CO-INTEGRATION AND CAUSALITY IN THE BRICS STOCK MARKETS: EVIDENCE FROM THE GLOBAL FINANCIAL CRISIS

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ABSTRACT

This study investigates both the static and dynamic interdependence among the stock markets of BRICS countries, that of Brazil, Russia, India, China, and South Africa, 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, Co-integration, Global Financial Crisis, Causality

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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 composite 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 in the BRICS emerging economies, over a period from 2003 to 2014, with the global financial crisis 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 considered to be developing rather than developed.

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 BRICS equity markets and the linkages - both long run and short run, between them.

BACKGROUND

The British Broadcasting Corporation (BBC) has documented the GFC in detail on its website[1], 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

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[1] http://news.bbc.co.uk/2/hi/business/7521250.stm, "Timeline: Credit crunch to downturn".

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.

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 and results from the standard Engle—Granger two-step ordinary least squares procedure are compared with those from the Johansen (1988) maximum likelihood procedure. It is found that the two techniques lead to different conclusions in certain cases, and there is evidence of co-integration 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 no long term linkages among the markets. However, in the short term, with the exception of Indonesia, all the ASEAN markets had significant linkages with each other.

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 over the pre- and post- October 1997 Asian financial crisis period.

AuYong, Gan, and Treepongkaruna (2004) examined the cointegration level, changes in the existence and directions of causality of the foreign exchange (FX) rates in the Asian and emerging markets during the 1990s financial crises - the 1994 Mexican, 1997 Asian, 1998 Russian, and 1999 Brazilian crises. Many of the causality relationships disappeared during the post-crises period, implying the existence of contagion effect of the currency crises examined.

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). Some information about each of these indices is given in the box 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 emerging economies. The correlation analysis is performed to ascertain the degree of association among the emerging 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 both the pre- and post-crisis periods. Table 1a shows the summary statistics of the sample countries for the pre-crisis period, and Table 1b shows the summary statistics for the sample markets for the post-crisis period.

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 South Africa (0.00107%). As far as volatility is concerned, again Brazil has the highest volatility (0.02447%), closely followed by Russia (0.01979%). The lowest volatility is observed in the case of China (0.01465%).

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 clearly indicate that there is serial correlation in levels with the exception of Brazil, China, and South Africa. All the sample markets exhibit serial correlation in squared terms suggesting the existence of volatility clustering.

	BRAZIL	CHINA	INDIA	RUSSIA	S.AFRICA
Mean	0.00184	0.00123	0.00133	0.00161	0.00107
Std. Dev.	0.02115	0.01465	0.01513	0.01979	0.01484
Skewness	-0.37222	-0.03231	-1.02964	-0.61966	-0.43469
Kurtosis	4.09944	7.74145	10.44855	7.11545	4.59889
Jarque-Bera	87.1934	1112.0950	2953.7280	913.6369	163.8191
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
Q	15.546	17.264	27.193	19.528	12.297
Prob.	[0.113]	[0.069]	[0.002]**	[0.034]**	[0.266]
Q2	115.310	64.269	553.490	215.860	178.670
Prob.	[0.000]**	[0.000]**	[0.000]**	[0.000]**	[0.000]**
ARCH test	10.050	5.445	492.969	39.598	14.521
Prob.	[0.002]**	[0.020]**	[0.000]**	[0.000]**	[0.000]**
Obs	1187	1187	1187	1187	1187

Table 1a: Summary Statistics of the returns series – Pre Crisis

In the post-crisis period, the highest mean daily return is observed in the case of Brazil (10.34357%) with 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 three other countries 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.

Figure 1 shows the time series plots of the returns for the five national stock markets across the entire sample period. All the graphs show high volatility, especially on and/or around October 2008 (referenced by point 1500 on the horizontal axis) which pertains to period during the global financial crisis. However, as seen in the graph, South Africa's returns are more negative than the other markets. Volatility clustering is also evident from the graphs. The graphs add to the summary statistics and confirm the quite common characteristics of financial time series – asymmetries, fat tail, and non-normality.

