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An empirical study on the interrelationships among the BRICS stock markets during financial Crisis of COVID-19

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Abstract
The five main emerging economies of the globe are represented by the BRICS economic bloc, which is made up of Brazil, Russia, India, China, and South Africa. These nations have cooperated with each other in the areas of financial aids, trade, and technical know-how despite their geopolitical differences. This goes a long way towards their sustainable economic integration. Through the routes of such economic integration, the economic vulnerabilities generated in any one of the BRICS countries during the first wave of COVID-19 swiftly spread to the others. In light of the global financial crisis caused by COVID-19, it is crucial to investigate if their economic interdependence has affected their stock market ties. The study looks at the causation and long-term co-integrating relationships across the brics stock markets in the backdrop of global catastrophe caused by COVID-19, covering a study period from February 24, 2020, to June 23, 2020. The COVID-19 pandemic and its economic aftershock were primarily to blame for the steep decline in the performance of the global stock market from February to June 2020. Five stock indices—IBOVESPA (Brazil), MOEX (Russia), SENSEX (India), SSECI (China), and JTOPI (South Africa)—selected using a judgment sampling technique are used to represent the stock market performances of each BRICS country. The Johansen co-integration technique has been used to assess long-term co-integrating relationships among the stock indices. It has been noted that the market has long-term cointegrating relationships among one another. Short-term causation between the markets has since been examined using the Vector Error Correction Model (VECM) Wald test. However, it was shown that there was a two-way causal relationship between the Indian market and the South African and Russian markets separately.

Keywords: BRICS, block exogeneity wald test, covid-19, co-integration, VECM

Introduction

There has been witnessed an economic interconnection among different economic groups, such as BRICS, Organisations for Economic Cooperation and Development (OECD), G7, which had always drawn the attention of the policymakers and investors. Existing literature showed that economic growth, inflation and stock markets had important causal linkages in OECD countries (Pradhan, *et al*. 2015) [15]. The United States (US) and BRICS economies had been sharing the trade relationship from the last decade. During the global financial crisis period, a partial integration among the US and BRICS markets had been observed. Shocks in US Standard and Poor's (S&P) 500 significantly influenced the stock returns in Brazil, China and South Africa. Actually, there was a strong integration between the US and BRICS economy (Singh and Singh, 2016; Jin and An, 2016) [17, 7]. In a comparatively recent study, Bhardwaj, Sharma and Mavi (2022) [2] exposed the possible impact of COVID-19 on the short run and long-run integration of five emerging Asian economies. Though they have not specifically considered BRICS as their sample, China and India was incorporated in their study. Additionally, South Korea, Indonesia and Taiwan was considered. The study found that COVID-19 weakened integration among the select economies. The absence of long-run integration was observed. While during the pre-covid period, unidirectional as well as bi-directional causal relations were present, but after the outbreak, only South Korea and China reported short-term linkage. However, Mishra and Mishra (2022) [11] looked at how COVID-19 affected the performance and level of integration of equity markets in the BRICS bloc. According to the research, the markets were not integrated during the pandemic, mostly due to trade performance, real interest rates, inflation rates, and real exchange rates. While it created more opportunities for international portfolio diversification, the need to control macroeconomic uncertainties such as inflation, interest rates, and exchange rate fluctuations during the global health crisis was also eminent in order to foster stable economic conditions and, eventually to ensure equity market integration.

Emerging market confidence was harmed by the BRICS countries' struggles during the COVID-19-induced economic crisis because they, particularly China had already demonstrated their importance to global growth. While China had demonstrated proactive policy actions that helped to somewhat contain the financial turbulence, Brazil neglected the effects of COVID-19 for a long time. It led to its economic downfall, even though it had a robust healthcare system. Russia and Brazil, two of the BRICS's largest oil exporters, also suffered financially as a result of the abrupt reduction in oil prices during the pandemic. Meagre growth, high levels of debt, a lack of institutional capacity to mobilize fiscal resources, significant socioeconomic gaps, inadequate health facilities, and other factors contributed to the economic hardships for South Africa and India during this time (Park and Garcia-Herreo, 2020) [14].

