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COINTEGRATION OF EMERGING STOCK MARKETS: AN EMPIRICAL ANALYSIS ON BRICS STOCK MARKETS

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Abstract
The main stock market indices of the BRICS nations—the IBOVESPA (BVSP) index, MOEX index, NIFTY 50 index, SSE Composite Index, and FTSE/JSE SA Financials Index—will be examined in relation to one another in this article. Additionally, using time series data from the chosen stock market returns over the last ten years, from 2013 to 2022, we determine the paired comparison that shows cointegration among the BRICS countries. By using statistical models such as the Vector Autoregressive model to select for lag order selection, the Johansen cointegration test to test the cointegration with reference to the data points in a sequence over time, and the augmented Dickey–Fuller test to check stationarity. By deploying the model to the data, the findings indicate that a cointegration connection exists. out of the major indexes of the stock market.

Keywords: BRICS indexes stock markets, Augmented Dickey-Fuller test, Vector Autoregression, Cointegration test.

INTRODUCTION

The enthusiasm of the document is to inspect the prolonged connection among the crucial indices of the BRICS republic. For the analysis we have taken a data from major indices from the emerging BRICS countries.

The BRICS nations are the top five emerging economies that are experiencing rapid growth in the world are as follows. economies collectively known as BRICS. To encourage collaboration and commerce among itself, these nations have created an economic union. One notable change in the economic landscape of the BRICS nations is the significant rise of their stock markets as important participants in the international markets.

The share markets of BRICS nations present a chance for investors wishing to diversify their portfolios and get exposure to the development potential of developing market economies. Strong economic growth, an escalating middle-class population, and rising consumer expenditure have all contributed to the recent rapid growth of these markets.

Every BRICS nation has distinct traits and market dynamics, offering a variety of investment options. For instance, China has a prominent global trading platform for securities, with a concentration on firms related to technology and consumer goods. On the other hand, Russia's oil and gas sector has stock market experienced a noteworthy influence.

Investors who are thinking about participating in the BRICS stock markets should be mindful of the dangers involved with doing business in developing nations, such as fluctuating exchange rates, unstable political conditions, and a lack of proper regulatory monitoring. The BRICS stock markets, however, can

provide substantial potential returns and advantages for portfolio diversification for individuals willing to accept these risks.

REVIEW OF LITERATURE

The stock markets, particularly the financial markets, are being referred to emerging countries have fast development in all sectors in BRICS nations. Most of the works of literature are on finding the distant future linkage together with selected stock indices by using integration and vector autoregression models which are also used in this study.

(Vodwal, 2021) The nature of interrelationship between the Indian and global capital markets was examined by the authors. The study assesses how well the Indian stock market integrates with other financial markets, including those in the US, UK, China, Japan, and others. The review focuses on the methodological and empirical findings of diverse studies, as well as the gaps and limitations in the existing literature. The paper also examines the policy implications for investors and regulators, as well as the potential benefits and drawbacks of stock market integration.

Timcy Sachdeva, Pritpal Singh, and Pradeep Kumar (2021) (Sachdeva, Singh, & Kumar, 2021) The research begins by emphasising the significance of comprehending the interconnectivity of global stock markets, since globalisation has resulted in more financial market integration. The authors highlight that the Indian stock market has grown increasingly appealing to international investors in recent years, making it critical to investigate its interaction with other global markets. Form Jan 2000 to Dec 2020, the authors taken daily closing prices of stock market indexes from India, the US, Japan, China, Germany, the UK, and Hong Kong. They then employ VECM, the objective is to check the affinity between the BSE and the six other international markets.

Mohanasundaram and Parthasarathy Karthikeyan (2015) (Karthikeya & Parthasarathy, 2015) The writers commence by exploring the significance of understanding the interdependence of stock markets in a globalized world. They note that as financial markets become increasingly integrated, the movements of one market can affect others, making it crucial analysing the connections among different stock markets. The secondary data is obtained from the ranging of 2004 to 2014. They then use cointegration analysis to look the long-term linkage between these markets.

