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EXAMINING COINTEGRATION AND CAUSALITY OF EXCHANGE RATES: AN EVIDENCE FROM BRICS COUNTRIES

Rufsha M
(Research scholar), mrufsha@gmail.com

Dr. K. Samsudheen
(Assistant professor), samsuprl@gmail.com
Research Department of Commerce and Management Studies, Farook college (Autonomous), Kozhikode, Kerala, India

Abstract
The purpose of this paper is to investigate a form of the linkage between exchange rates of BRICS countries, based on daily exchange rates quoted in USD over a 10-year period. i.e. 01-01-2009 to 31-12-2018, (BRL / USD, RUB / USD, INR/USD, CNY/USD and ZAR / USD). retrieved from BIS (Bank for International Settlements). To investigate this, the econometric technique such as, Johansen cointegration test, Vector Error Correction Model (VECM) are used. The results of the Johansen cointegration test show that this series is cointegrated. The Granger causality tests revealed that China does not help predict Brazil, India, or South Africa. Brazil does help predict South Africa. This shows that there is a long-term causal relationship between exchange rates in the BRICS countries and that the coefficient should have a negative sign, indicating the ability to return to equilibrium.
Keywords: Exchange rates, BRICS countries, Johansen cointegration, Vector Error Correction Model
Originality/value: The present paper is original work
Paper type: Research paper

I. INTRODUCTION

Since the collapse of the Bretton Woods in the late 1970's, the international monetary system has been dominated by the floating exchange rate system. The currencies around the world are mainly determined by the laws of the supply and demand. International trade has been the engine of growth and the cause of stability in many countries. International trade flows have increased extremely over the last three decades. The reduction of trade and policy barriers have contributed in the rise of global trade, but the interesting question is if the exchange rates play any role in international economic relations. Global economic leadership is progressively shifting from the G7 to the BRICS, the popular symbol use to refer to Brazil, Russia, India, China and South Africa. (Maradiaga et al., 2012) projects that the BRICS will "overtake" the G6 (UK, US, France, Italy, Japan and Germany) by 2040.The expansion of economic globalization has led to interconnection, trade, and capital flow among the five major developing economies; those of Brazil, Russia, India,

China, and South Africa, commonly known as BRICS(Analysis et al., 2022). The BRICS members remain the beneficiaries of vital investment globally, and they are leading trading partners with the USA, Japan, and Germany, and thus their stock markets are closely connected with these major economies (Garcia & Bond, 2021)

With 41% of the global population, 24% of the global GDP, and more than 16% of the global trade, BRICS is a significant organization that brings together the major emerging economies from around the world. Over the past year, BRICS nations have been the primary drivers of global economic growth. In recent months, BRICS nations have gathered to discuss crucial issues under the three pillars of political and security, economic and financial development, and people-to-people contacts. It can be assumed that the medium-term strengthening of the BRICS group's positions in international finance will proceed steadily, evolutionarily, and with a slight increase in these nations' contributions to global production and trade. This will necessitate the implementation of a wide range of policies aimed, among other things, at the establishment of significant international financial centers in the BRICS nations, the acceleration of national currencies' internationalization processes, and the development of efficient state regulatory frameworks for cross-border financial flows. States could promote the import and export of investments in the key sectors for the BRICS nations by offering loans, guarantees, and other forms of financial assistance for important international projects and transactions, primarily through development institutions.The study's main goal is to comprehend the long- and short-term relationships between the variables and to determine which of these relationships can be used to predict other variables in the group.

Five sections make up the paper. Section 2 discusses the literature. The methodology & research tools & techniques are covered in Section 3, and the Results and Discussions are covered in Section 4. In Sections 5 and 6, respectively, the study's findings and their implications are covered.

II. LITRATURE REVIEW

In order to provide in-depth analysis on a variety of concepts related to the idea of cointegration between financial markets, the literature review has been divided into two sections.