COVID-19 revealed the shortcomings of the administrative processes in all five nations in balancing health and economic priorities. It had inevitable impact on the general public's standard of living (Nilsen and Holdt, 2020) [13]. However, BRICS had stood by China and Russia during their confrontation with the United States (US) over COVID-19 and the ensuing vaccination issues. In fact, US-China competition had emerged as a major international relations issue during this time (Grigoryeva, 2020) [5]. India and Russia had been economically dependent on one other because to their defence connections during COVID-19 (Rajagopalan, 2020) [16]. While the economies of India and China was interconnected with one another through trade contacts, they had recently engaged in a number of conflicts (such as defense breaches, the prohibition of Chinese apps, propaganda to bar Chinese goods, etc.) that may sabotage any future economic ties between these countries (Brar, 2020) [3]. During the crisis, the stock market interconnectedness served as a symbol of the BRICS countries' economic interdependence (Mroua and Trabelsi, 2020) [12]. Under these circumstances, it is essential to investigate if the countries' economic interdependence has affected their stock market ties as well.

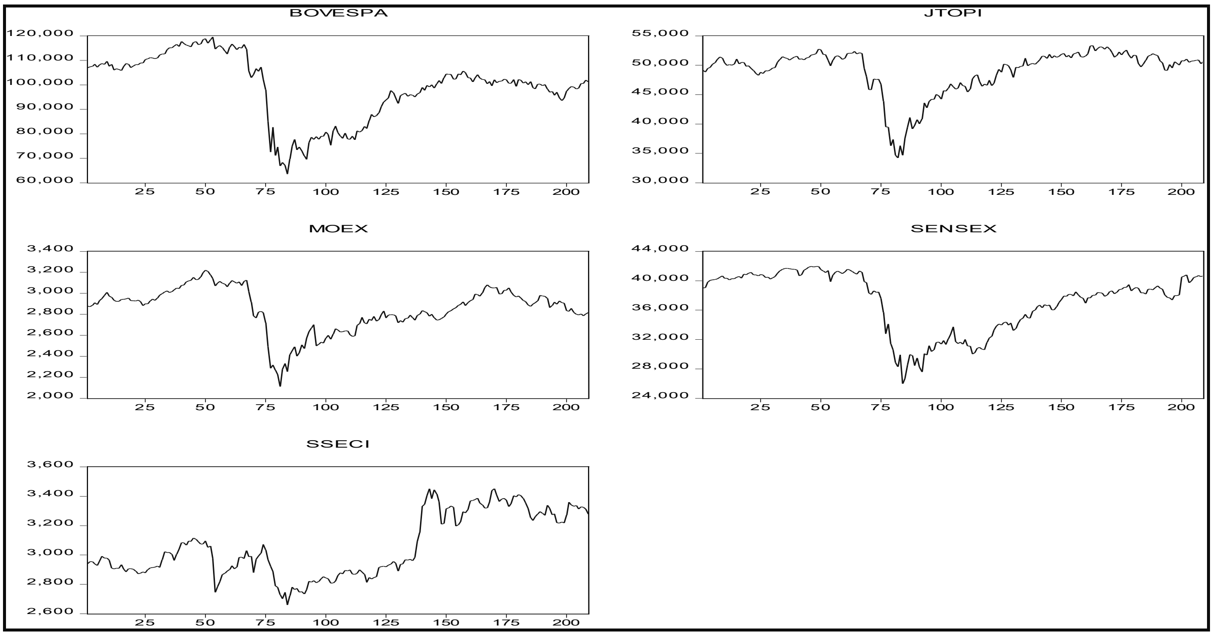
Objective of the Study

The major objective of the study is to estimate the long-run relationship and causality among stock markets of BRICS nations during global crisis period caused by Covid-19.

