

Stock Market Interlinkages among Indian Equity Market and Bangladesh Equity Market

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Abstract

The financial markets of interlinked nations exhibit an increasing co-movement trend. The knowledge of their integration, causality and innovation response enhances the vision of investors and financial regulators. Investors on the basis of gained knowledge make their investment decisions and financial regulators monitor the financial contagion. The present treatise aims to explore the inter-linkages between equity markets of two neighbour countries; India and Bangladesh; on the basis of return correlations, cointegration, causality and spillovers. The daily stock price data for the period of September 2014 to September 2016 on BSE Sensex and DSE 30 have been taken from the online database maintained by the Bombay Stock Exchange and the Dhaka Stock Exchange respectively. The data of these two indices was studied for stationarity, serial correlation, cross correlation, integration, causality and spillovers with the help of augmented Dickey-Fuller test, autocorrelation function and partial auto correlation function, Ljung-Box Q-statistics, cross correlogram, Johansen cointegration test, vector autoregression Granger causality tests (Block exogeneity test), impulse response function and variance decomposition. The results provide evidences on the segmentation of equity markets of India and Bangladesh as there is no significant inter-linkage between these two markets. The findings of this paper have implications for policy makers and international investors. The segmentation of these markets provides signals to policy makers to take appropriate decisions that may attain and sustain the financial stabilisation of their country. The international investors can avail the long-run diversification benefits across these two segmented markets.

Keywords: block exogeneity, cointegration, cross correlation, impulse response function, serial correlation, spillovers, stationarity, variance decomposition and vector autoregression.

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1. INTRODUCTION

India and Bangladesh are South Asian neighbours having civilisational, social, cultural and economic links. They are like normal neighbours who share a relationship of friendship along with disputes over some issues that can be resolved with positive efforts. These two nations have been in friendly relation in general with some murky border disputes. Recently, they have signed a historic land boundary agreement on 6 June 2015 that stopped all irritants in ties and opened a new era in their relations. There are many facets that connect these two countries like shared history, common heritage, linguistic ties, cultural ties and economic ties. They are common members of South Asian Sub-regional Economic Cooperation (SASEC), South Asian Association for Regional Cooperation (SAARC), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), Indian Ocean Rim Association (IORA) and the Commonwealth. The inter-linkages among economies have been quantitatively estimated by the analysis of data of their bilateral trade, investment and financial markets. The researchers have studied the inter-linkages among various economies largely on the basis of main indices of national stock exchanges of the economies. Eun & Shim (1989) studied daily stock market returns of Australia, Japan, France, Canada, Switzerland, Germany, US and the UK. The study confirmed the substantial interdependence among the national stock markets with US being the most influential market. All European and Asia-Pacific markets respond strongly against US innovations with a one day lag and the most responses are completed within two days. Hamao, Masulis & Ng (1990) used daily and intraday price and stock returns

data to find spillover effects in the US, UK and Japanese stock market. They found significant spillover effects from the US and the UK stock markets to the Japanese market but there was no spillover effect from Japanese market to the US and the UK stock markets. Park & Fatemi (1993) examined the linkages between the equity markets of the Pacific Basin countries with those of the UK, US and Japan. They also concluded that the US market was the most influential as compared to that of Japan and UK. They concluded that Australia was most sensitive to the US market; Singapore, Hong Kong and New Zealand exhibited moderate linkages; Korea, Taiwan and Thailand exhibited little linkage. Lin, Engle & Ito (1994) found that foreign returns significantly influence the domestic returns of Japan and US. They also found that cross-market interdependence in returns as well as volatilities. The interdependence was bi-directional between the New York and Tokyo markets. Booth, Martikeinan & Tse (1997) examined the price and volatility spillovers in the four Scandinavian stock markets by employing the multivariate EGARCH model. They investigated for the period 2 May 1988 to 30 June 1994. They found that volatility transmission was asymmetric in Danish, Norwegian, Swedish and Finnish stock markets. Janakiraman & Lamba (1998) empirically examined the linkages between the Pacific-Basin stock markets. The results showed that the US influenced all other markets, except for relatively isolated market of Indonesia. Markets that were geographically and economically close and/or had large number of cross-border listings exert significant influence over each other. Overall, the influence of the US market on the Australian markets had diminished over more recent years, and the emerging market

of Indonesia was becoming more integrated with these markets. Kanas (2000) examined the volatility spillover effect between the exchange rate and the stock price of the United States, the United Kingdom, German, Japan, France and Canada. They concluded that there was a significant volatility spillover effect from the stock market to the exchange market in all nations except Germany. Johnson & Soenen (2002) investigated the degree of integration of equity markets in Asia with Japanese equity market. They found that the equity markets of China, Australia, Hong Kong, Malaysia, New Zealand and Singapore were highly integrated with the Japanese stock market. They also found that the Asian markets became more integrated over time. Balaa & Premaratne (2002) investigated volatility co-movement between the Singapore stock market and the markets of UK, US, Hong Kong and Japan. They employed Univariate GARCH, Vector Autoregression and Multivariate and Asymmetric Multivariate GARCH model with GJR extensions to the daily returns from 1992 to 2002. They found a high degree of volatility co-movement between Singapore stock market and UK, US, Hong Kong and Japan. The order of volatility co-movement was Hong Kong, US, Japan and UK. There was small but significant volatility spillover from Singapore stock market into Hong Kong, Japan and US markets. Kaur (2004) employed various volatility estimators and diagnostic tests to investigate the nature and characteristics of volatility in the Indian stock market. She found that volatility clustering, asymmetry, intra-week and intra-year seasonality were present in Sensex and Nifty. There was mixed evidences of volatility spillover between the US and Indian markets. Beirne, Guglielmo, Marianne & Nicola

