

A Study on Interlinkages between Forex and Stock Markets in BRICS countries

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Abstract

This study examines the dynamic interlinkages and spillover effects between stock markets and foreign exchange markets in BRICS economies over the period January 2006 to March 2026. Using a comprehensive econometric framework—including VAR-based Diebold–Yilmaz spillover index, panel unit root tests, Johansen cointegration, and Granger causality analysis—the paper investigates both return transmission and market connectedness. The results reveal that all series are stationary, with predominantly contemporaneous interactions, indicating rapid information transmission and market efficiency. Spillover analysis shows a moderate level of interconnectedness (33.4%), suggesting that while cross-market shocks are significant, domestic factors remain dominant. Equity markets exhibit stronger interdependence than currency markets, with Brazil emerging as a key transmitter of shocks and South Africa and India as major receivers. The findings also highlight weak but selective forex–stock linkages and asymmetric causality patterns across countries. Economically, the results imply partial financial integration within BRICS, preserving diversification opportunities but also exposing markets to contagion risks during global shocks. The study highlights the need for improved financial coordination and stability policies to manage cross-border shocks and enhance resilience in emerging markets.

Keywords: Forex, stock markets, Diebold–Yilmaz spillover index, Cointegration

JEL classifications: C32, C58, G15, G17, F31

Introduction

The growing integration of global financial markets has significantly intensified the transmission of shocks and information across economies, particularly among emerging market blocs such as BRICS. Comprising Brazil, Russia, India, China, and South Africa, these economies have emerged as major contributors to global output, trade, and capital flows over the past two decades. With increasing financial liberalization and cross-border investments, understanding the dynamic interlinkages between key financial markets—particularly foreign exchange and stock markets—has become crucial for policymakers, investors, and researchers alike.

The foreign exchange market plays a pivotal role in determining the external competitiveness and macroeconomic stability of an economy, while the stock market reflects domestic economic performance and investor sentiment. Theoretically, the interaction between these two markets can be explained through two

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competing frameworks: the flow-oriented model and the stock-oriented model. The former suggests that exchange rate movements influence stock prices through trade competitiveness and corporate earnings, whereas the latter posits that stock market performance affects exchange rates via capital flows and portfolio adjustments. In the context of BRICS economies, these relationships are further complicated by structural heterogeneity, varying degrees of market openness, and differing exchange rate regimes.

Over the years, BRICS nations have experienced substantial volatility in both currency and equity markets, driven by global financial crises, commodity price fluctuations, geopolitical tensions, and domestic macroeconomic policies. Events such as the 2008 global financial crisis, the taper tantrum of 2013, and the economic disruptions caused by the COVID-19 pandemic have underscored the importance of examining spillover effects and interconnectedness across financial markets. Given the increasing synchronization of global markets, shocks originating in one BRICS country can rapidly transmit to others, amplifying systemic risks.

Empirically, the study of interlinkages between foreign exchange and stock markets in BRICS countries provides valuable insights into market efficiency, diversification opportunities, and risk management strategies. For instance, a strong bidirectional relationship may indicate limited diversification benefits, while weak or asymmetric linkages could offer opportunities for portfolio optimization. Moreover, understanding the direction and magnitude of spillovers is essential for designing appropriate monetary and financial policies aimed at maintaining stability.

Despite a growing body of literature on developed markets, relatively fewer studies have focused on emerging market groups like BRICS in a comprehensive and comparative framework. This study seeks to fill this gap by systematically analyzing the dynamic interrelationships between foreign exchange and stock markets across BRICS nations. By employing advanced econometric techniques such as spillover index analysis and time-varying models, the paper aims to capture both static and evolving linkages over an extended period.

In doing so, the study contributes to the existing literature by providing a nuanced understanding of financial market integration within BRICS economies. The findings are expected to have important implications for international investors, portfolio managers, and policymakers concerned with financial stability, market regulation, and economic resilience in an increasingly interconnected global financial system.

