Int. Journal of Management and Development Studies **4(2)**: 211-220 (2015)
ISSN (Online): 2320-0685. ISSN (Print): 2321-1423

Co-integration among Equity Markets of the BRICS Economies and USA – Evidence from the Global Financial Crisis

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Abstract: *This study investigates interdependence among the stock markets of BRICS countries, that of Brazil, Russia, India, China, and South Africa and the mature stock market of USA, with the global financial crisis of 2007-09 as the focal point. Using data from 2003 to 2014, the study employs correlation and co-integration analysis to describe the behavior of the above markets, both before and after the global financial crisis. Granger causality helps in explaining short-run relationships among the markets. The study finds that there is no significant increase in long-run integration of the markets, implying potential for diversification for investors.*

Keywords: BRICS, Equity Markets, Co-integration, Global Financial Crisis, Granger Causality

Introduction

Global financial markets have increasingly become more integrated with the floating of exchange rates, and lifting of barriers to the flow of capital across countries. Advances in technology, which have increased both the accessibility to world news and the speed of information transmission, have also helped to accelerate financial market integration. Stock markets are no exception, with stock indices across countries becoming increasingly correlated with each other over time.

Stronger co-movement between the markets implies enhanced information flows, and hence greater market efficiency and reduction in diversification opportunities, which is a concern for investors. The issue of stock market linkages is also relevant from a policy perspective in an environment where moves towards greater regional economic integration are being promoted. Increased linkages between stock markets is a component of regional or international capital market convergence, which is in itself important for the integration of the goods and services markets to be effective.

Most of the research on international stock market linkages has been concentrated on the major world stock markets (US, Japan, UK and Germany), although there has also been some work on the smaller developed country markets and Asian markets (Hong Kong, Singapore, etc.).

The purpose of this study is to examine stock market linkages among the BRICS stock markets and USA, over a period from 2003 to 2014, with the global financial crisis of 2007-09 as the focal point. We choose these countries because they represent fast developing economies that are linked by some common business conditions. Brazil, Russia, India, China, and South Africa represent the BRICS nations. These markets are usually classified as emerging markets because they are, relatively, small in size and young in age. The economies of these countries are

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considered to be developing rather than developed. USA is the most advanced economy[2] and mature equity market, as per the World Economic outlook of April 2015.
The time frame of the study is divided into two sub-periods, covering the pre- and post- Global Financial Crisis (GFC) period ranging from 2007 to 2009. The main question this study attempts to answer pertains to the likely effects of the GFC on the sample equity markets and the interdependencies - both long run and short run, between them.

Background

The British Broadcasting Corporation (BBC) has documented the GFC in detail on its website[3], which is alternatively referred to as a credit crunch, or subprime crisis - "Between 2004 and 2006 US interest rates rose from 1% to 5.35%, triggering a slowdown in the US housing market. Homeowners, many of whom could only barely afford their mortgage payments when interest rates were low, began to default on their mortgages. Default rates on sub-prime loans - high risk loans to clients with poor or no credit histories - rose to record levels. The impact of these defaults were felt across the financial system as many of the mortgages had been bundled up and sold on to banks and investors".

The scale of the crisis emerged on August 9 2007, when France's largest bank BNP Paribas told investors they will not be able to take money out of two of its funds because it cannot value the assets in them known as collateralised debt obligations (CDOs), or packages of sub-prime loans, owing to a "complete evaporation of liquidity" in the market.
By the next month the rate at which banks lent to each other had risen to its highest level since December 1998. Several banks across the world which were exposed to the subprime loans either announced losses or started to crumble. Northern Rock, RBS and Lloyds TSB (England), UBS (Switzerland), Bear Stearns, Citigroup and Merrill Lynch (USA), etc. leading up to September 15, 2008, when Lehman Brothers filed for Chapter 11 bankruptcy protection, becoming the first major bank to collapse since the start of the credit crisis.

The US economy officially declared a recession on December 1, 2008. UK and other European and Asian economies followed and it had become a global recession which, in this study, has been marked as ending on October 18, 2009 (the European Debt Crisis started on October 19, 2009).