(2009) modelled volatility spillovers from mature stock markets to emerging stock markets, tested for the changes in the transmission mechanism during turbulences and examined the implications for conditional correlations between mature market returns and emerging market returns. They applied Tri-variate GARCH-BEKK model and Wald test on the data of 41 emerging market economies. They found significant volatility spillovers from mature stock markets to emerging stock markets. They also found that spillover parameters change during turbulent episodes and conditional correlations between local markets and mature markets had increased during these episodes. Chang et al. (2009) applied GJR-GARCH model and found that there was an asymmetric threshold and a co-integration relationship between the exchange and the stock markets. Choi (2009) used the multivariable EGARCH model to measure the volatility spillover between the exchange market and stock markets of New Zealand after the Asia financial crisis in 1997. The study concluded that the volatility of the stock price had a spillover effect on the New Zealand's three indices. Zhizhen & Xiuquan (2010) used co-integration Granger causality test to examine the interaction of the exchange and stock markets. They confirmed that there was a long-term and stable relationship between the exchange and stock markets. They also concluded that there was a one-way price spillover effect and volatility spillover effect between these markets. Xinling & Peng (2011) examined the volatility spillover effect of China's exchange rate and stock price. Contrary to earlier studies they found two-way volatility spillover effect between the exchange rate and the stock price. They also found that the effect of the exchange rate volatility on stock

price volatility was less significant than the effect of stock price volatility on exchange rate volatility. Arora Srinivasan, P. (2012) examined the price discovery process and volatility spillovers in Indian spot-futures commodity markets by using Johansen cointegration, vector error correction model and EGARCH model. The four futures and spot indices of MCX representing agriculture, energy, metal and the composite index were taken. The study confirmed the presence of long-term equilibrium relationships between the futures price and its underlying spot price of the commodity markets and there is a flow of information from spot to futures commodity markets. Louzis (2013) examined the return and volatility spillovers among the money, foreign exchange, stock and bond markets of the euro area. They utilized the forecast-error variance decomposition framework of a generalized VAR model to estimate the predictive directional measurement of volatility spillovers. They found the presence of high level of total return and volatility spillover effects throughout the sample. They also identified stock market as the main transmitter of both return and volatility spillovers. Bonds of the periphery countries that were under financial support mechanisms were receivers of return spillovers. Natarajan, Singh & Nagarajan (2014) used a time series generalized auto regressive conditional heteroscedasticity in the Mean GARCH (1,1)-Mean model to examine mean-volatility spillovers across national stock markets. They found statistically significant mean spillovers from the markets of USA to the Australian market and Germany market. They also found that the past USA returns had a greater effect on current returns in Germany as compared to Australia. Zhang & Jaffry (2015)

explored the influence of the global financial crisis on the volatility spillover between China stock market and Hong Kong stock market. They broke the data into two sub-periods: pre-crisis from January 04, 2002 to June 30, 2007 and crisis period from July 01, 2007 to December 31, 2013. They applied asymmetric BEKK-GARCH and adopted the vector autoregressive approach as a robustness test. They concluded that there was no volatility spillover in the pre-crisis period and strong bi-directional volatility spillover in the crisis period. Larisa, Janusz & Chi (2016) provided empirical evidence on the patterns of intra-regional and inter-regional transmission of information across emerging and developed markets. They examined data of ten developed markets and eleven emerging markets in America, Asia, Europe and Africa. They used stock indices and stock index futures to examine the main transmission channels from 2005 to 2014. They applied the generalized vector autoregressive framework and found that these markets are more susceptible to region-specific and domestic volatility shocks than to inter-regional contagion. They also found difference in patterns of international signals transmission between models that were employed on indices and futures data. The futures data provided more efficient channels of information transmission due to the magnitude of return and volatility spillovers across them.

Studies of inter-linkages between financial markets have focused primarily on return correlations and volatility spillovers of developed countries with other developed nations or few emerging economies. But there is lack of exploration of inter-linkages among emerging economies. The present treatise is an attempt to fill this lacuna by studying the inter-linkages

between Indian stock market and Bangladesh stock market.

2. OBJECTIVES OF THE STUDY

The present treatise attempts to explore the stock market inter-linkages between Indian equity market and Bangladesh equity market. The main objective of the present treatise can be further delineated into following points:

- i) To examine the cointegration of Indian stock market and Bangladesh stock market.
- ii) To study the causality among Indian stock market and Bangladesh stock market.
- iii) To study the spillovers between Indian and Bangladesh stock market.

3. RESEARCH METHODOLOGY

The daily stock price data for the period of September 2014 to September 2016 on BSE Sensex and DSE 30 have been taken from the online database maintained by the Bombay Stock Exchange and the Dhaka Stock Exchange respectively. BSE Sensex is considered as pulse of the domestic stock markets in India and DSE 30 is considered as pulse of the domestic stock markets in Bangladesh. BSE Sensex is also called as BSE 30 or S&P Bombay Stock Exchange Sensitive Index. It is a free-float market-weighted index of thirty well-established and financially sound companies which are listed on the Bombay Stock Exchange. The component companies are some of the largest and most actively traded stocks in India which represents various industrial sectors of the Indian economy. DSE 30 index is also called as DS30. This index is a float-adjusted market weighted index of thirty leading companies which are listed on the Dhaka Stock Exchange. The component companies are the largest and most actively traded stocks

in Bangladesh representing various industrial sectors of the Bangladesh economy. The series of 373 returns has been analyzed to explore the stock market inter-linkages.

4. ECONOMETRIC METHODOLOGY

The data of two indices was studied for stationarity, serial correlation, cross correlation, integration, causality and spillovers through following statistical tests.

The data were initially studied for stationarity with the help of **Augmented Dickey-Fuller test**. This test is important as the vector error correction model, vector autoregression model and Granger causality tests can be applied to stationary time series only. In case the series are non-stationary then only Johansen cointegration test can be applied to the series. The series needed to be transformed into stationary series by appropriate method so that vector error correction model, vector autoregression model and Granger causality test can be used for estimation. It is a test for a unit root in a time series sample. It examines whether a time series variable is non-stationary using an autoregressive model. It tests the existence of a unit root as the null hypothesis. The testing procedure for the ADF test consists of estimation of the following regression:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \dots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

The unit root test is carried out under the null hypothesis $\gamma = 0$ against the alternative hypothesis of $\gamma < 0$. Once a value for the test statistic is computed, it is compared to the relevant critical value for the Dickey-Fuller test. If the test statistic is less than the critical value, then the null hypothesis is rejected implying no unit root is present.

Autocorrelation function (ACF) and Partial Auto-correlation Function (PACF): Tintner (1953) defined autocorrelation as “lag correlation of a given series with itself, lagged by a number of time units”. The autocorrelation at lag t by r_t is given by

$$r_t = \frac{\sum_{i=k+1}^n (X_i - \bar{X})(X_{i-k} - \bar{X})}{\sum_{i=1}^n (X_i - \bar{X})^2}$$

All autocorrelations at lags 1, 2, ..., n together make up the autocorrelation function. Partial auto correlation function measure the relationship between X_t and $X_{(t-k)}$ in time series after removing the effects of other time lags 1, 2, ..., $k - 1$. The return is white noise in case the ACF and PACF coefficient lie within the critical values i.e. $\pm 1.96(1/N)$.

