Shock and Volatility Spillovers between Stock Markets of India and Select Asian Economies

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Abstract

Flow of information and volatility coming from stock markets of other countries have significant impact on the stock market of a country. Volatility is even higher in the case the countries enjoy good economic conditions among themselves. The present manuscript aims to probe into the spread of impacts over a large range of returns and volatility in four major equity markets of Asia viz. India, China, Hongkong and Japan for a period of 18 years ranging from 2000 to 2017. The study uses VAR based GARCH model to determine the volatility spillover among the chosen countries for the period under assessment. The empirical outcomes of the study present that all selected markets have responded to their own lag of conditional volatility along with news shocks. The impact of conditional variance is higher in comparison to shocks which is an indication that markets fundamentals are stronger than corrections or shocks. The results of cross country spillover show that volatility of Shanghai Stock Exchange of China and shocks from Japan and Hongkong markets assert a significant effect over volatility of Indian equity market. Volatility of stock markets of Japan and China is not affected by the cross market volatility and shocks spillover from India. In contrast, volatility of Hongkong market is affected by shocks and volatility of Indian equity markets. Findings of the research have meaningful insights for the Governments and regulators, academicians, researchers, investors and fund managers in framing investment strategies in the chosen markets.

Keywords: Return, volatility spillovers, VAR, GARCH, stock markets.

Introduction

The swift pace of liberalisation and globalisation has created connectivity among nations for which change in economic activities in any part of the world spills over every country. The consequences of this impinge on the portfolio investors in quest of diversification by putting money in the diverse stock markets. In the aftermath of liberalisation, globalization and the advent of technology, interconnectivity between the equity markets across the globe has intensified manifolds. In this epoch, the stock of diverse economies are influenced by many universal factors (Mahajan, 2014). These universal factors may have their origin in one sole nation but their scorched is felt on all economies which are integrated with it. However, the pattern and severity of this fall out may be different from one economy to another economy because of different sensitivity levels of economies to these universal macroeconomic variables and asymmetric nature of information in all markets (Koutmos and Booth, 1995; Kodres and Pritsker, 2002). The cross country flow of news accros countries is usually referred to as spillover effect which can further be decomposed into mean and volatility spillover effect (Liu, 2016).

The literature has profuse examples explaining how a fiscal happening in one economy can spill to numerous other integrated economies. The most apt illustration that can be cited here is the subprime crisis of USA of 2008 accountable for the slump of several banks and financial institutions together with the fall of financial giant Lehman Bros. in USA causing depression & collapse in different...
economies around the globe through contagious effect (Syriopoulos, 2007; Yilmaz, 2010; Singh, 2012; Bekiros, 2014; Salma, 2015; Syriopoulos et al, 2015; Singh and Kaur, 2016; Ruan, 2018). There are evidences which postulate that this diffusion of crisis does not only happens to and from developed economies only (Theodossiou and Lee, 1993; Karolyi 1995) but it may spread from developed economies to growing countries as well (Li & Giles, 2015; Salma, 2015). Prior knowledge of the character and vigor of financial contagion and strength of spread out is immensely useful for stakeholders to ensure the diversification and safety of their portfolio which are less connected with each other (Jebran, 2014).

Given the backdrop, this study intends to investigate the integration and spread of precariousness amongst select rich and rising economies of Asia between years 2000 and 2017. The stock markets forming part of this research pursuit include China, Hongkong and Japan along with India. The motivation behind the selection of these stock markets is their nearness in terms of distance along with their economic interdependence with India. The present study also proposes to distinct itself in several ways. At the outset, this study covers stock markets of Asian developed and developing countries striving to give a strong impetus to existing knowledge on precariousness spread out in the region. Also, the study period of 17 years is wide-ranging which includes the phase of 2008 catastrophe, pre and post crises periods.

The second section of this study provides a review of the existing literature and methodology employed. The ensuing section of research offers observed outcomes and last part of it contains results and implication.