The remainder of this article is organized as follows: Section 2 provides the review of the literature on stock market linkages. Section 3 presents the data and methodology of the study. The empirical results and discussion are provided in Section 4, and Section 5 presents concluding remarks.

Review of Literature

Arshanapalli and Doukas (1993) study the linkages among stock prices in major world stock exchanges such as Germany, the United Kingdom, France, Japan and the United States, using daily closing data from January 1980 through May 1990. They also examine the relationship of stock price indices before and after the October crash and find significant interdependence among the countries post-crash.

[2] http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf
[3] http://news.bbc.co.uk/2/hi/business/7521250.stm, "Timeline: Credit crunch to downturn".

Allen and MacDonald (1995) analyse the benefits available from international equity diversification to Australian investors for the period 1970–92 using monthly index data for 16 countries. The co-integration framework is utilized evidence is found among a subset of the indices considered.

Roca, Selvanathan, and Shepherd (1998) investigated the extent and structure of price linkages among five ASEAN markets (Malaysia, Singapore, Philippines, Indonesia and Thailand), both in the long run and in the short run using co-integration based on the Johansen (1988) procedure, Granger causality and variance decomposition and impulse response analyses. The authors found short term linkages (except Indonesia) but no long term linkages among the markets.

Chen, Firth, and Rui (2002) investigated the interdependence of the major stock markets in Latin America over the period 1995-2000, employing co-integration analysis. Their results suggested limited potential for risk diversification, by investing in different Latin American markets.

Daly (2003) employed correlation and co-integration analysis to investigate interdependence of the stock markets of Indonesia, Malaysia, the Philippines, Singapore, Thailand, and the advanced stock markets of Australia, Germany, and the United States. Although there is evidence of integration between the Southeast Asian stock markets, overall the results suggested no significant increase in the integration between the Southeast Asian stock markets during the time period under study.

Data and Methodology

The data-set in this study consists of daily stock price indexes in US dollars for the sample countries from January 1, 2003 to June 30, 2014. All data are daily closing prices, obtained from Bloomberg. The precise indices used are the Ibovespa (Brazil), MICEX (Russia), CNX Nifty (India), SSE50 (China), and the JSE Top40 (South Africa). DJIA30 was used to represent the US equity markets. Some information about each of these indices is given as an Appendix.

In the case of China, the series were backward spliced for upto a year because the SSE50 index series began from January 2004, while our series were starting a year prior to that. We spliced SSE50 and SSE180 together to get prices comparable to SSE50 for the period January 2003-December 2003.

The dataset has been divided into two sub-periods. The pre-crisis period ranges from January 1, 2003 to August 8, 2007; and the post crisis period from October 19, 2009 to June 30, 2014. We use correlation analysis and Johansen's co-integration test, to investigate dependencies in stock returns of the economies. The correlation analysis is performed to ascertain the degree of association among the stock markets, and co-integration test to verify whether long-term relationship exists. Granger Causality test is conducted to test the causation relationships among the sample markets.

Empirical Results

We begin by examining summary statistics for daily percentage returns of the country market indices over the sample period, for the full sample, as well as the pre- and post-crisis periods. Table 1a shows the summary statistics of the sample countries for the full sample. Table 1b and

1c show the summary statistics for the sample markets for the pre-crisis and the post-crisis period, respectively.

For the full sample, the highest mean daily return is observed in the case of Brazil (0.00067%) with the lowest being observed for the USA (0.00023%). As far as volatility is concerned, again Brazil has the highest volatility (0.02447%), closely followed by Russia (0.02407%). The lowest volatility is observed in the case of the USA (0.01135%).

All the stock markets in the sample have negative skewness. All the markets exhibit leptokurtosis. The Jarque-Bera (JB) test indicates that all stock market returns are non-normal as attested by the significant p-values.

