Empirical Examination of Stock Market Volatility : An International Comparison

* Shalini Aggarwal
** Simmi Khurana

Abstract

The purpose of this paper was to investigate the market integration among the four selected BRIC economies namely Brazil, Russia, India, and China from January 2008 to August 2015. Johansen cointegration test was used to study the long term relationship between the four stock markets. Further, to ascertain the short term association, vector error correction model and impulse response function were used. The results showed that there existed one long run cointegrating relationship between the four stock markets under study. Although there was no long run causality among the four stock markets, but there existed short term causality running from Russian, Chinese, and Brazilan stock markets to the Indian stock market.

Key words : BRIC, Johansen cointegration, vector error correction model, impulse response

JEL Classification : G1, G15, N25

Paper Submission Date : May 1, 2017 ; Paper sent back for Revision : November 15, 2017 ; Paper Acceptance Date : December 21, 2017

Due to globalization and liberalization, the world stock markets have been cointegrated. The issue of cointegration has been widely researched in financial economics. It studies about the international portfolio diversification and financial stability of a country. Before the 1970s, empirical studies on stock market integrations showed that there were fewer correlations among markets prior to 1970s. Solnik (1974) found the existence of future benefits of international portfolio diversification.

In today's scenario, the world stock markets are increasingly integrated and co-movements among the prime financial markets have been growing (Blackman, Holden, & Thomas, 1994 ; Ghosh, Saidi, & Johnson, 1999; Masih & Masih, 1997; Tripathi & Sethi, 2012). The idea of financial integration developed from the law of one price. For example, Lee and Kim (1993) found that the degree of integration among financial markets increased after the October 1987 stock market crash. Agmon (1972) proved that markets of U.S., UK, Germany, and Japan were interdependent for a period from 1961 to 1966. The economic relations among these countries were the major reason of interdependence of these markets. Similarly, Eun and Shim (1989) concluded that the markets of Australia, France, Germany, Canada, Hong Kong, Britain, and USA were interdependent.

As for the exchange rate integration, Aggarwal and Mougoue (1996) examined that Asian currencies were found to be cointegrated with the control of the Japanese Yen increasing relative to the U.S. dollar in contemporary years. Since 1980, economic integration among Japan's neighbors intensified and their business cycles were highly harmonized. These cycles were closely associated to fluctuations in the Yen/Dollar exchange rate - through changes in the export competitiveness, inflows of foreign direct investment, and intra-Asian income effects.

* *Associate Professor,* Chandigarh University, Gharuan, Mohali - 140 413, Punjab. E-mail: shaliniaggar@gmail.com
** *Assistant Professor,* Ajay Kumar Garg Institute of Management, Ghaziabad - 201 009, Uttar Pradesh.
E-mail: khurana.simmiajay@gmail.com

Based on a review of the available empirical evidence on market integration crossways and national capital markets, Chen, Lobo, and Wong (2005) studied the long term relationship between the three pairs of stock markets namely India, China, and U.S . The results proved that all three pairs of stock markets were moderately integrated ; whereas, the linkages between Indian and Chinese stock markets were strong during the period of the study. Similarly, Bhar and Nikolova (2007) concluded that there was a high degree of integration between the BRIC countries but lesser with the rest of the world.

Singh and Singh (2010) investigated the linkage between Indian and Chinese stock markets with four main developed markets. They found that both Indian and Chinese stock markets were cointegrated with all the developed markets. Further, there existed a bilateral causality between China and India. Similar results were found by Zeren and Koc (2013) in their study. They found that Istanbul stock market was cointegrated in the long run with U.S., UK, Japan, and France. Blackman, Holden, and Thomas (1994) also displayed the evidence of cointegration among the markets of USA, Japan, Hong Kong, Malaysia, Indonesia, Philippines, South Korea, Taiwan, and Thailand. The effect of shock on U.S. stock market to East Asian Economies namely Korea, Taiwan, Hong Kong, and Singapore was studied by Kim (2010). The author found that there was a unidirectional fundamental relationship between the U.S. stock market and East Asian economies running from U.S. to East Asian economies. Ibrahim (2005) concluded that integration among the stock markets gave better ideas for portfolio diversification and financial stability for investors.

Recently, Gahlota (2013) examined the nature of volatility and volatility spillover among South Asian countries. He found the presence of bilateral causal linkage between India and U.S., both in short and long term. Moreover, the recession was found to have a higher shock effect on the permanent component of volatility ; whereas, a study conducted by Mukherjee (2011) had a mixed response. He analyzed the volatility of stock returns in India with that of the stock market volatility of emerging and developed markets. The results showed that United States and Republic of Korea positively influenced the Indian stock market returns ; whereas, there was a negative influence of Hong Kong and China on the Indian stock market.

Yu, Fung, and Tam (2007) studied the weak bond market integration in the region for the duration of 1997 to 2003 period. They found that the lack of progress might be due to the "local" or "eccentric" factors in some Asian economies. Plummer and Click (2005) argued that the deepening of local bond markets could toughen the financial integration.

Karim and Gee (2006) studied the impact of financial crisis on the degree of cointegration between the Malaysia market and its major trading partners. It was found that cointegration between stock markets increased substantially during the financial crisis but declined after the financial crisis. Similarly, Armeanu, Doia, Hancila, and Cioaca (2013) researched that Turkey remained unaltered from the 2008 crisis, and in parallel, had a successful stock market.

