On the Return and Volatility Spillover between US and Indian Stock Market

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Abstract

The issue of return and volatility spillover across the stock markets of different countries has become important as return and volatility shock of one market is transmitted from one market to another in terms of information transmission. Present study using the AR(p) - GARCH(1,1) model has investigated the contemporaneous as well as the dynamic return and volatility spillovers from the US stock markets (represented by NYSE Composite Index) to its Indian counterpart (represented by Sensex) and vice versa. A bi-directional contemporaneous return spillover has been reported while a unidirectional dynamic return spillover from US to India is revealed. However, a bi-directional contemporaneous as well as dynamic volatility spillover effect between the two markets is observed barring in the post-crisis period when no dynamic volatility has been reported from the Indian stock market to US stock market.

Keywords: Volatility Spillover, Sensex, NYSE Composite Index, AR(p)-GARCH(1,1)

1. Introduction

Due to openness in trade and investment which is a corollary of globalization, national markets are interacting and increasingly becoming global (Wei et al (1995)). Rapid use of internet in the trading process has increased the speed of trading decision and operating efficiency of the market. Cross listing with different stock exchanges and the use of GDRs have enabled firms to be listed and traded with more than one stock exchange (Sabri (2006)).

On one hand, many opportunities of investment are being created while the negative sides of such interaction could not be ignored too. Therefore, financial crisis originating in one country is transmitted to other parts of the world. Asian stock market crisis in 1997, Russian default in 1998 and US sub prime mortgage crisis in 2007-08 are some of the notable happenings that not only affected the neighbouring economies but also jolted the distant ones.

The issue of volatility spillover across the stock markets of different countries has become important as return and volatility shock of one market is transmitted from one market to another in terms of information transmission due to strong economic cooperation and free flow of capital.

The analysis of volatility spillover in the markets serves as the subject of interest for most of the international fund managers, investors and academicians. Markowitz (1952) was the first to show that portfolio efficiency could be optimized by combining assets based on the correlation in their returns. Grubel (1968) extended the work of Markowitz (1952) stating that portfolio efficiency could be increased through international diversification.

Moreover, Rigbon and Sack (2003) stated that volatility spillover is to be researched because analyzing a single market without paying due attention to others would lead to ignoring relevant information. They were also of the opinion that the change of asset price in one market due to the volatility shock of the other and its reaction to the other market is very important. Calvet et al (2006) reported how volatility can affect return of portfolio selection and derivative price.

Most of the studies till date dealing with this issue have investigated the influence of US market on the regional stock exchanges or that of a regional giant say Japanese market on the regional stock exchanges. It is expected that developed stock markets would influence the emerging markets and the mean and volatility spillover effect would

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be unidirectional.

Eun and Shim (1989) conducted a study for the period ranging from December 1979 to December 1985 and found that the stock market of the US was the worldwide leader. Cheung and Mak (1992) also found that US market was the global factor leading both the developed and most of the Asian markets. Park and Fatemi (1993) examined the linkages between the equity markets of the US, UK and Japan. It was reported that the US market was the most influential in comparison to other markets.

Study conducted by Chou et al (1999) revealed that volatility spillover from US market to Taiwan. Miyakoshi (2003) showed volatility spillover from Japan to other regional stock markets.

The leadership of US market is further established when Liu et al (1995) revealed that Tokyo market had lesser influence than New York on the Hong Kong and Taiwan.

Researchers are of opinion that bidirectional volatility spillover could be observed between the developed stock markets. For example, Kanas (1998) found bidirectional volatility spillover between the London and Paris markets and that of between the Paris and Frankfurt markets.

The study conducted by Amin and Imam (2008) examined volatility spillover among the G7 countries for the study period from July 1993 to January 2004. The study reported a significant volatility spillover from the US market to other developed countries. It was also revealed that there was a strong regional volatility dependency across the major European markets.

In this context, the study conducted by Bala and Premaratne (2003) is an exception. They reported a significant volatility spillover from Singapore capital market to that of the US, Hong Kong and Japan.

Furthermore, studies of linkages between developed and emerging financial markets have focused primarily on the implications of market liberalization and integration for return correlations and volatility spillovers, and the possibility of transmission of volatility shocks during the crisis periods in developed markets. The sub-prime crisis of 2007-08 provides an opportunity to investigate the possible return and volatility spillover effect from the US market to its Indian counterpart and vice versa during the recent crisis period.

