CO-Integration among the Stock Markets of Brics Economies

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Introduction

The acronym BRIC was first used in 2001 by Goldman Sachs in their Global Economics Paper, "The World Needs Better Economic BRICs" on the basis of econometric analyses projecting that the economies of Brazil, Russia, India and China would individually and collectively occupy far greater economic space and would be amongst the world's largest economies in the next 50 years or so. "Normally developing economies are dominated by US or Japan. It is found that the empirical evidence suggest that some countries are dominated by the US, some are dominated by Japan, and the remaining countries are dominated by neither during the time period investigated." (Ghosh, Saidi and Johnson, 1999)

BRICS bring together five major developing economies viz., Brazil, Russia, India, China and South Africa respectively. According to IMF, GDP Growth rate of these five economies are Brazil at -3.59%, Russia at -0.25%, India at 6.8%, China at 6.7%, South Africa at 0.28%. BRICS economies are emerging and developing economies. They are monitored by all developing economies.

Economic Parameter	Brazil	Russia	India	China	South Africa
GDP Growth 2016	-3.59%	-0.25%	6.8%	6.7%	0.28%
Total Investment (% of GDP) 2016	17.45%	44.08%	31.41%	25.63%	19.46%

Source: International Monetary Fund

From the table, it can be found that all economies are capable of attracting at least one fifth of their GDP as investment. China and India are the favourite investment destinations. BRICS in their official website claim that in relation to the BRICS coordination in international fora and organizations, the mechanism focuses on the economic-financial and political governance spheres. The economic – financial sphere stands out as one of the most promising areas of activity for the BRICS. From 2000 to 2012, Brazil was one of the fastest-growing major economies in the world, with an average annual GDP growth rate of over 5%, with its economy in 2012 surpassing that of the United Kingdom, temporarily making Brazil the world's sixth largest economy.[1]

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BRICS summit has been conducted eight times so far. It is conducted twice at Brazil, Russia and India and once at China, South Africa. Periodical summits at various locations ensure the stability of BRICS. So Investors focus on BRICS markets. Though BRICS represent the emerging markets and investors gives more preference to emerging market stocks, but New York Times argued that developed countries stocks are preferred over emerging markets stocks by quoting the Investors who are saying "why take an additional volatility with emerging market stocks when you get better returns for less volatility in the developed world?. So it has become inevitable to test whether the emerging markets are important for the Investors in India. This article analyses the cointegration of Indian stock market and the economies in BRICS.

This article divides the contents into Ten sections. Section 2 comprises review of literature. Section 3 has details about the data. Section 4 lists the summary statistics. Section 5 comprises Correlation and covariance among BRICS economies Indices. Section 6 discusses the results of Test of stationarity and Section 7 has the results of Test of co-integration among BRICS economies indices. Section 8 has the results of Test of Causality. Section 9 provides the test for volatility. It provides the results of GARCH process. Section 10 lists out the summary of all findings and Conclusion.

Review of literature

Co-integration has become a core topic after globalization embraces almost the whole world. It is the area of interest of many researchers how various stock markets are co-integrated and how a major happening in one country affects the other countries' stock markets. If the markets are not co-integrated, then investors would prefer to test whether any chance for making arbitrage profit exists or not. Authors provide evidence on the evolution of contemporaneous and lead / lag relationships among eight national stock markets.(Koch and Koch, 1991). They suggest that regional interdependencies have grown over time. As far as co-integration of developing economies' stock markets are concerned, authors find no co-integration between the emerging markets like Malaysia, Thailand and Korea and the developed markets like United States, United Kingdom and Japan.(W.K.Wong, J.Penm,R.D.Terrell and K.Lim,2004). On the other hand, the increase in financial links for open and semi-open markets in the 1990s suggests that the relaxation of foreign ownership restrictions might have enhanced links with world markets. (K.Phylaktis, F.Ravazzolo, 2005)

About The Data

Data consists of 12 years monthly performance of five major indices of respective countries. Ibovespa Brasil Sao Paulo Stock Exchange Index for Brazil, BSE Sensex for India, South Africa 40 Index for South Africa, Modulation and Coding Scheme Index – MCX Index for Russia, SSE Composite index for China are the indices selected for study. 12 years data or 144 monthly data are taken for analysis. The data starts from 1, January 2005 to 31, December 2016. The use of monthly data is preferred since they can mitigate possible distortionary effects of non trading, non synchronous trading and also the bid/ ask spread bias that are usually associated with weekly or daily data of stock returns. While analyzing Istanbul stock exchange, authors used 171 monthly indices data to find co-integration between ISE and developed economies (Benkota and Darrat, 2003). So we have also used 144 latest monthly data to check the co-integration among BRICS economies stock markets.