Veraros and Kasimati (2007) examined the cointegration between Greece, European, and U.S. stock markets. They found that the Greece stock market had more influence on the European market as compared to the U.S. stock market. In a study conducted by Subha, Menon, and Sagaran (2009), they found that the Indian markets were integrated to some of the markets around the world. In another instance, long run equilibrium of the Indian stock market with some selected countries of the world was studied by Bhattacharjee and Swaminathan (2016). The results showed that there was integration among the stock markets under study. Hoque (2007) found similar results of cointegration among the stock markets of the emerging market economies of Bangladesh with that of USA, Japan, and India. Similarly, the study by Patel (2017) concluded the long run association between the 14 stock markets of the world.

The relationship between the stock market of BRICS countries was studied by Sharma, Mahendru, and Singh (2013). The results showed that these markets were influenced by each other but not to a large extent. Also, domestic factors influenced the movements of the stock markets.

However, there are certain studies which found that markets are not correlated. Malliaris and Urruttia (1992) studied about Japan, Hong Kong, Singapore, USA, and Australia. The results showed that there was no Granger causality among these markets before and after the crash of October 1987. The leading role of USA was suspicious. In a similar study conducted by Richards (1995), he supported the fact that there was no correlation among the countries due to negative results of the cointegration test. Byers and Peel (1993) concluded the same results after analyzing the data of countries like Germany, Britain, Japan, and Holland, and found no long run co-integration between these countries. Similarly, no correlation was experienced by Huang, Yang, and Hu (2000) for China, Hong Kong, Taiwan, South China, and USA for the long run period and in the short run, USA led the rest of the markets.

Due to the revolution in information technology tools, investors now have updated information of capital markets on a real time basis, and they respond to the flow of information around the world. With integration of equity markets, investors, governments, and institutions are more concerned about the visible connectivity of geographically separated markets, though a perfect link is far beyond reality. Moreover, the difference in opening and closing times of stock markets worldwide has an effect as when one market opens, another market in another part of the world closes. The Bombay Stock Exchange and Shanghai open with the index information from NASDAQ and Dow Jones.

The latest global event of Black Monday on August 24, 2015 took place in China as the world's second largest economy suffered huge financial losses causing trillions of dollars removed from the global stock markets. On August 24, 2015, the Chinese stock market suffered huge downfall in one day, with Shanghai's main share index closing down at 8.49%. That's why it was called 'Black Monday'. As part of the 2015 Chinese Stock Market collapse, over 7% was lost on next day, another 1.27% on Wednesday (August 26), leaving the Shanghai Composite Index down over 16% over the week despite another unsuccessful interest rate cut and significant monetary slackening by the Central bank. As a result, billions of Yuans were lost on global stock markets. The Sensex crashed 1625 points (6%) to 25,742, a one year low level, its biggest single day loss from close to close. Nifty crashed 400 points to below 7900. All 30 Sensex and 50 Nifty stocks ended in red. The effects were felt globally, and the global markets lost nearly $10 trillion, which is five times India's GDP .

Many researchers have studied various behavioral aspects of capital markets worldwide. A number of studies have been carried out to test the cointegration and interdependencies among various capital markets (Bala & Mukund, 2001).

This paper seek to the examine the co-integration analysis among the stock markets of BRIC countries comprising of Brazil stock market (Ibovespa), Russian stock market (RTS), Indian stock market (BSE Sensex), and China stock market (Shangai's SSE Composite). These four countries have implemented reforms and have implemented various globalization processes for the last two decades and are sprouting as emerging markets. In this context, there is a perception that stock market movement of one market has an effect on the stock market of other group of nations. As India is one nation among the emerging markets (BRICs), the study of the market cointegration and spillover of the same from various markets is essential for the better formulation of different policies such as monetary and fiscal policies in India. Further, the same helps in understanding movement of international portfolio management cash flows among the markets and how to face the future challenges.

Database

The data used in the study consists of four indices which includes Brazil, Russia, India, and China. The Table 1 gives the description of the name of the indices used along with their symbols. The indices used are the most commonly used for the markets they represent. Seven year daily data, that is, from January 2008 to August 2015 has been taken into consideration for the study. It has been taken from the website of Yahoo finance.

Table 1. Indices Used in the Study

Country	Symbol	Index
INDIA	BSESN	S&P BSE SENSEX
RUSSIA	RTSI	Russia Trading System Index
CHINA	SHCOMP	Shanghai Stock Exchange Composite Index
BRAZIL	IBOV	SAO PAULO SE BOVESPA INDEX

Source: https://in.finance.yahoo.com/world-indices

There is a problem of missing observations as there is a difference in the non - trading days of each country. Therefore, the missing observations have been filled by taking the data of previous date that follows the study of Karim, Kassim, and Arip (2010). Moreover, the entire sample is thoroughly examined to ensure the consistency in the data of the four indices. Microsoft Excel and Eviews 7.0 software package have been used for the analysis.

Methodology

The study analyzes the long run and short run equilibrium relationship among the four indices. Various tools have been used to analyze the data. Unit root test is applied to check the nature of the time-series data (stationary or non-stationary). Further, the cointegration test, vector error correction model, impulse response, and variance decomposition were applied to check the long and short term relationship among the indices.

(1) Unit Root Test : The variables in a regression model must be stationary so as to avoid a spurious regression situation. In the present attempt, Augmented Dickey-Fuller test (ADF) and the Phillips - Perron Test (PP) are used to check the stationarity in the series. If the calculated DF and ADF statistic is less than their critical values (1%, 5%, & 10%), then we can reject the null hypothesis, that is, unit root exists and vice- versa. When the series does not exist in unit root, then it needs to transform into unit root by using difference data of an appropriate level.