The present study in this context therefore, has sought to investigate the issue of bidirectional return and volatility spillover effect between the Indian capital market represented by Sensex and the US stock market represented by NYSE composite index. It has also an underlying objective to explore the nature of the above during the turbulent and non turbulent period.

2. Literature Review

Despite the extensive research in the field, relatively a few attempt have been made as far as Indian market is concerned. This section deals with the important studies to date involving Indian stock markets regarding return and volatility spillover.

Kumar and Mukhopadhyay (2002) examined the return and volatility spillover from NASDAQ to Nifty. Daily returns for the period from July 1999 to June 2001 period were fitted to two stage GARCH and ARMA-GARCH model to capture the said effect. It was found that Nifty returns and volatility were significantly affected by the previous day's day time returns and volatility of NASDAQ composite.

Kaur (2004) applied both the EGARCH and TGARCH models to study return and volatility spillover between the Indian capital market represented by Sensex and the US stock market represented by NASDAQ and S&P 500. She found mixed evidence of return and volatility spillover between the US and Indian markets.

Wang (2005) studied that prospective return and volatility spillover effect from US and Japan to India, Pakistan and Sri Lanka. It was reported that there is a significant volatility spillover from US to India and Sri Lanka and that of between Japan to Pakistan.

Mukherjee and Mishra (2006) examined the issue of return and volatility spillover among Indian stock market with that of 12 other developed and emerging Asian countries for a fairly long period from November 1995 to May 2005. They fitted both open to close and close to open return data in GARCH process and found that the Indian open to close return are more related to foreign market return than its close to open return. On the other hand close to open (overnight) volatility of Indian market was more affected by the foreign markets.

Kumar and Mukhopadhyay (2007) studied intraday data from July 1999 to June 2001 to estimate the volatility from NASDAQ to Nifty and found that there was a significant unidirectional volatility spillover from US to Indian market. Most importantly, this study reported that the simple ARMA- GARCH model performed better than the more complex M-GARCH model.

Recently, Mukherjee (2011) revealed a bidirectional volatility spillover effect between Indian stock market and that of the Japan, the Republic of Korea, Singapore, Hong Kong and China.

Iqbal et al (2012) explored the volatility linkages between four Asian equity markets, namely, Pakistan (Karachi Stock Exchange), India (Bombay Stock Exchange), Hong Kong (Hang Sang Index) and Singapore (Strait Time Index). Using Multivariate GARCH BEKK model on weekly returns from January 2000 to August 2011 they found linkages among all markets with respect to conditional mean returns and volatility.

Sakthivel et al (2012) also found bidirectional volatility spillover between US market represented by S&P 500 and Indian market represented by BSE Sensex. They also found a unidirectional volatility spillover from Japan and United Kingdom to India.

3. Data and Preliminary Analysis

3.1. Data

The data used in this study is daily indices of the US (represented by NYSE Composite Index) and India (represented by Sensex) for the period from January 2, 2004 to December 31, 2011. The sample period has been divided into two sub periods. The pre-crisis period covers from January 2,2004 to December 31,2007 (a total of 966 observations), the post-crisis period covers from January 2,2008 to December 31,2011 (a total of 958 observations). The data have been obtained and downloaded from the website www.finance-yahoo.com.

The intensity of spillover may vary over time and the nature of such spillover may also change during the course of time. Thus, the subdivision of the study period is justified after the US sub-prime crisis during the period 2007-08. By doing this, it has been expected that a comparison could be made in the nature and direction of spillover between the sub periods.

Daily Market Returns (R_t) have been computed as follows:

$$R_t = \ln(I_t) - \ln(I_{t-1})$$

Where, ln denotes natural logarithm

I_t is the closing index value at day 't'

I_{t-1} is the closing index value at day before 't'

As for the missing data due to holidays in one market while other market is open, the previous day's closing price index has been used.

3.2. Preliminary Analysis

3.2.1. Descriptive Statistics

Table 1 provides descriptive statistics of daily market returns of full sample of two markets under consideration. It is seen that daily mean return for both the markets are close to zero. Both return series have distributions with positive kurtosis which is more than 3. So both distributions are leptokurtic.

Moreover, to test normality of the time series data the study applies Jarque-Bera Test in the following form:

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

Where, n = number of observations,

S = Skewness

K= Kurtosis

For a normal distribution the values of S and K should be 0 and 3 respectively so that JB becomes equal to 0. A high value of JB is an indicator of non-normality.