Table 1: Summary Statistics of the Returns series – Full Sample

	Brazil	**China**	**India**	**Russia**	**S.africa**	**Usa**
Mean	0.00067	0.00026	0.00058	0.00050	0.00049	0.00023
Std. Dev.	0.02447	0.01701	0.01798	0.02407	0.01913	0.01135
Skewness	-0.225620	-0.066842	-0.062524	-0.291954	-0.886578	-0.068611
Kurtosis	10.342020	6.678902	11.585420	17.250860	14.466050	14.162560
Jarque-Bera	6680.200	1673.131	9101.975	25114.890	16619.270	15385.580
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Q	11.6940	16.6560	31.9570	24.0640	20.4650	36.3670
Prob.	0.306	0.082	[0.000]**	[0.007]**	[0.025]**	[0.000]**
Q2	2294.900	456.910	497.240	794.400	1196.200	2595.400
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ARCH test	72.923	49.615	90.044	36.880	16.716	107.257
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Obs	2963	2963	2963	2963	2963	2963

We also report the Ljung-Box (LB) statistic up to ten orders in levels and squared of returns for the sample markets. The results clearly indicate that there is serial correlation in levels with the exception of Brazil and China. All the sample markets exhibit serial correlation in squared terms suggesting the existence of volatility clustering.

In the pre-crisis period, the highest mean daily return is observed in the case of Brazil (0.00184%) with the lowest being observed for the USA (0.00039%). As far as volatility is concerned, again Brazil has the highest volatility (0.02447%), closely followed by Russia (0.01979%). The US market has the lowest volatility (0.00752%).

All the sample countries have negative skewness, and exhibit leptokurtosis. The Jarque-Bera (JB) test indicates that all stock market returns are non-normal as attested by the significant p-values. We also report the Ljung-Box (LB) statistic up to ten orders in levels and squared of returns for the sample markets. The results indicate that there is serial correlation in levels in the case of India and Russia. All the sample markets exhibit serial correlation in squared terms suggesting the existence of volatility clustering.

Table 1b: Summary Statistics of the Returns series – Pre Crisis

	Brazil	China	India	Russia	S.africa	Usa
Mean	0.00184	0.00123	0.00133	0.00161	0.00107	0.00039
Std. Dev.	0.02115	0.01465	0.01513	0.01979	0.01484	0.00752
Skewness	-0.37222	-0.03231	-1.02964	-0.61966	-0.43469	-0.07670
Kurtosis	4.09944	7.74145	10.44855	7.11545	4.59889	4.94315
Jarque-Bera	87.1934	1112.0950	2953.7280	913.6369	163.8191	187.9094
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Q	15.546	17.264	27.193	19.528	12.297	18.346
Prob.	[0.113]	[0.069]	[0.002]**	[0.034]**	[0.266]	[0.049]
Q2	115.310	64.269	553.490	215.860	178.670	259.820
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ARCH test	10.050	5.445	492.969	39.598	14.521	8.429
Prob.	[0.002]**	[0.020]**	[0.000]**	[0.000]**	[0.000]**	[0.004]**
Obs	1187	1187	1187	1187	1187	1187

In the post-crisis period, the highest mean daily return is observed in the case of Brazil (10.34357%), with the US following (9.45533) and the lowest being observed for Russia (3.85472%). Brazil also has the highest volatility (0.22807%), with the lowest volatility observed in the case of South Africa (0.08893%).

Brazil and South Africa's returns are skewed negatively and the rest of the markets have positive skewness in their stock returns. Only Russia's stock returns exhibit leptokurtosis. The Jarque-Bera (JB) test indicates that all stock market returns are non-normal as attested by the significant p-values. The LB statistics clearly indicate that there is no serial correlation in levels with the exception of China. All the sample markets, except China, exhibit serial correlation in squared terms suggesting the existence of volatility clustering.