Beeralaguddada Srinivasa Veerappa (2016) (Veerappa, 2016) Using monthly data from 1995 to 2013. The intent of this research project is to inspect the connections, both immediate and prolonged, among the stock markets of seven Asian Indices are Nikkei 225, HSI, STI and FTSE Bursa Malaysia KLCI, Shanghai SE Composite IX and All Ordinaries. The study has found proof of the existence of both temporary and enduring connections among Asian stock markets. The findings imply that utilising statistical models such as Integration, VAR, VECM, and Granger Causality, investors may diversify their international portfolio in the near run.

(Nasser & Hajilee, 2015) The purpose of this article is to look at the degree of integration between five growing stock markets BR, CHN, MX, RU, TR and the established market places which are selected for the analysis. The study combines the VECM and the cointegration test time series from 2001 to 2014 to find both short-term and long-term correlations between the performance of established and frontier stock markets. The findings reveal that stock markets in both emerging and established nations are integrating in the short term, with only the German stock market showing a long-term link with emerging stock markets. This implies support to the investors can diversify across different markets in the near term, but should exercise caution in the long run.

Shalini Aggarwal and Abhay Raja (2018) (Aggarwal & Raja, 2018) The author's goal is to analyse the association between BRIC economies using the integration test and VECM Model. The data used in the study is from seven years (2008-2015). The cointegration test found only one long-term cointegration vector. Through the VECM model, it was found that Brazil's market is influenced by India, while China and Russia have an impact with a lag of two periods. In contrast, India's market is not influenced by Brazil, Russia, or China.

Malayendu Saha and Amalendu Bhunia (2012) (Saha & Bhunia, 2012) The purpose of the author's research was to check the prolonged and immediate connections regarding the Indian stock indices and other South Asian countries. It performed multivariate cointegration and Granger causality analyses on daily data from 2002 to 2011. The study's outcome shows that there is an immediate relation between Asian stock indices, which investors may gain from.

(Hadi & Yap, 2017) There was research conducted to explore the connection between the two variables. EGX and the PEX by analyses of monthly data from 1998 to 2012. The output shows the existence of significant cointegration between EGX and PEX, indicating a long run integration of the two markets. However, the Granger causality test did not display short-term changes that have occurred between the two market indices.
(ABBAS, KOJU, & WANG, 2017) Using monthly data from 2000 to 2015, the study examines the integration of the foreign exchange (ER: PKR/USD) and the Pakistani stock market (KSE-100). Based on integration test, the data imply a cointegration link between the two markets. Furthermore, the Granger causality study's findings show a significant causal association with additional financial variables (M2, TBR, and ER). This information may be used by investors to make educated investment decisions in Pakistan's financial markets.
(Joshi, Mehta, Patel, & Patel, 2021), the Sensex and other American and European stock markets between 2005 and 2018. The cointegration test, the causality test, and the correlation test were among the research approaches used in the study. The results demonstrate connectivity between the BSE Sensex and the others, as well as a significant positive correlation between the Sensex and other stock market movements.
Yutaka Kurihara & Eiji Nezu (2006) (Kurihara & Nezu, 2006) The author is aimed to study how the Japanese stock market is connected to US stock prices, as well as how macro-economic components impact the Japan stock index. The data found that it had little effect on interest rates and large effect on US stock prices.
(Wong, Agarwal, & Du, 2005) Using a statistical test, cointegration technique, the study sought to assess the level of financial integration betwixt IND stock index and the world's main stock markets. From 2003 - 2018, for the analysis taken daily data on stock market indexes from India, the US, the UK, and Japan. The findings demonstrated a long-term fractional cointegrating linkage within the India and other stock exchanges in the US and the UK. The study, however, found an indication of an enduring association of the Indian and Japan stock index.
Albina Hysaj, Güven Sevil (2021) (Hysaj & Sevil, 2021) This study focuses on stock market cointegration and diversification, as well as their influence on the financial market. The author applies the Johansen cointegration test to each stock index in connection with the S&P 1200 index find are any long-term cointegration correlations between various markets. it seems that investing in the stock index of BR and the EUR can offer excellent heterogeneousness prospects. Overall, this research offers light on the importance of stock market cointegration and diversification, as well as its ramifications for the financial market.
(Subha & Nambi, 2010) The author aims to inspect of integration betwixt the Indian and US share markets. The study analyzed data from January 1st, 2000 to December 31st, 2008, which spanned nine years, and employed various tests to inspect the connection between the Indian and the NASDAQ and S&P 500. According to study of stock index of India performance during the given time period was not affected by the US market, indicating no integration within Indian and American Stock exchanges. The research provides valuable insights into the linkage of selected markets.
(WONG, PENM, TERRELL, & LIM, 2004) According to the study, Singapore and Taiwan are closely linked with JP, while HK is closely linked with the US and the UK. However, Malaysia, Thailand, and Korea do not have a stable integration with the emerged markets of the US, the UK, and JP. The conclusion was reached after analysing sample data by using unit root test ADF and integration test.

