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Causal relationship among the stock markets: An empirical study on BRICS Countries

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Abstract
The purpose of this study is to explore the relationship among the BRICS (Brazil, Russia, India, China, South Africa) nation's stock market. The idea behind the selection of BRICS economies is to know how the stock markets of these prominent countries are related to each other. The study employs daily closing prices of BRICS stock market indices viz., IBOVESPA, RTSI, SENSEX, SSE Composite Index and JSE ALSI for the period from 4th January, 2001 to 1st June 2017. All the selected BRICS stock index returns are stationary at level. All the variables are positively correlated, RTSI and JSE ALSI have a high positive association and IBOVESPA and SSE CI have lowest correlation coefficient during the study period. Granger causality test is applied to identify the presence of predictive variable among the selected stock indices. Unidirectional relationship exists between IBOVESPA and all other markets and there is no relation between JSE ALSI and RTSI. This shows that there is a chance for the investors to diversify their portfolio to other BRICS countries.

Keywords: BRICS, equity market, stock index return, causal relationship, portfolio diversification

Introduction

The financial liberalisation processes of the 1990's opened the gates to foreign capital, which were contributing to the growth of national economies of the developing countries, which intensifies the integration process among the financial markets of various countries. It may be noted that financial integration refers to the extent the domestic financial markets are connected to each other at the domestic, regional, or international levels (Agénor, 2003; Ayuso and Blanco, 2001; Fahami, 2011; Worthington and Higgs, 2010) [10, 9, 4]. Stock market integration has been defined in two ways, asset pricing and statistical perspective (Yusof andMasjid, 2006) [14]. From asset pricing point of view, integration is a situation where investors earn the same risk-adjusted expected return on similar financial instruments in different markets (Jorion and Schwartz, 1986) [8]. Statistically integration is, the markets sharing a long-run equilibrium relationship (Yosuf and Masjid, 2006) [14].

In this era of globalization, the investment in international financial market has seen a magnificent increase, because investors have more investment avenues to shed their funds in different asset classes across globally. As a consequence of market liberalisation, financial markets tend to become more integrated. When the world integrates financially, it is important for the investors to understand the relationship that exists between the nations, in order to get the benefits of portfolio diversification. The increased co-movements between financial markets can have negative effects on the benefits from international portfolio diversification. The higher integration between international markets calls for studying the integration among emerging markets for international portfolio diversification. However, the financial crises that struck in America led investors to search for emerging markets like BRICS to invest in. Though it is a group formed with common goal, there are vast differences between each one of them. So BRICS is a heterogeneous group formed for a common goal. The emerging markets can provide more opportunities for the investors to increase the benefits from international diversification. After globalisation stock market integration has become a topical area for many researchers, investors and policy makers.

Interdependence among the global stock exchanges has been widely investigated by many researchers. However the results of these studies are mixed, inconsistent and sometimes even contradict with each other ((Hilliard (1997) [6], Aggarwal *et. al*. (2003) [3], Abbas and Chancharat (2008)) [1].

Review of Literature

Mohanasundaram and Karthikeyan (2015) [12] in their study explored the nature of association and the possible existence of a shortrun and long-run relationship between the stock-market indices of South Africa, India and the USA for the period from April 2004 to March 2014. The researchers discovered a strong correlation between the selected stock market indices and it is high between South Africa and India. By applying the Granger causality test it was proved that NASDAQ index has no predictive ability as far as the JALSH and NIFTY indices are concerned and JALSH index has a predictive ability on the NIFTY index. The Johansen and Juselius multivariate cointegration approach result showed the absence of a long-run relationship among the three stock market indices.

Tripti Nashier (2015) [13] examined the integration among the stock markets of BRICS (Brazil, Russia, India, China and

South Africa) and the stock markets of the U.S. and U.K, using daily closing price for the period from 1st January 2004 to 31st December 2013. The integration is modeled using the correlation test and the Johansen's co-integration test. The study found evidence for both the short-term static and long-term dynamic integration between the stock markets.