**Review of Literature**

Over a period, good amount of studies have proliferated on spread out of precariousness (Jebran and Iqbal, 2016). Few of the preliminary researches in the area (Hamao et al., 1990; Susmel and Engle, 1994; Karolyi, 1995; Sheicher, 2001 are engaged in studying many developed and promising economies of USA and fraction of Europe (Diebold and Yilmaz, 2009; Wang and Wang, 2010; Yilmaz, 2010). However, studies for emergent stock markets of Asia are still minuscule (e.g., Wong et al., 2004; Mukherjee and Mishra, 2010; Joshi, 2011; Jebran and Iqbal, 2016). Literature on chosen topic is not restricted to one segment of financial market but also diffuses to few other segments (Baillie and Bollerslev, 1991; Koutmos and Booth, 1995; Chou et al., 1999; Kanas, 2000; Ng, 2000; Malik and Ewing, 2009; Du, Cindy and Hayes, 2011; Syllignakis and Kourtas, 2011; Nazlioglu et al., 2013; Kumar, 2015; Jiang, Ma, Yang and Ren, 2018).

Empirical researches on examination of spillover of volatility in financial markets have been extensively carried out in the entire world and the majority of them have taken place in rich economies (Hamao et al., 1990; Ng, 2000; Billio and Pelizzon, 2003; Baele, 2005; and Xiao and Dhesi, 2010). Few of the imperative studies are with respect to rising economies in Asia and rest of the globe embrace (Eun and Shin, 1989; Chung and Ng, 1992; Miyakoshi, 2003; Wong et al., 2004; Mukherjee and Mishra, 2010; Yilmaz, 2010; Joshi, 2011; Zhou et al., 2012; Padhi and Lagesh, 2012; Gahlot, 2013; Talwar, 2015; Jebran and Iqbal, 2016). The outcome of these studies have produced explicit evidences which substantiate the unstable periods and qualified nature of volatility (Panagiotidis et al., 2003; Xiao and Dhesi, 2010; Bonilla and Sepulveda, 2011). Accordingly, there is a growing propensity to employ nonlinear models for the evaluation of the spillover of volatility (Talwar, 2016).
Large number of researches (Karolyi, 1995; Hong, 2001; Koopman et al, 2005; Hammoudeh and Li, 2008; Khemiri, 2011; Bonilla and Sepulveda, 2011; Fiszeder and Orzeszko, 2012; Salma, 2015; Mittal and Kumar, 2016; Demirer, Gupta and Wong, 2019) adopted non-linear ARCH/GARCH family models (Engle, 1982; Bollerslev, 1986) for probing precariousness of different types of time series data. The literature further state that predominance of the research studies in Asia have implemented vector autoregression (VAR) framework, Co-integration and Granger causality test only (Joshi, 2011; Tuan et al, 2015). Research pursuits (Engle, 2002; Worthington et al., 2005; Hassan and Malik, 2007; Beirne et al, 2009; Xiao and Dhesi, 2010; Yilmaz, 2010; Padhi and Lagesh, 2012; Fiszeder and Orzeszko, 2012; Tuan et al, 2015) make use of more sophisticated GARCH models involving multiple variables for analysing volatility spillovers in various financial markets. There are also studies, though few only, which advocate range based measures of volatility due to their superiority over traditional models of GARCH family (Yang and Zhang, 2000). These models too have serious shortcomings as these are not capable of handling subjective volatility (Chou, 2005). Literature also suggests that results of the empirical studies in this area are not uniform especially in the stock markets of developing countries. Many other research pursuits in the area (Kenourgios et al, 2011; Calomiris et al., 2012; Gahlot, 2013; Mensi et al, 2014; Yang and Hamori, 2013; Donadelli, 2015) have provided empirical support for the fact that economic crises impending from US are expected to be more impactful and this upshot will be subdued if it is coming from an emerging economy. Bordo and Murshid (2006), Wang( 2014) in their respective studies observed that volatility coming from United State spreaded more amongst the developed economies and in contrast the penetration rate for emerging economies was weaker during the on course of subprime crisis of 2008 in USA. Besides this, few of the studies have also reported the reverse contagion effect from stock markets of emerging countries to the stock markets of USA and other developed nations (Samarakoon, 2011).

An insight into the literature referred here has considerably facilitated the understanding of the nature and intensity of volatility spillover among the integrated economies thus enabling the construction of optimal investment portfolio.