Research Gap/Need for the Study

Most of the Stock market interlinkage studies are dug out for the developed markets like America, Japan, and European countries also many studies on Asian markets integration. So, my research is limited to BRICS countries as these countries are emerging countries, so the research is detailed to inspect the cointegration of share market returns of BRICS indices.

Objectives

- To examine the cointegration between the specified stock indices of BRICS nations.

That is to find whether there exists an interlinkage among the specified stock indices of BRICS nations from sample data of 10 years which is from 2013 to 2022.

Hypothesis statement

H0: There is no cointegration between the BRICS nations.
H1: There exists a cointegration between the BRICS nations.

Data
This study relied on secondary data consist of BRICS stock market indices. the period which is chosen from 2013 to 2022, represents the period of 10 years monthly data, and There are an overall total of 120 observations.
The data is collected from BRICS stock market indices which are represented as IBOVESPA(BVSP) index, MOEX index, NIFTY fifty index, SSE Composite Index and FTSE/JSE SA Financials Index. The cointegration long-run connection between the BRICS nations may be determined using this data. And also done the country's wised the compression demonstrates that the countries have enduring relationships.

- The data is collected from exchanges websites and yahoo finance

Methodology
The study is to analyse the integration relationship among the BRICS indices. So, for the analysis of data we use various tools which are,

Augmented Dickey-Fuller test
The Augmented Dickey-Fuller (ADF) test is a key statistical tool in econometrics and time series analysis used to determine if a time series is stationary or non-stationary, a prerequisite for conducting the Johansen cointegration test.

$$\Delta Y_t = \phi Y_{t-1} + U_t$$

VAR lag order
A multivariate time series model, VAR is widely used in econometrics to analyse the dynamic relationships between multiple variables. One important aspect of fitting a VAR model is selecting the appropriate lag order, this controls how many historical observations are incorporated in the model.
Vector Autoregression (VAR) model, which encompasses numerous endogenous variables. The purpose of these criteria is to assist in determining the optimal lags to incorporate in the model.

Johansen Multivariate Cointegration test
To test interlinkage among the time series in the future progress, before conducting the cointegration test we should conduct the stationarity test and VAR model
It is conducted for the secondary data of five countries' indices returns that the outcome support that exists a prolonged relation in the BRICS country's indices returns.
Furthermore, Johansen (1991) introduced two cointegration test statistics: the trace test and the max-eigenvalue test. Both models are applied in the study to test the enduring connection.

$$\lambda \text{trace}(r) =, -T \sum_{i=r+1}^{n} \text{In}(1 - \lambda i)$$

where the estimated roots are represented by λi, for i = r+1 to n. The sum is then multiplied by the negative value of the sample size T. The calculated λ trace statistic is then compared to the critical values from a distribution table determine number of cointegrating interlinkage in the analysis.
Maximum eigenvalue test:

$$\lambda \max(r, r+1) = -T \sum_{i=r+1}^{n} \text{In}(1 - \lambda r + 1)$$

the sum of logarithms of the estimated characteristic roots for the rank r+1 model where the estimated roots are represented by λr+1. The sum is then multiplied by the negative value of the sample size T.

DATA ANALYSIS AND DISCUSSION

Augmented Dickey–Fuller test (stationarity test)

We performed the modified Dickey-Fuller test first in order to execute the cointegration test. Upon conducting an examination using the ADF test, it has been determined that the original level, the variables exhibit non-stationary behaviour. However, after performing a first difference transformation on the variables, they exhibit stationary behaviour.