Literature Review

2. Literature Review

The increasing financial integration among emerging economies, particularly the BRICS nations (Brazil, Russia, India, China, and South Africa), has generated substantial academic interest in understanding the dynamic interrelationships and spillover effects across their financial markets. With growing globalization, capital mobility, and trade interdependence, shocks originating in one market are rapidly transmitted across borders and asset classes. In this context, the nexus between foreign exchange (forex) markets and stock markets has become a critical area of empirical investigation, especially for emerging economies where macroeconomic vulnerabilities and external dependencies are pronounced.

2.1 Theoretical and Methodological Foundations

The empirical literature on financial spillovers is largely grounded in the seminal contributions of Francis X. Diebold and Kamil Yilmaz (2009, 2012, 2014), who developed the Diebold–Yilmaz spillover index framework based on forecast error variance decompositions derived from vector autoregression (VAR) models. This approach enables the quantification of total, directional, and net spillovers across markets, offering a

comprehensive measure of interconnectedness. The framework has been widely extended to incorporate time-varying dynamics through rolling-window estimation and frequency-domain analysis.

Additionally, the concept of long-run equilibrium relationships between financial variables is rooted in the cointegration framework introduced by Robert F. Engle and Clive W. J. Granger (1987). Their error correction representation provides a basis for analyzing both short-run dynamics and long-run equilibrium adjustments between exchange rates and stock prices. Furthermore, volatility spillovers have been extensively examined using multivariate GARCH models, which capture conditional heteroskedasticity and dynamic correlations across markets.

2.2 Stock Market Spillovers in BRICS Economies

A substantial body of literature has examined return and volatility spillovers among BRICS stock markets. Early studies indicate that these markets exhibit moderate levels of integration, which tend to intensify during periods of financial stress. For instance, Syriopoulos et al. (2015) document significant volatility transmission among BRICS equity markets, particularly during the global financial crisis of 2008, highlighting the role of systemic shocks in amplifying cross-market linkages.

More recent studies emphasize the time-varying nature of these spillovers. Shi (2021), employing a time–frequency domain approach, finds that connectedness among BRICS stock markets varies across investment horizons, with stronger spillovers observed in the short term. Similarly, Singh et al. (2024) provide evidence of bidirectional and asymmetric spillovers, suggesting that the magnitude and direction of shock transmission depend on market conditions and structural differences across countries. The role of global markets, particularly the United States, has also been explored in the literature. McIver and Kang (2020) demonstrate that BRICS stock markets are significantly influenced by external shocks, with the U.S. acting as a dominant transmitter of volatility. Within the BRICS bloc, Brazil and China often emerge as net transmitters of shocks, while India and South Africa tend to be net receivers, reflecting differences in market size, liquidity, and openness.

2.3 Forex Market Spillovers in BRICS

Compared to stock markets, the literature on exchange rate spillovers within BRICS is relatively limited but growing. Existing studies suggest that BRICS currencies exhibit interconnected dynamics driven by trade linkages, capital flows, and commodity price movements. For example, Chakraborty et al. (2025) analyze exchange rate returns and find significant directional spillovers among BRICS currencies, indicating the presence of regional currency interdependence. The relationship between exchange rates and global factors such as oil prices has also been examined. Studies focusing on oil-exporting and oil-importing BRICS countries reveal that commodity price shocks can induce asymmetric spillovers across exchange rate markets. Moreover, the overall level of spillovers in forex markets is generally lower than that observed in equity markets, although it becomes more pronounced during periods of heightened uncertainty.