Data are taken from Yahoo!finance.com and Investing.com

Descriptive Statistics

Table 1 reports summary statistics of the monthly stock returns [=100 (log (Pt / Pt -1), where Pt is the value of price index at time t] for BSE and other four BRICS economies stock markets.

Table 1: Summary statistics

Descriptive Statistics	Brazil	Russia	India	China	South Africa
Mean	0.80	1.27	1.19	1.01	1.05
Median	0.60	2.04	1.08	0.96	1.10
Maximum	16.97	22.06	28.26	27.45	12.86
Minimum	-24.8	-28.77	-23.89	-24.63	-14.91
Standard Deviation	6.64	7.64	6.68	8.75	4.71
Skewness	-0.13	-0.56	-0.08	-0.25	-0.14
Kurtosis	3.64	4.91	5.39	3.89	3.72

The average monthly return Brazil is 0.80, Russia 1.27, India 1.19, China 1.01 and South Africa 1.05. Russia has been generating more monthly return 1.27% (16.35% per annum), India stands second with monthly return 1.19 (15.25% per annum), China's monthly return 1.01 (12.81% per annum) has almost been equal to South Africa's Monthly return 1.05 (13.35% per annum). And Brazil stood last with monthly return 0.80 (10.03% per annum).

Considering the risk in the market, China is more risky among the five nations' markets whose standard deviation is 8.75. India's standard deviation has been almost equal to Brazil's and both are around 6.6. South Africa has less risky market comparing the four remaining markets and South Africa market's standard deviation has been 4.71. India has made the maximum monthly gain with 28.26% return. All the indices have negative coefficient of skewness which means they have few large values (monthly returns) and they have many small values (monthly returns).

Correlation and Covariance Between The Indices

Table 2: Correlation among the BRICS countries

	Sensex	Bovespa	MCX	Shangai	South Africa 40
Sensex	1	0.49	0.72	0.48	0.95
Bovespa	0.49	1	0.61	0.57	0.35
MCX	0.72	0.61	1	0.63	0.66
Shangai	0.48	0.57	0.63	1	0.36
South Africa 40	0.95	0.35	0.66	0.35	1

Correlation and covariance are better parameters to study the markets integration. A recent Example of covariance and variance influencing conditionally expected national returns is proposed in their study of US and Japan. (Chan, Karolyi and Stulz, 1992)

If you look at correlation among BRICS countries, there is almost perfect correlation between South African Stock market and Indian Stock Market. The Correlation between these two markets is 0.95. The next maximum correlation is 0.72 between Russian stock market and Indian stock market.

The next better correlation is 0.66 between Russian stock market and South African Stock market and There exists almost similar correlation between Chinese stock market and Russian Stock market and the correlation is 0.63. The least correlation exists between Chinese stock market and South African Stock market which stood at 0.35. The next least correlation exists between Brazil Stock market and South African Stock market and the value is also 0.35. As far as Indian stock market is concerned, Indian stock market has better correlation with South African stock market(0.95), Russian Stock market (0.72) and Brazil Stock market (0.49). The least correlation is with Chinese Stock market (0.48).

Table 3: Covariance among change in BRICS countries indices

	Sensex	Bovespa	MCX	Shangai	South Africa 40
Sensex	44.39	27.82	31.20	21.00	17.46
Bovespa	27.82	43.84	32.43	27.03	18.98
MCX	31.20	32.43	58.04	19.12	20.86
Shangai	21.00	27.03	19.12	76.20	15.43
South Africa 40	17.46	18.98	20.86	15.43	22.09

Test for Stationarity

To test whether Time Series indices have Unit roots, a most popular test among researchers is Augmented Dickey Fuller Test. Let X_t be a time series. The ADF Test finds the following equation

$$\Delta X_t = \alpha + \beta t + (\rho - 1) X_{t-1} + \Sigma_{i=1}^{k-1} \varphi_i \Delta X_{t-i} + \varepsilon_i \text{ and testing whether } \rho = 1.$$

In this equation Δ

1- L (where L is a lag operator); *t* is a trend; and ε_i is a white noise term. Phillips and Perron (1988) tests were also conducted, which allow for more general error terms (heteroskedastic and autocorrelated errors).