From the computed JB statistic it is clear that both the data series are not normal.

3.2.2. Unit Root Test

To test the stationarity the unit root test is applied on the time series return data. In this regard, the Phillips-Perron Unit Root Test is used. Phillips and Perron (1988) propose a nonparametric method of controlling for serial correlation when testing for a unit root.

The MacKinnon(1996) critical value calculations have been used to compare the computed t value. If the computed value is less than the critical value at 1% significant level there is no unit root.

The computed values of PP statistic have been reported in Table 2. It could be seen that the computed values of both the series are -41.29430 and -49.19901 respectively while the critical value is -3.43355 at 1% significant level. Hence, there is no unit root and thus both the return series are stationary.

Table 2: Phillips-Perron Unit Root Test

	Sensex Return	*NYSE Return*
Computed Value	-41.29430	-49.19901
Critical Value at 1% Sig. Level	-3.43355	-3.43355

4. Empirical Model

Stage 1:

The basic AR(p)- GARCH(1,1) model has been applied in the study. The mean and variance equations are as under:

$$R_{i,t} = \mu_i + \varphi_i R_{i,t-p} + \varepsilon_{i,t} \quad .(1)$$

$$\sigma_{i,t}^2 = \varpi_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2 \quad (2)$$

$$R_{j,t} = \mu_j + \varphi_j R_{j,t-p} + \varepsilon_{j,t} \quad (3)$$

$$\sigma_{j,t}^2 = \varpi_j + \alpha_j \varepsilon_{j,t-1}^2 + \beta_j \sigma_{j,t-1}^2 \quad (4)$$

Where,

$R_{i,t}$: Return of Sensex at day t

$R_{i,t-p}$: Return of Sensex at day t-p

$R_{j,t}$: Return of NYSE at day t

$R_{j,t-p}$: Return of NYSE at day t-p

$\sigma_{i,t}^2$: Volatility of Sensex at day t

$\sigma_{i,t-1}^2$: Volatility of Sensex at day t-1

$\sigma_{j,t}^2$: Volatility of NYSE at day t

$\sigma_{j,t-1}^2$: Volatility of NYSE at day t-1

For non negativity α_i. 0 and β_i. 0 and $\alpha_i + \beta_i$. 1

&

α_j. 0 and β_j. 0 and $\alpha_j + \beta_j$. 1"

In all cases p=1 signifies that the estimated model is an AR(1) process except an AR(8) process has been a good fit for equation 3 in the post-crisis period.

The standardized residuals series and (e_{Sensex} and e_{NYSE}) and their squares of these standardized residuals (e^2_{Sensex} and e^2_{NYSE}) have been saved from the stage 1 equations to be used in the stage 2 equations.

Stage 2:

In the second stage, the return and volatility spillover effects between two markets have been estimated. The contemporaneous return and volatility spillover model for two markets after substituting standardized residuals in the mean equations and squared standardized residuals in variance equation as an exogenous variable are as follows:

$$R_{i,t} = \mu_i + \varphi_i R_{i,t-p} + \lambda_i e_{t,NYSE} + \varepsilon_{i,t} \quad (5)$$

$$\sigma_{i,t}^2 = \varpi_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2 + \gamma_i e^2_{t,NYSE} \quad (6)$$

&

$$R_{j,t} = \mu_j + \varphi_j R_{j,t-p} + \lambda_j e_{t,Sensex} + \varepsilon_{j,t} \quad (7)$$

$$\sigma_{j,t}^2 = \varpi_j + \alpha_j \varepsilon_{j,t-1}^2 + \beta_j \sigma_{j,t-1}^2 + \gamma_j e^2_{t,Sensex} \quad (8)$$

It is noteworthy that both the exchanges do not have any overlapping trading hours. There is a time lag of 12 and a half hour between US Eastern Standard Time and Indian Standard Time. Keeping this time lag in consideration the dynamic return and volatility spillover effects have also been investigated. The dynamic models are as follows:

$$R_{i,t} = \mu_i + \varphi_i R_{i,t-p} + \lambda_i e_{t-1,NYSE} + \varepsilon_{i,t} \quad (9)$$

$$\sigma_{i,t}^{2} = \varpi_i + \alpha_i \varepsilon_{i,t-1}^{2} + \beta_i \sigma_{i,t-1}^{2} + \gamma_i e_{t-1,NYSE}^{2} \quad (10)$$