II.1. cointegration or co-movement between financial markets, exchange rates and stock market

(Kim & Mo, 1995) shows, The long-run forecast of the dollar/DM exchange rate is generated using multivariate cointegration. It is demonstrated. that, while the random walk model outperforms the monetary structural models in the short run, the latter, based on historical data, outperforms the former in the long run. By using Johansen Cointegration test, and Granger Causality by VECM (Pala, 2013) They find a clear long-run relationship between crude oil price index and food price index. By using wavelet-based techniques(Das et al., 2017) investigated the cross-country co-movement of gold spot returns among the major gold consuming countries in Asia. After examine the pricing efficiency of the Malaysian crude palm oil (CPO) market prior to and following the structural break using Johansen cointegration, VECM, TAR, and M-TAR models for the daily closing price of CPO and CPO futures (CPO-F) for the period spanning from June 2009 to August 2016. The study found that a structural break in the Malaysian CPO price series has no impact on the market's pricing efficiency. The causal relationship between FDI and GDP was also examined

by (Gupta & Singh, 2016). The Johansen Cointegration result established a single cointegrating vector (long run relationship) between FDI and GDP for Brazil, India, and China. According to (Jacob et al., 2022), the industrial production index, foreign direct investment, foreign portfolio investment, interest rate, and wholesale price index all have a favorable effect on the exchange rate (REER). There have been more studies, with an emphasis on stock market and exchange rates. Exchange rates and stock returns were shown to be positively correlated using cointegration analysis and multivariate Granger causality tests on monthly data from January 1980 to January 2009 (Diamandis & Drakos, 2011). Apply Granger causality and data from 1992 to 2005 for Australia, Canada, Japan, Switzerland, and the United Kingdom, in contrast (Alagidede et al., 2011) and their research demonstrates that there is no sustained relationship between stock prices and exchange rates. Moreover, it has been demonstrated by (He et al., 2021)that the variables (foreign exchange rate returns and stock market returns) have a negative relationship. These two economic series also had an impact on the performance of the US stock market. The results show that the relationship between exchange rates and stock prices is moderated by the US stock market. The exchange rate and all stock market indices have a bidirectional causal relationship, according to (Demirhan, 2016)and (Bahmani-oskooee & Sohrabian, 2006). Markov switching VAR models, when tested in low and high volatility regimes, suggest that stock markets have more influence on exchange rates during both calm and turbulent periods (Chkili & Khuong, 2014). In a later study (Maradiaga *et al.*, 2012), cointegration was found in some but not all of the countries studied in relation to the volatility of the Euro-USD and Yen-USD exchange rates and agricultural exports from Brazil, India, China, and South Africa. There is no cointegration equation among the variables, according to the most recent studies discovered by (Sadhwani, 2020) using the Johansen cointegration test. Additionally, (Of & Manat, 2022) from 1995 to 2020, the import-export activities of Azerbaijan were examined using a cointegration analysis in relation to the manat exchange rate and population income. A vector error correction model was created to describe the long-term equilibrium relationship between the studied indicators and how to get back on if it veered off course after Johansen's tests were used to determine cointegration.

II.2. co-movement between the markets in BRICS countries

The co-movements between financial markets have been studied by numerous researchers using a variety of models over time, but this research concentrates on the most recent studies carried out in the BRICS nations. (Hess et al., 2019)Examine the effects of the global financial crisis on the economies of Brazil, Russia, India, China, and South Africa (BRICS) in terms of total factor productivity (TFP). In the long run, Johansen co integration revealed a single balanced relationship among the BRICS countries, while cross-correlation, Granger causality tests, and Wald tests all revealed statistically significant unidirectional linkages later on (Dhingra & Patel, 2021) and the average TFP growth experienced a setback.(Analysis et al., 2022) Analyze the long-term relationships between stock prices in the BRICS countries using a bivariate framework with two endogenous structural breaks. The study found evidence of stock markets across the BRICS nations' cointegration. When examining the effects of income, technological innovation, income inequality, and industrialization on environment quality in Brazil, Russia, India, China, and South

Africa (BRICS) between 1996 and 2016 (Rai & Rawat, 2022), cointegration test confirms a long-term relationship between the concerned variables. Additionally, the COVID-19 pandemic's impact on the BRICS economies' reliance on foreign exchange is assessed by (Xu & Lien, 2022). Four stages of the COVID-19 episode were identified, and we have described how the COVID-19 had a detrimental effect on the BRICS's reliance on the CNY.

The literature cited above clearly shows that significant research has been conducted to show that exchange rates and financial markets move counter to one another in different countries and at different times. Despite the researcher's focus on the BRICS nations, there haven't been many studies looking at the cointegration of exchange rates, particularly in the BRICS nations. To fill in the gaps in the existing literature, the study has been conceptualized and planned.