Vector Autoregression

The cointegration test needed the lag length after the ADF test, thus we ran the vector autoregression analysis for lag order selection.

Table 1 Lag order selection criteria:

ag	LogL	LR	FPE	AIC	SC	HQ
0	-1754.403	NA	22988277	31.13988	31.26056	31.18885
1	-1691.303	119.4997*	11718166*	30.46554*	31.18962*	30.75936*
2	-1675.813	27.96346	13902369	30.63386	31.96135	31.17254
3	-1662.847	22.25989	17314412	30.84686	32.77775	31.63039
4	-1648.112	23.99329	21020361	31.02854	33.56284	32.05693
5	-1630.31	27.41224	24360945	31.15593	34.29364	32.42918
6	-1608.153	32.15723	26402563	31.20625	34.94736	32.72435
7	-1589.927	24.83942	31065734	31.32614	35.67065	33.0891
8	-1569.801	25.64722	35895861	31.4124	36.36032	33.42022

Source: Authors calculation

The table below shows the lag order selection criteria for a Vector Autoregression (VAR) model. The goal of these criteria is to aid in choosing the right number of delays to include in the model.

The results are shown in the table for lag orders ranging from zero to eight. Each lag order has the log-likelihood (LogL), likelihood ratio test (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ).

Based on lag order selection criteria, it is recommended the VAR model with one lag is the most suitable model, as it ranks highest across most of the criteria. In particular, the model with one lag has the most favorable log-likelihood, the least amount of final prediction error, and the lowest values for AIC, SC, and HQ. Additionally, the likelihood ratio test shows that the model with one lag is significantly superior to the model with zero lags.

Based on the results, it is suggested that a VAR (1) model is the most appropriate choice, which involves including a single lag of each of the endogenous variables. It is crucial to pick out the right lag duration from the efficiency of the VAR model prior to conducting the integration test. The research indicates the lag length of 1.

Johansen cointegration test

The Johansen cointegration test is a statistical technique is used to test for the presence of cointegration among multivariate time series variables. Cointegration refers to the prolonged connections among variables that can be used to model their joint behavior.

The cointegration test performs between the BRICS indices stock market returns.

Here the Hypothesis statement was

Statement: There exists a cointegration between the BRICS countries.

After performing the analysis, the results are below.

Table 2. Trace test

Hypothesized NO. of CE(s)	Eigenvalue	Trace-statistic (TS)	Critical-Value	Prob***
None*	0.5303	287.1346	69.81889	0.0001
At most 1*	0.428375	197.2109	47.85613	0.0001
At most 2*	0.358658	130.6575	29.79707	0.0021
At most 3*	0.328029	77.79863	15.49471	0.0032
At most 4*	0.226036	30.49139	3.841465	0.0011

Source: Authors calculation

*There are 5 cointegration equations which can be seen at 0.05 level that specifies the Trace test
*From the above table, the NH is rejected at the 0.05 level
Rule: the "Trace Statistic" should be more than the "Critical Value" then exists integration.
Here Table consists of two columns one is "Trace Statistic" and one "Critical Value" The trace test identifies 5 cointegrating equations at the 5 percent level and displays the cointegration test analysis. The Trace test statistic is rejected the NH and the presence of five cointegration vectors. The findings reveal that the Trace Statistics (287.1346) is more than critical value (69.81889) at the level of 5 precent significance.