Material and Methods

In order to addressing the objectives of the study, the largest stock exchanges of each country based on judgement sampling technique. For this purpose, the market capitalisation of all the stock exchanges in each country has been considered and the stock exchange with the highest market capitalisation in a country has been selected (WEF, 2019) [19]. Accordingly, the selected stock exchanges are as follows: (a) B3: Brazil Stock Exchange and Over the Counter Market (Brazil); (b) Moscow Exchange (Russia); (c) Bombay Stock Exchange Ltd. (BSE) (India); (d) Shanghai Stock Exchange (SSE) (China); and (e) Johannesburg Stock Exchange Ltd. (JSE) (South Africa). The most prominent index in each of these stock exchanges are also selected based on judgement sampling techniques as follows: (a) IBOVESPA (BOVESPA) (Brazil); (b) MOEX (Russia); (c) Sensitivity Index (SENSEX) (India); (d) SSE Composite Index (SSECI) (China); and (e) JTOPI (South Africa). Initially, data on the adjusted closing price of the aforesaid indices for a period of one year (from October 24, 2019 to October 23, 2020) has been collected from www.investing.com and internal inconsistency among the datasets due to date mismatch in different stock indices has been removed applying appropriate data mining. It is observed that stock markets in all the countries under consideration have passed through a recession presumably due to Covid-19 pandemic and its ensuing economic shutdown from February to June 2020 within this period (Figure 1).

Fig 1: Stock Market Performance of BRICS Countries



Source: Compilation of secondary data using Eviews 9

Based on this observation, the period of study is decided from February 24, 2020 to June 23, 2020 with 68 observations as Covid-19 global crisis period. For further analysis, the data is converted into their natural logarithmic form (LNBOVESPA; LNJTOPI, LNMOEX, LNSENSEX; and LNSSECI) to reduce skewness in the data.

Stationarity in the dataset is tested using Augmented Dickey Fuller (ADF) test (McKinnon, 1991; Enders, 2004) [10, 4]. If the data series are integrated of the same order, long run relationship among them is estimated using Johansen Julius (JJ) co-integration technique (Johansen, 1988) [8]. If the data-series are co-integrated in the long run, causality among them may be explored based on underlying Vector Error Correction Model (VECM) (Thierry *et al*. 2016) [18].

Stationarity of the Data-series

DF test is based on following hypothesis: H_0: $\delta = 0$ against H_1: $\delta \neq 0$ where ρ is the autocorrelation between Y_t and Y_{t-1} in the equation: $\Delta Y_t = \delta Y_{t-1} + u_t$. In case of ADF test, the DF regressions are augmented by including 'm' lags of the Dependent Variable (DV) to correct serial correlation in the disturbance term (u_t). Where m= Int. $12*(T/100)^{1/4}$. In the present study ADF test is to be conducted to test whether the data series are random walk (RW) with trend and drift $(\Delta Y_t = \alpha + \beta t + \delta Y_t + \sum_{i=1}^{m} Y_i \Delta Y_{t-1} + \mu_t)$. Appropriate lag length is selected based on Schwarz Bayesian Criterion (SBC). If H_0 in this model accepted, the series is a non-stationary series and vice versa. If a log-transformed series is stationary at level, it is integrated of order 0 [I (0)], and if a series is non-stationary at level and stationary at first difference, it is integrated of order 1 [I (1)].