Sowmya Dhanaraj *et al.* (2013) [11]; Valadkhani and Chancharat (2008) [1] used Granger causality test to examine the presence of any causal relationship between Asian and developed markets (the US and the UK). The study found that the developed markets, particularly the US, influence Asian markets.

Queensly Jeyanthi (2010) [7] examined the existence of cointegration and causality between the stock prices of BRIC (Brazil, Russia, India and China) countries and the US and Japan. The study found evidence of a long-run relationship between the BRIC countries and the US and Japan. In the short-run, the Indian stock market is dominated by the US market, while Russia is dominated by Japan.

Most of the above studies have accepted that there is a considerable level of relationship among the stock markets. This implies that the benefit of international diversification is minimal owing to a higher level of relationship among the stock markets. It is also noted that regional stock markets are experiencing more co-movement compared with other countries stock markets. Though there have been numerous studies examining relationship of stock markets, there have been relatively few studies that explored the relationship of stock markets among BRICS countries. So, this paper attempts to examine the causal relationship among the stock markets of BRICS economies.

Statement of the problem

Analyzing the dependence of the stock markets of BRICS countries is the main area of research in this study. If there is dependence among the BRICS stock markets, then portfolio diversification is not possible among these countries. The investors can diversify their portfolio and invest in these countries stock markets, only when there is no causal relationship. If there no causal relationship among these stock markets, then the investors can diversify their portfolio and invest in these countries stock markets. The research questions addressed in this study are as follows;

- Is there any relationship exists between the BRICS nation's stock market?
- Does any stock market of BRICS countries helps in predicting the behaviour of other stock markets in the group?

Objectives of the study

- To assess the stock market returns of BRICS economies
- To analyse the causal relationship among the stock markets of BRICS countries

Hypotheses of the study

- There is no causal relationship among the stock markets of BRICS countries.

Methodology of the Study

Collection of Data

The data set comprises of BRICS countries stock market indices, which is given in the tabular form below.

Table 1: BRICS stock market indices

Country	Brazil	Russia	India	China	South Africa
Exchanges	Sao Paulo Stock Exchange	Moscow Stock Exchange	Bombay Stock Exchange	Shanghai Stock Exchange	Johannesburg Stock Exchange
Index	BOVESPA Index	Russian Trading System Index	SENSEX Index	SSE Composite Index	Johannesburg All Share Index
Index ID	IBOVESPA	RTSI	SENSEX	SSE CI	JSE ALSI

***Source*:** Compiled by author

The selection of stock exchanges of the BRICS countries is based on high Market Capitalisation for the study. Data consists of the daily closing prices of each index for the period from 4th January, 2001 to 1st June, 2017 which consists of 3379 observations per country. The data is omitted for the days when any of the stock markets were closed. Thus data is collected on the same dates across all the selected stock exchanges. The closing prices of stock market indices are obtained from the respective websites of the stock exchanges and Yahoo finance. As the returns are to be calculated, there is no necessity to convert the closing prices of all stock indices selected to a common currency. So the stock index prices are expressed in local currencies.

Tools used for Analysis

Stock market Returns

The analysis is done on the daily log return series of the indices; computed as follows:

$$R_t = \text{Log } P_t - \text{Log } P_{t-1}$$

where, R_t is the daily return at time t, P_{t-1} and P_t are daily closing prices of the indices at two successive days t-1 and t respectively.

According to the framework of the present study, the following methodologies are employed to examine the interdependence between stock markets of BRICS economies.

Correlation between the stock markets

A widely known measure of dependence is the correlation coefficient, which provides information on the degree of statistical relationship between the variables of interest. The correlation coefficient indicates the extent to which a stock market is linearly associated with another stock market. If a stock market is linearly associated with or influenced by

another market, the correlation coefficient between the two markets is higher i.e., close to 1. However, if the return series are heteroskedastic, correlation coefficients may be biased upward and do not provide a sound basis for exploring interdependence. Moreover, correlation only measures the degree of linear association between two variables. It does not provide insight on the long run dynamic linkages between stock markets.