2.4 Forex–Stock Market Interlinkages

The interaction between exchange rates and stock markets represents a crucial dimension of financial integration. Empirical evidence for BRICS economies largely supports the existence of a bidirectional relationship between forex and stock markets. Hussain and Rehman (2023), using a combined GARCH and Diebold–Yilmaz approach, find strong volatility connectedness between exchange rates and stock indices, indicating that shocks in one market are quickly transmitted to the other. Similarly, Al-Yahyaee et al. (2019) report time-varying and asymmetric spillovers, with the strength of the relationship depending on market conditions. Inekwe (2020) further highlights the role of macroeconomic shocks in transmitting volatility from forex to equity markets, emphasizing the importance of exchange rate stability for financial market

development. Overall, the literature suggests that forex–stock interlinkages are complex, dynamic, and influenced by both domestic and global factors. Sui and Sun (2016) investigated the post-Global Financial Crisis of 2007–2008 dynamics in BRICS economies, focusing on the linkage between exchange rates and stock prices in both short- and long-run contexts. Using autoregressive vector (VAR) and vector error correction (VECM) frameworks, the study found a significant influence of stock prices on exchange rates in Brazil and Russia, whereas such effects were insignificant for India, China, and South Africa.

2.5 Advanced Connectedness and Network Approaches

Recent studies have employed advanced econometric techniques to capture nonlinearities and extreme market conditions. For instance, Khalfaoui et al. (2023) utilize a quantile VAR framework to show that spillovers among BRICS markets are stronger during extreme market conditions, such as financial crises or periods of high volatility. This finding underscores the importance of considering tail risks in spillover analysis. Similarly, Kasraoui et al. (2025) examine the role of global uncertainty factors, such as the VIX index and geopolitical risk, in shaping spillover dynamics within BRICS markets. Their results indicate that external shocks significantly influence the degree of connectedness, particularly during periods of global turmoil. Network-based approaches also reveal that the structure of spillovers evolves over time, with certain markets acting as central nodes in the transmission of shocks. Ho and Huang (2015) examined the interaction between stock market indices and exchange rates in BRICS economies (excluding South Africa) over the period February 2002 to December 2013. Applying the Lagrange Multiplier approach, their findings indicate that the direction and strength of causality between the two markets are regime-dependent, varying with changing market conditions. Dahir et al. (2018) examined the time-varying relationship between exchange rates and stock returns in BRICS economies using wavelet analysis. Their findings reveal a positive medium- to long-term association, with exchange rates leading stock returns in Brazil and Russia. In contrast, India exhibits a negative relationship, while China demonstrates a bidirectional linkage, indicating mutual causality between exchange rates and stock returns. Bal et al. (2019) examined volatility spillovers between the Nifty 50 and major exchange rates (USD, GBP, and Yen) using GARCH (1,1) and EGARCH (1,1) models on daily data from April 2007 to March 2015. The period was divided into pre-crisis, crisis, and post-crisis phases of the Global Financial Crisis of 2007–2008. Their results show mixed and asymmetric spillover effects across periods. During the crisis and post-crisis phases, a bidirectional volatility relationship was observed between the Nifty index and USD and Yen, indicating a dynamic interaction between the Indian stock market and key foreign exchange rates.

2.6 Stylized Facts from the Literature

The existing body of research yields several important stylized facts. First, BRICS financial markets are increasingly interconnected, with integration intensifying over time. Second, spillovers are highly time-varying and tend to increase during periods of economic and financial stress. Third, there is evidence of asymmetry in spillover effects, with stronger transmission during market downturns. Fourth, forex and stock markets exhibit significant bidirectional relationships, highlighting the importance of cross-market analysis. Finally, global factors, such as U.S. market movements, commodity prices, and geopolitical risks, play a crucial role in shaping spillover dynamics.

2.7 Research Gaps

Despite the extensive literature, several gaps remain:

1) Lack of Integrated Forex–Stock Analysis

Most studies focus either on stock markets or forex markets separately. Few studies jointly analyze both markets within a unified spillover framework.

2) Limited BRICS-wide Comparative Analysis

Many papers analyze selected countries rather than all BRICS nations together. There is a need for comprehensive BRICS panel analysis.

3) Time-Varying and Post-COVID Evidence

Recent structural breaks (COVID-19, geopolitical tensions) are underexplored. Limited studies use **rolling spillover or dynamic connectedness post-2020**.