**Objectives of the Study, Data and Methodology Employed**

**Objectives**

- To check volatility overrun among select stock markets of Asia including India, China, Hongkong and Japan.
- To review the enormity and strength of volatility overrun for the period of the study.

**Data Period and Source used for the Study and Descriptive statistics of the sample**

This paper makes use of every day closing price values of benchmark indices of sample countries from January, 2000 to March, 2017. The related facts have been congregated from the website of Yahoo Finance (*Table 1 in Appendix*).

From the data obtained, this research has computed the daily continuously compounded return with the help of mathematical equation given below:

\[ R_{i,t} = \log_e \left( \frac{P_i,t}{P_i,t-1} \right) \times 100 \]  

(1)

here; \( R_{i,t} \) represents continuous return and \( P_i,t \) stands for adjusted final closing prices of a day of an index of a given stock exchange for time \( t \). Daily continuously compounded return has been projected graphically (*Figure 1 in Appendix*). The figures of all the four return series give a common impression of volatility clustering. For this kind
of pattern, nonlinear models such as ARCH and GARCH are more effective (Joshi, 2011).

Note: Volatility Clustering, a phenomenon where period of high volatility is followed by more number of such periods and period of tranquility is followed by more number of periods of calmness.

Comprehensive descriptive statistical values of the incessant return time series of benchmark indices of the chosen stock exchanges are presented in Table 2 (in Appendix).

Descriptive statistics show that average daily returns are highest for India and lowest for Hongkong markets in that order. In spite of yielding the highest daily return the absolute risk of Indian stock market on the basis of standard deviation is the least and the same is highest for China followed by Japan and Hong-Kong in descending order. Skewness coefficient indicate that stock markets of India and Hongkong have higher mean values in comparison to modal values thus are positively skewed and the same is negative for Japan and China. It also indicates that probability of getting positive return on a day is moderately higher for stock markets of India and Hongkong in comparison to their counterparts in Japan and China. The values for coefficient of kurtosis are greater than the standard normal value of 3 for all the stock markets which mean that returns in these markets are far from being normal and are leptokurtic or have higher peaks than normal distribution. The p-value for Jarque-Bera test of normality also confirms the non-normality of the sample data.

**Methodology**

Before applying a higher order statistical technique, it becomes imperative to ensure the stationarity of a time series data. Without meeting the condition of stationarity, results are likely to be spurious. For probing the stationarity of four time series data the study applies three different unit root tests namely; ADF, PP and KPSS which are done to ensure the robustness of our results. As learnt from the literature, heteroskedasticity is also a major anomaly of time series data for which heteroskedasticity ARCH-LM test is proposed. In the presence of heteroskedasticity, the assumption of linearity amongst the variables, does not hold good, and which warrants the use of non-linear univariate models such as ARCH and GARCH but in the presence of more number of variables the results of these models don’t effectively explain the flow of volatility coming from overseas markets. This shortcoming of traditional ARCH and GARCH models stands removed by the use of multivariate GARCH models. Besides, this another VAR based GARCH model suggested by Ling and McALeer (2003) is a different valuable technique useful for investigating the spread out of volatility or instability emerging from connected stock markets (Hammoudeh et al., 2009; Arouri et al., 2012; Salma, 2015). The major advantage associated with it is its superiority in ascertaining spillover effects in return and conditional volatilities coming from domestic and overseas stock markets. Given the advantage of this technique the study employs bivariate VAR/GARCH (1, 1) technique, to analyse the spill of volatility coming from 3 overseas stock markets to India.

The VAR-GARCH model specifies following set of equations for working out the conditional mean:

\[ R_t = \alpha + \beta R_{t-1} + \varepsilon_t \]  \hspace{1cm} (2)

and \( \varepsilon_t = h_t^{1/2} \eta_t \)

here;

- \( R_t = (R_{t}^{\text{Ind}} \text{ and } R_{t}^{\text{Japan/China/Hongkong}}) \) represents series of daily return values, \( t \) represents time.
- \( \varepsilon_t = (\varepsilon_{t}^{\text{Ind}}, \varepsilon_{t}^{\text{Japan/China/Hongkong}}) \) are the residuals of the return series.
• $\eta_t = (\eta_{t, \text{Ind}}, \eta_{t, \text{Japan/China/Hongkong}})$ represents innovation which is independent and identically distributed.