Testing for stationarity

For presence of cointegration, all the return series are required to be integrated of the same order. Therefore the return series are checked for stationarity using Augmented Dickey Fuller (ADF) Test developed by Dickey and Fuller (1979) [5] and the Phillips-Perron (PP) test developed by Phillips and Perron (1988). The Augmented Dickey Fuller specification used here is as follows:

$$\Delta Y_t = b_0 + \beta Y_{t-1} + \mu_1 \Delta Y_{t-1} + \mu_2 \Delta Y_{t-2} + \ldots\ldots + \mu_p \Delta Y_{t-p} + u_t$$

Where, Y_t represents the time series to be tested, b_0 is the intercept term, β is the coefficient of interest in the unit root test, μ_p is the parameter of the augmented lagged first difference of Y_t to represent the pth order auto regressive process and u_t is the white noise error term.

Examining the causal relationship

The Granger-causality test is used to find out whether one time series helps in forecasting the other. A time series X_t Granger causes another time series Y_t if series Y_t can be predicted with better accuracy by using past values of X_t

$$\Delta J_t = \alpha_1 + \beta_{11}\Delta J_{t-1} + \beta_{12}\Delta J_{t-2} + \beta_{1n}\Delta J_{t-n} + \gamma_{11}\Delta N_{t-1} + \gamma_{12}\Delta N_{t-2} + \ldots + \gamma_{1n}\Delta N_{t-n} + u_1$$

Where, ΔJ_t is the first difference at time 't' of JSE ALSI where the series is non-stationary, 'α' is the constant, 'n' is a positive integer, βj and γj are parameters, N and u_t are error terms.

Empirical results

The below are the graphical representation of the BRICS nation's daily stock index returns for the period from 2001 to 2017.