Long-Run Relationship

Long run relationship among I (1) data series is estimated using JJ Co-integration technique. There are two tests under this technique – (a) Trace test and (b) Max-Eigen value test. Trace test is conducted based on following hypothesis H_0: $r = r_1 < k$ [where r is number of distinct co-integrating vector(s)], against H_1: r=k. The test statistic for trace can be specified as $\lambda_{Trace} = -T \sum_{i=r+1}^{n} Ln(\lambda - 1)$. Where λ_i is the i^{th} largest value of co-integrating matrix Π and T is the number of observations. Here, Π = -(I – A1 – A2 -...Ap) where I is an identity matrix and A1, A2,…Ap are coefficients in the equation $Zt = A1\, Zt - 1 + A2Zt - 2 + \ldots .Ap\, Zt - p + ut.$ On the other hand Max-Eigen value test is based on following hypothesis: H_0: $r = r_1 < k$ against H_1: $r = r_1 + 1$. The test statistics under Max-Eigen value test can be specified as λ_{Max} = -T ln(1-λ_{r+1}) [where λ_{Max} is the $(r+1)^{th}$ largest squared Eigen value]. The appropriate lag length is determined based on Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), and Hannan-Quinn Criterion (HQC). The lag that reports the minimum value in AIC and SBC, is selected as the appropriate one. However, if there is an inconsistency in the lag length as per AIC and SBC, appropriate lag is selected based on HQC. The particular assumption for running the model is intercept but no trend in Co-integrating Equations (CE) and Vector Auto-Regression (VAR). The number of co-integrating relationship among the variables depends on number of hypothesised CEs for which the results of Trace and max-Eigen values are significant (Prob. <0.05 and H_0 cannot be accepted).

Presence of Causality

It is possible to test for long-term causation between data series if they are co-integrated. Long-term causality can be determined using the underlying Vector Error Correction Model (VECM) by evaluating the statistical significance of the Error Correction Term (ECT), which is actually the error term in the co-integration equation at lag 1. Section 4.2.2 discusses the specific methods used with regard to the current dataset.

Direction of Causality

Direction of causality among I (1) data series is estimated using Block Exogeneity Wald test on level data with underlying VECM. The test which is also known as Granger Causality in VECM is conducted with the following hypothesis. H_0: $R_\alpha=0$; against H_1: $R_\alpha \neq 0$ (where α is the vector of all VEC coefficients and R is suitably chosen non-causality restriction matrix having full row rank. The Wald statistic is $T\hat{\alpha}R'(R\widehat{\Sigma_{\hat{\alpha}} R'})^{-1}$where T=sample size; $\hat{\alpha}$ is the asymptotically normally distributed estimator of α; $\Sigma_{\hat{\alpha}} R$ is the covariance matrix of the asymptotic distribution and $\widehat{\Sigma_{\hat{\alpha}} R'}$ is its estimator. It follows χ^2(p-1) distribution. At 5% level of significance, if test statistics>critical value, H_0 cannot be accepted and vice versa. If H_0 cannot be accepted, causal relationship exists among two variables. For each equation in the model, causal effects of exogenous indices on endogenous index is measured individually and together.

Results and discussion

Stationarity of the Data-series

Results of ADF Test during global crisis period caused by Covid-19 are shown in Table 1.

Table 1: Results of ADF Test during global crisis period caused by Covid-19

Index	Level		First Difference		Nature of the Data Series at Level
	Prob. (Trend & Intercept)	Result	Prob. (Trend & Intercept)	Result	
LNBOVESPA	0.3974	Non-Stationary	0.0000***	Stationary	I(1)
LNJTOPI	0.2299	Non-Stationary	0.0000***	Stationary	I(1)
LNMOEX	0.0790	Non-Stationary	0.0000***	Stationary	I(1)
LNSENSEX	0.4709	Non-Stationary	0.0000***	Stationary	I(1)
LNSSECI	0.5054	Non-Stationary	0.0000***	Stationary	I(1)
***significant at 1% level of significance					

Source: Compilation of secondary data using Eviews 9

Results of ADF tests during the study period show that all the data series are (Table 1) non-stationary at level and stationary at first difference. Thus, all the data series during this period are I(1) series.

Long-Run Relationship and Causality During Covid-19 Global Crisis Period

Long-Run Relationship

Since all the stock indices during Covid-19 global crisis period are I (1) series (Table 1), long run relationship among them is estimated using JJ Co-integration technique. At lag-length 1 (as per HQC) and with the assumption of linear deterministic trend, the results of Trace test show 2 co-integrating relationship at 5% level of significance (at no and at most 1 hypothesised Co-integrating Equations).