(2) Johansen's Cointegration Test : After conducting the unit root test, assuming all the series, that is, Brazil, Russia, India, and China are of the same order, the cointegration test is conducted (Haron & Azmi, 2008). The cointegration analysis is conducted to evaluate the comovement of a long-term equilibrium relationship among the four stock market indices. The presence of even one cointegrating vector proves that the tested series will not move apart in the long-run. They will revert to their normal levels even if there is any short-term drift that may take place (Gujarati & Porter, 2011). Therefore, it can be inferred that the benefits of diversification available to the investors are reduced. In contrast, if it is found that there is no cointegrating vector, then it can be concluded that stock portfolio diversification amongst the markets in question does provide benefits.

Johansen's estimation model is as follows:

$$\Delta Z_t = \delta + \Gamma_i \Delta Z_{t-1} + \ldots\ldots + \Gamma k \, \Delta Z_{t-k} + \Pi \Delta Z_{t-k} + \epsilon_t \ \ldots\ldots\ldots.. (1)$$

where, Δ signifies the first difference, Z_t is (a * 1) vector of all the non-stationary time series indices ; Γ, (a x a) is matrix of coefficients ; Δ is a vector of (a x1) vector of constant ; ϵ_t is the white noise error term of (a x 1) vector ; k is an order of autoregression. Finally, Π signifies the long run association or cointegration among the four indices in the study. All the variables of the series have unit root if the matrix (a x a) has rank 0, which can be corrected by taking the first difference. The matrix form of the equation (1) can be :

$$\begin{pmatrix} \Delta BSESN \\ \Delta RTSI \\ \Delta SHCOMP \\ \Delta IBOV \end{pmatrix} = \begin{pmatrix} \delta_0 \\ \delta_1 \\ \delta_2 \\ \delta_3 \end{pmatrix} + \sum_{i=1}^{k} \Gamma i \begin{pmatrix} \Delta BSESN \\ \Delta RTSI \\ \Delta SHCOMP \\ \Delta IBOV \end{pmatrix}_{t-k} + \Pi \begin{pmatrix} BSESN \\ RTSI \\ SHCOMP \\ \text{IBOV} \end{pmatrix}_{t-1} + \begin{pmatrix} \varepsilon_0 \\ \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{pmatrix}$$

where, BSESB, RTSI, SHCOMP, and IBOV are the stock indices of India, Russia, China, and Brazil.

Further, Johansen (1991) has defined two test statistics for cointegration under the method, that is, trace test and maximum eigenvalue test. The study uses both the models to check the long term equilibrium relationship :

$$\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^{n} In(1-\lambda i) \ldots\ldots\ldots\ldots\ldots\ldots.. \quad (2)$$

$$\lambda_{\max}(r, r+1) = -T \sum In(1-\lambda_{r+1}) \ldots\ldots\ldots\ldots\ldots (3)$$

where, r is the number of cointegrating vectors under the null, λi estimates ith ordered eigenvalue from the matrices, and T is the sample size. Equation (2) defines the Trace statistics. It is a joint test that tests the null hypothesis of no cointegration (H0 : $r = 0$) against the alternative hypothesis of cointegration (H1: $r > 0$). Further, equation (3) defines the max Eigen value statistics wherein the test is conducted separately on each Eigen value. It tests whether the null hypothesis is accepted or rejected against the alternative hypothesis of r +1 cointegrating vectors (Brooks, 2008).

The study normalizes the results on the Indian stock market index. It ,therefore, makes the coefficient equal to one on this index. Further, by imposing restrictions, the test is conducted on each of the variables to ascertain the impact on the cointegrating equation.

(3) Vector Error Correction Model (VECM) : If the variables are cointegrated, we apply the VEC Model (Kurihara & Nezu, 2006). The model helps us to identify the variable that helps in creating a significant impact in the short run on the cointegrating relationship. Further, VECM helps to analyze the short run and long run causality among the variables under study. Further, the long run causality is tested through t - test of the error correction term. It contains the useful information for the long run. The short run causality among the variables can be observed by using the F-statistics or Wald test.

(4) Variance Decomposition Test (VDCs) and Impulse Response Function (IRFs) : Variance decomposition test helps to explain that how much movement in the dependent variable is explained due to its own shock vis a vis to the shock of other variables under the study. Hence, it helps to identify the importance of each variable which brings about the change in other variables under study.

IRFs attempt to find out that when the standard deviation shock is given to one variable then what is its corresponding impact on another variable. Although there are various methods of finding the impulse response function, the study uses the Cholesky method to find out the impulse response.

Data Analysis and Results

(1) Results of Descriptive Statistics : The statistical values of the different indices have been calculated which is shown in the Table 2. The result shows that the indices are not stable during the study period. The difference in the maximum and minimum values in the Indian stock market is 29681.77 and 8160.4, which is very high, which shows instability. The standard deviation shows similar results. Similarly, the maximum and minimum values of Brazil, Russian, and Chinese stock markets are very high, which also shows instability.

Positive skewness for China, Russia, and India indicates that the size of right hand tail is larger than the left hand tail ; whereas, the negative skewness in Brazil indicates the reverse scenario, that is, the left hand tail is larger than the right hand tail. Further, the results of kurtosis indicate that the graph will be platykurtic or leptokurtic. For Brazil and Russian stock markets, it is less than 3, which signifies that the distribution is platykurtic ; whereas, the value of kurtosis for Indian and Chinese stock markets is more than 3, which indicates that the distribution is leptokurtic. The probability value of Jarque bera test shows that none of the series are normally distributed except for the Russian stock market. Hence, the null hypothesis is rejected at the 1% level of significance.