• $h_t^{1/2} = \text{diag} \left((h_{t, \text{Ind}}^{1/2}, h_{t, \text{Japan/China/Hongkong}}^{1/2})\right)$ and $h_t$ stands for conditional variances

The Conditional variance equations used in the study are given below:

$$h_{t, \text{Ind}} = \alpha_{\text{Ind}} + \beta_{\text{Ind}} (\varepsilon_{t-1, \text{Ind}})^2 + \omega_{\text{Ind}} (h_{t-1, \text{Ind}}) + \beta_{\text{Japan/China/Hongkong}} (\varepsilon_{t-1, \text{Japan/China/Hongkong}})^2 + \omega_{\text{Japan/China/Hongkong}} (h_{t-1, \text{Japan/China/Hongkong}}) \quad (3)$$

$$h_{t, \text{Japan/China/Hongkong}} = \alpha_{\text{Japan/China/Hongkong}} + \beta_{\text{Japan/China/Hongkong}} (\varepsilon_{t-1, \text{Japan/China/Hongkong}})^2 + \omega_{\text{Japan/China/Hongkong}} (h_{t-1, \text{Japan/China/Hongkong}}) + \beta_{\text{Ind}} (\varepsilon_{t-1, \text{Ind}})^2 + \omega_{\text{Ind}} (h_{t-1, \text{Ind}}) \quad (4)$$

These equations manifest how precariousness moves amid two stock markets for the period specified in the study.

The cross value of the error term explain the ARCH effect of past distress known as temporary perseverance, lag values of conditional variances explain the enduring or the GARCH effect of earlier period volatilities of domestic and stock markets linked with it.

In the end, the conditional covariance between two stock markets has been computed by applying the equation given below:

$$h_{t, \text{Ind}, \text{Japan/China/Hongkong}} = \rho_{\text{Ind}, \text{Japan/China/Hongkong}} \ast (h_{t, \text{Ind}}^{1/2}, h_{t, \text{Japan/China/Hongkong}}^{1/2}) \quad (5)$$

where $\rho$ is the symbol of constant conditional correlation.

**Results & Interpretation**

Results of stationarity tests are presented in Table 3 (in Appendix). All of the three are applied for testing the stationarity of the presence of unit root indicate that four return series are devoid of unit root and hence are stationary. The outcome of ADF and PP tests are significant at 1 percent level which makes us to reject the null hypothesis of presence of unit root and those of KPSS test are not found significant resulting in non rejection of null hypothesis of absence of unit root.

**Table 3: Test for presence of Unit Root in Appendix**

Results of ARCH-LM test (P-value for F test is significant) for investigating the heteroskedasticity of the return series indicate the heteroskedasticity effect in all the series. These results are shown in Panel A of Table 4 in Appendix. Hence, the present set of data is amenable for the use of GARCH based models. Results of correlation state that there exists positive correlation between India and Hongkong whereas returns from Indian and Chinese markets are negatively correlated with each other (Panel B, Table 4). It leads to the conclusion that one can reap the benefit of diversification by investing in Indian and Chinese stock markets simultaneously.

**Table 4: Heteroskedasticity Test and Unconditional Correlation in Appendix**

**Return and volatility dependencies**

Table 5(a) contains the empirical results of VAR/GARCH model. Results are in the form of mean equation and variance equation. The findings of estimated VAR (1) - GARCH (1, 1) model are given in Table 5(a).

**Figure 2 in Appendix**

**Table 5(a) Result of VAR (1) – GARCH (1, 1) model for Nifty and Asian Market Indices in Appendix**

**Table 5(b) Appendix**

Our results explicitly establish that all four return series are affected by their own past values of conditional volatility as well as past shocks at 1% significance level. However, the sensitivity towards conditional volatility is higher vis-à-vis noise or shocks. These results are true for all the
markets included in the study. Reacting more to the conditional variance in comparison to shocks also confirms that fundamentals are more important than mere shocks or noise and past values of own conditional volatility is an important determinant in forecasting the volatility of the stock markets.