Table 1c: Summary Statistics of the Returns Series – Post Crisis

	BRAZIL	CHINA	INDIA	RUSSIA	S.AFRICA	USA
Mean	10.34357	5.65168	4.68618	3.85472	8.23105	9.45533
Std. Dev.	0.22807	0.11209	0.11277	0.12431	0.08893	0.15328
Skewness	-0.390883	0.392928	0.120711	0.555182	-0.511134	0.168964
Kurtosis	1.938457	2.635202	2.589527	3.154980	2.600031	1.933917
Jarque-Bera	87.771	37.908	11.452	63.475	60.853	63.162
Prob.	[0.000]**	[0.000]**	[0.003]**	[0.000]**	[0.000]**	[0.000]**
Q	6.232	21.065	5.665	7.101	12.979	19.985
Prob.	[0.795]	[0.021]**	[0.843]	[0.716]	[0.225]	[0.029]
Q2	167.960	14.118	247.930	98.600	240.910	562.090
Prob.	[0.000]**	[0.168]	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ARCH test	33.509	0.247	6.419	36.652	11.385	43.759
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Obs	1212	1212	1212	1212	1212	1212

Correlation and Co-integration

A simple test for integration is to look at correlation coefficients across daily returns of the national stock market indices. By comparing pre- and post-crisis periods, it can be determined whether the stock markets have become increasingly integrated. Table 2 reports the correlation coefficients for the pre- and post- crisis periods. The top diagonal displays the correlation coefficients for the pre-crisis period, with the lower panel displaying the corresponding correlations for the post-crisis period. A comparison of the average (mean) correlation coefficients across the pre- and post-crisis periods reveals that the average correlation coefficients for each market with the rest of the combined market indices increased significantly in the post-crisis period, as compared to the pre-crisis values. This indicates that the BRICS markets and the US market have become more integrated since the global financial crisis. This is, however, a static test, revealing only short term integration, if any, between the stock markets.

Table 2: Correlation Matrix, Pre- and Post Global Financial Crisis

	Brazil	**China**	**India**	**Russia**	**S. Africa**	**USA**	**Mean (pre-crisis)**
Brazil	1	0.09	0.16	0.23	0.40	0.52	0.28
China	**0.18**	1	0.08	0.05	0.09	0.06	0.07
India	**0.29**	**0.26**	1	0.27	0.27	0.10	0.17
Russia	**0.46**	**0.25**	**0.43**	1	0.37	0.16	0.16
S. Africa	**0.65**	**0.24**	**0.43**	**0.66**	1	0.27	0.28
USA	**0.68**	**0.11**	**0.25**	**0.52**	**0.65**	1	0.22
Mean (Post-crisis)	0.40	0.24	0.35	0.45	0.50	0.44	

Note: The top diagonal displays the correlation coefficients for the stock market indices over the pre-crisis period, while the bottom diagonal (in bold) represents the corresponding post-crisis correlations

In order to gain more insight into the integration of the above markets, we apply co-integration techniques to determine the presence of any long-run relationships that may exist over the sample period. First, we test whether the variables are stationary. We use the Augmented Dickey-Fuller (ADF) test, and the Phillips-Perron (PP) test to check for stationarity. The results are given in Table 3.

Table 3: Unit Root Test Results

Market	**ADF test results***			**PP test results****	
	Level	**First Difference**		**Level**	**First Difference**
Brazil	-2.74	-55.32		-2.81	-55.46
China	-1.40	-55.28		-1.39	-55.28
India	-2.23	-50.91		-2.22	-50.91
Russia	-2.61	-53.00		-2.61	-53.00
S. Africa	-2.12	-54.18		-2.10	-54.47
USA	1.0222	-42.8857*		1.1109	-61.1471**
* Critical Value (5% level): -2.86 (H_0: unit root vs H_A: no unit root)					

As can be seen in Table 3, for each market, the null hypothesis of the existence of unit roots was not rejected at the level form of the data but was accepted at the first-differenced form, by both the ADF and PP tests. Hence, it may be concluded that each data series is stationary and integrated of order 1 or I(1).

The second stage in the co-integration analysis is to decide on the order of the underlying vector autoregression (VAR) model. The order of the VAR is determined by an inspection of the Schwarz information criterion (SC). We selected the order of the VAR by choosing in each case the lowest SC coefficients.