Ljung-Box Q-statistics: The Ljung-Box Q statistics test the randomness on the basis of number of lags. It is also known as portmanteau test that indicates whether any group of autocorrelations of a time series are different from zero. The Q-statistic at lag is a test statistic for the null hypothesis that there is no autocorrelation up to order and is computed as:

$$Q = n(n + 2) \sum_{k=1}^h \frac{p_k^2}{n-k}$$

Note that in case the series is not based upon the results of autoregressive integrated moving average estimation, then as per the null hypothesis, Q is asymptotically distributed as a chi-squared distribution with degrees of freedom equal to the number of autocorrelations. The critical region for rejection for significance level (α) is $Q > \chi_{1-\alpha, h}^2$ (it is the α -quantile of the chi-squared distribution with h degrees of freedom).

Cross correlation: It is also known as cross correlogram. It is a measure of similarity of two time series as a function of the lag of one series relative to the other series. The correlations are asymptotically consistent approximations. This

analysis does not confirm the causality but rather determines the time lag between two variables. So, this analysis helps in determining the cross correlation in the following forms:

RSensex, RDSE30(-1)

RSensex, RDSE30(+1)

The first cross correlogram relates BSE Sensex returns to the past value of DSE30 returns and the second cross correlogram relates BSE Sensex returns to subsequent DSE30 returns.

Johansen Cointegration Test: It tests the cointegration of several $I(1)$ time series. It permits more than one cointegrating relationship. This test evaluates the long run or equilibrium relationship. If the residual from the regression equation of the series (which are non stationary in level but are stationary after first differencing) is stationary then it confirms that the series are cointegrated. Note that the vector error correction mechanism can be applied to co-integrated series only and if series found to be non co-integrated then vector autoregression models are applied. **Vector Error Correction Mechanism** examines the long run causality and short run causality between variables. There may be disequilibrium in the short run in the cointegrated series having long run relationship. The error generated from such cointegrated series is termed as equilibrium error. The error correction mechanism equation, stating the dependence of ΔY_t on ΔX_t and equilibrium error, is:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_t + \alpha_2 (Y_{t-1} - \beta_1 - \beta_2 X_{t-1}) + \varepsilon_t$$

Where $\Delta Y_t = Y_t - Y_{t-1}$

$$\Delta X_t = X_t - X_{t-1}$$

ε_t = Random error term

Vector Autoregressive Models: Sims (1980) suggested the vector autoregression models (VAR) as a substitute of dynamic simultaneous equation models involving too many arbitrary decisions. In these models, each variable is a function of its own past and the past values of other variables. The vector autoregression model used in the present treatise is based on the following equations:

$$RSENSEX_t = \lambda_{10} + \lambda_{11}^1 RSENSEX_{t-1} + \lambda_{12}^1 RDSE30_{t-1} + \dots + \lambda_{11}^p RSENSEX_{t-p} + \lambda_{12}^p RDSE30_{t-p} + \varepsilon_{1t}$$

$$RDSE30_t = \lambda_{20} + \lambda_{21}^1 RSENSEX_{t-1} + \lambda_{22}^1 RDSE30_{t-1} + \dots + \lambda_{21}^p RSENSEX_{t-p} + \lambda_{22}^p RDSE30_{t-p} + \varepsilon_{2t}$$

These equations can also be presented in the matrix form. The matrix form is as follows:

$$\begin{bmatrix} RSENSEX_t \\ RDSE30_t \end{bmatrix} = \begin{bmatrix} \lambda_{10} \\ \lambda_{20} \end{bmatrix} + \begin{bmatrix} \lambda_{11}^1 & \lambda_{12}^1 \\ \lambda_{21}^1 & \lambda_{22}^1 \end{bmatrix} \begin{bmatrix} RSENSEX_{t-1} \\ RDSE30_{t-1} \end{bmatrix} + \dots + \begin{bmatrix} \lambda_{11}^p & \lambda_{12}^p \\ \lambda_{21}^p & \lambda_{22}^p \end{bmatrix} \begin{bmatrix} RSENSEX_{t-p} \\ RDSE30_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

The compact form of above equation is as follows:

$$y_t = a_0 + A_1 y_{t-1} + \dots + A_p y_{t-p} + \varepsilon_t$$

Where, y_t = vector of all the k variables that are included in the system

a_0 = $k \times 1$ vector of intercepts

$A_1 \dots A_p$ = $k \times k$ matrix of coefficients

ε_t = vector of error terms

ε_t = is assumed to follow multivariate normal distribution and with zero autocorrelation.

The lag-order p is decided with the help of an individual or/and collective information criteria encompassing sequential modified likelihood ratio test statistic, Akaiki Information Criterion (AIC), Schwarz Bayesian Criterion (SBC) and

Hannan-Quinn information criterion (HQ). The interpretation of individual coefficients from vector autoregression model is done directly as well as with the help of following summary statistics:

- a) **Block significance:** The causality in a vector autoregression model is estimated with the help of **block significance test**. It examines the joint significance of lagged coefficients of one variable in the equation of another variable. In the present context of bivariate case, the causality is examined with the help of the Granger causality test. This test in vector autoregression model framework is also known as "**Block Exogeneity Test**".
- b) **Innovation response:** It is also known as **impulse response analysis** used to explore the volatility transmission or spill between the markets. The impulse response function requires a representation of a stable vector autoregression model of order k as an infinite order vector moving average process. This representation traces the time path of the impact of a shock in one variable on all the variables included in the vector autoregression model. This analysis assumes that at a time the shock occurs in one variable. So, this assumption is valid only if the shocks in different variables are not contemporaneously correlated. In case of the presence of significant contemporaneous correlation the results of innovation response analysis depends on the method of decomposition used. The **Cholesky decomposition method** is used to study the impulse response. This method is based on the assumption that all the contemporaneous correlation between two variables are accounted as caused by the

first variable. Therefore the order of the variables in the VAR system is very crucial to determine the impulse response.

- c) **Variance decomposition:** Cholesky decomposition method involves a sequential decomposition of the variance covariance matrix that converts the variance covariance matrix of contemporaneously correlated error terms into variance-covariance matrix of the non-correlated error terms. The first variable is considered as contemporaneously independent. The second variable is considered as contemporaneously dependent on the first

variable and the third variable is dependent on the first variable and the second variable and so on.