(2) Unit Root Test : Unit root test includes Augmented Dickey Fuller (ADF) test and Phillips - Perron (PP) test,

Table 2. Descriptive Statistics

	BRAZIL	CHINA	RUSSIA	SENSEX
Mean	56976.6	2658.235	1385.725	18847.9
Median	56610	2456.08	1404.285	18178.99
Maximum	73517	5180.51	2487.92	29681.77
Minimum	29435	1706.7	498.2	8160.4
Std. Dev.	8334.106	637.0641	392.8112	4732.801
Skewness	-0.37325	1.410279	0.08221	0.342175
Kurtosis	2.900185	5.027999	2.986928	3.13588
Jarque-Bera	46.65398	992.6204	2.237589	40.03921
Probability	0	0	0.326673	0

Table 3. Augmented Dickey Fuller Test (ADF) Unit Root Test

Series Name	ADF Statistic	Critical Value 1%	Critical Value 5%	Critical Value 10%	Interpretation
IBOV	-46.1283	-3.43347	-2.8628	-2.56749	Stationary
RTSI	-40.379	-3.43347	-2.8628	-2.56749	Stationary
BSESN	-40.8924	-3.43347	-2.8628	-2.56749	Stationary
SHCOMP	-19.6078	-3.43347	-2.8628	-2.56749	Stationary

Table 4. Phillips - Perron Test (PP) Unit Root Test

Series Name	PP Statistic	Critical Value 1%	Critical Value 5%	Critical Value 10%	Interpretation
IBOV	-46.3234	-3.43347	-2.8628	-2.56749	Stationary
RTSI	-40.3776	-3.43347	-2.8628	-2.56749	Stationary
BSESN	-40.725	-3.43347	-2.8628	-2.56749	Stationary
SHCOMP	-42.5127	-3.43347	-2.8628	-2.56749	Stationary

Table 5. VAR Lag Order Selection Criteria

Lag	*Log L*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-68474.37	NA	2.80e+25	69.94727	69.95867	69.95146
1	-49045.55	38758.42	6.86e+16	50.11803	50.17503	50.13898
2	-48860.05	369.2968	5.77e+16	49.94489	50.04748*	49.98260*
3	-48833.63	52.49815	5.71e+16	49.93425	50.08243	49.98872
4	-48817.38	32.20846	5.70e+16	49.93400	50.12777	50.00522
5	-48797.29	39.74750	5.68e+16*	49.92982*	50.16919	50.01781
6	-48789.43	15.53349	5.73e+16	49.93813	50.22309	50.04287
7	-48771.44	35.43211*	5.72e+16	49.93610	50.26666	50.05761
8	-48758.25	25.94651	5.73e+16	49.93897	50.31512	50.07723

Note : * indicates lag order selected by the criterion
LR : sequential modified LR test statistic (each test at 5% level)
FPE : Final prediction error
AIC: Akaike information criterion
SC : Schwarz information criterion
HQ : Hannan-Quinn information criterion

Table 6. Unrestricted Cointegrated Rank Test (Trace)

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
unrestricted cointegrated rank test(Trace)				
None *(r = 0)	0.019777	62.3895	47.85613	0.0012
At most 1 ($r \leq 1$)	0.008091	23.07798	29.79707	0.2422
At most 2(r<2)	0.00316	7.089925	15.49471	0.5672
At most 3(r<3)	0.000437	0.860777	3.841466	0.3535

Note : Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) *p*-values.

which are shown in the Table 3 and Table 4. The result shows that all the series are non stationary at 5% level of significance. So, they are tested again by taking their first difference and the results show the stationarity of the series, that is, the series are integrated of order 1.

(3) Optimum Lag Length Selection : The next step is to select the optimum lag length before we conduct the Johansen cointegration test. A total of five criteria are taken into account in the study. LR sequential modified LR test statistic, final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan Quinn information criterion (HQ) are used, which are shown in the Table 5. The LR, FPE, and AIC tests show the lag length of 7,5, and 5, respectively, which is very high. So, if we take such a high lag length, there is more risk. Therefore, lag length 2 as recommended by HQ and SC would be adopted in the present study.

(4) Results of Johansen's Cointegration Test : The results of Johansen's cointegration test are given in the Table 6 and Table 7. It shows the calculated values of trace statistics and maximum eigen value. The calculated value of trace statistics for all the four variables is 62.39 and maximum Eigenvalue is 39.31 at r = 0, that is, there is no cointegration. As the trace statistics's value and maximum eigen value are greater than MacKinnon Haug Michelis critical value at 5% level of significance, we reject the null hypothesis and accept the alternative hypothesis. It

Table 7. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
None *(r=0)	0.019777	39.31152	27.58434	0.001
At most 1 ($r \leq 1$)	0.008091	15.98805	21.13162	0.2255
At most 2($r \leq 2$)	0.00316	6.229148	14.2646	0.584
At most 3($r \leq 3$)	0.000437	0.860777	3.841466	0.3535

Max-eigenvalue test indicates 1 cointegrating eqn(s) at 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
** MacKinnon-Haug-Michelis (1999) *p*-values

Table 8. Vector Error Correction Estimates

SENSEX	BRAZIL	CHINA	RUSSIA
1	2.751097	-24.02701	-58.2067
	(-0.60499)	(-5.16532)	(-12.3286)
	[-4.547]	[4.651]	[4.72127]