Since the unit root test results show that each of the data series is I(1), pairwise co-integration test based on the Johansen procedure is conducted on Eviews software. Table 4 displays the bivariate co-integration test results between the sample stock market indices, for both the pre-crisis and post-crisis periods. The table shows the maximum eigenvalue tests and trace tests for bivariate co-integration over the sample period. The table is used to determine (r), the number of co-integrating vectors for each pair of stock market indices; in other words, the results inform us whether there exists a long-run equilibrium relationship between the two stock market indices. For each test, we compare the null hypothesis of no co-integration against the alternative of co-integration.

Table 4: Bivariate Co-integration Test Results

			Pre-Crisis		**Post-Crisis**	
Countries	**Null**	**Alternative**	**Eigenvalue**	**Trace**	**Eigenvalue**	**Trace**
Brazil	r = 0	r = 1	17.6099	18.48384*	11.31196	13.43804
China	r ≤ 1	r = 2	0.873992	0.873992	2.126072	2.126072
Brazil-	r = 0	r = 1	21.3459	21.69673*	4.872833	5.380667
India	r ≤ 1	r = 2	0.350828	0.350828	0.507834	0.507834
Brazil-	r = 0	r = 1	5.525004	5.956323	12.21186	14.43945
Russia	r ≤ 1	r = 2	0.431319	0.431319	2.22759	2.22759
Brazil-	r = 0	r = 1	13.54148	13.9025	12.71285	12.99227
S.Africa	r ≤ 1	r = 2	0.361013	0.361013	0.279413	0.279413
Brazil-	r = 0	r = 1	6.116756	7.040552	15.68957	15.70636*
USA	r ≤ 1	r = 2	0.923796	0.923796	0.016795	0.016795
China-	r = 0	r = 1	19.12508	19.17314*	6.606501	11.5133
India	r ≤ 1	r = 2	0.048053	0.048053	4.906804	4.906804
China-	r = 0	r = 1	19.96372	19.96614*	10.70249	15.37861
Russia	r ≤ 1	r = 2	0.002418	0.002418	4.676123	4.676123
China-	r = 0	r = 1	19.80508	19.80514*	14.58929	18.7548*
S.Africa	r ≤ 1	r = 2	0.00	0.00	4.165507	4.165507
China-	r = 0	r = 1	16.60379	18.46217*	10.80089	11.4454
USA	r ≤ 1	r = 2	1.858377	1.858377	0.644513	0.644513
India-	r = 0	r = 1	7.703236	8.162155	9.390578	14.2153
Russia	r ≤ 1	r = 2	0.45892	0.45892	4.824719	4.824719
India-	r = 0	r = 1	11.6224	11.90983	10.5656	14.23238
S.Africa	r ≤ 1	r = 2	0.287435	0.287435	3.666786	3.666786
India-	r = 0	r = 1	9.37219	9.431381	5.785134	6.743256
USA	r ≤ 1	r = 2	0.059191	0.059191	0.958122	0.958122
Russia-	r = 0	r = 1	4.614198	5.07632	13.08225	15.74311*
S.Africa	r ≤ 1	r = 2	0.462122	0.462122	2.660857	2.660857
Russia-	r = 0	r = 1	6.027517	6.911573	10.20894	10.26285
USA	r ≤ 1	r = 2	0.884056	0.884056	0.053909	0.053909
S.Africa-	r = 0	r = 1	3.985917	4.195855	12.33344	12.54884
USA	r ≤ 1	r = 2	0.209937	0.209937	0.215399	0.215399

As can be seen in Table 4, in the pre-crisis period, the Chinese stock market is co-integrated with all the other markets in the sample, including that of USA. In addition to these, the stock markets of Brazil and India are also found to be co-integrated. Post-crisis, the long run relationship among the markets disappears, except the China-South Africa co-integration that existed pre-crisis, which persists post-crisis too. Newer linkages in the post-crisis period are observed between the Brazil-USA and Russia-South Africa stock markets.

