Dynamic Linkages between the Brazilian, Russian, Indian & Chinese Stock Markets

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Abstract: *The present study is being contemplated with the objective of studying volatility of four stock market of BRIC (Brazil, Russia, India & China) for the period of 10 years from April 2007 to March 2017. The study is based on secondary data related to daily closing prices. Using Unit root test, Granger Causality Test, Correlation Test & Co-Integration Test have shown positive provides evidence of positive and significant correlation of return volatility. In this paper it showed that Indian Stock Market is correlated with Russian Stock Market, RTSI with correlation of 62%. Indian stock market is very less correlated with Chinese and Brazilian Stock Market, with a correlation of 16% and 2 % only. Overall it was seen that Indian Stock Market has good connection with Russian Stock Market but as far as other BRIC countries are concerned, SCI and BOVESPA are very less related to Indian stock market.*

Keywords: *Volatility, Unit root test, Granger Causality Test, Correlation Test & Co-Integration Test.*

I. INTRODUCTION

In the era of globalization and liberalization, the capital markets assume a greater importance. The smooth functioning of the capital market depends on the regulators, participants and investors. The past decade has been a golden age for securities market in India. It is now a far more important source of finance than traditional financial intermediaries for corporate sector which is poised to dominate the future of corporate finance in India.

Volatility may be described as a phenomenon, which characterizes changeableness of a variable under consideration. Volatility is associated with unpredictability and uncertainty. In literature on stock market, the term is synonymous with risk, and hence high volatility is thought of as a symptom of market disruption whereby securities are not being priced fairly and the capital market not functioning as well as it should be. As a concept volatility is simple and intuitive. It measures the variability or dispersion about a central tendency. However, there are some subtleties that make volatility challenging to analyze and implement. Since volatility is a standard measure of financial vulnerability, it plays a key role in assessing the risk/return tradeoffs.

The high volatility is due to much foreign equity inflows. This results into dependence of Indian equity market on global capital market variations. It means any happening outside India will have its impact here as well. As when US economy was improving, resulted into falling rupee led negative sentiments to stock market crash.

Research is not only related to the review of the information to date knowledge but find out new particulars concerned during the process dynamic changes in the society. As a system of methods and rule & regulation to make possible the collection and analysis of data is called Methodology. It comprises different steps that are usually adopted by a researcher in studying research problem. Research Methodology not only includes research methods but also considers the logic behind the methods used by the researcher in the context of research study and explains why particulars methods or technique was used and why others have not been used so that research results capable of being evaluated.

II. REVIEW OF LITERATURE

Shin (2005) evaluated the relationship between expected stock returns and conditional volatility. This study showed different findings on risk-return tradeoff patterns between developed and emerging markets could be attributable to the different threshold levels of volatility.

Chen et al. (2006) examined the bilateral relations between three pairs of stock markets, namely India-US, India-China and China-US. The empirical results showed that all three pairs of stock markets are fractionally co integrated.

Chukwuogor (2006) examined 15 emerging and developed European financial markets to analyze the financial markets' trends such as the annual returns, daily returns and volatility of returns. There was normally high volatility of returns in the European markets.

Kumar & Dhankar (2009) examined the cross correlation in stock returns of South Asian stock markets, their regional integration and interdependence on global stock market The researchers suggested that investors adjust their risk premium in advance for the expected volatility and that they did not alter their portfolios in response to the expected variations in stock returns. The study concluded reports weak interdependency among the South Asian stock markets and also with the global stock market.

Raju (2009) discussed the issues of volatility and risk as these have become increasingly important due to the growing linkages of national markets in recent times. Mainly, developed and emerging markets show distinct pattern in return and volatility behavior. Asymmetry pattern by skewness and kurtosis have been different for both markets. And current meltdown has a significant impact on the statistical properties of financial time series.

Joshi (2010) investigated the stock market volatility in the emerging stock markets of India and China using daily closing price. This study suggested that the persistence of volatility in Chinese stock market is more than Indian stock market

Singh & Singh (2010) focused the linkages of the two leading emerging markets i.e. Chinese and Indian market with developed markets. The result of this study further confirmed with the analysis of Granger causality where the both Chinese and Indian markets have at least had unilateral causality with all four developed markets.

Gupta & Aggarwal (2011) found the correlation of Indian Stock market with five other major Asian economies: Japan, Hong Kong, Indonesia, Malaysia and Korea. The results of the study would show that whether Indian Stock markets (BSE Sensex) offer major diversification to institutional and international investors in the short and long run.

Singh and Sharma (2012) examined the inter linkages of Brazil, Russia, India and China. The results showed that Russian, Indian and Brazilian stock markets affect each other but Chinese stock market was not affected by these markets but these markets were affected by Chinese stock market.