III. DATA & METHEDOLOGY

Data

The data set consists of daily observations of prices of BRICS currencies. That are quoted in the USD (BRL / USD, RUB / USD, INR/USD, CNY/USD and ZAR / USD). The data for the study secondary data and retrieved from BIS (Bank for International Settlements). The study is done on the daily prices for the period of 10 years, i.e. 01-01-2009 to 31-12-2018. The period chosen for the study is (01-01-2009 to 31-12-2018) in order to avoid two crisis periods, namely the year beginning with 2009, that is, up to 2008 was a financial crisis period, and the year ending 2018, that is, covid-19 pandemic started in the year.

Methodology

3.1 Unit Root

The ADF test is used to examine the stationarity and non-stationarity of time series. The presence of the unit root test in all four variables is checked with the help of Augmented Dickey Fuller (ADF) (1981) test.

3.2 Johansen cointegration

In addition to the unit root test, the efficient maximum likelihood test (Johansen, 1988, 1991, 1995) was used to look for a long-term association between exchange rates for the individual BRICS countries, Cointegration tests identify situations in which two or more non-stationary time series are integrated in such a way that they cannot deviate from equilibrium over time. The cointegration test can be used to confirm the correlation and Granger causality for long-run movement among variables. All time series data are non-stationary at the level, but they are stationary at the first order difference. Johansen's approach begins with the vector autoregression (VAR) of order p provided by

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t , \quad (1)$$

where y_t is an nx1 vector of variables that are integrated of order one – commonly denoted I(1) – and t ε_t is an nx1 vector of innovations.

Johansen suggests the trace test and maximum eigenvalue test, for r = 0, 1, 2, and n-1, the maximum Eigenvalue statistics compares the alternative of r+1 cointegrating relations to the null hypothesis of r cointegrating relations. The statistics are calculated as follows:

$$LR_{\max}(r/n+1)=-T*\log(1-\hat{\lambda}) \quad (2)$$

Here λ is the maximum Eigenvalue T is the sample size. Trace statistics compare the alternative of n cointegrating relations to the null hypothesis of r cointegrating relations, where n is the number of variables in the system for r=0, 1, 2... n-1. Its equation is calculated using the formula below.

$$LR_{tr}(r/n) = T * \sum_{i=r+1}^{n} \log(1-\hat{\lambda}\iota) \quad (3)$$

3.3 VECM

After analyzing the long-term relationship between the variables, standard Granger causality based on VAR system or Granger causality based on vector error correction model are typically used to determine the direction of causality between the variables. A vector error correction model can be used if the variables are cointegrated. The augmented Granger causality test is the name given to this technique. This method incorporates the VAR system with an error correction term (ECT). The significance t-statistic for the ECT parameter shows that there is proof of the long-term causality and relationship between the variables. A dynamical system that predicts both the effect of one variable on another by explicitly indicating the rate at which one variable will adjust to return the system to equilibrium following the change in another variable

3.4 Granger causality test

The Granger Causality Test suggested by Granger (1969) is used to determine the relationship between two variables in a time series. The test checks whether one variable comes before another, that guides in determining whether a time series X is useful in forecasting another Y.

IV. RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics

Initially we examined, the descriptive statistics of Exchange rates of BRICS Countries. the highest and lowest mean values were found in India and Brazil, respectively. The Russian exchange rate had the highest value among the series, according to the standard deviations, while the Chinese currency had the lowest. On the other hand, the majority of exchange rates' skewness was positive, with the exception of South Africa and India. According to the kurtosis statistic, the distribution of exchange rates for the BRICS economies had flat tails. Finally, the Jarque-Bera (JB) statistic showed that all series' data had a normal distribution, rejecting the null hypothesis.

Table I Descriptive Statistics

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
BRL/ USD	0.894	0.823	1.437	0.428	0.295	0.200	1.596	227.361
CNY/	1.871	1.868	4.243	1.798	0.062	21.110	798.77	677.647

USD								
INR/ USD	4.046	4.107	4.309	3.784	0.152	-0.344	1.642	247.169
RUB/ USD	3.730	3.534	4.433	3.304	0.341	0.357	1.344	346.996
ZAR/ USD	2.324	2.341	2.820	1.885	0.261	-0.032	1.614	205.392

Source: Authors calculation

4.2 Unit root test Result

For cointegration and causality analyses, the unit root property of the data series is absolutely essential. Table II shows the results of the ADF test for each BRICS nation's exchange rate series. The results of the unit root test revealed that the null hypothesis of unit root for the selected variables, namely exchange rates for each individual country, was not rejected at levels. However, when the series are first differenced, they are discovered to be stationary and integrated at the order of one, I (1). This test looks for the presence of a unit root in the series at all three levels. That is, only constant, trend and constant, or no trend.