Causality Testing

Testing for causality among the pairs from the sample markets, we find from Table 5 that almost all the pairs which shared a causal relationship prior to the crisis retained that relationship post-crisis also, except for Brazil → USA which disappeared post-crisis.

Table 5: Granger Causality Test Results (at 95% significance level)

Pre Crisis	**Post Crisis**
Brazil → China	Brazil → China
Brazil → India	Brazil → India
Brazil → Russia	Brazil → Russia
Brazil → S.Africa	Brazil → S.Africa
Brazil → USA	S.Africa → China
China → S.Africa	USA → China
Russia → India	Russia → India
S.Africa ↔ India	Russia→ China
S.Africa → Russia	S.Africa → India
USA → India	S.Africa → Russia
USA → Russia	USA → India
USA → S.Africa	USA → Russia
	USA ↔ S.Africa

In addition, several relationships' causation changed or reversed directions from pre-crisis period, all of them featuring South Africa as one-half of the pairs with China, India, and USA markets. Newer causation post-crisis is observed between Russia → China and USA → China. Overall, the results are similar during the pre- and post-crisis periods, with South Africa and India sharing two-way causal relationship in the pre-crisis period. Brazil seems to be the most influential among the markets with uni-directional short-run causal relationship with the rest of the markets.

Summary and Conclusion

In this study, the Johansen methodology is used to test for bi-variate co-integrating relationships between the national stock market indices of the BRICS (Brazil, Russia, India, China, and South Africa) countries, and that of USA, with the global financial crisis of 2007-09 as the focal point.

As was revealed in Figure 1, all stock market series have high volatility around the period marked by the global financial crisis (October 2008) and the summary statistics in Tables 1a, 1b, and 1c show that the series are characterized by asymmetries, fat tails, and non-normality. The mean returns and volatility have increased significantly post-crisis. The correlation coefficients in Table 2 indicate an increase in relationship among the BRICS countries post-crisis as the average coefficients increased significantly from their pre-crisis values.

In order to get more insight into the relationships between these markets, Johansen's co-integration test was conducted. The markets were co-integrated prior to the crisis but not so post the crisis. Only the China-South Africa markets are co-integrated both prior to and after the crisis.

Short run causality was tested using Granger's causality test. The causal relationships pre- and post-crisis are retained with two new relationships appearing post-crisis, that of Russia → China and USA → China. It can be interpreted that the short run linkages were not affected even after the global financial crisis among the sample markets.

Overall, the stock markets of the BRICS countries and the USA seem to have no significant long-term price linkages, but several significant short run relationships. Hence, it can be concluded that there is long-term portfolio diversification potential among the emerging markets of the BRICS countries, and also with the mature market of USA, but not in the short-run.

This study has implications for investors and portfolio managers – in making decisions related to market selection and diversification. It may also be relevant for policy makers and regulators. If the probability of transmission of shocks across various markets is high, then more rapid collaboration among the authorities of these countries may be required.

Appendix

Information about the Indices used in this study:

- The Ibovespa Index is =a gross total return index weighted by traded volume & is comprised of the most liquid stocks traded on the Sao Paulo Stock Exchange.
- MICEX Index is cap-weighted composite index calculated based on prices of the 50 most liquid Russian stocks of the largest and dynamically developing Russian issuers presented on the Moscow Exchange.
- The CNX Nifty, a free float market capitalization index, is the leading index for large companies on the National Stock Exchange of India. It consists of 50 companies representing 24 sectors of the economy.
- SSE 50 Index includes 50 of the largest, highly liquid and most representative SSE-listed stocks and reflects the performance of a number of leading and most influential enterprises in Shanghai securities market.
- The FTSE/JSE Top40 Index is a capitalization weighted index. Companies included in this index are the 40 largest companies by market capitalization included in the FTSE/JSE All Shares Index.
- The Dow Jones Industrial Average is a price-weighted average of 30 blue-chip stocks that are generally the leaders in their industry. It has been a widely followed indicator of the stock market since October 1, 1928.

Source: Bloomberg

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