Jeyanthi (2012) examines the long - run and short - run relationships between the stock prices of BRIC countries, using daily data for the period April 2000 to March 2010. The empirical results of this paper supported the view that international investors have long-run opportunities for portfolio diversification by acquiring stocks from these BRIC countries.

Dasgupta (2014) found in his paper that the Indian stock market has strong impact on Brazilian and Russian stock markets. It was found that BRIC stock markets are the most favorable destination for global investors in the coming future and among the BRIC the Indian stock market

Juneja & Gupta (2016) recognized whether Indian and sampled international stock markets were volatile or not. The researchers found that different factors not only national but international enlarged the volatility in the market and therefore the returns changed. Lots of studies were studied by the researchers on this issue that supported to calculate the comparison between the volatility of Indian Stock Market and Sampled International stock Markets. This study carried to know the stock market volatility patterns in Indian market and international markets.

Objectives of the Study

The present study is designed to analyze and compare volatility of Brazilian, Russian, Indian & Chinese Stock Markets. Accordingly, the present research work is focused on the comparison the Volatility of Brazilian, Russian, Indian & Chinese Stock Markets.

III. RESEARCH METHODOLOGY

Sample

This study identifies to analyze and compare the volatility of BRIC (Brazil, Russia, India and China) Stock Markets. The daily closing prices of the eleven indices is taken from these stock markets from April 2007 to March 2017. The data is collected from the reliable sources such as Bloomberg, www.yahoo.finance.com and the websites of respective stock indices such as bseindia.com. The daily closing value is used for the analysis. Engle and Mezrich (1995) suggested that at least eight years of data should be used for correct GARCH estimation.

The description of the sampling frames includes the population and target population unit. The population of the study includes the stock markets of the International stock markets. However the daily data of selected stock markets is collected for the time period of April 2007 up to March 2017.

Table1: Stock Markets and Index of BRIC countries

S. No	Country	Stock Market	Indices	Abbreviation
1	Brazil	Sao Paulo Stock Exchange	BOVESPA	BVSP
2	Russia	Russia Trading System	RTSI	RTSI
3	India	Bombay Stock Exchange	SENSEX	SENSEX
4	China	Shanghai Composite Index	SCI	SCI

Statistical Tools

Statistical tools used to see the trends in stock market returns and volatility patterns in post liberalization period.

To calculate the returns, logarithmic difference of two periods is taken by using the following:

$$R_t(In\,P_t - In\,P_{t-1}) * 100$$

where Rt is the return in period t, Pt and Pt-1 are the daily closing prices of the index at time t and t-1 respectively.

Unit root test

A unit root test is an essential condition to test the stationary nature of the selected time series. In the study, the Augmented Dickey-Fuller test is used to check the null hypothesis of the presence of a unit root in the selected series. The outcome of ADF test for a unit root for selected stock markets under study is reported in the study. In unit root test the optimal lag length was taken with the Schwartz Info Criterion (SCI) and maximum leg was put to 36. Phillips-Perron Test checks the null hypothesis of variable autocorrelation prevalent in the series. =For testing stationary, let us consider an AR (1) model:

$$\gamma_t = p_1\gamma_{t-1} + \varepsilon_t$$

The simple AR(1) model represented in above equation is called a *random walk model*. In this AR(1) model if $|p_1|<1$, then the series is I(0) i.e. stationary in level, but if $p_1= 1$ then thereexist what is called unit root problem. In other words, series is non-stationary.

Augmented Dickey Fuller Test

Dickey-Totaler test involve estimating regression equation and carrying out the hypothesis test. The simplest approach to testing for a unit root is with an AR(1) model. AR(1) process:

$$\gamma_t = c + p\gamma_{t-1} + \varepsilon_t$$

Where *c* and ρ are parameters and is assumed to be white noise. If -1<p<1, then y is a stationary series while if ρ=1 , y is a non-stationary series. If the absolute value of ρ is greater than one, the series is explosive. Therefore, the hypothesis of a stationary series is involves whether the absolute value of ρ is strictly less than one.

Phillips–Perron Test

The Phillips–Perron test (named after Peter C. B. Phillips and Pierre Perron in 1998) is also a unit root test. This test suggests an alternative method (nonparametric) for controlling for serial correlation. This test is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. This method estimates the non-augmented DF test of the null hypothesis δ=0 in

$$\Delta yt = \delta y_{t-1} + \mu t$$

Where Δ is the first difference operator. The ADF test addresses this issue by introducing lags of Δy_t as regressors in the test equation.Similar to this test, the Phillips–Perron test addresses the matter that the process generating data for y_t might have a higher order of autocorrelation than the equation of the test – makingy_{t-1} endogenous.

Whilst this test is robust with respect to unspecified autocorrelation and heteroscedasticity test equation.