Note : (Standard errors in parentheses) [*t* - statistics in brackets]

Table 9. Long Run Causality

	Coefficient	Std. Error	*t* - Statistic	Prob.
C(1)	0.000619	0.000272	2.278395	0.0228
C(2)	-0.010944	0.023948	-0.457003	0.6477
C(3)	-0.032577	0.023144	-1.407569	0.1594
C(4)	-0.342954	0.104250	-3.289716	0.0010
C(5)	-0.001684	0.104358	-0.016139	0.9871
C(6)	1.965709	0.201302	9.764992	0.0000
C(7)	0.137251	0.211726	0.648249	0.5169
C(8)	0.031490	0.006506	4.840425	0.0000
C(9)	0.004010	0.006374	0.629129	0.5293
C(10)	5.498532	5.200510	1.057306	0.2905
R-squared	0.092156	Mean dependent var	4.038654	
Adjusted *R*-squared	0.087985	S.D. dependent var	241.2718	
S.E. of regression	230.4133	Akaike info criterion	13.72269	
Sum squared resid	1.04E+08	Schwarz criterion	13.75106	
Log likelihood	-13499.99	Hannan-Quinn criterion	13.73312	
F-statistic	22.09551	Durbin-Watson stat	1.989053	
Prob(*F*-statistic)	0.000000			

shows that there is at least one cointegrating vector among the four variables in the long run (Hoque, 2007).

↳ **Results of Vector Error Correction Model :** The long run cointegration equation would be :

$$\text{India} = -49192.64 + 24.02\,(\text{China}) + 58.20\,(\text{Russia}) - 2.75(\text{Brazil})$$

Since there exists one cointegrating equation, therefore, there exists a stable equilibrium relationship. The results are normalized on the Indian stock market index, which is shown in the Table 8. Further, the signs are changed to enable proper interpretation. The Brazilian stock market is statistically significant but has a negative impact according to the *t* - values shown. The Chinese and Russian stock markets have negative and insignificant relationships with the Indian stock market.

(5) Long Run Causality : The Table 9 shows the results of long run causality. *C* (1) shows the error correction term which is positive (0.000619) but significant, which is explained by the probability value (0.000). This indicates that there does not exist long run causality running from Russia, China, Brazil towards India.

(6) Short Run Causality : The results of short run causality are shown in the Table 10. It is based on block exogenity Wald test. The results show that there is short run causality running from Brazil, Russian, and Chinese stock markets to the Indian stock market as the value of χ^2 is statistically significant in all the three cases.

Table 10. Block Exogenity Wald Test Results

Model	Dependent Variable	Independent Variables	χ^2 value	Probability value	Implication
1	BSESN	IBOV	3967091	0.00	No Causality
2	BSESN	RTSI	95.3582	0.00	No Causality
3	BSESN	SHCOMP	10.8275	0.0045	No Causality

(7) Results of Variance Decomposition : The Table 11 shows the results of variance decomposition of Indian, Russian, Brazilian, and Chinese stock markets, respectively. On day 1, 100% of variations in the error terms of Indian stock market can be explained with the help of its own lagged values. But on 10^{th} day, variation in the Indian stock market increased due to shocks in Brazilian and Russian stock markets from 0 to 4.3% and 0 to 4.9%, respectively, which is very less. This shows that the variables under study have less or minimal effect on the Indian stock market. Meanwhile, in the Russian stock market, there is an increase in the variation due to the shocks in the Brazilian stock market from about 10% to 17% from 1 day to 10^{th} day. This shows that the Russian stock market is being affected by the shocks in the Brazilian stock market.

Similarly, in the Brazilian stock market, the variations increased due to the shocks in Indian and Russian stock markets from 6.3% to 6.7% and 0 to 9%, respectively. Hence, the Russian stock market has more effect on the Brazilian stock market. The Chinese stock market is less affected by the markets under study. Due to shocks in the Russian, Indian, and Brazilian stock markets from 0 to 1.7 %, 3.2% to 4.9%, and 0.2% to 2.4%, there is an increased variation in the Chinese stock market.

(8) Results of Impulse Response Function : The impulse response function's results are shown in the Figure 1. It analyzes the response when one standard deviation shock is given to Indian, Chinese, Russian, and Brazilian stock markets. It is based on Cholesky method. The results can be predicted with 95% confidence level. From the Figure 1, it can be observed that when the shock is given to Indian stock market, it produces a positive result in all the stock markets under study. Similarly, the shock given to Brazilian and Russian stock markets produces positive results in all the stock markets. But when the shock is given to the Chinese stock market, it impacts the Russian and Indian stock markets in a negative manner, and the Brazilian stock market has a positive effect.