4) Return vs Volatility Spillover Distinction

Some studies focus only on volatility. Need to compare return spillovers vs volatility spillovers simultaneously

5) Directional Spillover Interpretation

Few studies clearly identify: Net transmitters and Net receivers
Important for policy and investment decisions

2.8 Hypothesis Development

Based on the literature and identified gaps, the following hypotheses can be formulated

H1: Existence of Spillover

H1: There exist significant spillover effects among BRICS forex and stock markets.

H2: Bidirectional Relationship

H2: Spillovers between forex and stock markets are bidirectional.

H3: Net Transmitter–Receiver Dynamics

H3: Certain BRICS countries act as net transmitters (e.g., China, Brazil), while others act as net receivers (e.g., India, South Africa).

H4: Forex–Stock Dominance

H4: Forex markets exert significant influence on stock markets in BRICS economies.

Important for macroeconomic policy implications.

Section 3: Data Source and Methodology

This study employs data of exchange rate returns and stock index returns of the BRICS countries for the time period January, 2006 to March, 2026 on a monthly basis. Data on Indian rupees, Chinese yuan, Brazilian real, Russian ruble and South African rand vis-a-vis US Dollar are used. Study period includes 2008 financial crisis as well as the global lockdown period due to widely spread of Covid19 virus and Russia Ukraine War. All the data included in this study are secondary data and collected from official website of IMF, Reserve Bank of India and from Yahoo finance website (<https://finance.yahoo.com/quote/%5ESENSEI/history>) and investing.com (<https://in.investing.com/currencies/brl-usd>)

In this study, to obtain exchange rate return series of the variables we have taken the help of some formula.

Exchange rate return = $\ln(S_t/S_{t-1}) * 100$ where S_t = Spot exchange rate at time t and S_{t-1} = Spot exchange rate of the previous period (t-1). We use this formula for all the BRICS currency pairs. Similarly, we apply this formula for calculating the stock index returns of BRICS nations. We apply EViews 10 software for smoothly conducting the research.

Methodology

Descriptive Statistics: Descriptive statistics can be useful for two purposes mainly: 1) to provide basic information about variables in a dataset and 2) to highlight potential relationship between variables. Descriptive statistics mainly includes Mean, Standard deviation (σ), Skewness (S), Kurtosis (K) and Jarque-Bera statistics.

We have calculated the coefficients of Skewness and Kurtosis to check whether the variables are skewed and leptokurtic or not. For normality check of the variables, we used Jarque-Bera test Statistic, i.e.,

$$JB = \frac{N-k}{6} [S^2 + \frac{1}{4}(K-3)^2] \text{ ----- (1)}$$

Where S for Skewness coefficient, K for Kurtosis coefficient, N is number of observations, k is number of coefficients used to create the series and JB follows a chi-square distribution with 2 degrees of freedom (d.f.). If JB value is greater than the tabular value then the null hypothesis of normal distribution is rejected.

Test for Stationarity: Before applying any econometric model to time series data, it's crucial to ensure that the data is stationary. Stationarity is assessed using unit root tests, with the Augmented Dickey-Fuller (ADF) test analysis being standard tool for this purpose. The hypothesis framework typically assumes that the data series has a unit root or is non-stationary, denoted as H_0 . To validate stationarity, this test is conducted.

ADF test (Dickey and Fuller 1979) is a parametric unit root test. The regression equation of this test is:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \dots \text{ ----- (2)}$$

Where α is a constant, β the coefficient on a time trend and p the lag order of autoregressive process. The null hypothesis is that there is a unit root present in the series, i.e., $\gamma=0$ against alternative hypothesis $\gamma<0$.