5. PROPERTIES OF BSE SENSEX RETURNS AND DSE30 RETURNS SERIES

The series of indices on BSE Sensex and DSE 30 have been converted into return series by applying the following formula:

$$R_t = (\ln P_t - \ln P_{t-1}) * 100$$

where R_t is the return for day t , P_t is indices for day t , P_{t-1} is the indices of previous trading day and \ln is natural log. The basic statistics of return indices are portrayed in following table:

Table 1: Basic statistics of BSE sensex returns and DSE30 returns

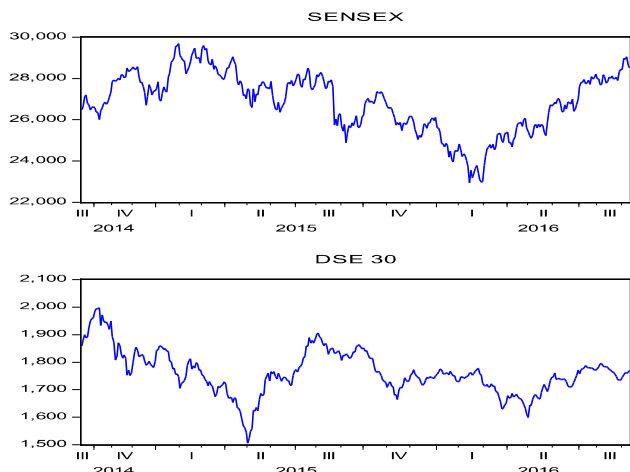
Descriptive Statistics	BSE Sensex	DSE 30
Mean	0.000198	-0.00013
Median	0.000285	-0.00043
Maximum	0.033574	0.041801
Minimum	-0.06999	-0.0353
Std. Dev.	0.01158	0.009516
Skewness	-0.6895	0.07924
Kurtosis	6.514284	5.26678
Jarque-Bera	221.4969	80.24798
Probability	0.000000	0.000000
Observations	373	373

The average statistics of BSE Sensex returns is positive implying the fact that this indices has increased over the period whereas the average statistics of DSE30 returns is negative implying the decrease in the indices over the period. The returns are negatively skewed in BSE Sensex that indicate the high probability of earning negative returns. The DSE 30 returns are positively skewed that indicates the high probability of earning positive returns. The value of kurtosis statistics is more than three in both indices. It means that the data is leptokurtic. BSE Sensex and DSE 30 returns series have a heavier tail as

compared to the standard normal distribution. Jarque-Bera test confirms the non-normality of return series of Indian and Bangladesh main market indices as the value of probability is zero i.e. the null hypothesis of normal distribution cannot be accepted by the Jarque-Bera test.

The time series of BSE Sensex and DSE 30 are first tested for stationarity by graphical method and then by applying Augmented Dickey-Fuller test. The graphical presentation in exhibit 1 for BSE Sensex and DSE 30 indicates that both time series are non stationary.

Figure 1: Time series of BSE Bankex and DSE30



The augmented Dickey-Fuller test is further applied to test the null hypothesis of unit root. Table 2 indicates the results of augmented Dickey-Fuller test for indices series of BSE Sensex and DSE 30.

Table 2: Results of augmented Dickey-Fuller test on BSE sensex and DSE 30 indices

Null Hypothesis: BSE SENSEX has a unit root					
			t-Statistic	Prob.*	Durbin-Watson stat
Augmented Dickey-Fuller test statistic			-1.909153	0.3280	1.978725

Null Hypothesis: DSE30 has a unit root					
			t-Statistic	Prob.*	Durbin-Watson stat
Augmented Dickey-Fuller test statistic			-2.211237	0.2027	1.826851

The null hypothesis that indices series of BSE Sensex and DSE 30 have unit root cannot be rejected as the probability value is greater than 0.05. A peculiar point to note here is that value of Durbin-Watson statistic i.e. d in BSE Sensex indices is almost equal to 2 indicating no autocorrelation whereas the same statistic is less in DSE30 indicating the chances of autocorrelation.

Transformation of non-stationary time series to stationary time series: The series of BSE Sensex and DSE30 are non-stationary time series as

confirmed by the results of augmented Dickey-Fuller test. These non-stationary time series are transformed to stationary time series by estimating differentiated log of BSE Sensex and by estimating differentiated log of DSE 30. Again the augmented Dickey-Fuller test is applied on differentiated log of BSE Sensex {dlog(Sensex)} and on differentiated log of DSE30 {dlog(DSE30)} to test the null hypothesis of unit root. Table 3 indicates the results of augmented Dickey-Fuller test for differentiated log of BSE Sensex and DSE30.

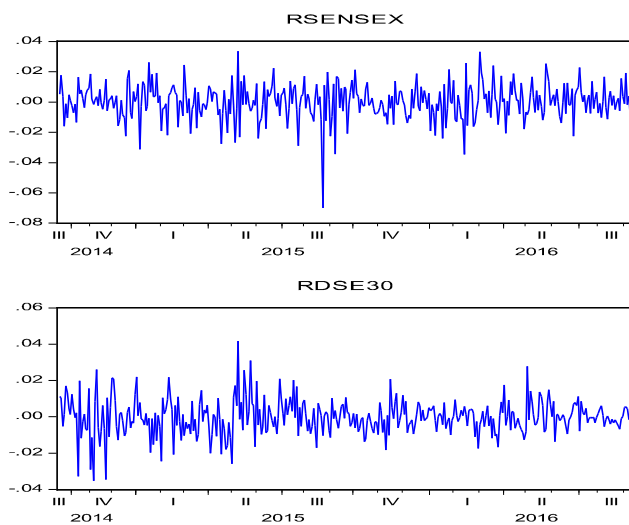
Table 3: Results of augmented Dickvey–Fuller test on BSE sensex returns and DSE 30 returns

Null Hypothesis: RSENSEX has a unit root					
			t-Statistic	Prob.*	Durbin-Watson stat
Augmented Dickey-Fuller test statistic			-19.33606	0.0000	1.996984

Null Hypothesis: RDSE30 has a unit root					
			t-Statistic	Prob.*	Durbin-Watson stat
Augmented Dickey-Fuller test statistic			-17.69191	0.0000	2.017458

The null hypotheses that BSE Sensex returns and DSE 30 returns have unit root are rejected as the probability value is 0 i.e less than 0.05. The graphical presentation of BSE Sensex returns and DSE 30 returns in exhibit 2 indicates transformation of non-stationary time series to stationary time series.