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

Table 1b: Summary Statistics of the returns series – Post Crisis

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 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.
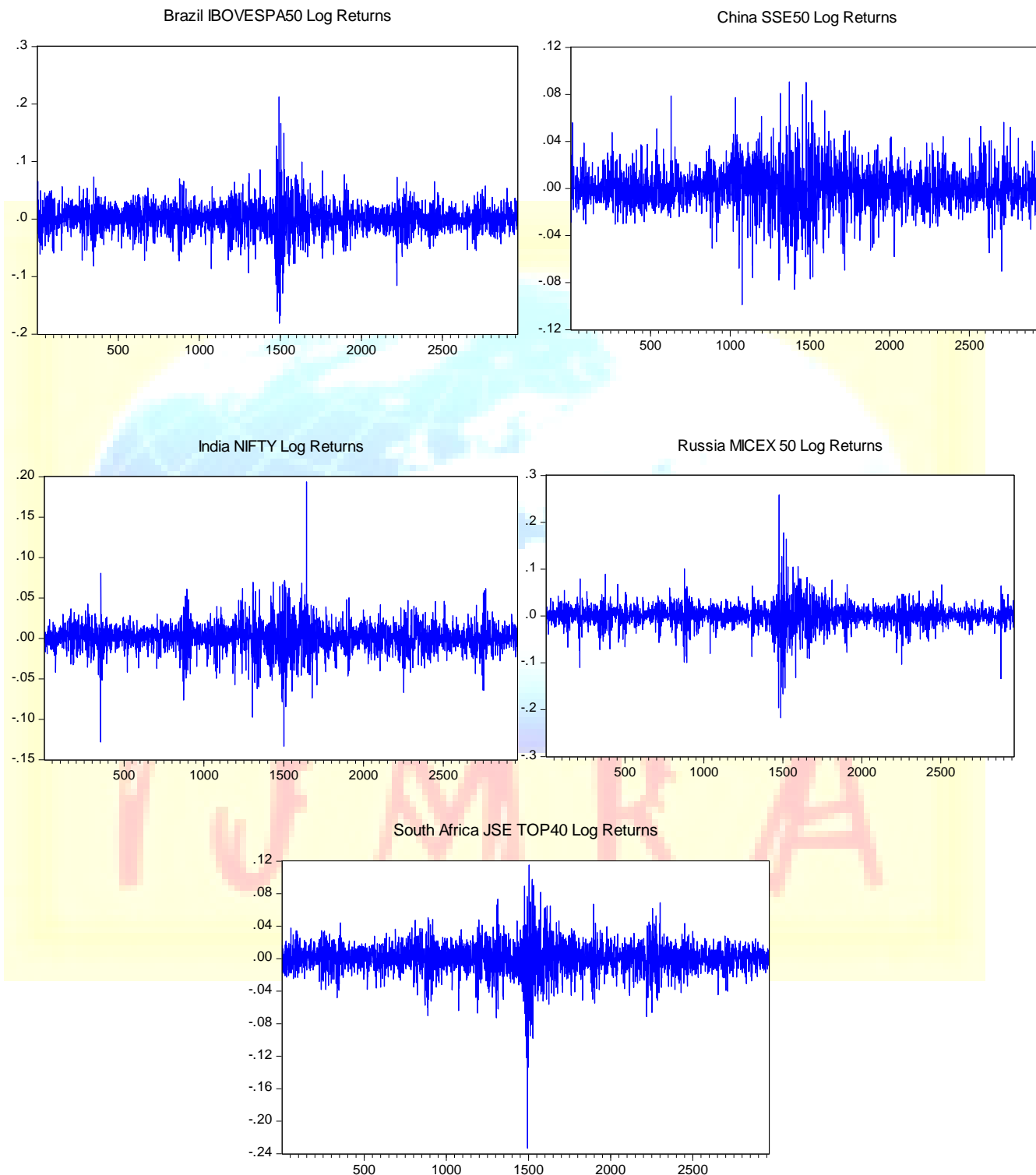
Brazil IBOVESPA50 Log Returns

China SSE50 Log Returns

India NIFTY Log Returns

Russia MICEX 50 Log Returns

South Africa JSE TOP40 Log Returns

Figure 1: Time Series Plots of Stock Returns

	Brazil	China	India	Russia	S. Africa	Mean (pre-crisis)
Brazil	1	0.09	0.16	0.23	0.40	0.22
China	**0.18**	1	0.08	0.05	0.09	0.08
India	**0.29**	**0.26**	1	0.27	0.27	0.19
Russia	**0.46**	**0.25**	**0.43**	1	0.37	0.23
S. Africa	**0.65**	**0.24**	**0.43**	**0.66**	1	0.28
Mean (Post-crisis)	0.40	0.24	0.35	0.45	0.50	

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

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 Johansen's co-integration test 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.

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

* Critical Value (5% level): -2.86
(H_0: unit root vs H_A: no unit root)

Table 3: Unit Root Test Results

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), co-integration test based on the Johansen procedure is conducted on Eviews software. Table 4 displays co-integration test results between the BRICS stock market indices. The table shows the maximum eigenvalue tests and trace tests for multivariate co-integration over the full sample period, and pre and post crisis periods. The tables are 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 BRICS stock market indices. For each test, we compare the null hypothesis of no co-integration against the alternative of co-integration.

The null hypothesis of zero co-integrating vectors is not rejected at 95 percent level for the full sample period, but is rejected in the pre-crisis period, thereby implying long-run relationship between the markets prior to the crisis. Post the crisis, the long run relationship among the markets disappears.

Countries	Null	Alternative	Full Sample		Pre Crisis		Post Crisis	
			Eigenvalue	Trace	Eigenvalue	Trace	Eigenvalue	Trace
Brazil	r = 0	r = 1	33.686	58.560	37.575*	74.033*	28.104	59.475
China	r ≤ 1	r = 2	10.096	24.874	17.523	36.458	15.561	31.371
India	r ≤ 2	r = 3	8.340	14.778	14.957	18.935	11.150	15.810
Russia	r ≤ 3	r = 4	3.750	6.438	3.925	3.978	4.485	4.660
S. Africa	r ≤ 4	r = 5	2.689	2.689	0.053	0.053	0.175	0.175

Table 4: Multivariate Co-integration Test Results
Significant at 95%t level

To test the robustness of the results, the Johansen procedure was tested using multiple VAR lags. The results indicated that the finding of no co-integration was not altered when different lag lengths were used in the estimation procedure.

Overall, the results of the multivariate co-integration testing tell us that the BRICS stock markets did not become more integrated after the global financial crisis.

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 → China and Russia → China which developed a uni-directional causal relationship post-crisis. South Africa and India share bi-directional causality in the pre-crisis period, but uni-directional causality post-crisis. 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 BRICS markets.

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

Table 5: Granger Causality Test Results

Significant at 95% level

SUMMARY AND CONCLUSION

In this study, the Johansen methodology is used to test for multivariate co-integrating relationships between the national stock market indices of the BRICS (Brazil, Russia, India, China, and South Africa) countries, 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 and 1b 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 after the crisis the null of no co-integration is not rejected.

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 Brazil → China and Russia → China. It can be interpreted that the short run linkages were not affected even after the global financial crisis among the BRICS markets.

Overall, the stock markets of the BRICS countries 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 BRICS markets, but not in the short-run.

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.

Source: Bloomberg

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