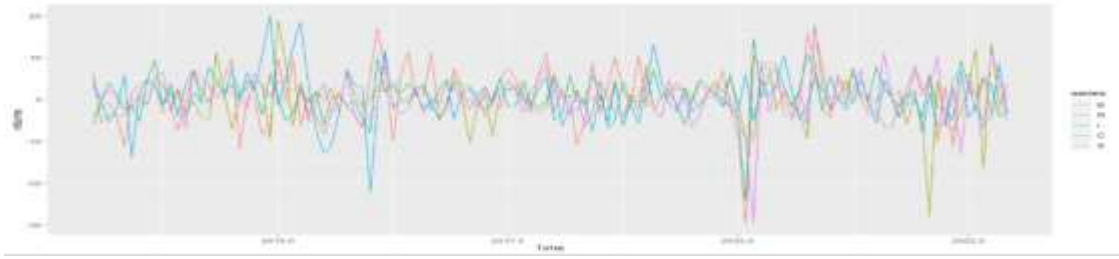
Table 3. Max-Eigenvalue

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen statistic	Critical-Value	Prob***
None*	0.540901	89.92368	33.87687	0.0000
At most 1*	0.27939	66.55348	27.58434	0.0002
At most 2*	0.126319	52.85882	21.13162	0.0003
At most 3*	0.068888	47.30724	14.2646	0.0001
At most 4*	0.048438	30.49139	3.841465	0.0000

Source: Authors calculation

*There are 5 cointegration equations which can be seen at 0.05 level that specifies the Max-Eigen statistic test
*From the above table, the NH is rejected at the 0.05 level
the table used is referred to as a Max-Eigenvalue table. To determine whether a cointegration vector is present, the Max-Eigenvalue test is utilized. At a 5% level of significance, the results of the test for five cointegrating vectors indicate that the NH is rejected. At 5% significance, the Max-Eigen value of 89.92368 is more than the Critical value of 33.87687. This indicates the presence of a cointegrating vector. The Trace test and the Max-Eigenvalue test both show the rise of integration among the BRICS indexes, according to the tables above.

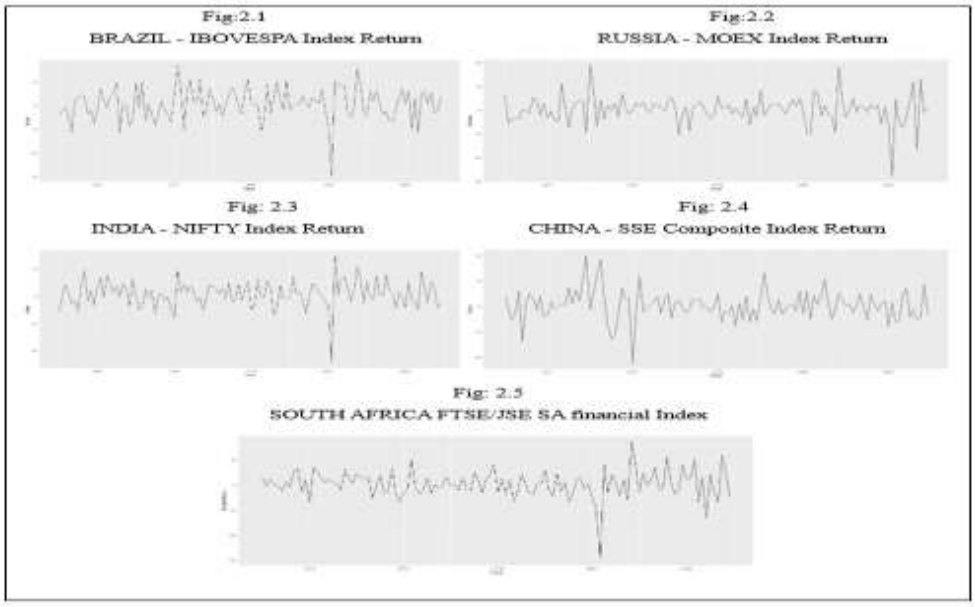
Figure:1 BRICS Stock market returns Graph.



Here the graph consists of the X axis consisting of values and the Y axis consisting of the time period from 2013 to 2022. And the red line indicates Brazil stock market indices returns, the brown line indicates Russia

stock market indices returns, the green line indicates India stock market indices returns, the blue line indicates China stock market indices returns and the pink line indicates South Africa stock market indices returns. From the above graph the maximum spikes are appeared in the graph from the time period of 2020 to 2021 due to the effect of pandemic covid19 negative returns exceeded and majorly Brazil, Russian, Indian, South Africa face greater changes during the 2020 year.