Figur 2: Plot of daily returns of BSE Bankex and DSE30



Cointegration between BSE Sensex and DSE30 indices series: The time series of BSE Sensex indices and DSE30 indices are non-stationary at level form and stationary at the first difference. So it can be concluded that both series are I(1) series and these series may be cointegrated. Johansen cointegration test is first applied to determine either the BSE Sensex indices series and DSE30 indices series are cointegrated or not. Table 4 portrays the result of Johansen cointegration test on BSE Sensex indices series and DSE30 indices series encompassing the Eigen value and Trace statistics.

The results clearly indicate that the null hypothesis of no-cointegration cannot be rejected even at the 10%. So, the time series of BSE Sensex indices series and DSE30 indices are not cointegrated as confirmed by the result of Johansen cointegration test. The vector error correction mechanism cannot be applied to these non-cointegrated series. The vector autoregression models are applied to these series in the present treatise.

Table 4: Result of Johansen cointegration test on BSE sensex indices series and DSE30 indices series

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.023441	11.44134	15.49471	0.1858
At most 1	0.007259	2.688510	3.841466	0.1011
Trace test indicates no cointegration at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.023441	8.752828	14.26460	0.3073
At most 1	0.007259	2.688510	3.841466	0.1011
Max-eigenvalue test indicates no cointegration at the 0.05 level				

Autocorrelation: The next stage is to statistically detect the autocorrelation with the help of autocorrelation function (ACF), partial autocorrelation function (PACF) and Q statistics in the BSE Bankex return series and DSE30 returns series. Note that the Durbin statistic is not suitable for autoregressive models that is why Q statistics is used in the present treatise to investigate the autocorrelation. Table 5 portrays the results of ACF, PACF and Q statistics and its

associated probabilities values for BSE Sensex return series. The ACF and PACF coefficients are not significant as they do not fall in the rule of thumb range of +0.14 to -0.14. The probability value of Q statistic is also more than 0.05 at each lag in BSE Sensex return series indicating the chances of no autocorrelations in all lags of BSE Sensex returns series. So, null hypothesis of no autocorrelation is not rejected.

Table 5: Results of ACF, PACF and Q statistics for the BSE sensex return series

Autocorrelation	Partial Correlation		AC	PAC	Q - Stat	Prob
. .	. .	1	-0.005	-0.005	0.0099	0.921
. .	. .	2	-0.005	-0.005	0.0203	0.990
. .	. .	3	-0.019	-0.019	0.1556	0.984
* .	* .	4	-0.122	-0.122	5.7544	0.218
. .	. .	5	0.028	0.026	6.0472	0.302
. .	. .	6	0.056	0.055	7.2322	0.300
. .	. .	7	-0.053	-0.058	8.3048	0.306
. *	. .	8	0.084	0.072	11.037	0.200
. .	. .	9	-0.038	-0.029	11.581	0.238
. .	. .	10	-0.062	-0.053	13.053	0.221
. .	. .	11	-0.004	-0.017	13.058	0.290
* .	* .	12	-0.101	-0.087	17.025	0.149
. .	. .	13	-0.046	-0.057	17.834	0.164
. *	. .	14	0.076	0.055	20.112	0.127
. .	. .	15	-0.055	-0.050	21.300	0.128

Table 6 portrays the results of ACF, PACF and Q statistics and its associated probabilities values in case of DSE30 return series. This series may

have autocorrelation at one, two and four lag at the 10% level.

Table 6: Results of ACF, PACF and Q statistics for the DSE30 return series

Autocorrelation	Partial Correlation		AC	PAC	Q - Stat	Prob
. *	. *	1	0.085	0.085	2.7227	0.099
. *	. *	2	0.089	0.082	5.7129	0.057
. .	. .	3	-0.011	-0.025	5.7598	0.124
. *	. *	4	0.079	0.075	8.1031	0.088
. .	. .	5	0.038	0.029	8.6497	0.124
. .	. .	6	-0.022	-0.042	8.8418	0.183
. .	. .	7	-0.031	-0.029	9.2155	0.238
. .	. .	8	0.049	0.056	10.133	0.256
. .	. .	9	-0.042	-0.053	10.800	0.290
. *	. *	10	0.087	0.090	13.718	0.186
* .	* .	11	-0.119	-0.121	19.194	0.058
* .	* .	12	-0.118	-0.126	24.602	0.017
* .	. .	13	-0.099	-0.056	28.390	0.008
. .	. .	14	-0.061	-0.044	29.822	0.008
. .	. .	15	0.040	0.070	30.450	0.010

Cross correlation: The cross correlation between BSE Sensex return series and DSE30 returns series is portrayed in table 7. The first cross correlogram in a form of {RSensex, RDSE30(-1)} related BSE Sensex returns to the past value of DSE30 returns. The negative correlations suggest that past growth or lagged growth in DSE30 returns reduces BSE Sensex returns. The second cross

correlogram in a form of RSensex, RDSE30(+1) related BSE Sensex returns to subsequent DSE30 returns. It shows that recent BSE Sensex returns tends to be negatively related to subsequent DSE30 returns. Note that this analysis does not confirm the causality between BSE Sensex return series and DSE30 return series but rather it determines the time lag between two variables.

Table 7: Results of cross correlogram of BSE sensex return series and DSE30 return series

Rensex, Rdse30(-I)	Rensex, Rdse30(+I)	i	lag	Lead
. .	. .	0	0.0412	0.0412
* .	. .	1	-0.0563	-0.0059
. .	. .	2	-0.0097	-0.0379
. .	. .	3	-0.0151	-0.0340
. *	. *	4	0.0632	0.0697
. .	. .	5	0.0001	0.0451
. *	* .	6	0.0500	-0.0641
. .	. .	7	0.0163	-0.0300
* .	* .	8	-0.0746	-0.0521
. *	. .	9	0.0936	-0.0274
. .	. .	10	0.0054	-0.0245
. .	* .	11	-0.0079	-0.0533
. .	. .	12	0.0185	0.0199
. .	. .	13	0.0330	0.0324
. .	. .	14	-0.0053	-0.0235
. .	. .	15	-0.0319	-0.0409

Vector autoregression: The mixed evidences of autocorrelations and cross correlation necessitate the further investigation with the help of vector

autoregression models. Table 8 portrays the results of VAR lag order selection criteria.