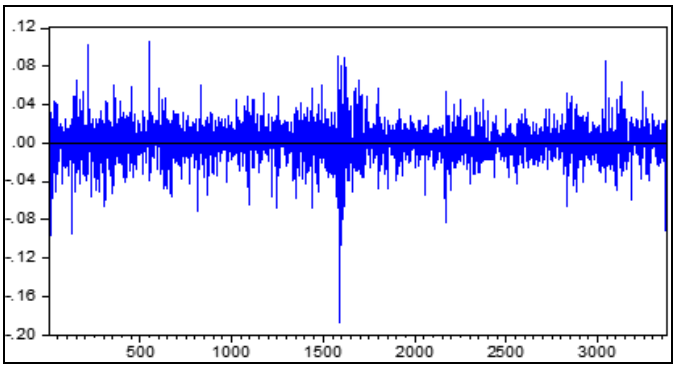

Fig 1: Ibovespa Index Daily Return

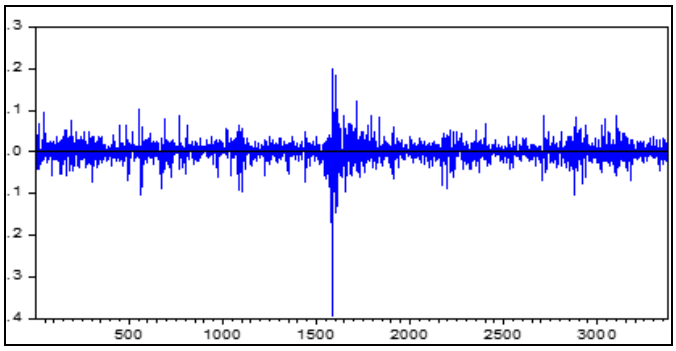

Fig 2: RTSI daily return

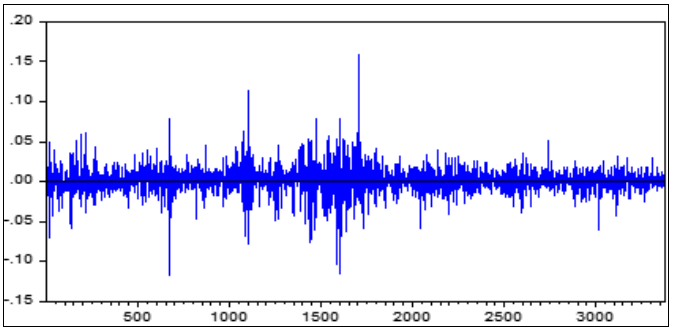

Fig 3: BSE SENSEX daily return

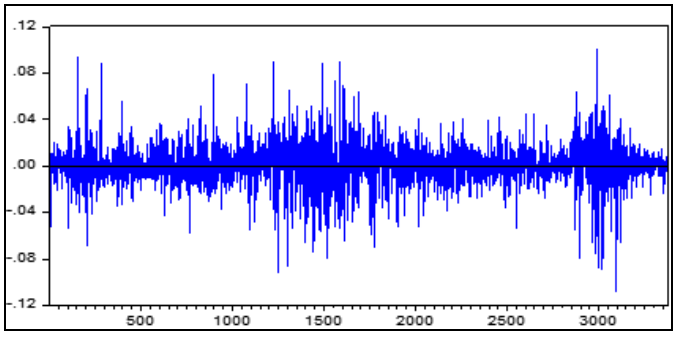

Fig 4: SSE CI daily return

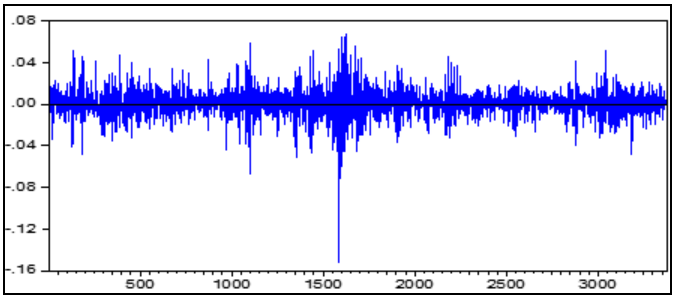

Fig 5: JSE ALSI daily return

From the graph it is inferred that China's stock market index SSE CI returns shows more variation than any other markets selected for the study. During the study period, all selected stock market returns shows fluctuating trend and moves more or less in similar pattern.

Statistical properties for BRICS stock returns

The descriptive statistics for BRICS nation's stock index returns are given in Table 2. The summary statistics revealed that the average daily returns of the selected stock indices are positive. Russian stock market provides highest returns among the selected stock markets and it is followed by Indian stock market with an average of 0.060 percent. Standard deviation, a measure of volatility is high for Russia and less for South Africa.

Table 2: Descriptive Statistics of stock market returns of BRICS Countries

	IBOVESPA	RTSI	SENSEX	SSE CI	JSE ALSI
Mean	0.000391	0.000615	0.000603	0.000112	0.000555
Median	0.000782	0.001565	0.001077	0.000496	0.000793
Maximum	0.106213	0.202039	0.1599	0.100453	0.06834
Minimum	-0.187495	-0.394545	-0.118092	-0.108325	-0.153071
Standard Deviation	0.019402	0.023827	0.015902	0.01788	0.01324
Skewness	-0.465958	-1.373977	-0.118515	-0.191943	-0.423923
Kurtosis	8.349081	31.11269	11.44743	7.429145	10.87329
Jarque-Bera	4150.699	112334.1	10054.67	2782.704	8828.698
Probability	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	3379	3379	3379	3379	3379

Source: calculated from stock index returns

It is observed from Table 2 that the market providing the highest return is also the most volatile which is in congruence with the high risk-high return theory. The returns of all the selected market indices are negatively skewed, so the distribution is left skewed in the study period. The kurtosis result showed that the distributions are leptokurtic as the values are greater than 3.

After testing for normality, it is necessary to verify whether or not the data used in the study has unit root. ADF and PP tests are carried out to verify the stationarity of the time series data. The lowest value of the Akaike's Information Criterion (AIC) was used to determine the optimal lag length in the estimation procedure.