Table II Unit Root Test result

variable	**At level**			**At First Difference**			**Result**
	With intercept	**With Trend and intercept**	**With no trend**	**With intercept**	**With Trend and intercept**	**With no trend**	
BRL	-0.013 (0.9587)	-2.997 (0.1331)	1.058 (0.9247)	-54.455 (0.0000)	-54.494 (0.0000)	-54.44 (0.0000)	I(1)
RUB	-0.477 (0.8930)	-1.838 (0.6859)	10455 (0.9247)	-45.934 (0.0000)	-45.930 (0.0000)	-45898 (0.0000)	I(1)
INR	-0.662 (0.8541)	-2.231 (0.4713)	1.455 (0.9644)	-38.065 (0.0000)	-38.059 (0.0000)	-38,023 (0.0000)	I(1)
CNY	1.032 (0.9989)	1.032 (0.9213)	1.0325 (0.9213)	-2.936 (0.1512)	-2.823 (0.0551)	-2.821 (0.0047)	I(1)
ZAR	-0.588 (0.8707)	-2.865 (0.1742)	0.750 (0.8761)	-50.857 (0.0000)	-50.862 (0.0000)	-50.854 (0.0000)	I(1)

Source: Authors calculation

Note: Significant at the 5% level

Table III: selection of optimal lag in the VAR system

Lag	**Log L**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	13411.3	NA	1.89E-11	-10.50239	-10.4909	-10.4982

1	39809.66	52672.63	2.01E-20	-31.16307	-31.0943*	-31.1381*
2	39854.06	88.4087	1.98E-20	-31.17827	-31.0523	-31.1326
3	39880.06	51.67581	1.98e20*	-31.17905*	-30.9959	-31.1126
4	39891.25	22.20164	2.00E-20	-31.16823	-30.9278	-31.0811

Source: Authors calculation

Note: * optimal lag length

(AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion, Optimal Lag selection based on AIC = 3))

The optimal lag length is 3 and is based on the lowest Akaike information criterion (AIC) value, which in our case is -31.17905. FPE values, which are lowest at lag 3, also support the same level of lags.

4.3 Correlation Analysis

Table 3 demonstrates that almost all currencies have a strong correlation, with China and South Africa having a strong positive correlation (0.961 and 0.970), China and India having a correlation of 0.9217, and China and Russia having a correlation of 0.9217. The fact that two variables are positively correlated encourages much more investigation to ascertain whether one variable can be used to forecast the current or future value of the other.

Table IV Correlation Matrix

	BRL	**CNY**	**INR**	**RUB**	**ZAR**
BRL	1	0.082931	0.921751	0.961897	0.970356
CNY	0.082931	1	-0.08578	0.131047	0.033293
INR	0.921751	-0.08578	1	0.859313	0.94954
RUB	0.961897	0.131047	0.859313	1	0.932976
ZAR	0.970356	0.033293	0.94954	0.932976	1

Source: Authors calculation

4.4 Cointegration Test Result

The results are shown in Table 5. Since we cannot reject the null hypothesis of one cointegrating vector against the alternative hypothesis of two or more cointegrating vectors. We can conclude that there is one cointegrating vector of five exchange rates.

Table V: Johansen Cointegration Test for cointegration

Ho	**Eigenvalue**	**Trace**	**p-value**	**max**	**p-value**
r = 0	0.01221	80.884*	0.0051	31.399	0.096
r=1	0.00778	49.484*	0.0349	19.958	0.344
r=2	0.00579	29.526	0.0537	14.848	0.299
r=3	0.00434	14.678	0.0661	11.124	0.148
r=4	0.00139	3.5539	0.0594	3.5539	0.059

Source: Authors calculation

Note: * indicates the existence of cointegration at least at the 5% level

4.5 VECM

After confirming the existence of cointegration among the exchange rates of BRICS countries namely BRL, CNY, INR, RUB, ZAR, that Exhibits a long term relationship, then employ the VECM, this model is used to investigate the long-run and short-term casualties of the dependent and independent variables. Following the execution of the VECM, the goal of ECM is to indicate the speed of adjustment from short-term equilibrium to long-term equilibrium. C (1) is a negative and significant (long term correlation) that demonstrates long run causality between BRL, CNY, INR, RUB, and ZAR. The coefficient should have a negative sign, indicating the ability to return to equilibrium is at the rate of .54%. As this study has a coefficient of -0.005404. Its sign shows a .54% speed of adjustment, which is significant at 1% level. Finally, it is postulated that if there is an exogenous shock, it will make .54% adjustment per month to reach the long-term equilibrium. This indicate that there is a long-term causal relationship between exchange rate in BRICS countries.