&

$$R_{j,t} = \mu_j + \varphi_j R_{j,t-p} + \lambda_j e_{t-1,Sensex} + \varepsilon_{j,t} \quad (11)$$

$$\sigma_{j,t}^{2} = \varpi_j + \alpha_j \varepsilon_{j,t-1}^{2} + \beta_j \sigma_{j,t-1}^{2} + \gamma_j e_{t-1,Sensex}^{2} \quad (12)$$

Thus the hypotheses can be written as follows:

Hypothesis 1

$H_0 : \lambda_i = 0$ (No mean return spillover effect from the US stock market to Indian stock market)

$H_1 : \lambda_i \quad 0$ (Mean return spillover effect from the US stock market to Indian stock market is present)

Hypothesis 2

$H_0 : \lambda_j = 0$ (No mean return spillover effect from the Indian stock market to US stock market)

$H_1 : \lambda_j \quad 0$ (Mean return spillover effect from the Indian stock market to US stock market is present)

Hypothesis 3

$H_0 : \gamma_i = 0$ (No volatility spillover effect from the US stock market to Indian stock market)

$H_1 : \gamma_i \quad 0$ (Volatility spillover effect from the US stock market to Indian stock market is present)

Hypothesis 4

$H_0 : \gamma_j = 0$ (No volatility spillover effect from the Indian stock market to US stock market)

$H_1 : \gamma_j \quad 0$ (Volatility spillover effect from the Indian stock market to US stock market is present)

5. Empirical Results

5.1. Stage 1: Basic AR(p) - GARCH (1, 1) Model

The estimated results of equations 1,2,3 and 4 have been reported in Table 3. It is seen that the model is a good fit for both the markets in all three cases, i.e., for entire study period, and two sub periods. In each case α s and β s are highly significant and non-negativity condition has been satisfied. It also appears that for each period and in case of both the markets ($\alpha + \beta$)s are very closed to 1 which indicates volatility is persistent. The Box-Pierce Q statistic [$Q = n\sum_{k=1}^{m} \hat{\rho}_k^{2} \sim \chi^2$ m, where, n=sample size and m= lag length.] for standardized residuals and squared standardized residuals are insignificant which signifies that no ARCH effect is left.

The standardized residual series of the estimated model have been saved to use in the second stage to model the mean return and volatility spillover effect.

Table 3: Stage 1- AR(p) -GARCH(1,1) Model Estimation

	2004-2011		*2004-2007*		*2008-2011*	
	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)
Mean Equation (1) & (3)						
μ_i / μ_j	0.001256* (4.41741)	0.00054* (2.56364)	0.001820* (4.55330)	0.000549* (2.40419)	0.000549 (1.11559)	0.000394 (0.97341)
φ_i / φ_j	0.076396* (3.03958)	-0.074559* (-2.88044)	0.082694* (2.34784)	-0.057421 (-1.58083)	0.062330 (1.701125)	-0.087768* (-2.28584)
Variance Equation (2) & (4)						
ω_i / ω_j	5.78E-06* (5.7855)	1.34E-06* (4.70948)	9.36E-06* (4.74187)	1.69E-06* (3.07554)	3.61E-06* (2.79375)	3.59E-06* (2.84647)

	2004-2011		2004-2007		2008-2011	
α_i / α_j	0.13945* (14.9790)	0.083931* (10.2231)	0.137653* (8.66425)	0.056148* (4.64185)	0.127411* (10.0760)	0.107085* (7.04126)
β_i / β_j	0.848829* (81.6375)	0.909795* (103.516)	0.819571* (40.2207)	0.918414* (51.5539)	0.873441* (66.4061)	0.884678* (56.2692)
Box-Pierce Q statistic of Standardized residuals						
Q(15)	19.653	10.30	19.174	16.022	10.725	8.653
Box-Pierce Q statistic of squared standardized residuals						
Q(15)	13.382	23.305	26.56	16.087	5.336	25.646

* significant at 1% level

5.2. Stage 2: Return and Volatility Spillover Effects

5.2.1. Contemporaneous Relationship

The estimated results of equations 5,6,7and 8 have been reported in Table 4. From the results it is revealed that both the λ_i and λ_j are positive and significant in the whole study period and the two sub periods as well. So null hypothesis 1 of no mean return spillover effect from the US stock market to Indian stock market and null hypothesis 2 of no mean return spillover effect from the Indian stock market to US stock market are rejected in the whole study period and in the pre and post crisis periods. Therefore, alternative hypotheses are accepted in each case. Hence, there is a significant positive spillover effect in mean returns between both the markets. It is also clear that the magnitude of mean return spillover between the countries increases in the post-crisis period.