The tests are carried out with the null hypothesis of non stationarity (unit root) for each data series and the result indicates that all the data series are non-stationary at level and become stationary after first order difference as per ADF and PP test. Table 3 reports the results of ADF Test and PP Test for the BRICS stock market.

Table 3: Testing of stationary of stock prices of BRICS countries

Augmented Dickey - Fuller (ADF) Test - Intercept and trend				
Data Series	**At Level**		**At first-order difference**	
	t-statistic	**Prob.**	**t-statistic**	**Prob.**
IBOVESPA	-2.041094	0.5779	-58.86258	0.0000
RTSI	-1.690588	0.7555	-53.68513	0.0000
SENSEX	-2.924954	0.1546	-56.24552	0.0000
SSE CI	-2.072329	0.5605	-31.72932	0.0000
JSE ALSI	-3.023246	0.1259	-43.80997	0.0000
Phillips and Peron (PP) Test - Intercept and trend				
Data Series	**At Level**		**At first-order difference**	
	t-statistic	**Prob.**	**t-statistic**	**Prob.**
IBOVESPA	-1.887209	0.6609	-59.04297	0.0000
RTSI	-1.712097	0.746	-53.69939	0.0000
SENSEX	-2.974367	0.1396	-56.21584	0.0000
SSE CI	-2.04359	0.5766	-55.76042	0.0000
JSE ALSI	-2.769587	0.2088	-59.06205	0.0000

***Source*:** calculated from stock index returns.

Note: Significant at 5% level.

As the t-statistic values shown in table 3 are higher than the critical p-value the null hypothesis has been rejected. The results proved that the data series are stationary, hence no unit root.

Correlation test is carried out between the selected indices to get a preliminary insight into the existence of co-movement among the time series variables. Table 4 displays the correlation coefficients between the selected stock-market indices. The point when the correlation between the returns of the equity markets increases, risk exposure of the portfolio will also start to increase and at a certain point international diversification will no longer look beneficial. However the test result shows that none of the selected stock markets are very highly correlated allowing investors to spread their portfolio across markets which in return reduce risk when diversified effectively.

Table 4: Correlation matrix for stock market returns of BRICS countries

	IBOVESP A	RTSI	SENSE X	SSE CI	JSE ALSI
IBOVESPA	1				
RTSI	0.441107	1			
SENSEX	0.285494	0.386171	1		
SSE CI	0.157151	0.173716	0.188702	1	
JSE ALSI	0.421627	0.566156	0.414118	0.172477	1

***Source*:** calculated from stock index returns

Table 4 depicts the correlation matrix for the selected stock market indices. RTSI and JSE ALSI have a high positive association (56.61 per cent), which indicates that both markets are following somewhat similar trend over the applicable period. IBOVESPA and SSE CI have lowest correlation coefficient during the study period. But all the selected stock market indices are positively correlated during the study period.

Granger causality test is used to test whether the past returns of one stock market indices improves the prediction of present and future of other stock market indices. Pair-wise Granger Causality test is applied to examine the causal relationship between the BRICS countries stock markets. Table 5 shows the result of Granger Causality test.

Table 5: Testing of Causal relationship between the stock market returns of BRICS countries