Johansen's Cointegration Test

Johansen's co integration test is considered to be most influential among the various available tests. Johansen's Co integration test involves quite complex mathematics; therefore in the study the results obtained from the E views software are reported and discussed. Johansen's Co integration test is used to study the long term equilibrium relationship between the different time series of the same integrated order.

$$\Delta x_t = \theta_2 (y_t - \beta x_t)_{t-1} + \sum_{i=1}^{p} \gamma_{2i}\Delta Y_{t-i} + \sum_{j=1}^{p} \delta_{2j}\Delta x_{t-j} + \epsilon_{2t}$$

This test permits more than one co-integrating relationship so is more usually applicable than the Engle–Granger test which is based on the Dickey–Totaler test for unit roots in the residuals from a single co-integrating relationship.

Granger Causality Test

This technique considered for determining whether one time series is useful in forecasting another. If two variables, x and y are correlated, it is possible that: x is caused by y, y is caused by x, Both x and y are caused by some other variable C. Causality cannot be incidental from contemporaneous correlations. Granger Causality is based on the simple logic that effect cannot precede cause. We may have mainly three situations: One way causality; No causality between x and y; and Two-way or feedback causality.

IV. DATA ANALYSIS AND INTERPRETATION

Analysis of Unit Root Test (At Level) of BRIC Countries

A unit root is an essential condition to test the stationary, the Augmented Dickey-Fuller test is used to check the null hypothesis of a unit root. The outcome of ADF test for a unit root for seven stock markets under study is presented in Table 2. The optimal lag length was taken with the Schwartz Info Criterion (SCI) and maximum leg was put to 36. Phillips-Perron Test checks the null hypothesis of variable autocorrelation prevalent in the series. The method is Bartlett Kernel and Newey Best Bandwidth is used at the time of application of PP Test. Augmented Dickey Fuller and PP unit root test was performed including intercept at level for the period of ten years from April 2007 to March 2017.

Table2: Analysis of Unit Root Test (At Level) of BRIC Countries

	ADF		PP	
Indices	t-Statistic	Prob.*	t-Statistic	Prob.*
BOVESPA	-2.8811	0.0477	-2.7162	0.0714
RTSI	-1.4045	0.5816	-1.3701	0.5984
SENSEX	-0.8085	0.8161	-0.8142	0.8145
SCI	-1.996	0.2888	-1.9456	0.3115

*indicates significance at 1% and 5% level

Table shows that at 5% significant level, all series are insignificant so that the null hypothesis that series has unit root problem was accepted and it was found that series were non-stationary.

Analysis of Unit Root Test (At First Difference) of BRIC Countries

Augmented Dickey Fuller and PP unit root test was performed including intercept at first difference for the period of ten years from April 2007 to March 2017. The Augmented Dickey-Fuller test is used to check the null hypothesis of a unit root. The optimal lag length was taken with the Schwartz Info Criterion (SCI) and maximum leg was put to 36 in ADF test. Phillips-Perron Test checks the null hypothesis of variable autocorrelation prevalent in the series. The method is Bartlett Kernel and Newey Best Bandwidth is used at the time of application of PP Test.

Table3: Analysis of Unit Root Test (At First Difference) of BRIC Countries

	ADF		PP	
Indices	t-Statistic	Prob.*	t-Statistic	Prob.*
BOVESPA	-50.699	0.0001*	-50.868	0.0001*
RTSI	-49.146	0.0001*	-49.156	0.0001*
SENSEX	-49.778	0.0001*	-49.777	0.0001*
SCI	-22.25	0.0000*	-47.75	0.0001*

*indicates significance at 1% and 5% level.

Table shows that at 5% significant level, all series are significant so that the null hypothesis that series has unit root problem was rejected and it was found that series were stationary. It means a smooth looking series, without drift, steady variance over time, a constant autocorrelation structure over time and no episodic variations.

Granger Causality Test Analysis of Indices of BRIC Countries

The result of Granger Causality test of BRIC countries under study for the time period of ten years from April 2007 to March 2017 is shown in Table 4.

Granger Causality Test shows the short term association of priority among variables. This test was applied on the return series which was generated by taking log of closing prices of the series. The most favorable number of lag length was picked by using the SIC criteria and it was found to be Lag 2 in case of all indices. The test checks that whether the today's return of Indian stock market is influenced by the previous day return of any other international stock market.

Table4: Granger Causality Test Analyses of BRIC Countries

Null Hypothesis:	Obs	F-Statistic	Probability
SENSEX does not Granger Cause BOVESPA	2450	4.59689	0.01017*
BOVESPA does not Granger Cause SENSEX		3.54955	0.02889*
SENSEX does not Granger Cause RTSI	2450	2.95128	0.05246*
RTSI does not Granger Cause SENSEX		2.37823	0.09293
SENSEX does not Granger Cause SCI	2450	0.4247	0.65402
SCI does not Granger Cause SENSEX		0.94303	0.38959

*indicates significant at 1% and 5% level.