In case of volatility spillover, it has also been observed that both the γ_i and γ_j are significant in the entire study period and in the sub-periods. The volatility spillover effect from US market to Indian market is positive in all periods while a significant negative volatility spillover is reported in the pre-crisis period from the Indian market to its US counterpart. However, both the null hypotheses 3 and 4 are rejected and Volatility spillover effect is present from the US stock market to Indian stock market and vice versa.

Table 4: Stage2- AR(p) -GARCH(1,1) Model Estimation (Contemporaneous Spillover Effect)

	2004-2011		2004-2007		2008-2011	
	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)
Mean Equation (5) & (7)						
μ_i / μ_j	0.001258* (4.643678)	0.00053* (2.55910)	0.001915* (5.14844)	0.000455 (0.96866)	0.000344 (0.79319)	0.000596 (1.389947)
φ_i / φ_j	0.072622* (3.03236)	-0.131861* (-5.15213)	0.079357* (2.37802)	-0.165713* (-2.57580)	0.056815 (1.65845)	-0.158544* (-4.40400)
λ_i / λ_j	0.003488* (10.5191)	0.002293* (10.8212)	0.00245* (5.338246)	0.00231* (6.03611)	0.004778* (9.88156)	0.00434* (9.87558)
Variance Equation (6) & (8)						
ω_i / ω_j	-2.03E-06 (-1.63525)	-2.60E-07 (-0.5205)	-4.60E-07 (-0.22627)	4.29E-05* (2.5647)	-1.97E-06 (-1.37964)	-8.43E-07 (-0.47526)
α_i / α_j	0.120752* (12.3089)	0.079548* (9.61124)	0.109065* (7.93544)	0.148295 (1.96893)	0.107983* (6.58910)	0.098375* (6.3950)
β_i / β_j	0.849524* (75.5214)	0.91094* (102.2003)	0.821494* (41.9600)	0.595109* (3.47556)	0.881388* (51.2519)	0.886171* (56.9352)

	2004-2011		2004-2007		2008-2011	
	Sensex (i)	*NYSE (j)*	*Sensex (i)*	*NYSE (j)*	*Sensex (i)*	*NYSE (j)*
Mean Equation (5) & (7)						
γ_i / γ_j	1.08E-05* (6.40062)	1.91E-06* (3.82360)	1.38E-05* (5.07734)	-5.38E-06* (-26.1372)	6.99E-06* (3.50491)	5.55E-06* (2.53084)
Box-Pierce Q statistic of Standardized residuals						
Q(15)	20.798	11.403	20.155	21.860	14.096	16.892
Box-Pierce Q statistic of squared standardized residuals						
Q(15)	9.371	29.926	27.791	81.613	5.328	21.499

* significant at 1% level

5.2.2. Dynamic relationship

The estimated results of equations 9, 10,11and 12 have been reported in Table 5. It appears that all the λ_i s are positive and significant. Thus, null hypothesis 1 of no mean return spillover effect from the US stock market to Indian stock market is rejected and the alternative hypothesis mean return spillover effect from the US stock market to Indian stock market is accepted. However, in neither of the sub-periods nor in the entire study period λ_j s are found to be significant. So the null hypothesis 2 has been accepted while the dynamic relationship is concerned. So there is no dynamic mean return spillover effect from the Indian stock market to US stock market.

Moreover, it has been observed that all the γ_i s are significant in the entire study period and in the sub periods. The γ_i is positive in the entire study period and pre- crisis period while a significant negative volatility spillover has been reported in the post-crisis period. Hence, the null hypothesis 3 has been rejected and volatility spillover effect is present from the US stock market to Indian stock market. On the other hand, it has also been seen that γ_j s are significant and positive in the entire study period and in the pre-crisis period while no significant outcome has been reported in the post-crisis period. Therefore, null hypothesis 4 is rejected in entire study period and in the pre-crisis period but it has been accepted in the post-crisis period.