Table 2: Unrestricted Cointegration Rank Test (Trace)

Hypothesised No. of CE(s)	Eigen Value	Trace Statistic	Critical Value (5%)	Prob**
None *	0.405907	86.91768	69.81889	0.0012
At most 1 *	0.325573	52.55017	47.85613	0.0170
At most 2	0.174780	26.55327	29.79707	0.1130
At most 3	0.144388	13.87433	15.49471	0.0865
At most 4	0.052832	3.582410	3.841466	0.0584
* Denotes rejection of the hypothesis at the 0.05 level				
** MacKinnon-Haug-Michelis (1999) p-values				

Source: Compilation of secondary data using Eviews 9

Table 2: Unrestricted Cointegration Rank Test (Maximum Eigen Value)

Hypothesised No. of CE(s)	Eigen Value	Max-Eigen Value Statistic	Critical Value (5%)	Prob**
None *	0.405907	34.36751	33.87687	0.0437
At most 1	0.325573	25.99690	27.58434	0.0787
At most 2	0.174780	12.67894	21.13162	0.4822
At most 3	0.144388	10.29192	14.26460	0.1935
At most 4	0.052832	3.582410	3.841466	0.0584
* Denotes rejection of the hypothesis at the 0.05 level				
** MacKinnon-Haug-Michelis (1999) p-values				

Source: Compilation of secondary data using Eviews 9

However, Max Eigen-value test specifies only 1 co-integrating relationship at 5% level of significance (at no hypothesised Co-integrating Equations) [Table 2(a) and 2(b)]. It can be resolved that stock indices are co-integrated during this period. Thus, a long-run relationship is evident among the stock market performances of the BRICS nations during Covid-19 global crisis period.

Presence of Causality

The long-run relationships among the indices under VECM may be represented as follows:

$$\Rightarrow \Delta LNBOVESPA_t = a_0 + \lambda_1 \epsilon_{t-1} + \sum_{j=1}^{p} a_{1p}\, \Delta LNBOVESPA_{t-j} + \sum_{j=1}^{p} a_{2p}\, \Delta LNJTOPI_{t-j} + \sum_{j=1}^{p} a_{3p}\, \Delta LNMOEX_{t-j} + \sum_{j=1}^{p} a_{4p}\, \Delta LNSENSEX_{t-j} + \sum_{j=1}^{p} a_{5p}\, \Delta LNSSECI_{t-j} + \mu_t \text{....(1)}$$

$$\Rightarrow \Delta LNJTOPI_t = b_0 + \lambda_2 \epsilon_{t-1} + \sum_{j=1}^{p} b_{1p}\, \Delta LNBOVESPA_{t-j} + \sum_{j=1p}^{p} b_2\, \Delta LNJTOPI_{t-j} + \sum_{j=1}^{p} b_{3p}\, \Delta LNMOEX_{t-j} + \sum_{j=1}^{p} b_{4p}\, \Delta LNSENSEX_{t-j} + \sum_{j=1}^{p} b_{5p}\, \Delta LNSSECI_{t-j} + \mu_t \text{....(2)}$$

$$\Rightarrow \Delta LNMOEX_t = c_0 + \lambda_3 \epsilon_{t-1} + \sum_{j=1}^{p} c_{1p}\, \Delta LNBOVESPA_{t-j} + \sum_{j=1}^{p} c_{2p}\, \Delta LNJTOPI_{t-j} + \sum_{j=1}^{p} c_{3p}\, \Delta LNMOEX_{t-j} + \sum_{j=1}^{p} c_{4p}\, \Delta LNSENSEX_{t-j} + \sum_{j=1}^{p} c_{5p}\, \Delta LNSSECI_{t-j} + \mu_t \text{....(3)}$$