While considering the cross market, results it may easily be inferred that volatility in stock market of China has a significant effect on Indian stock market. However, there is no feedback effect from India to China. There is no significant impact of cross market shocks between Indian and Chinese Stock Markets. The similar results amid stock markets of India and Japan manifest that shocks from Japanese stock markets travels to India but shocks from Indian stock markets do not enter to stock market of Japan. Cross results connecting stock markets of India and Hongkong present that Hongkong stock market is sensitive to the news flow and unpredictability coming from stock market of India. Similarly, news coming from Hongkong is important for Indian markets as well but there is no cross spillover of volatility from Hongkong to India. Thus, it may easily be concluded that Hongkong market is very reactive to Indian stock market.

In brief, it may be concluded that stock market of India is more exposed towards news coming from Japan and Hongkong in comparison to news coming from China which have relatively less effect on Indian markets. There is unidirectional flow of volatility between India and China from China and no spill of volatility has been observed from Japan and Hongkong to India. Results also indicate that two of the larger economies i.e. China and Japan are not affected by the news flow or volatility emanating from Indian equity market to their countries.

**Conclusions and Implications**

In our research results, we have noted a vibrant involvement between stock markets of India and other three Asian stock markets of Japan, China and Hongkong. The present research covers the period from January, 2000 to March, 2017 i.e. 17 years is wide ranging and complete. The study uses of VAR/GARCH technique because of its superiority over the other possible econometric techniques. Empirical results of the study corroborate that lag values of error terms and volatility term have a significant impact on returns from stock markets. In furtherance, results divulge a positive precariousness sprawling from stock market of China to that of India and transmission of precariousness from Indian market to Hongkong market is negative. News effect or shocks from Japanese and Hongkong stock markets on Indian stock market is positive and significant. No cross diffusion of shocks has been examined between China and India. There is a bi-directional news flow between India and Hongkong. The study also reveals that shocks in Indian stock markets have a negative impact on the volatility in Hongkong markets while the news flow approaching from stock market of Hongkong cause a favourable effect on Indian market volatility. In the end, it may be concluded that Hongkong stock market is most responsive amongst the sample stock markets and in contrast to it; there is no evidence for cross market volatility transmission and shocks dependence vis-à-vis India from Japan and China stock markets.

The study has important insinuations for investors as it facilitates investors in formulating a portfolio strategy which absorbs the risk coming from other stock markets included into the study and vice versa. The study may also be valuable to the policy makers in establishment of an impeccable system so as to shield the financial markets from the events taking place in overseas neighborhood stock markets enjoying good economic ties with India.
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### APPENDIX

#### Table 1: Economy, Leading Stock Exchange and Benchmark Index

| Name of the Economy | Name of the Stock Exchange       | Major Index    |
|---------------------|----------------------------------|----------------|
| India               | National Stock Exchange (NSE)    | Nifty          |
| China               | Shanghai Stock Exchange (SSE)    | Shanghai –Composite |
| Japan               | Tokyo Stock Exchange (TSE)       | Nikkei 225     |
| Hongkong            | Hongkong Stock Exchange          | Hang-Seng Index |

#### Table 2: Descriptive Statistics

| Descriptive Statistics | $R_t^{ind}$ Mean | $R_t^{china}$ Mean | $R_t^{japan}$ Mean | $R_t^{hongkong}$ Mean |
|------------------------|------------------|---------------------|---------------------|-----------------------|
| Mean                   | 0.000553         | 0.000401            | 0.000199            | 0.000163              |
| Median                 | 0.000922         | 0.000700            | 0.000364            | 0.000386              |
| Maximum                | 0.173393         | 0.098568            | 0.141503            | 0.143471              |
| Minimum                | -0.111385        | -0.088407           | -0.114064           | -0.127000             |
| Standard Deviation     | 0.015271         | 0.016044            | 0.015528            | 0.015338              |
| Skewness               | 0.050199         | -0.120336           | -0.192695           | 0.117288              |
| Kurtosis               | 11.15577         | 7.588666            | 9.163982            | 11.44194              |
| Jarque-Bera (Probability) | 10813.10  | 3431.870            | 6199.859            | 11592.69              |