Conclusion and Implications

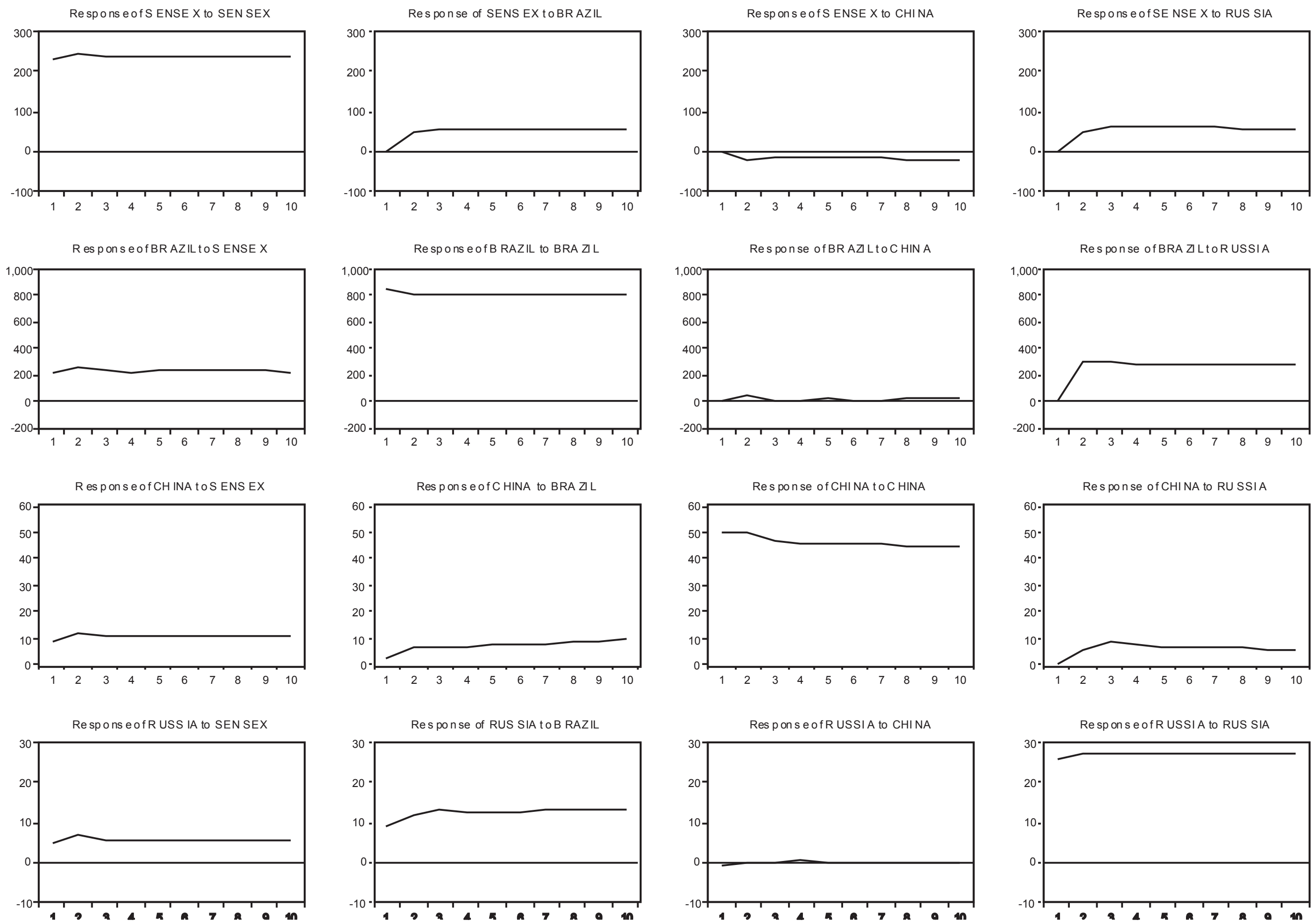
The aim of this study is to investigate the cointegration relationships between four stock markets of the BRIC, that

Table 11. Results of Variance Decomposition

Period		INDIA	BRAZIL	CHINA	RUSSIA
Relative variance in					
1	**INDIA**	100.0000	0.000000	0.000000	0.000000
2		95.82006	1.728679	0.332768	2.118492
3		93.42124	2.621255	0.396061	3.561442
4		92.27841	3.156947	0.411078	4.153568
5		91.61039	3.489425	0.424013	4.476167
6		91.17252	3.719446	0.440395	4.667636
7		90.85700	3.901116	0.457498	4.784387
8		90.61487	4.053020	0.474631	4.857483
9		90.42074	4.184870	0.492029	4.902360
10		90.25986	4.302784	0.509686	4.927665
1	**BRAZIL**	6.353617	93.64638	0.000000	0.000000
2		7.092786	87.42891	0.093384	5.384923
3		7.209950	85.51909	0.062241	7.208715
4		7.007709	85.10399	0.048653	7.839645
5		6.904423	84.82668	0.043646	8.225249
6		6.844912	84.61170	0.039661	8.503729
7		6.801180	84.45257	0.037001	8.709245
8		6.768153	84.32685	0.035421	8.869575
9		6.742458	84.22166	0.034495	9.001383
10		6.721753	84.13128	0.034022	9.112943
1	**CHINA**	3.233155	0.172890	96.59395	0.000000
2		4.444819	1.036389	94.01109	0.507705
3		4.630123	1.237119	92.65694	1.475816
4		4.670081	1.428493	92.16406	1.737370
5		4.685996	1.611786	91.88882	1.813396
6		4.728816	1.770587	91.64819	1.852404
7		4.781414	1.927436	91.42873	1.862420
8		4.836815	2.086634	91.22442	1.852131
9		4.894834	2.247883	91.02750	1.829788
10		4.954774	2.411887	90.83368	1.799657
1	**RUSSIA**	3.231597	10.95858	0.120678	85.68915
2		4.098790	12.93885	0.061054	82.90130
3		3.760231	14.64557	0.040578	81.55362
4		3.548208	15.28793	0.031178	81.13269
5		3.431344	15.69031	0.024789	80.85356
6		3.357935	16.00753	0.020569	80.61397
7		3.310831	16.26746	0.017674	80.40404
8		3.279010	16.49211	0.015739	80.21314
9		3.256943	16.69400	0.014544	80.03451
10		3.241659	16.87983	0.013952	79.86456

Figure 1

Response to Cholesky One S.D. Innovations



is, S&P BSE SENSEX (BSESN), Shanghai Stock Exchange (SHCOMP), Brazil Stock Exchange (IBOV), and Russia Trading system (RTSI). The four indices taken in the study are the important indices used for the market they represent.