$$\Rightarrow \Delta LNSENSEX_t = d_0 + \lambda_4 \epsilon_{t-1} + \sum_{j=1}^{p} d_{1p}\, \Delta LNBOVESPA_{t-j} + \sum_{j=1}^{p} d_{2p}\, \Delta LNJTOPI_{t-j} + \sum_{j=1}^{p} d_{3p}\, \Delta LNMOEX_{t-j} + \sum_{j=1}^{p} d_{4p}\, \Delta LNSENSEX_{t-j} + \sum_{j=1}^{p} d_5\, \Delta LNSSECI_{t-j} + \mu_t \text{....(4)}$$

$$\Rightarrow \Delta LNSSECI_t = e_0 + \lambda_5 \epsilon_{t-1} + \sum_{j=1}^{p} e_{1p}\, \Delta LNBOVESPA_{t-j} + \sum_{j=1}^{p} e_{2p}\, \Delta LNJTOPI_{t-j} + \sum_{j=1}^{p} e_{3p}\, \Delta LNMOEX_{t-j} + \sum_{j=1}^{p} e_{p4}\, \Delta LNSENSEX_{t-j} + \sum_{j=1}^{p} e_{5p}\, \Delta LNSSECI_{t-j} + \mu_t \text{....(5)}$$

Here, $\epsilon_{t-1}$is the ECT, which can be written as: $LNBOVESPA_{t-1} + \beta_0 + \beta_1 LNJTOPI_{t-1} + \beta_2 LNMOEX_{t-1} + \beta_3 LNSENSEX_{t-1} + \beta_4 LNSSECI_{t-1}$; and λ_i is the ECT coefficient measuring the speed an exogenous shock that can be adjusted back to the equilibrium. If λ_i<0 and significant at 5% level of significance, the endogenous variable and other regressor variables have long run causality flowing from the later to the former. Here, the co-integrating relationship among the stock indices during Covid-19 global crisis period may be represented as follows:

- LNBOVESPA(-1)=-0.856262125271*LNJTOPI(-1)+0.991349525471*LNMOEX(-1)+ 0.951804268637*LNSENSEX(-1)+ 3.13235263005*LNSSECI(-1) - 22.1136791016
- ECT=LNBOVESPA(-1)+0.856262125271*LNJTOPI(-1)-0.991349525471*LNMOEX(-1)- 0.951804268637*LNSENSEX(-1)- 3.13235263005*LNSSECI(-1)+22.1136791016

VECM estimates give equations considering five stock indices individually as endogenous variables:

- D(LNBOVESPA)=C(1)*ECT+C(2)*D(LNBOVESPA(-1))+C(3)*D(LNJTOPI(-1)) +C(4)*D(LNMOEX(-1)) + C(5)*D(LNSENSEX(-1)) + C(6)*D(LNSSECI(-1)) + C(7)...............(8)
- D(LNJTOPI)=C(8)*ECT+C(9)*D(LNBOVESPA(-1))+C(10)*D(LNJTOPI(-1)) + C(11)*D(LNMOEX(-1)) + C(12)*D(LNSENSEX(-1)) + C(13)*D(LNSSECI(-1)) + C(14)
- D(LNMOEX)=C(15)*ECT+C(16)*D(LNBOVESPA(-1))+C(17)*D(LNJTOPI(-1)) + C(18)*D(LNMOEX(-1))+C(19)*D(LNSENSEX(-1)) + C(20)*D(LNSSECI(-1)) + C(21)
- D(LNSENSEX)=C(22)*ECT+C(23)*D(LNBOVESPA(-1))+C(24)*D(LNJTOPI(-1))+ C(25)*D(LNMOEX(-1))+C(26)*D(LNSENSEX(-1)) + C(27)*D(LNSSECI(-1)) + C(28)
- D(LNSSECI)=C(29)*ECT+C(30)*D(LNBOVESPA(-1))+C(31)*D(LNJTOPI(-1)) + C(32)*D(LNMOEX(-1))+ C(33)*D(LNSENSEX(-1)) + C(34)*D(LNSSECI(-1)) + C(35)