Both The Augmented Dickey Fuller Test (ADF Test) and the Philips Perron Test (PP Test) are unit root tests for stationarity. Unit roots can cause unpredictable results in time series analysis. Null

Hypothesis for ADF Test and PP Test is Unit root exists in the Time series taken for study. Alternative hypothesis for ADF Test and PP Test is Unit root does not exist in the Time series taken for study.

Table 4 : Test of stationarity – unit root test of all Indices – Augmented Dickey Fueller test results

	ADF Test value (Variable in Levels)	ADF Test value (variable in first differences)	PP Test value (Variable in levels)	PP Test value (Variable in first differences)
Sensex	-1.39	-11.84**	-1.44	-11.86**
Bovespa	-2.55	-10.35**	-2.69	-10.38**
MCX	-1.85	-10.49**	-2.16	-10.58**
Shangai	-2.11	-10.89**	-2.59*	-11.18**
South Africa 40	1.21	-13.47**	-1.19	-13.40**

An ** indicates rejection of null hypothesis of non-stationarity at 5 percent level of significance. A * indicate rejection of null hypothesis of non stationarity at 10 percent level of significance.

Table 3 displays the unit root test results for all five indices from the ADF tests and PP Tests. The results clearly indicate null hypothesis of existence of non stationarity can not be rejected for all stock indices expressed in levels. However, null hypothesis of existence of non stationarity can be rejected if the indices data are converted into first differences. Therefore we may conclude that all five stock indices are integrated of order one (zero).

Test for Cointegration

The Unit root results suggest that all indices are differenced at one. They are I(I). Therefore Co integration test can be used to test whether BRICS countries markets are co integrated or not. If they are co integrated, there will be less chance for arbitrage and therefore it will not be possible to make abnormal profit in the long run.

Study results of Johansen Test indicate existence of a long run relationship between the stock markets under study. However long run relationships among various stock markets do not completely prove that international diversification is no longer beneficial. (Ilona V Tregub, 2016) (Cheyung and Lai, 1993)

Table 5: The Johansen Juselius co-integration test results
(Co-integrating vector: IN, BR,RU,CH,SA)

Period under study are between Jan 1, 2005 and Dec 31, 2016

Hypothesized no of CEs	The Trace value		The Maximal Eigen value	
	Test Statistics	CV (95%)	Test Statistics	C.V.(95%)
None *	88.2450	69.8189	49.5874	33.8768
At most 1	38.6575	47.8561	21.6947	27.5843
At most 2	16.9628	29.7970	8.8219	21.1316
At most 3	8.1408	15.4947	6.3830	14.2646
At most 4	0.0125	1.7578	1.7578	3.8414

An * indicate rejection of null hypothesis of no co-integration at the 95% level of significance.

From the table, JJ Test results it can be inferred that there is a cointegrating relationship between India and other four markets of BRICS economies. This inference is supported by both the trace and the maximal Eigen value statistics of JJ approach. Both of these statistics are more than enough to reject the null hypothesis of no cointegration (r=0) among BRICS markets at 95 percent level of confidence.

Test for Causality

Causal relations between macro and micro economic indicators and stock markets have been pursued in the literature on cointegration. While others have found evidence of possible correlation between or among stock markets across countries, authors analysed the cointegration of latin American markets with US between January 1995 and March 2001 and their results however showed no integration between the series. They however found a short term causality where causality flows from Brazilian stock market to other Latin American Stock markets. (Tabak and Lima, 2002). To test Causality, Granger Causality Test is used.