Table VI: Result of VECM

	brazil	china	India	Russia	South Africa
ecm (-1)	-0.005404	-0.02332	0.009529	0.02896	-0.01505
`R^2	-0.00118	-0.05306	-0.01198	-0.02526	-0.00495
S.E of Regression	[-4.57827]	[-0.43942]	[0.79555]	[1.14663]	[-3.03739]

Source: Authors calculation

4.6 Granger Causality

Table VII: Granger Causality Test Result

NULL HYPOTHESIS	Prob.	Decision on H0
CHINA does not granger cause BRAZIL	0.008	rejected
INDIA does not granger cause BRAZIL	0.4687	Not rejected
RUSSIA does not granger cause BRAZIL	0	rejected
SOUTH_AFRICA does not granger cause BRAZIL	0.2381	Not rejected
BRAZIL does not granger cause CHINA	0.2069	Not rejected
INDIA does not granger cause CHINA	0.8293	Not rejected
RUSSIA does not granger cause CHINA	0.4702	Not rejected
SOUTH_AFRICA does not granger cause CHINA	0.0912	Not rejected
BRAZIL does not granger cause INDIA	0.1433	Not rejected
CHINA does not granger cause INDIA	0.0001	rejected
RUSSIA does not granger cause INDIA	0.6839	Not rejected
SOUTH_AFRICA does not granger cause INDIA	0.0872	Not rejected
BRAZIL does not granger cause RUSSIA	0.0279	rejected
CHINA does not granger cause RUSSIA	0.0462	rejected

INDIA does not granger cause RUSSIA	0.4955	Not rejected
SOUTH_AFRICA does not granger cause RUSSIA	0.7058	Not rejected
BRAZIL does not granger cause SOUTH AFRICA	0	rejected
CHINA does not granger cause SOUTH AFRICA	0.0257	rejected
INDIA does not granger cause SOUTH AFRICA	0.4647	Not rejected
RUSSIA does not granger cause SOUTH AFRICA	0.5255	Not rejected

Source: Authors calculation

Granger Causality test result shows that null hypothesis china does not granger cause Brazil, china does not granger cause India, Brazil does not granger cause Russia, China does not granger cause Russia, Brazil does not granger cause South Africa, China does not granger cause south Africa. This Indicates that china does help to predict Brazil, china does help to predict India, Brazil does help to predict South Africa, china does help to predict south Africa.

V. CONCLUSIONS AND DISCUSSION

This study investigated the relationship between daily exchange rates of BRICS countries quoted in USD over a 10-year period, from 01-01-2009 to 31-12-2018. The Johansen cointegration test was employed followed by VECM and standard Granger Causality Test. The results of the Johansen cointegration test show that this series is cointegrated. The Granger causality tests revealed that China does not help predict Brazil, India, or South Africa. Brazil does help predict South Africa at a 5% level. The coefficient should have a negative sign, indicating the ability to return to equilibrium is at the rate of .54%. As this study has a coefficient of -0.005404. Its sign shows a .54% speed of adjustment, which is significant at 1% level. Finally, it is postulated that if there is an exogenous shock, it will make .54% adjustment per month to reach the long-term equilibrium. This indicate that there is a long-term causal relationship between exchange rate in BRICS countries.

IMPLICATIONS OF THE STUDY

We have significant market implications based on our empirical findings. First, the empirical finding suggests that there is a dynamic relationship between the BRICS countries' exchange rates. As a result, it is crucial for investors, decision-makers, and other market participants. We will better understand the relationships between the five countries thanks to this study, Insightful information about both short- and long-term investment opportunities is provided by the study. Because some of the BRICS exchange rates are not integrated, an investor can diversify their portfolio in the short term by holding assets in these unintegrated exchange rates. Overall, this study shows that market participants like portfolio managers and investors can create their own strategies to manage or hedge the risk when making investments in particular variables.

It is important to note that, like every other research paper, the researcher has some limitations. Only the relationship between daily exchange rates of BRICS countries quoted in USD over a ten-year period was examined in the current study. This study only found BRICS currency cointegration; finding the relationship between the currencies of more nations would be more advantageous for a better understanding of investment portfolios. To better understand the study's

findings, future research might, for instance, look into the cointegration of the foreign exchange market with other financial markets.