Table 5: Stage2- AR(p) - GARCH(1,1) Model Estimation (Dynamic Spillover Effect)

	2004-2011		2004-2007		2008-2011	
	Sensex (i)	*NYSE (j)*	*Sensex (i)*	*NYSE (j)*	*Sensex (i)*	*NYSE (j)*
Mean Equation (9) & (11)						
μ_i / μ_j	0.001364* (4.947698)	0.000513* (2.46037)	0.002018* (5.34974)	0.000532* (2.22859)	0.003085* (3.95245)	-7.82E-05 (-0.05418)
φ_i / φ_j	0.017145 (0.69289)	-0.078069* (-2.96469)	0.036941 (1.05809)	-0.051874 (-1.41547)	0.057918 (1.90003)	-0.117932 (-1.67703)
λ_i / λ_j	0.003341* (10.4828)	0.000267 (1.23452)	0.003159* (7.27143)	2.99E-05 (0.11722)	0.005680* (9.87600)	0.000681 (0.61961)
Variance Equation (10) & (12)						
ω_i / ω_j	-1.50E-07 (-0.10902)	-2.49E-08 (-0.04968)	2.10E-06 (0.88311)	7.57E-09 (0.01385)	0.000179* (9.43963)	0.000311* (2.59523)
α_i / α_j	0.126934* (11.1236)	0.079847* (10.1406)	0.130948* (7.95674)	0.042497* (4.21916)	0.137685* (5.16109)	0.142052** (2.09551)
β_i / β_j	0.855481* (73.0831)	0.912426* (107.761)	0.802254* (36.5478)	0.931241* (61.2842)	0.488279* (10.7994)	0.569882* (3.61925)

	2004-2011		2004-2007		2008-2011	
	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)	Sensex (i)	NYSE (j)
Mean Equation (9) & (11)						
γ_i / γ_j	6.67E-06* (4.64528)	1.58E-08* (3.36464)	1.07E-05* (3.69169)	1.75E-06* (4.14101)	-2.06E-05* (-17.6431)	-2.17E-05 (-1.56423)
Box-Pierce Q statistic of Standardized residuals						
Q(15)	22.858	9.999	21.003	16.322	20.803	21.438
Box-Pierce Q statistic of squared standardized residuals						
Q(15)	14.621	24.345	23.628	17.219	56.601	485.38

* significant at 1% level

** significant at 5% level

6. Conclusion

Present study using the AR(p) - GARCH(1,1) model has investigated the contemporaneous as well as the dynamic return and volatility spillovers from the US stock markets (represented by NYSE Composite Index) to its Indian counterpart (represented by Sensex) and vice versa. A bidirectional contemporaneous return spillover has been reported while a unidirectional dynamic return spillover from US to India is revealed. It is also clear that the magnitude of mean return spillover between the countries increases in the post-crisis period. Koutmos and Booth (1995) also document similar greater mean and volatility spillovers after the crash across the New York, Tokyo, and London stock markets. Moreover, a bidirectional contemporaneous as well as dynamic volatility spillover effect between the two markets is observed barring in the post-crisis period when no dynamic volatility spillover has been reported from the Indian stock market to US stock market. The results contradict the findings of some of the previous studies where only unidirectional return and volatility spillover from the US market to the Indian market was reported. This may be due to the selection of different study period. However, the results are at par with Sakthivel et al. (2012). In two cases negative volatility spillover effect has also been reported. One plausible explanation of this may be found in Fernàndex-Izquierdo and Lafuente (2004). Fernàndex-Izquierdo and Lafuente (2004) found significant leverage effects in all the markets under consideration during the Asian financial crisis. They observed that the financial crisis had resulted in negative shock among these markets and volatility spillovers represent the noisy transmission of the negative news. The significant negative sign also implies the possible diversification opportunity by investors. The roll of speculators and noise traders can not be ignored either. A separate in-depth study may be required to investigate this.

Finally, since this research has found evidence of bidirectional spillover between Indian and US markets if contemporaneous relationship is accepted then it would not be impossible to consider India as another leader in the integration of capital markets in the region.

Reference

Amin, A. S. & Imam, M. O. (2008). Transmission of Stock Return and Volatility Across G-7 Countries. Working Paper, University of Houston.

Bala, L. & Premaratne, G. (2003). Volatility Spillover and Covement: Some New Evidence from Singapore. Working Paper, National University of Singapore.

Calvet, L. E., Fischer, A., & Thompson, S. (2006). Volatility Comovement: A Multifrequency Approach. Journal of Econometrics, 131, pp. 179 - 215.

