within and across markets of different countries. This phenomenon is more prominent in the stock market, which is very sensitive in nature being one of the most important and active components of the financial sector of any economy. Any information, originating

domestically or internationally can make the stock market volatile which in turn can lead to a sequence of reactions influencing ultimately affecting financial stability of the economy. The recent global financial crisis, which actually originated in the US realty sector created massive turmoil in the stock markets of different countries. This was caused by the spillover of return and volatility from the US markets through different channels like trade, financial and confidence. While there exists a plethora of studies on volatility transmission among markets, domestic and cross border, very few works have focused on the intermarket relationship within the Indian financial market around the recent global financial crisis. In such a scenario, this study is a humble attempt to explore the dynamic pattern of interlinkages between the Indian stock market and the stock market of USA in terms of volatility spillover, around the financial crisis of 2007-2008. The study reflects the impact of the crisis on the pattern of spillover in

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each stock market under two different types of market exposure, domestic and foreign. Further changes in the stock market behaviour covering the entire crisis episode, upturn, peak and downturn, is analysed.

The present study is organized as follows. Section II documents a brief overview of the existing literature. Section III explains the methodology applied of the study. Section IV analyses the empirical results estimated and finally, Section V summarises the study.

### Literature Review

Some of the researches among the plethora of studies are mentioned herein below.

Among the studies that focus on stock market of a particular country, *Haugen et al* (1991), *Whitelaw* (1994), *Wu* (2001) estimated volatility changes in daily returns of US stock market and found asymmetric nature in the volatility response to the market. *Baillie* (1990) did not find any strong relationship between US stock market mean returns and own variance. *Neely* (2011) and *Jorion* (1995) observed existence of statistically significant volatility in US exchange market. Few researchers like *Majumder* (2012), *Srimany, Gayen & Ranjeev* (2011) analyzed the Indian stock market in terms of volatility.

On the working of the international transmission mechanism, *Hamao, Masulis and Ng. (1990), Kee-Hang Bae and Andrew Karalyi (1994)* explored US, UK and Japan stock markets and observed that New York daytime returns significantly influence other market returns and there exists cross market interdependence. *Li & Giles (2013)* examined the linkages of stock markets across the U.S., Japan and six Asian developing countries in terms of volatility spillover through asymmetric multivariate GARCH model and observed significant unidirectional shock and volatility spillovers from the U.S. market to the Japanese and the Asian markets during the Asian financial crisis. *Kiran Kumar & Mukhopadhyay (2002, 2007)* found evidences of return spillover effects from both domestic and foreign markets but significant volatility spillover effects only from foreign market. *Gunasinghe (2005), Mukherjee and Mishra (2006), Joshi (2011)* found significant bidirectional return, shock, and volatility spillover effect among almost all stock markets of India and other Asian markets.

Strong evidences of volatility spillover from USA covering the subprime crisis have been found in the studies by *Olowe & Ayodeji (2009)* for Nigeria, *Anaraki (2010)* for Europe, *Chinzara (2011)* for Africa, *Zhang et al. (2011)* for China, *Karunanayake, Valadkhani and O'Brien (2010)* for Australia, Singapore and UK, *Parsva & Lean (2011)* for 6 Middle Eastern Countries. With India as one of the countries for study, *Ali & Afzal (2012), Gangadharan (2011)* and *Manda (2010)* found similar results. However, considering China, *Chong (2011)* and considering UK and Japan, *Schwert (2011)* observed that the effect of financial crisis transmitted to other countries was short lived.

It has been observed that there exists a gap in the crisis literature in examining the changing pattern of market behaviour covering the crisis build up period going to the peak and then the post crisis sliding down phenomenon. The contribution of this paper harps on analysing the changing pattern of spillover of the stock market return and volatility from the Pre Crisis to In Crisis to Post Crisis scenario to bridge this gap. Market performances are investigated through own and cross mean return spillover, own and cross volatility spillover and the asymmetric effects of information spillover under both Intra Country and Inter Country structural set ups.

### Data & Methodology

To analyse and compare the nature of dynamic relationship between the stock markets of India and US in terms of return and volatility spillover, the daily close data of BSE SENSEX and NASDAQ Composite are collected from [www.finance.yahoo.com](http://www.finance.yahoo.com) for a period of almost 10 years (from Jan 1, 2004 to September 13, 2013). The daily return series ( $close_{t-1}$  to  $close_t$ ) are derived for the analysis as the first difference between the log of closing prices on consecutive trading days. All the preliminary tests like Unit root test, tests for autocorrelation and seasonality are duly performed. Structural break test identifies the break dates as 10/10/2007 from Pre Crisis to In Crisis and 9/3/2009 from In Crisis to Post Crisis. Our study explores each stock market under two different market exposures.