The study makes use of secondary data for the period of 7 years ranging from January 2008 to August 2015. Augmented Dickey-Fuller test (ADF) and the Phillips - Perron Test (PP) have been used to check stationarity in the series. The results show the presence of non stationarity of the series, however, the series were made stationary after taking their first difference. Further, the cointegration tests confirm the presence of one cointegrating vector. Since there exists one cointegrating equation, therefore, a long run relationship is present. The results are normalized on the Indian stock market, and it is found that the Brazilian stock market has a significant but negative effect on the Indian stock market in the long run. The Chinese and Russian stock markets have a negative and insignificant relationship with the Indian stock market. Furthermore, the results show that there does not exist long run causality running from Chinese, Brazilian, and Russian stock markets towards the Indian stock market ; whereas, there exists short run causality running from Chinese, Brazilian, and Russian stock markets towards the Indian stock market as the value of χ^2 is not significant in all the three cases.

The study provides a holistic view of the relationships of the four stock market indices in the long run perspective. The presence of one cointegrating relationship during the period of study shows that the investor will have no or limited benefits if he/she diversifies his/her portfolio between the studied markets. The series will revert to an equilibrium level in the long run even if they drift apart in the short run period. Our findings are consistent with the findings of Tripathi and Sethi (2012), Bhar and Nikolova (2007), Hoque (2007), and many more, which also suggests that diversification in the stock market will reap no benefit because of the presence of the cointegration factor.

The results provide a better understanding of the cointegration of the stock market of BRIC economy, which is important for the investors, brokers, and academicians to know whether investing in different stock markets will reap benefits or not.

Due to the presence of one cointegrating equation, there exists long run association, which shows that the investment in different markets will not be beneficial. The series will revert to an equilibrium level in the long run even if they drift apart in the short run period.

MNCs have an exposure in the foreign countries. Stock market volatility directly impacts their financial policies. During the East Asia crisis in 1997, which started in Thailand and spread to all the other neighbouring countries, their stock markets were severely affected, and MNCs had financial problems. Furthermore, exchange rate volatility has a direct impact on the MNCs operating in international countries. The stock market of a country bears a direct relation with the movement in exchange rates. Therefore, knowledge of stock market volatility gives the direction of exchange rate movements. It provides an insight to the managers to manage their different risks while operating in BRIC economies. Also, the study gives valuable information to investors and policy makers to know whether investing in BRIC stock markets will enable them to reap benefits or not.

Limitations of the Study and Scope for Further Research

The study focuses only on the stock markets of the four countries of BRIC, that is, Brazil, Russia, India, and China due to time and resource constraints. This study suggests further research to enhance the knowledge of various investors and policy makers for doing trade at the international level. Cointegration between the Indian stock market and developed nation's stock markets can be studied. Furthermore, to have in-depth knowledge of the stock market, technical and fundamental analysis can be studied.

References

Aggarwal, R., & Mougoue, M. (1996). Co integration among Asian currencies : Evidence of the increasing influence of the Japanese Yen. *Japan and the World Economy, 8* (3), 291 - 308.

Agmon, T. (1972). The relations among equity markets : A study of share price co-movements in the United States, United Kingdom, Germany, and Japan. *Journal of Finance , 27* (4), 839 - 855.

Armenau, D., Doia, C.A., Hancila, M., & Cioaca, S. (2013). The analysis of the correlation intensity between emerging market during economic crisis. *Romanian Statistical Review Supplement, 61*(2), 307 - 318.

Bala, A., & Mukund, K.S. (2001). Interrelationship between Indian and US stock markets. *Journal of Management Research, 1* (3), 141 - 148.

Bhar, R., & Nikolova, B. (2007). Analysis of mean and volatility spillovers using BRIC countries, regional and world equity index returns. *Journal of Economic Integration, 22* (2), 369 - 381.

Bhattacharjee, S., & Swaminathan, A. M. (2016). Stock market integration of India with rest of the world : An empirical study. *Indian Journal of Finance, 10* (5), 22 - 32. DOI: 10.17010/ijf/2016/v10i5/92934

Blackman, S., Holden, K., & Thomas, W. (1994). Long term relationships between international share prices. *Applied Financial Economics, 4* (4), 297 - 304.

Brooks, C. (2008). *Introductory econometrics for finance.* New York : Cambridge University Press.

Byers, M.D., & Peel, D.A. (1993). Some evidence on the interdependence of national stock markets and the gains from international portfolio diversification. *Journal of Applied Financial Economics, 3* (3), 239 - 242.

Chen, H., Lobo, B. J., & Wong, W. K. (2005). *Links between the Indian, U.S., and Chinese stock markets* (Working Paper No. 0602). Retrieved from http://www.fas.nus.edu.sg/ecs/pub/wp/wp0602.pdf

Eun, C.S., & Shim, S. (1989). International transmission of stock market movements. *The Journal of Financial and Quantitative Analysis, 24* (2), 241 - 256.

Gahlota, R. (2013). Capturing volatility and its spillover in South Asian. *Journal of Economic & Financial Studies, 1*(1), 44 - 60.

Ghosh, A., Saidi, R., & Johnson, K.H. (1999). Who moves the Asia-Pacific stock markets – US or Japan? Empirical evidence based on the theory of cointegration. *Financial Review, 34* (1), 159 - 170.