Table 6: The Granger Causality test results

Null Hypothesis	p value	Findings
Sensex does not cause Bovespa	0.9729	Null Hypothesis is Accepted
Sensex does not cause MCX	0.2531	Null Hypothesis is Accepted
Sensex does not cause Shangai_Composite_Index	0.7374	Null Hypothesis is Accepted
Sensex does not cause South_Africa_40_Index	0.7197	Null Hypothesis is Accepted
Bovespa does not cause MCX	0.0804	Null Hypothesis is Rejected*
Bovespa does not cause Sensex	0.4096	Null Hypothesis is accepted
Bovespa does not cause Shangai_Composite_Index	0.4720	Null Hypothesis is Accepted
Bovespa does not cause South_Africa_40_Index	0.1613	Null Hypothesis is Accepted
MCX does not cause Bovespa	0.6891	Null Hypothesis is Accepted
MCX does not cause Sensex	0.3394	Null Hypothesis is Accepted
MCX does not cause Shangai_Composite_Index	0.7226	Null Hypothesis is Accepted
MCX does not cause South_Africa_40_Index	0.4773	Null Hypothesis is Accepted
Shangai_Composite_Index does not cause Bovespa	0.3397	Null Hypothesis is Accepted
Shangai_Composite_Index does not cause MCX	0.5964	Null Hypothesis is Accepted
Shangai_Composite_Index does not cause Sensex	0.5506	Null Hypothesis is Accepted
Shangai_Composite_Index does not cause Sout_Afric_40_Index	0.2087	Null Hypothesis is Accepted
South_Africa_40_Index does not cause Bovespa	0.9913	Null Hypothesis is Accepted
South_Africa_40_Index does not cause MCX	0.4591	Null Hypothesis is Accepted
South_Africa_40_Index does not cause Sensex	0.0712	Null Hypothesis is Rejected*
South_Africa_40_Index does not cause Shangai_Composite_Index	0.7989	Null Hypothesis is Accepted

* Null hypothesis is rejected at 90% confidence level.

From the findings of Granger Causality Test, it is understood that no index granger-causes any other index. All null hypotheses are accepted. Except, we reject null hypothesis that South Africa 40 does not granger-cause Sensex at 90% confidence level and We also reject null hypothesis Bovespa does not granger-cause MCX at 90% confidence level. So at 90% confidence level, it can be inferred that South Africa 40 Index granger-causes Sensex and Bovespa granger-causes MCX. So remaining every index does not cause any other index. So it can be inferred that there is no co-integration among BRICS Economies stock markets.

Test for Volatility

A GARCH (p,q) model expresses the conditional variance of a given time series (Φ^2) as a linear function of p lagged squared errors and q lagged variances. Since estimation is difficult with large values of p and q, researchers usually assume p=q=1.

A GARCH (1,1) Process can be written as:

$$\sigma^2 = \beta_0 + \beta_1 \varepsilon^2_{t-1} + \lambda \sigma^2_{t-1}$$

where ε^2_{t-1} is the squared errors lagged one period, and these errors are obtained from regressing stock returns against a constant. We use GARCH process to measure volatility in stock returns of the five markets of BRICS economies

Table 7: Measuring Stock Return Volatility using GARCH process

(Sample Average of Time varying conditional standard deviations in Monthly Percent)

Period under study are between Jan 1, 2005 and Dec 31, 2016

Sl No	BRICS Country	GARCH based Conditional Standard Deviation
1	Brazil	3.27
2	Russia	7.80
3	India	7.17
4	China	9.84
5	South Africa	4.82

From the table it can be observed that Brazil and South Africa are comparatively less volatile than India, Russia and China. China's stock market is more volatile than other BRICS economies stock market.

Summary of Findings

Among BRICS countries, India and China have been growing faster than other three countries. Their GDP Growth are 6.8% and 6.7% respectively. As far as their return on capital markets is concerned, Russia has been generating more monthly return 1.27% (16.35% per annum), India stands second with monthly return of 1.19 (15.25% per annum), China's monthly return 1.01 (12.81% per annum) has almost been equal to South Africa's Monthly return 1.05 (13.35% per annum). And Brazil stood last with monthly return 0.80 (10.03% per annum).

Indian Stock market is perfectly positively correlated with South African stock market and Indian market is also positively correlated with Russian market and South African market is also positively correlated with Russian market.

The Unit root test results clearly indicate null hypothesis of existence of non stationarity cannot be rejected for all stock indices expressed in levels. However, null hypothesis of existence of non stationarity can be rejected if the indices data are converted into first differences. Therefore we may conclude that all five stock indices are integrated of order one (zero).

JJ Test results reveal that there is a co-integration between India and other four markets of BRICS economies. This inference is supported by both the trace and the maximal Eigen value statistics of JJ approach. Both of these statistics are more than enough to reject the null hypothesis of no co-integration (r=0) among BRICS markets at 95 percent level of confidence. At 95% confidence level, Using Granger Causality Test, it can be found that no BRICS stock market granger-cause other BRICS stock market. Through GARCH process, it is found that Brazil and South Africa are comparatively less volatile than India, Russia and China. China's stock market is more volatile than other BRICS economies stock market.

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