**a) Intra Country Volatility Spillover Analysis:** Each of the two stock markets of India and US are explored exclusively under a closed structure without considering any other effect. For this purpose, a Univariate EGARCH model is applied to determine the impact of own past return, volatility and information on present volatility of each return series. The concerned system is given as follows:

$$R(t) = C(1) + C(2)*R(t-1), \quad R : \text{return series of BSE and NASDAQ}$$

Since the EGARCH model is capable of capturing the asymmetric effect of negative information Vis-a-Vis positive information, therefore, present volatility of a return series is explained through previous period return, variance as well as information.

**b) Inter Country Volatility Spillover Analysis:** In this section, the impact of the global financial crisis on the own and cross market relationship between the return series of BSE and NASDAQ in terms of volatility spillover is explored. For estimation, a Multivariate GARCH model, specifically, a Diagonal VECH Model is chosen with a threshold term. This particular model is apt to capture the asymmetric effect of different types of information on volatility along with mean and volatility spillover. The system developed for the Inter Country analysis is given as:

$$\begin{aligned} \text{BSE}(t) &= C(1) + C(2)*\text{BSE}(t-1) + C(3)*\text{NAS}(t-1) \\ \text{NAS}(t) &= C(7) + C(2)*\text{BSE}(t-1) + C(3)*\text{NAS}(t-1) \end{aligned}$$

## Empirical Results

a) **Intra Country Volatility Spillover Analysis:** The results of spillover to the volatility for both BSE and NASDAQ under the Intra Country structure are obtained using EVIEWS 6 software and presented in the Table No – 1.

According to the estimated result, though during the Pre-Crisis period, **own mean spillover** effect was significant for the volatility of the BSE return series, the effect was blurred during the In Crisis and the Post Crisis periods. This may be due to the over dominating crisis panic which spilled over to the BSE return series and overshadowed the impact of the past return values. On the other hand, **own mean spillover** effect was insignificant for the volatility of the NASDAQ return series before the advent of the crisis but was negative and significant during the In Crisis and the Post Crisis periods. During the Pre-Crisis period, there was a crisis build up pressure in the realty sector of the US financial market. Therefore, NASDAQ could not reflect own past return values on its current volatility as the realty sector drew the attention of the US financial market players during that period. However, with the commencement of the crisis, volatility spillover effect is found to be significantly negative referring to the inverse relationship

between the mean and volatility of NASDAQ – while the return value of NASDAQ was falling day by day, its volatility was increasing during the In Crisis and Post Crisis periods. The **own volatility spillover** effects for both the return series are found to be significant for all the three sub periods implying that past volatility of a return series significantly determines current volatility of that return series irrespective of the phases of the crisis. According to the study, **size effect of information** is found to be significant for the volatility of the BSE return series during the Pre-Crisis and the Post Crisis periods only. During the In Crisis period, this effect is found to be insignificant. Under a global financial crisis, the market players became indifferent to the size of the news, and reacted to any news – small or big. Alternatively, as the crisis actually happened in the US, when the crisis appeared, the stock market became more concerned about the new information appearing as a shock to the market and as a consequence, the shock made the market more vulnerable to the size of the news in a panicked situation. So size effect of white noise became significant during the In Crisis period, which continued until the Post Crisis period also. The **sign effect of the new information** reveals significant asymmetric impact on volatility for all the three sub periods.

**Table-1: Volatility Spillover Analysis under the Intra Country Structure**

	PRE		IN		POST	
	BSE	NASDAQ	BSE	NASDAQ	BSE	NASDAQ
	MEAN					
C	0.1300(0.00)***	0.0194(0.56)	-0.3079(0.03)**	-0.2507(0.02)**	0.0325(0.37)	0.0777(0.03)**
BSE/NAS	0.0935(0.01)**	-0.0008(0.98)	0.0276(0.68)	-0.138(0.03)***	0.0225(0.48)	-0.0727(0.05)**
	VARIANCE					
C	-0.091(0.00)***	-0.0255(0.11)	0.0409(0.48)	-0.0414(0.49)	-0.0675(0.00)***	-0.0965(0.00)***
GARCH	0.8928(0.00)***	0.9617(0.00)***	0.9419(0.00)***	0.9676(0.00)***	0.9944(0.00)***	0.9444(0.00)***
SIZE	0.1937(0.00)***	0.0290(0.14)	0.0962(0.17)	0.1211(0.09)*	0.0898(0.00)***	0.1516(0.00)***
SIGN	-0.192(0.00)***	-0.104(0.00)***	-0.197(0.00)***	-0.132(0.01)**	-0.038(0.00)***	-0.1780(0.00)***