Gujarati, D., & Porter, D. (2011). *Basic econometrics.* USA : McGraw-Hill.

Haron, S., & Azmi, W.N.W. (2008). Determinants of Islamic and conventional deposits in the Malaysian banking system. *Managerial Finance, 34* (9), 618 - 643.

Hoque, H. A. A. B. (2007). Co-movement of Bangladesh stock market with other markets: Cointegration and error correction approach. *Managerial Finance, 33*(10), 810 - 820. DOI : https://doi.org/10.1108/03074350710779250

Huang, B., Yang, C., & Hu, J.W. (2000). Causality and cointegration of stock markets among the United States and South China growth triangle. *International Review of Financial Analysis, 9* (3), 281 - 297.

Ibrahim, M.H. (2005). International linkages of stock prices: The case of Indonesia. *Management Research News, 28* (4), 93 - 115.

Karim, B.A., Kassim, N., & Arip, M. A. (2010). The subprime crisis and Islamic stock markets integration. *International Journal of Islamic and Middle Eastern Finance and Management, 3* (4), 363 - 371.

Karim, M.Z.A., & Gee, C.S. (2006). Stock market integration between Malaysia and its major trading partners (1994 - 2002). *Applied Econometrics and International Development, 6* (3), 203 - 224.

Kim, H. (2010). *Dynamic causal linkages between the U.S. stock market and the stock markets of the East Asian Economies* (Working Paper No. 236). CESIS - Centre of Excellence For Science And Innovation Studies. Retrieved from https://static.sys.kth.se/itm/wp/cesis/cesiswp236.pdf

Kurihara, Y., & Nezu, E. (2006). Recent stock price relationships between Japanese and U.S. stock markets. *Studies in Economics and Finance, 23* (3), 211 - 226.

Lee, S. B., & Kim, K. J. (1993). Does the October 1987 crash strengthen the co-movements among national stocks markets. *Review of Financial Economics, 3* (1), 89-102.

Malliaris, A.G., & Urrutia, J. L. (1992). The international crash of October 1987: Causality tests. *Journal of Financial and Quantitative Analysis , 27* (3), 353 - 364.

Masih, A.M., & Masih, R. (1997). A comparative analysis of the propagation of stock market fluctuations on alternative models of dynamic causal linkage. *Applied Financial Economics, 7*(1), 59 - 74.

Mukherjee, P.(2011). An exploration on volatility across India and some developed and emerging equity markets. *Asia Pacific Development Journal, 18* (2), 79 - 103.

Patel, R.J.(2017). Co-movement and integration among stock markets : A study of 14 countries. *Indian Journal of Finance, 11* (9), 53 - 66. DOI: 10.17010/ijf/2017/v11i9/118089

Plummer, M.G., & Click, R. (2005). Bond market development and integration in ASEAN. *International Journal of Finance and Economics, 10* (2), 133 - 142.

Richards, A. J. (1995). Comovements in national stock market returns : Evidence of predictability, but not cointegration. *Journal of Monetary Economics, 36* (3), 455 - 479.

Sharma, G.D., Mahendru, M., & Singh, S. (2013). Are the stock exchanges of emerging economies interlinked ? : Evidence from BRICS. *Indian Journal of Finance, 7*(1), 26 - 37.

Singh, G., & Singh, P. (2010). Chinese and Indian stock market linkages with developed stock markets. *Asian Journal of Finance & Accounting, 2* (2), 21 - 39.

Solnik, B. (1974). Why not diversify internationally rather than domestically? *Financial Analysts Journal, 30* (4), 48 - 54.

Subha, M.V., Menon, R., & Sagaran, S. (2009). Cointegration of Indian stock markets with other leading stock markets. *Studies in Economics and Finance, 26* (2), 87- 99.

Tripathi, V., & Sethi, S. (2012). Inter linkages of Indian stock market with advanced emerging markets. *The Asian Economic Review, 54* (3), 507 - 528.

Veraros, N., & Kasimati, E. (2007). The effect of U.S. and European stock exchange on Greece's stock market: A VAR approach. *Applied Financial Economics Letters, 3* (2) 133 - 136.

Yu, I. - W., Fung, L., & Tam, C.-S. (2007). *Assessing bond market integration in Asia* (Working Paper 10/2007). Hong Kong Monetary Authority. Retrieved from http://www.hkma.gov.hk/media/eng/publication-and-research/research/working-papers/HKMAWP07_10_full.pdf

Zeren F., & Koc M. (2013). Analyzing integration between stock market of Turkey and G8 nations with Maki cointegration test. *Journal of Applied Finance and Banking, 3* (6), 135-142.

About the Authors

Dr. Shalini Aggarwal is working as an Associate Professor at Chandigarh University, Mohali, Punjab. She has done MBA, Ph.D., and MSc. Computer Science. She has completed her Ph.D from Kurukshetra University, Kurukshetra, Haryana. She has a working experience of more than 17 years in teaching as well as industry. She has presented various papers in National and International Conferences including conferences conducted by IIM Lucknow and IIM Bangalore. She has published more than 22 papers in good national and international journals (including Scopus indexed journals and journals having C ranking according to ABDC Journal Ranking. She has attended various workshops at IIT Roorkee, NITTTR Chandigarh, etc.

Dr. Simmi Khurana is working as an Assistant Professor at Ajay Kumar Garg Institute of Management, Ghaziabad. She has done PGDFM , Ph.D., and CFA. She has a working experience of 15 years, and has published 8 papers in various journals.