Table 8: Results of VAR Lag Order Selection Criteria

Endogenous variables: RSENSEX RDSE30						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	2290.845	NA	1.23e08*	12.54162*	12.52025*	12.53312*
1	2292.678	3.636181	1.24e08-	-12.52974	-12.46564	-12.50427
2	2294.326	3.249848	1.26e08-	-12.51685	-12.41001	-12.47439
3	2294.841	1.010202	1.28e08-	-12.49776	-12.34817	-12.43831
4	2300.255	10.56228*	1.27e08-	-12.50551	-12.31318	-12.42908
5	2300.903	1.256087	1.29e08-	-12.48714	-12.25208	-12.39372
6	2303.595	5.192503	1.30e08-	-12.47997	-12.20217	-12.36957
7	2304.632	1.989698	1.32e08-	-12.46374	-12.14320	-12.33635
8	2307.904	6.239013	1.33e08-	-12.45975	-12.09647	-12.31538
* 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						

The sequential modified likelihood ratio test statistic suggests the selection of four lags in the vector autoregression model whereas all other criteria suggest no selection of any lag of both indices series. So to proceed further and rigorously confirm the results statistically, the four lags are selected to frame the following equations of the vector autoregression models in the present case:

$$\begin{aligned}
 RSENSEX &= C(1) * RSENSEX(-1) + C(2) * RDSE30(-1) + C(3) \\
 &* RSENSEX(-2) + C(4) * RDSE30(-2) + C(5) * RSENSEX(-3) + C(6) \\
 &* RDSE30(-3) + C(7) * RSENSEX(-4) + C(8) * RDSE30(-4) + C(9) \\
 RDSE30 &= C(10) * RSENSEX(-1) + C(11) * RDSE30(-1) + C(12) \\
 &* RSENSEX(-2) + C(13) * RDSE30(-2) + C(14) * RSENSEX(-3) + C(15) \\
 &* RDSE30(-3) + C(16) * RSENSEX(-4) + C(17) * RDSE30(-4) + C(18)
 \end{aligned}$$

The results of vector autoregression estimates are portrayed in table 9 and the significance of individual variable explaining the dependent variable are portrayed in table 10. These results clearly indicate that the p value all coefficients of lag variables is not only more than 0.05 but also more than 0.10 except in case of C(7) which is the coefficient of fourth lag in BSE Sensex return series. So, the results clearly indicate that there is no lagged variable that is significant to explain the dependent variable (BSE Sensex return in equation 12 and DSE30 in equation 13) except for fourth lag of BSE Sensex returns.

Table 9: Results of Vector Autoregression Estimates

Standard errors in () & t-statistics in []		
	RSENSEX	RDSE30
RSENSEX(-1)	-0.007033 (0.05208) [-0.13506]	-0.001103 (0.04281) [-0.02577]
RSENSEX(-2)	-0.000577 (0.05217) [-0.01106]	-0.034831 (0.04289) [-0.81211]
RSENSEX(-3)	-0.016328 (0.05205) [-0.31368]	-0.020797 (0.04279) [-0.48597]
RSENSEX(-4)	-0.128061 (0.05198) [-2.46368]	0.059641 (0.04274) [1.39560]
RDSE30(-1)	-0.081131 (0.06383) [-1.27115]	0.082267 (0.05247) [1.56774]
RDSE30(-2)	-0.014166 (0.06406) [-0.22115]	0.084710 (0.05266) [1.60847]
RDSE30(-3)	-0.011644 (0.06395) [-0.18210]	-0.033347 (0.05257) [-0.63429]
RDSE30(-4)	0.083699 (0.06364) [1.31515]	0.070064 (0.05232) [1.33905]
C	0.000200 (0.00060) [0.33249]	-0.000145 (0.00050) [-0.29265]

Block exogeneity: Generally, the pairwise Granger causality tests cannot be applied in vector autoregression model framework. So, the block exogeneity Wald test is applied in the present treatise to estimate VAR Granger causality between BSE Sensex return series and DSE30 returns series. The causality here means the chronological ordering of movement in the BSE Sensex return series and DSE30 returns

series. The results portrayed in table 11 shows that the null hypothesis of non-significant lagged coefficients of one variable in the equation of another variable cannot be rejected as the probability value is greater than 0.05. So, it may be concluded that neither the lags of DSE30 returns explain the current BSE Sensex returns nor the lags of BSE Sensex return explain the current DSE30 returns.

Table10: Results of coefficient wise vector autoregression estimates

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.007033	0.052076	-0.135056	0.8926
C(2)	-0.081131	0.063825	-1.271149	0.2041
C(3)	-0.000577	0.052167	-0.011063	0.9912
C(4)	-0.014166	0.064056	-0.221153	0.8250
C(5)	-0.016328	0.052052	-0.313681	0.7539
C(6)	-0.011644	0.063946	-0.182096	0.8556
C(7)	-0.128061	0.051979	-2.463683	0.0140
C(8)	0.083699	0.063642	1.315150	0.1889
C(9)	0.000200	0.000602	0.332494	0.7396
C(10)	-0.001103	0.042815	-0.025770	0.9794
C(11)	0.082267	0.052475	1.567738	0.1174
C(12)	-0.034831	0.042889	-0.812107	0.4170
C(13)	0.084710	0.052665	1.608469	0.1082
C(14)	-0.020797	0.042795	-0.485971	0.6271
C(15)	-0.033347	0.052574	-0.634286	0.5261
C(16)	0.059641	0.042735	1.395596	0.1633
C(17)	0.070064	0.052324	1.339048	0.1810
C(18)	-0.000145	0.000495	-0.292647	0.7699
Determinant residual covariance		1.14E-08		

Table 11: Results of VAR Granger causality/block exogeneity wald tests

Dependent variable: RSENSEX			
Excluded	Chi-sq	df	Prob.
RDSE30	3.525609	4	0.4740
All	3.525609	4	0.4740
Dependent variable: RDSE30			
Excluded	Chi-sq	df	Prob.
RSENSEX	2.856491	4	0.5821
All	2.856491	4	0.5821

Impulse Response Analysis: The impulse responses identify the responsiveness of BSE Sensex returns and DSE30 returns in the vector autoregression when a shock or impulse is given to their error terms that is C(9) in equation 12 and C(18) in equation 13. The process of giving one positive standard deviation shock or impulse to the residuals of both equations checks how

the BSE Sensex returns and DSE30 returns are reacting to each other. Table 12 portrays the results of impulse response function that traces the time path of the impact of a shock in BSE Sensex returns on BSE Sensex as well as on DSE30 returns and the impact of a shock in DSE30 returns on DSE30 as well as on BSE Sensex returns.