Source: Stock market data are collected from [www.finance.yahoo.com](http://www.finance.yahoo.com) \*=> significant at level 10%, \*\* => significant at level 5%, \*\*\* => significant at level 1%

b) **Inter Country Volatility Spillover Analysis:** The impact of the global financial crisis on the BSE and NASDAQ return series are analysed simultaneously within a single structure under an Inter Country set up applying Multivariate VECH model in Table No – 2.

The estimated result substantiates that the crisis had a dominating impact on both the stock markets as **own mean spillover** effect was insignificant during the In Crisis period. The massive impact of the crisis overshadowed the influence of

the previous return values to determine its current volatility. But the past return effect became significant as the impact of the crisis gradually subsided during the Post Crisis period and significant own mean spillover effect is observed for both the return series. Past volatility emerged as a significant determinant of own volatility for both the stock markets over the study period since **own volatility spillover** is estimated as significant for all cases. The significant **own asymmetric information spillover** in BSE and NASDAQ over the study period could be observed.

**Table-2: The Results of Volatility Spillover Analysis under the Inter Country Structure**

	PRE		IN		POST	
	BSE	NASDAQ	BSE	NASDAQ	BSE	NASDAQ
	COEFFICIENTS					
BSE	0.1096 (0.00)***	0.0157 (0.11)	0.6915(0.03)**	0.2701 (0.30)	0.0193(0.00)***	0.0113(0.00)***
NASDAQ		0.0348(0.00)***		0.2547 (0.04)**		0.0589(0.00)***
	ARCH					
BSE	0.0685 (0.01)	-0.0629 (0.00)***	0.0007 (0.96)	0.0451 (0.48)	0.0201(0.01)**	-0.0128 (0.15)
NASDAQ		-0.0314 (0.01)**		0.0385 (0.48)		-0.041(0.00)***

GARCH						
BSE	0.8380 (0.00)***	0.9018 (0.00)***	0.7949(0.00)***	0.5988 (0.02)**	0.9410(0.00)***	0.9432(0.00)***
NASDAQ		0.9401 (0.00)***		0.8518(0.00)***		0.9039(0.00)***
ASYMMETRIC NEWS EFFECT						
BSE	0.0707(0.04)**	0.0760 (0.02)**	0.2254(0.00)***	0.1822 (0.17)	0.0524(0.00)***	0.0337(0.00)***
NASDAQ		0.1068 (0.00)***		0.1337(0.08)*		0.1711(0.00)***

Source: Stock market data are collected from [www.finance.yahoo.com](http://www.finance.yahoo.com) \*=> significant at level 10%, \*\* => significant at level 5%, \*\*\* => significant at level 1%

The insignificant **cross mean spillover** effect during the In Crisis period for both the stock markets under study implicates the overshadowing impact of the crisis on the inter market relationship between the concerned stock markets which continued till the Post Crisis period also. As per the results of this analysis, significant **cross volatility spillover** effect is found in all the cases. This observation is much expected given the crisis background of the analysis. No asymmetry is observed in the effect when information spills over between BSE and NASDAQ during the In Crisis period. This result is quite obvious since US was the origin of the crisis that created a huge panic among the investors and any information created similar impact in the markets. However, during the Post Crisis period, this effect was found to be significant.

### Summary & Conclusion

In general, both the markets, BSE SENSEX and NASDAQ, experience significant own and cross volatility spillover effect during all the three subperiods of 2007-08 crisis which implies that volatility spillover across markets is quite prominent compared to return spillover. This again establishes the famous saying in the financial wisdom: '*Fear is a much stronger emotion than Greed*'. Fear, which is represented by volatility, spreads more than the return. In addition, the study found strong evidences that news asymmetry contributes significantly to the volatility spillovers both within and among BSE and NASDAQ stock returns during all the three periods. In this context, understanding the relationship among international stock markets and their interlinkages assumes its own importance.

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