Cheung, Y. L. & Mak, S. C. (1992). A Study of the International Transmission of Stock Market Fluctuation between the Developed Markets and the Asian-Pacific Markets. Applied Financial Economics, l2(2), pp. 1 - 5.

Chou, R., Lin, J. & Wu, C. (1999). Modeling the Taiwan Stock Market and International Linkages. Pacific Economic Review, 4, pp. 305 - 320.

Eun, C. S. & Sangdal, S. (1989). International Transmission of Stock Market Movements. Journal of Financial and Quantitative Analysis, 24(2), pp. 241 - 56.

Fernández, I. Á. & Lafuente, J. A. (2004). International Transmission of Stock Exchange Volatility: Empirical Evidence from the Asian Crisis. Global Finance Journal, 15, pp. 125 - 137.

Grubel, H. (1968). Internationally Diversified Portfolios: Welfare Gains and Capital Flows. The American Economic Review, 58, pp. 1299 - 1314.

Iqbal, M. J., Rafique, S., Abrar, A., Jamil, N., Shah, A. A. & Satti, A. H. (2012). Volatility Linkages between Equity Markets of Pakistan, India, Singapore and Hong Kong: A GARCH BEKK Approach. Journal of Economics and Behavioral Studies, 4(1), pp. 47 - 54.

Kanas, A. (1998). Volatility Spillovers across Equity Markets: European Evidence. Applied Financial Economics, 8, pp. 245 - 256.

Kaur, H. (2004). Time Varying Volatility in the Indian Stock Market. Vikalpa, 29(4), pp. 25 - 42.

Koutmos, G. & Booth, G. G. (1995). Asymmetric Volatility Transmission in International Stock Markets. Journal of International Money and Finance, 14, pp. 747 - 62.

Kumar, K. K. & Mukhopadyay, C. (2002). Equity Market Interlinkages: Transmission of Volatility - A Case of US and India. NSE, INDIA Research Paper. Retrieved from http://www.nseindia.com.

Kumar, K. & Mukhopadhyay, C. (2007). Volatility Spillovers from the US to Indian Stock Market: A Comparison of GARCH Models. The ICFAI Journal of Financial Economics, 5(4), pp. 7 - 30.

MacKinnon, J. G. (1996). Numerical Distribution Functions for Unit Root and Cointegration Tests. Journal of Applied Econometrics, 11, pp. 601 - 618.

Markowitz, H. (1952). Portfolio Selection. Journal of Finance, 7, pp. 77 - 91.

Miyakoshi, T. (2003). Spillovers of Stock Return Volatility to Asian Equity Markets from Japan and US. Journal of International Financial Markets, Institutions & Money, 13, pp. 383 - 399.

Mukherjee, K. N. & Mishra, R. K. (2006). Information Leadership and Volatility Spillover across the Countries: A Case of Indian and Other Asian Equity Market. Paper presented at 9th Capital Markets Conference Indian Institute of Capital Markets, October. Retrieved from http://ssrn.com/abstract=874916.

Mukherjee, P. (2011). An Exploration on Volatility across India and Some Developed and Emerging Equity Markets. Asia - Pacific Development Journal, 18(2), pp. 79 - 103.

Park, J. & Fatemi, M. (1993). The Linkages between the Equity Markets of Pacific-Basin Countries and Those of the U.S., U.K., and Japan: A Vector Autoregression Analysis. Global Finance Journal, 4(1), pp. 49 - 64.

Phillips, P. C. B. & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. Biometrika, 75, pp. 335 - 346.

Rigobon, R. & Sack, B. (2003). Spillovers Across US Financial Markets. MIT Sloan Working Paper.

Sabri, N. (2006). Globalization and Stock Market Stability. Retrieved from http://ssrn.com/abstract=899708.

Sakthivel, P., Bodkhe, N. & B. Kamaiah. B. (2012). Correlation and Volatility Transmission across International Stock Markets: A Bivariate GARCH Analysis. International Journal of Economics and Finance, 4(3), pp. 253 - 264.

Wang, Y., Gunasekarage, A. & Power, D. M. (2005). Return and Volatility Spillovers from Developed to Emerging Capital Markets: The Case of South Asia. Contemporary Studies in Economic and Financial Analysis, 86, pp. 139 - 166.

Wei, J. K., Liu, Y. J., Yang, C. C. & Chaung, G. S. (1995). Volatility and Price Change Spillover Effects across the Developed and Emerging Markets. Pacific-Basin Finance Journal, 3, pp. 113 - 136.