The null hypothesis that SENSEX does not granger cause Brazilian Stock Market Index, BOVESPA and BOVESPA does not granger cause SENSEX has been rejected which means both markets have an impact on each other so there is bidirectional impact on both these markets.

Then, the null hypothesis that SENSEX does not granger cause Russian stock market index RTSI has been rejected which means Indian stock market have an impact on Russian stock market and the null hypothesis that RTSI does not granger cause SENSEX has been accepted which means Russian stock market is not affecting Indian stock market so there is unidirectional relation between these two markets.

The null hypothesis that SENSEX does not granger cause Chinese Stock Market Index, SCI and SCI does not granger cause SENSEX has been accepted which means both markets don't affect each other so there is no relation between these markets.

Overall, it was found Brazilian stock markets have bidirectional impact on Indian stock market so all news of Indian stock market not only will have affect not only Indian stock market but also Brazilian stock

market as well, side by side any information of these countries also will affect Indian stock market. But, on the other side, Russia Stock market will be affected by Indian stock market happenings but in reverse this country is not affecting Indian stock market. Lastly, Chinese stock market doesn't have any relation with Indian stock market.

Analysis of Correlation Test of Indices of BRIC Countries

The result of correlation test of BRIC Countries under the study for the time period of ten years from April 2007 to March 2017 is shown in Table 5.

Table 5: Analysis of Correlation Test of BRIC Countries

	BOVESPA	RTSI	SENSEX	SCI
BOVESPA	1.00000	0.403707	0.022247	0.196657
RTSI	0.403707	1.00000	0.622926	0.492867
SENSEX	0.022247	0.622926	1.00000	0.164499
SCI	0.196657	0.492867	0.164499	1.00000

It shows that Indian Stock Market is correlated with Russian Stock Market, RTSI with correlation of 62%. Indian stock market is very less correlated with Chinese and Brazilian Stock Market, with a correlation of 16% and 2 % only.

So, overall it was seen that Indian Stock Market has good connection with Russian Stock Market but as far as other BRIC countries are concerned, SCI and BOVESPA are very less related to Indian stock market.

Co-Integration Test Analysis of Indices of BRIC Countries

The result of Co-Integration test of BRIC Countries under study for the time period of ten years from April 2007 to March 2017 is shown in Table 6. It was found that Indian stock market is integrated with RTSI by trace value as these are significant at 5% significant level, so null hypothesis that these series are not integrated with Indian stock market is rejected.

Table6: Co-Integration Test Analysis of BRIC Countries

	Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**	Max-Eigen Statistic	0.05 Critical Value	Prob.**
BOVESPA	None	8.07813	15.4947	0.4571	7.34285	14.2646	0.4494
	At most 1	0.73528	3.84147	0.3912	0.73528	3.84147	0.3912
RTSI	None	16.3416	15.4947	0.0372*	14.9913	14.2646	0.0383*
	At most 1	1.3503	3.84147	0.2452	1.3503	3.84147	0.2452
SCI	None	5.24674	15.4947	0.7821	4.59348	14.2646	0.792
	At most 1	0.65327	3.84147	0.4189	0.65327	3.84147	0.4189

*indicates significant at 1% and 5% level.

As per Max-Eigen Value, Indian stock market is integrated with Russian Stock Market; RTSI as their values are significant at 5% significant level, so null hypothesis that these series are not integrated with Indian stock market is rejected. But other two markets i.e. Brazilian stock market, BOVESPA and Chinese stock market, SCI are not significant neither by trace value nor by Max Eigen value which means these series is not integrated with each other.

So, overall it was found that Indian Stock Market is integrated with Russian Stock Market only out of all BRIC countries.

V. CONCLUSION

International Stock Markets are integrated due to the modernized technology and Internationalization. Investors are concerned in getting the information regarding the inter-linkages of stock markets so that they can make the portfolio diversification. The above analysis is computed to make out the inter-dependence of Indian stock market with international stock markets. For this purpose four stock markets are considered, Brazil, Russia, India and China (BRIC) countries collectively would play an increasingly important role in the International economy. The results found that The null hypothesis that SENSEX does not granger cause Brazilian Stock Market Index, BOVESPA and BOVESPA does not granger cause SENSEX has been rejected which means both markets have an impact on each other so there is bidirectional impact on both these markets. It showed that Indian Stock Market is correlated with Russian Stock Market, RTSI with correlation of 62%. Indian stock market is very less correlated with Chinese and Brazilian Stock Market, with a correlation of 16% and 2 % only. Overall it was found that Indian Stock Market is integrated with Russian Stock Market only out of all BRIC countries.

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