In the above equations, coefficients of ECTs [C (1); C (8); C (15); C (22); and C (29)] measures the speed of adjustment of any deviation from the long-run equilibrium back to the equilibrium through a partial short-run dynamic adjustment. With a view to testing the H_0 of no long-run causality of one stock index with remaining four indices, significance of the coefficients at 5% level is estimated using ordinary least square (OLS) procedure. If the coefficient is negative and significant (Prob. <0.05), the endogenous stock index is caused by other four indices in the long-run. The estimated values of the coefficient, t-statistic and probability values are shown here:

Table 3: Statistical Significance of ECT Coefficients

Eqn.	Coefficient	Estimate	Decision	t-statistic	Prob.	Decision Rule	Decision
8	C(1)	-0.305413	Estimate<0	3.213588	0.0015	Prob.<0.05	Rejected
9	C(8)	-0.210218	Estimate<0	4.095682	0.0001	Prob.<0.05	Rejected
10	C(15)	-0.248197	Estimate<0	5.529150	0.0000	Prob.<0.05	Rejected
11	C(22)	-0.221516	Estimate<0	3.609561	0.0004	Prob.<0.05	Rejected
12	C(29)	-0.082763	Estimate<0	3.547632	0.0005	Prob.<0.05	Rejected

Source: Compilation of secondary data using Eviews 9

It is observed that the coefficients of the ECTs are all significant at 5% level of significance with negative value (Table 3). Thus, it can be concluded that each stock index during the Covid-19 global crisis is caused by the remaining 4 stock indices in the long-run.

Direction of Causality

The results of the Block Exogeneity Wald Test as depicted in the table-4 shows that Brazilian stock market is Granger caused only by the Chinese stock market. However, South African stock market is individually Granger caused by the stock markets of Russia, India and China. Moreover, the market is also Granger caused by the stock markets of all the four countries (i.e. Brazil, Russia, India and China) together. Moreover, Russian stock market is also Granger caused by the stock markers of South Africa, India and China. However, when stock market movements of all the four countries (i.e. Brazil, South Africa, India and China) are taken together, they together seem to Granger cause Brazilian stock market.

Stock markets of Brazil, South Africa, Russia and China collectively Granger cause Indian stock market. Moreover, stock markets of South Africa, Russia and China individually Granger causes Indian stock market. Finally, Chinese stock market is Granger caused only by the Indian stock market.

Table 4: Results of Block Exogeneity Wald Test

Dependent variable: D(LNBOVESPA)			
Excluded	Chi-square Statistic	Degree of Freedom	Probability
D(LNJTOPI)	1.469207	1	0.2255
D(LNMOEX)	2.428425	1	0.1192
D(LNSENSEX)	0.920524	1	0.3373
D(LNSSECI)	4.889467	1	0.0270*
All	7.994764	4	0.0918
Dependent Variable: D(LNJTOPI)			
Excluded	Chi-square Statistic	Degree of Freedom	Probability
D(LNBOVESPA)	0.593923	1	0.4409
D(LNMOEX)	15.66038	1	0.0001*
D(LNSENSEX)	10.93421	1	0.0009*
D(LNSSECI)	10.57435	1	0.0011*
All	34.89010	4	0.0000*
Dependent Variable: D(LNMOEX)			
Excluded	Chi-square Statistic	Degree of Freedom	Probability
D(LNBOVESPA)	0.180057	1	0.6713
D(LNJTOPI)	9.608602	1	0.0019*
D(LNSENSEX)	6.672908	1	0.0098*
D(LNSSECI)	12.54876	1	0.0004*
All	26.82802	4	0.0000*
Dependent Variable: D(LNSENSEX)			
Excluded	Chi-square Statistic	Degree of Freedom	Probability
D(LNBOVESPA)	0.804901	1	0.3696
D(LNJTOPI)	4.613776	1	0.0317*
D(LNMOEX)	6.790474	1	0.0092*
D(LNSSECI)	8.878610	1	0.0029*
All	18.96128	4	0.0008*
Dependent Variable: D(LNSSECI)			
Excluded	Chi-square Statistic	Degree of Freedom	Probability
D(LNBOVESPA)	0.000204	1	0.9886
D(LNJTOPI)	0.304180	1	0.5813
D(LNMOEX)	3.425866	1	0.0642
D(LNSENSEX)	5.048953	1	0.0246*
All	9.286632	4	0.0543
*Significant at 5% level			