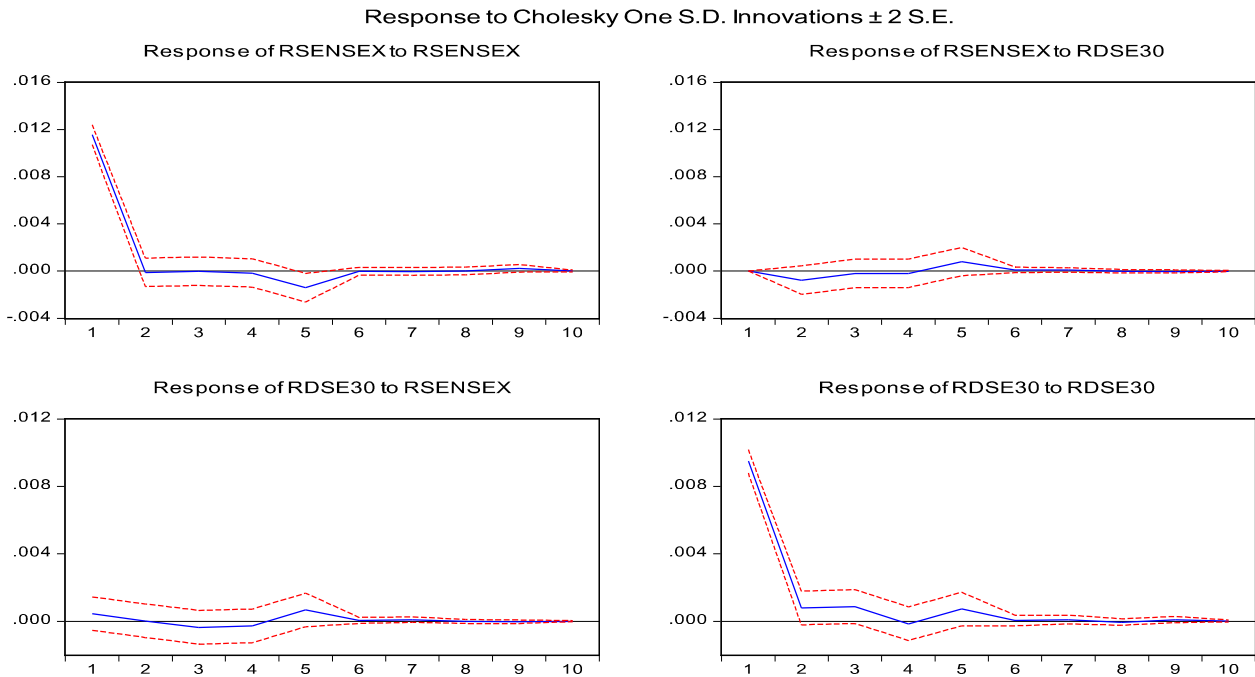
Table12: Results of vector autoregression impulse responses

Response of SENSEX:		
Period	RSENSEX	RDSE30
1	0.011552	0.000000
2	-0.000118	-0.000770
3	-1.42E-05	-0.000192
4	-0.000165	-0.000190
5	-0.001411	0.000799
6	-1.88E-05	9.49E05-
7	-3.48E-05	8.79E05-
8	4.80E06-	-1.87E-05
9	0.000236	-4.06E-05
10	6.59E06-	-1.83E-05
Response of RDSE30:		
Period	RSENSEX	RDSE30
1	0.000449	0.009487
2	2.42E05-	0.000780
3	-0.000362	0.000869
4	-0.000279	-0.000152
5	0.000669	0.000723
6	4.58E05-	3.61E05-
7	9.61E05-	9.47E05-
8	-9.84E-06	-5.52E-05
9	-2.99E-05	9.55E05-
10	-4.11E-06	7.08E06-
Cholesky Ordering: RSENSEX RDSE30		

As it was expected given the parameters estimates and the VAR Granger causality results, again few interlinkages between BSE Sensex returns series and DSE30 returns series are established here. The graphical presentation in exhibit 3

indicates that the responses to the one positive standard deviation shock or impulse are very small except for the response of BSE Sensex and DSE30 to their respective own shocks.

Figure 3: Plot vector autoregression impulse responses



Variance decomposition: The results of variance decomposition of BSE Sensex returns and DSE30 returns using Cholesky decomposition method is portrayed in table 13. In the short run that is on day 1, impulse or shock to BSE Sensex returns account for hundred percent variation of the fluctuation in BSE Sensex returns and the shock to DSE30 returns do not cause any variation of the fluctuation in BSE Sensex returns. On day 2, shock to BSE Sensex returns account for 99.55 percent variation of the fluctuation in BSE Sensex returns and shock to DSE30 returns

causes only 0.44 percent variation of the fluctuation in BSE Sensex returns. The variance decomposition of DSE30 returns shows that on day 1, impulse or shock to DSE30 returns account for 99.776 percent variation of the fluctuation in DSE 30 returns and the shock to DSE30 returns causes only 0.223 percent variation of the fluctuation in BSE Sensex returns. On day 2, shock to DSE 30 returns account for 99.777 percent variation of the fluctuation in DSE 30 returns and shock to DSE30 returns causes only 0.222 percent variation of the fluctuation in BSE Sensex returns.

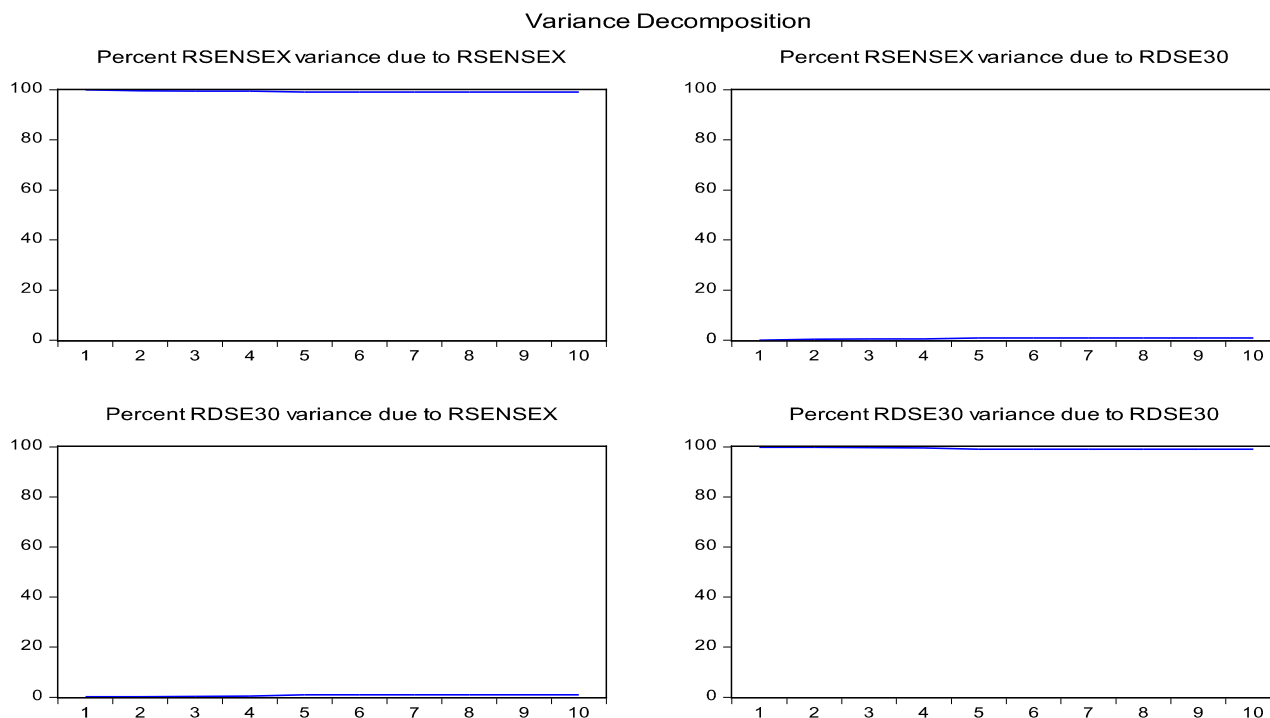
Table13: Results of variance decomposition