Null Hypothesis	F-Statistic	Prob.	Decision on H0	Direction
Causal relationship between RTSI and IBOVESPA				
RTSI does not Granger Cause IBOVESPA	0.10851	0.8972	Not rejected	Unidirectional
IBOVESPA does not Granger Cause RTSI	60.5867	0.0000	Rejected	
Causal relationship between SENSEX and IBOVESPA				
SENSEX does not Granger Cause IBOVESPA	1.74707	0.1744	Not rejected	Unidirectional
IBOVESPA does not Granger Cause SENSEX	60.8314	0.0000	Rejected	
Causal relationship between SSE CI and IBOVESPA				
SSE CI does not Granger Cause IBOVESPA	0.94405	0.3892	Not rejected	Unidirectional
IBOVESPA does not Granger Cause SSE CI	19.5295	0.0000	Rejected	
Causal relationship between JSE ALSI and IBOVESPA				
JSE ALSI does not Granger Cause IBOVESPA	2.21079	0.1098	Not rejected	Unidirectional
IBOVESPA does not Granger Cause JSE ALSI	83.6925	0.0000	Rejected	
Causal relationship between SENSEX and RTSI				
SENSEX does not Granger Cause RTSI	2.79242	0.0614	Not rejected	Unidirectional
RTSI does not Granger Cause SENSEX	9.05966	0.0001	Rejected	
Causal relationship between SSE CI and RTSI				
SSE CI does not Granger Cause RTSI	0.9804	0.3753	Not rejected	Unidirectional
RTSI does not Granger Cause SSE CI	8.24666	0.0003	Rejected	
Causal relationship between JSE ALSI and RTSI				
JSE ALSI does not Granger Cause RTSI	2.004	0.135	Not rejected	None
RTSI does not Granger Cause JSE ALSI	2.70144	0.0673	Not rejected	
Causal relationship between SSE CI and SENSEX				
SSE CI does not Granger Cause SENSEX	0.98507	0.3735	Not rejected	Unidirectional
SENSEX does not Granger Cause SSE CI	6.70185	0.0012	Rejected	
Causal relationship between JSE ALSI and SENSEX				
JSE ALSI does not Granger Cause SENSEX	16.7603	0.0000	Rejected	Unidirectional
SENSEX does not Granger Cause JSE ALSI	1.15197	0.3161	Not rejected	
Causal relationship between JSE ALSI and SSE CI				
JSE ALSI does not Granger Cause SSE CI	8.99278	0.0001	Rejected	Unidirectional
SSE CI does not Granger Cause JSE ALSI	0.51903	0.5951	Not rejected	

Source: calculated from stock index returns.
Note: * Significant at 5% level.

It is inferred from table 5 that some null hypotheses have been rejected while accepting others. In the short term, there is a unidirectional Granger causality running from the returns of the IBOVESPA to all the other stock market indices selected for the study. The rejection of null hypothesis RTSI does not Granger Cause SENSEX and SSE CI explains that RTSI price can be a predictor variable for SENSEX and SSE CI. SENSEX can be predictive factor for SSE CI, as the null hypothesis SENSEX does not Granger Causes SSE CI has been rejected. The result also shows that SENSEX changes with JSE ALSI and JSE ALSI changes with SSE CI during the study period. Except JSE ALSI and RTSI, all the other indices show unidirectional relationship.

Conclusion

Modeling dependence among the BRICS countries is of great importance for the market participants, as the results can help to make important portfolio allocation decisions. So, this

study has been carried out to examine the link between the stock markets of BRICS countries. To start the analysis, the variables are tested for stationary using ADF and it is found that all the variables are non-stationary at level and become stationary at first difference. The ADF test finds no evidence to support the presence of unit root in level of data series of the selected indices. As the variables are stationary at first-order difference, PP test is also used to check the accuracy of ADF result; this result also proved that data series have no unit root. Correlation test is used to test the relationship among the selected stock markets and found that all the BRICS nation's stock markets are correlated with one another. In order to get more insight into the relationships between the selected stock markets, Granger Causality test is applied and found that some stock market index prices can be predicted with other stock market index prices. There is unidirectional Granger Causality running from IBOVESPA to all the other indices; RTSI prices can be used to predict SENSEX and SSE COMPOSITE INDEX; SENSEX price helps to predict SSE COMPOSITE INDEX; JLSI prices serves as a predictor for SENSEX and SSE COMPOSITE INDEX. It is found that only few indices move in the direction of other indices, so the investors have the chance to diversify their portfolio in the rest of the stock market indices.

To conclude with, the result of this research would be particularly helpful for international investors, as there is a chance to diversify their portfolio. But it is important for the investors to be cautious while making investments in simultaneous international markets.

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