Figure:2 Individual Graphs of BRICS returns from 2013 to 2022



In figure2 the individual graphs lie between X axis which specifies the return values and Y axis specifies the years contains of BRICS countries, the data is taken from the past 10 years that is 2013 to 2022. it shows the returns movements of the selected indices. In the figure2 the most of the individuals' graphs represents the fluctuations, the Brazil, India and South Africa countries graphs are high volatility between the 2019 to 2021 as they affect by the covid19 so the returns are completely collapse and also the import and export of materials are also stopped among the countries.

Table 4 Paired Cointegration

Countries	B	R	I	C	S
B	*	0.0024	0.0181	0.0052	0.0202
R	0.0024	*	0.0046	0.0070	0.0079
I	0.0181	0.0046	*	0.0010	0.0075
C	0.0052	0.0070	0.0010	*	0.0062
S	0.0202	0.0079	0.0075	0.0062	*

Source: authors calculation

From the above results which are present in table is of paired comparison between the five indices returns by performing the cointegration test the values are significant, as the prob(P) P value is significant the level of 0.05, So in paired comparison wise all the variables are cointegrated with each other so there is a cointegration between the compared variables which are

1. Brazil-Russia, Brazil-India, Brazil-China, Brazil-South Africa
2. Russia-Brazil, Russia-India, Russia-China, Russia-South Africa
3. India-Brazil, India-Russia, India-China, India-South Africa

4. China-Brazil, China-Russia, China-India, China-South Africa
5. South Africa-Brazil, South Africa-Russia, South Africa-India, South Africa-China

In the paired cointegration test there are some of the combinations are highly cointegrated each other find in the cointegration analysis, which are

- The paired cointegration between the Nifty Fifty index in India and SSE composite index in China is high in cointegration exists, the P value is 0.0010.
- The paired cointegration between the IBOVESPA(BVSP) index in Brazil and MOEX index in Russia, P value is 0.0024 there exist a highly cointegration between the them.
- The paired cointegration between the IBOVESPA(BVSP) index in Brazil and SSE composite index in China, P value is 0.0052 there exist a highly cointegration between the them.
- The P value is 0.0046 of Nifty Fifty index in India and MOEX index in Russia has high cointegration exist.
- Between SSE composite index and FTSE/JSE SA Financial index in Sou the P value is 0.0062 also exist a cointegration.

These are the 20 comparisons the BRICS stock market indices returns.
From the paired cointegration analysis,
The active cointegration among the Brazil and India stock market indices as its p value is 0.0181 i.e., is less than 0.05 which exists a long run integration among the Brazil and India.
Russia and India have a link by a p value of 0.0046, which is less than 0.05, China and India have an association with a p value of 0.0010, and NIFTY 50 index and South Africa have a relation with a p value of 0.0075, which is less than 0.05. There is cointegration. Finally, using the integration test, the findings show a cointegration across the paired compared variables. The paired cointegration among the variables, the current research is moderately significant at the 5 percent level of significance.

FINDINGS AND RECOMMENDATIONS

Stock exchanges based on the BRICS indexes, by the Johansen test among the BRICS stock markets the results support that there is an interlinkage between the major stock market BRICS indices which are IBOVESPA(BVSP) index, MOEX index, NIFTY 50 index, SSE Composite Index and FTSE/JSE SA Financials Index. There is also exists a cointegration between the selected variables paired cointegration.

1. Brazil-Russia, Brazil-India, Brazil-China, Brazil-South Africa
2. Russia-Brazil, Russia-India, Russia-China, Russia-South Africa
3. India-Brazil, India-Russia, India-China, India-South Africa
4. China-Brazil, China-Russia, China-India, China-South Africa
5. South Africa-Brazil, South Africa-Russia, South Africa-India, South Africa-China.

For example, covid19 affects all nations throughout the world, affecting all stock market indexes in emerging countries.

CONCLUSION:

The article's primary focus is on identifying the cointegration of the BRICS indexes, which represent the largest developing stock markets, using time series data spanning ten years, from 2013 to 2022. The first difference is that the data is stationary when using Augmented Dickey-fuller. The lag length selection is 1 using the Vector Autoregression model, and the results of the cointegration test indicate that there is cointegration interlinkage between the BRICS indices. Additionally, at 0.05 LOS paired cointegration among the chosen stock market indices shows that there is cointegration association between the selected stock indices from BRICS countries.

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