Source: Author’s Calculations
Table 3: Test for presence of Unit Root

| Series       | With intercept | With trend and intercept | None | With intercept | With trend and intercept | None | With intercept | With trend and intercept |
|--------------|----------------|--------------------------|------|----------------|--------------------------|------|----------------|--------------------------|
| $R_{\text{ind}}$ | -59.117*       | -59.115*                 | -59.050* | -59.121*       | -59.119*                 | -59.996* | 0.144423 | 0.127386                 |
| $R_{\text{china}}$ | -61.8303 | -61.822*                 | -61.800* | -62.186*       | -62.179*                 | -62.182* | 0.076475 | 0.076130                 |
| $R_{\text{Japan}}$ | -64.5435 | -64.541*                 | -64.540* | -64.747*       | -64.753*                 | -64.743* | 0.092810 | 0.055676                 |
| $R_{\text{hongkong}}$ | -63.4690 | -63.461*                 | -63.468* | -63.584*       | -63.587*                 | -63.587* | 0.083373 | 0.085852                 |

Source: Author’s calculations  
* significant at 1% level

Table 4: Heteroskedasticity Test and Unconditional Correlation

Panel A: Heteroskedasticity Test

|                | India               | China               | Japan               | Hong-Kong            |
|----------------|---------------------|---------------------|---------------------|----------------------|
| F-statistic    | 140.9846*           | 83.61179*           | 304.7073*           | 478.4434*            |
| Obs*R-squared  | 136.1320*           | 81.89755*           | 282.7550*           | 426.3455*            |

Panel B: Correlation

Correlation Coefficient

|                | 1       | -0.0022345 | 0.0423071 | 0.067397* |
|----------------|--------|------------|-----------|-----------|

Author’s Calculations  
* significant at 1% level

Table 5(a): Result of VAR (1) – GARCH (1, 1) model for Nifty and Asian Market Indices

| Var.         | India     | China     | India     | Japan     | India     | Hongkong   |
|--------------|-----------|-----------|-----------|-----------|-----------|------------|
| $R_{\text{ind}}$ (-1) | 0.07044* | 0.01693   | 0.06874*  | -0.00294  | 0.06824*  | -0.09014*  |
| $R_{\text{Asia}}$ (-1) | -0.01183 | -0.00709  | 0.01616   | -0.02524  | -0.00959  | -0.10128*  |

Mean Equation

|                | India     | China     | India     | Japan     | India     | Hongkong   |
|----------------|-----------|-----------|-----------|-----------|-----------|------------|
| $\epsilon_{\text{ind}}$ (-1)$^2$ | 2.91E-06* | 2.61E-06* | 2.19E-06* | 4.84E-06* | 3.01E-06* | 0.00014*   |
| $\epsilon_{\text{Asia}}$ (-1)$^2$ | 0.10989* | -0.00332  | 0.10075*  | 0.00340   | 0.09208*  | -0.01550*  |
| $h_{\text{ind}}$ (-1) | -0.00249 | 0.07422*  | 0.01180*  | 0.11619*  | 0.03598*  | 0.14837*   |
| $h_{\text{Asia}}$ | 0.08670* | 0.00241   | 0.87823*  | -0.00175  | 0.85449*  | -0.01750*  |

Variance Equation

|                | India     | China     | India     | Japan     | India     | Hongkong   |
|----------------|-----------|-----------|-----------|-----------|-----------|------------|
| $\sqrt{\epsilon_{\text{ind}}}$ | √         | √         | √         | √         | √         | √          |
| $\sqrt{\epsilon_{\text{Asia}}}$ | √         | √         | √         | √         | √         | √          |
| $\sqrt{h_{\text{India}}}$ | ×         | √         | ×         | ×         | ×         | ×          |
| $\sqrt{h_{\text{Asia}}}$ | √         | ×         | ×         | ×         | ×         | ×          |

Author’s Calculations  
* significant at 1% level

Table 5(b)

|                | India     | China     | India     | Japan     | India     | Hongkong   |
|----------------|-----------|-----------|-----------|-----------|-----------|------------|
| Own Past Shocks | √         | √         | √         | √         | √         | √          |
| Own Past Volatility | √         | √         | √         | √         | √         | √          |
| Past Shock of other country | ×         | √         | ×         | ×         | ×         | ×          |
| Past Volatility of other country | √         | ×         | ×         | ×         | ×         | ×          |

√ means significant impact  
× means no significant impact