References

Alagidede, P., Panagiotidis, T., & Zhang, X. (2011). Causal relationship between stock prices and exchange rates. *Journal of International Trade and Economic Development*, *20*(1), 67–86. https://doi.org/10.1080/09638199.2011.538186

Analysis, A. R. S. C., Siddiqui, A., Shamim, M., & Asif, M. (2022). *Are Stock Markets among BRICS Members Integrated ?* 1–25.

Bahmani-oskooee, M., & Sohrabian, A. (2006). *Stock prices and the effective exchange rate of the dollar Stock prices and the efective exchange rate of the dollar*. *June 2013*, 37–41.

Chkili, W., & Khuong, D. (2014). Research in International Business and Finance Exchange rate movements and stock market returns in a regime-switching environment : Evidence for BRICS countries. *Research in International Business and Finance*, *31*, 46–56. https://doi.org/10.1016/j.ribaf.2013.11.007

Das, D., Kannadhasan, M., Al-yahyaee, K. H., & Yoon, S. (2017). A Wavelet Analysis of Co-movements in Asian Gold Markets. *Physica A*. https://doi.org/10.1016/j.physa.2017.09.061

Demirhan, E. (2016). *The Relationship between Stock Prices and Exchange Rates Evidence from Turkey*. *January 2009*.

Dhingra, V. S., & Patel, P. (2021). An empirical analysis of brics bond market integration. *SCMS Journal of Indian Management*, *18*(1), 22–36.

Diamandis, P. F., & Drakos, A. A. (2011). Financial liberalization, exchange rates and stock prices: Exogenous shocks in four Latin America countries. *Journal of Policy Modeling*, *33*(3), 381–394. https://doi.org/10.1016/j.jpolmod.2010.11.004

Garcia, A. S., & Bond, P. (2021). *Amplifying the contradictions: the centrifugal brics*. *May*.

Gupta, P., & Singh, A. (2016). Causal nexus between foreign direct investment and economic growth: A study of BRICS nations using VECM and Granger causality test. *Journal of Advances in Management Research*, *13*(2), 179–202. https://doi.org/10.1108/JAMR-04-2015-0028

He, X., Gokmenoglu, K. K., Kirikkaleli, D., & Rizvi, S. K. A. (2021). Co-movement of foreign exchange rate returns and stock market returns in an emerging market: Evidence from the wavelet coherence approach. *International Journal of Finance and Economics*, *December 2020*, 1–12. https://doi.org/10.1002/ijfe.2522

Hess, A., Campos, C., & Moloi, T. (2019). Assessing the resilience of Brazil, Russia, India, China and South Africa economies following the global financial crisis. *Acta Commercii*, *19*(1). https://doi.org/10.4102/ac.v19i1.659

Jacob, T., Raphael, R., & Antony, A. (2022). *Relationship between Foreign Portfolio Investment and Exchange Rate : The Case of India Using VECM Testing Approach*. 1–17.

Kim, B. J. C., & Mo, S. (1995). Cointegration and the long-run forecast of exchange rates. *Economics Letters*, *48*(3–4), 353–359. https://doi.org/10.1016/0165-1765(94)00591-O

Maradiaga, D. I., Zapata, H., & Pujula, A. L. (2012). Exchange Rate Volatility in BRICS

Countries. *Journal of Economic Surveys*, 1–18.

Of, R., & Manat, T. H. E. (2022). *INTERNATIONAL ECONOMICS*. 45–54. https://doi.org/10.51582/interconf.19-20.04.2022.004

Pala, A. (2013). *Structural Breaks , Cointegration , and Causality by VECM Analysis of Crude Oil and Food Price*. *3*(3), 238–246.

Rai, S. K., & Rawat, A. (2022). Exploring the nexus between environment quality, economic development and industrialization in BRICS nations: the role of technological innovation and income inequality. *Environmental Science and Pollution Research*, *29*(25), 37842–37853. https://doi.org/10.1007/s11356-021-18181-z

Sadhwani, R. (2020). Cointegration analysis of selected currency pairs traded in indian foreign exchange market. *International Journal of Management*, *11*(5), 476–485. https://doi.org/10.34218/IJM.11.5.2020.045

Xu, Y., & Lien, D. (2022). COVID-19 and currency dependences: Empirical evidence from BRICS. *Finance Research Letters*, *45*(July 2020), 102119. https://doi.org/10.1016/j.frl.2021.102119