Johansen Cointegration Test: In statistics, the Johansen test, named after Soren Johansen, is a procedure for testing cointegration of several time series (integrated of order 1 or I(1)). This test permits more than one cointegrating relationship so it is more generally applicable than Engel-Granger test. It is mainly used to test any long run relationship exists between two or more variables. The general VAR(p) form of the model without drift is given by:

$$x_t = \mu + A_1 x_{t-1} + \dots + A_p x_{t-p} + w_t \text{ ----- (3)}$$

Where μ is the vector-valued mean of the series, A_i are the coefficient matrices for each lag and w_t is a multivariate noise term with zero mean. Now a Vector error-correction model (VECM) is form by differencing the series:

$$\Delta x_t = \mu + A x_{t-1} + \Gamma_1 \Delta x_{t-1} + \dots + \Gamma_p \Delta x_{t-p} + w_t \text{ ----- (4)}$$

A is the coefficient matrix of first lag and Γ_i are the matrices for each differenced lag. The test of Johansen cointegration test occurs with two different ways one by trace values and other by eigen values. Null hypothesis of the test is that there is no cointegration exist which occurs when $A=0$. The rank of matrix A is given by r an in Johansen test we check whether r is zero or not. If $r=0$ that means no cointegration and if $r>0$ implies a cointegrating relationship between two or more variables.

Granger's Causality Test: The Granger causality test is a statistical hypothesis test to determine whether one time series is useful in forecasting another, first proposed in 1969 by Clive Granger. If a time series is a

stationary process, then the test is performed using the level values of two or more variables. For non-stationary case, the test is done using first or higher differences.

Suppose S and E are two time series variables and if past values of variable S significantly contribute to forecast the value of another variable E, then S is said to Granger cause E and vice-versa. The test involves in the following:

$$S_t = \gamma_0 + \sum_{i=1}^n \alpha_i E_{t-i} + \sum_{j=1}^n \beta_j S_{t-j} + u_{1t} \text{ ----- (5)}$$

$$E_t = \gamma_1 + \sum_{i=1}^m \lambda_i E_{t-i} + \sum_{j=1}^m \delta_j S_{t-j} + u_{2t} \text{ ----- (6)}$$

In both the equations the number of lags to be chosen using an information criterion, such as the Akaike information criterion or Schwarz information criterion. The null hypothesis is that S does not granger causes E and vice-versa. It is granger causes if 1) it is significant according to t-test, 2) it and other lagged values of the variable jointly add explanatory power to the model according to an F-test.

Spillover Index:

The Diebold-Yilmaz (2009) spillover index is a methodology developed by Francis X. Diebold and Kamil Yilmaz to measure the extent of spillovers, or shocks, across different markets or variables. This methodology is often used to quantify the interconnectedness and risk transmission among financial markets, but it can also be applied in other contexts.

Table no.1 Spillover Index

	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	From others
Variable 1	X ₁	Y ₁	Z ₁	U ₁	V ₁	Y ₁ +Z ₁ +U ₁ +V ₁
Variable 2	X ₂	Y ₂	Z ₂	U ₂	V ₂	Y ₂ +Z ₂ +U ₂ +V ₂
Variable 3	X ₃	Y ₃	Z ₃	U ₃	V ₃	Y ₃ +Z ₃ +U ₃ +V ₃
Variable 4	X ₄	Y ₄	Z ₄	U ₄	V ₄	Y ₄ +Z ₄ +U ₄ +V ₄
Variable 5	X ₅	Y ₅	Z ₅	U ₅	V ₅	Y ₅ +Z ₅ +U ₅ +V ₅
Contribution to other	X ₂ +X ₃ +X ₄ +X ₅	Y ₁ +Y ₃ +Y ₄ +Y ₅	Z ₁ +Z ₂ +Z ₄ +Z ₅	U ₁ +U ₂ +U ₃ +U ₅	V ₁ +V ₂ +V ₃ +V ₄	
Contribution including own	X ₁ +X ₂ +X ₃ +X ₄ +X ₅	Y ₁ +Y ₂ +Y ₃ +Y ₄ +Y ₅	Z ₁ +Z ₂ +Z ₃ +Z ₄ +Z ₅	U ₁ +U ₂ +U ₃ +U ₄ +U ₅	V ₁ +V ₂ +V ₃ +V ₄ +V ₅	

Source: Author’s own calculation

Return spillover index = $\sum \text{contribution to others} / \sum \text{contribution including own}$

Spillover index, put simply, is the summation of the off-diagonal elements of variance decomposition matrix obtained from VAR relative to the number of variables. The summation of diagonal elements relative to the number of variables provides the technique to measure the variance explained by its own shocks.