Variance Decomposition of RSENSEX:			
Period	S.E.	RSENSEX	RDSE30
1	0.011552	100.0000	0.000000
2	0.011578	99.55807	0.441930
3	0.011580	99.53061	0.469386
4	0.011583	99.50387	0.496132
5	0.011696	99.04671	0.953291
6	0.011696	99.04019	0.959813
7	0.011697	99.03460	0.965399
8	0.011697	99.03435	0.965651
9	0.011699	99.03355	0.966450
10	0.011699	99.03331	0.966693
Variance Decomposition of RDSE30:			
Period	S.E.	RSENSEX	RDSE30
1	0.009498	0.223460	99.77654
2	0.009530	0.222604	99.77740
3	0.009576	0.363527	99.63647
4	0.009581	0.447832	99.55217
5	0.009632	0.925768	99.07423
6	0.009632	0.927992	99.07201
7	0.009633	0.937766	99.06223
8	0.009633	0.937839	99.06216
9	0.009634	0.938700	99.06130
10	0.009634	0.938717	99.06128
Cholesky Ordering: RSENSEX RDSE30			

The graphical presentation of variance decomposition in exhibit 4 portrays the same results. The percentage of the errors that is attributable to own shocks is 100 percent in the case of BSE Sensex returns and 99.77 percent in DSE30 returns. These results clearly indicate that with the increase in lag there is decrease in the percent variation of fluctuation in BSE Sensex returns due to domestic shock (i.e. shock in BSE

Sensex) whereas there is increase in the percent variation of fluctuation in BSE Sensex returns due to shock in DSE30 returns. In the same way, with the increase in lag there is decrease in the percent variation of fluctuation in DSE30 due to domestic shock (i.e. shock in DSE30) whereas there is increase in the percent variation of fluctuation in DSE30 returns due to shock in BSE Sensex returns.

Figur 4: Plot of variance decomposition



6. DISCUSSION

Eun & Shim (1989), Hamao, Masulis & Ng (1990), Park & Fatemi (1993), Lin, Engle & Ito (1994), Janakiraman & Lamba (1998), Kanas (2000), Balaa & Premaratne (2002), Marianne & Nicola (2009), Natarajan, Singh & Nagarajan (2014), Larisa, Janusz & Chi (2016) found the substantial interdependence among the national stock markets with US being the most influential market. Johnson & Soenen (2002), Xinling & Peng (2011), Arora Srinivasan, P. (2012), Louzis (2013) investigated the degree of integration of equity markets in Asia and found that the Asian equity markets were highly integrated and these markets became more integrated over time. Zhang & Jaffry (2015) found no volatility spillover in the pre-crisis period and strong bi-directional volatility spillover in the crisis period between China stock market and Hong Kong stock market. These studies show the presence of inter-linkages between financial

markets of developed countries with other developed nations or few emerging economies. The present treatise explores the inter-linkages between Indian stock market and Bangladesh stock market on the basis of returns correlation, cointegration, causality, vector autoregression, block significance, impulse response and variance decomposition. It is found that the Indian stock market and Bangladesh stock market are not significantly cointegrated to each other. The more interlinked are stock markets the less is the scope of exploiting opportunity of diversification to earn benefits. So, the segmentation of these equity markets provides the long-run diversification benefits to investors across these two markets. The results of the present study is based on the daily returns indices of two years only and these results can be further improved by extending the data of larger period and even on high frequency data to explore the interdependence between the equity markets of these two neighbour countries.

7. CONCLUSION

The earlier studies of inter-linkages between stock markets have focused primarily on return correlations and volatility spillovers of developed countries mainly US and UK with other developed nations or few emerging economies. But there is lacuna in the investigation of inter-linkages among emerging economies. The present treatise attempts to study the inter-linkages between equity markets of India and Bangladesh. The daily stock price data for the period of September 2014 to September 2016 on BSE Sensex and DSE 30 have been taken from the online database maintained by the Bombay Stock Exchange and the Dhaka Stock Exchange respectively. The data of these two indices was initially studied for stationarity, serial correlation and cross correlation. The series of BSE Sensex and DSE30 found to be non stationary. The Johansen cointegration test was applied to both non stationary series and the results showed the absence of significant cointegration. The results are further verified with the help of augmented Dickey-Fuller test, autocorrelation function and partial auto correlation function, Ljung-Box Q-statistics, cross correlogram, vector autoregression Granger causality tests (block exogeneity test), impulse response function and variance decomposition. All the results provide evidences on the segmentation of stock markets of India and Bangladesh. There was no significant inter-linkage between these two markets. The responses to shock or impulse are very small except for the response of BSE Sensex returns and DSE30 returns to their respective own shocks. So, it may be concluded that the recent policy changes and bilateral agreements have not significantly reduced the stock market segmentation of Indian equity market from Bangladesh equity market. The findings of

this paper have implications for international investors and policy makers. The segmentation of the equity market provides the long-run diversification benefits to investors across these two markets. It also provides signals to policy makers to take appropriate decisions that may attain and sustain the financial stabilisation of their country.

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