Source: Compilation of secondary data using Eviews 9

The results suggest that Indian stock market has bidirectional causality with the stock markets of South Africa, Russia and China. Moreover, there is also a bidirectional causality between stock markets of Russia and South Africa. While Chinese stock market individually Granger causes the stock markets of Brazil, South Africa Russia, it is not Granger caused by them.

Conclusion

Limitations of the Study

In the present study, an attempt has been made only to identify the long-run integration and short run causality among the stock markets of BRICS nations keeping in view a small period (From February to June, 2020) when under consideration. However, the study suffers from following limitations

a. While the study considers a small period (From February to June, 2020) when stock prices of all the countries plummeted significantly in all the five countries, considering a larger study period could have provided could provide more reliable insights.
b. Though The study is an attempt to see the long-run integration and short run causality among the BRICS stock market only during the crisis period when the impact of COVID-19 loomed over the stock markets of all the nations, the study may have considered a different sample period (e.g. pre-Covid or post-Covid) to strengthen the validity of the conclusions.
c. Though the study attempts to find out only the long-run cointegration and short run causality among the stock markets of BRICS nations during COVID-19 induced crisis period, impact of the volatilities of select macro-economic variables on the stock market performances of these five countries could have strengthened the conclusions.
d. The study failed to address the endogeneity concerns arising out of correlation between independent and dependent variables. Since the study attempts to understand the long-run integration and short run causality among select stock markets, identification of independent and dependent variables was not possible. However, the instrumental variables, fixed effect regression, or structural equation modelling may be considered in future researches to do away with this problem.

Economic Implications

The stock markets of the BRICS countries predict a long-term link despite their geopolitical and economic variety. This is because of the COVID-19 pandemic and the subsequent economic shutdown. COVID-19 has revealed the shortcomings in the administrative system in each of the five nations when it comes to balancing economic and health objectives, and its inevitable effects on the general public's standard of living. Stock markets had a severe slump from February to June 2020, and these negative market attitudes may have contributed to their long-term cointegration. All stock markets have projected a long-term causal relationship at this time, presumably as a result of their coordinated efforts to prevent and treat COVID-19 and to create favourable conditions for equipment supply. In addition to taking hostile measures against one another, the BRICS countries have stood by China and Russia during the US-China rivalry that has become a major issue in international relations due to the COVID-19 conflict and the ensuing vaccinations issues. Stock markets of India have projected a bidirectional causal relationship with that of China, South Africa, and Russia in the near term. Their economies have become dependent on one another as a result of their defence ties; joint movement at the World Trade Organization (WTO) for the easing of intellectual property (IP) regulations; and their current trade relations. However, India and China have recently engaged in a number of conflicts (such as defence breaches, the prohibition of Chinese apps, propaganda to bar Chinese goods, etc.) that might potentially damage Sino-Indian economic ties in the future.

In this backdrop, it may be finally concluded that the stock markets of BRICS bloc are integrated in the long run during COVID-19 pandemic. Furthermore, Indian stock market is also found to have bi-directional causal relationship with some of its foreign counterparts. Hence, the pandemic did not leave significant scope of portfolio diversification for international investors. However, since economic interconnectedness results in volatility spill-over, Indian economy may consider revising their trade relations and economic ties with other countries in the block to avert similar situations in the future.

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