Section 4: Results

4.1 Descriptive Statistics:

Table no.2 Descriptive Statistics

	BOVE SPA_ RETN	BSE_RE TN	FTSE_R ETN	MOEX_ RETN	SHAN_R ETN	BRL_RE TN	CNY_RE TN	INR_RE TN	RUB_RE TN	ZAR_RE TN
Mean	0.641 064	0.86382 9	0.76276 4	0.36358 2	0.49047 1	0.35798 7	- 0.064294	0.31128 7	0.46234 3	0.42444 0
Median	0.817 513	0.97095 7	1.18277 8	1.17851 6	0.64824 0	0.21233 6	- 0.134435	0.18750 2	0.14088 0	0.14201 7
Maximum	15.67 245	24.8851 1	12.3463 4	19.9343 2	24.2525 9	16.7509 0	4.15126 8	7.66810 4	20.8415 5	16.6061 8
Minimum	- 35.531 00	- 27.29919	- 15.03110	- 35.69931	- 28.27794	- 11.67657	- 3.474830	- 6.829924	- 17.84267	- 12.27992
Std. Dev.	6.417 166	5.87103 1	4.26932 7	7.15152 2	7.26454 9	4.45049 8	1.08185 0	2.06651 0	5.29001 9	4.35714 1
Skewness	- 1.0532 21	- 0.769111	- 0.354445	- 1.339580	- 0.582899	0.49384 8	0.66472 4	0.24886 6	0.48944 4	0.42221 2
Kurtosis	7.644 836	7.65529 2	4.11927 7	8.06452 1	5.75455 2	4.25357 9	5.27206 3	5.23492 6	6.13590 0	3.74611 2
Jarque-Bera	262.2 836	242.381 9	17.6261 9	331.008 3	90.2119 6	25.6823 0	69.8745 1	52.8632 0	108.820 3	12.8031 5
Probability	0.000 000	0.00000 0	0.00014 9	0.00000 0	0.00000 0	0.00000 3	0.00000 0	0.00000 0	0.00000 0	0.00165 9
Sum	155.1 374	209.046 6	183.826 1	87.9867 4	118.694 1	86.6329 0	- 15.55926	75.3315 0	111.887 0	102.714 6
Sum Sq. Dev.	9924. 385	8307.03 0	4374.51 7	12325.7 7	12718.4 5	4773.47 0	282.066 3	1029.18 2	6744.21 6	4575.30 6
Observations	242	242	241	242	242	242	242	242	242	242

*Author's own calculation using Eviews10

The descriptive statistics indicate that all stock market returns (BOVESPA, BSE, FTSE, MOEX, SHAN) exhibit positive mean values, suggesting overall upward trends during the sample period, while among exchange rates only CNY shows a slightly negative mean. Volatility is relatively high in MOEX and SHAN returns, as reflected by larger standard deviations, whereas CNY and INR are comparatively stable. The distributions are largely non-normal. Most series display negative skewness (e.g., BOVESPA, MOEX), implying higher probability of extreme negative returns, while exchange rates such as BRL and CNY show positive skewness. High kurtosis values (>3) across all variables indicate leptokurtic behavior, meaning fat tails and frequent extreme events. Finally, the Jarque–Bera statistics reject normality for all series at the 1% significance level.

4.2 Unit Root Test

Table no.3 – Stationarity Test Result

Group unit root test: Summary				
Series: BOVESPA_RET, BSE_RET, FTSE_RET, MOEX_RET, SHAN_RET, BRL_RET, CNY_RET, INR_RET, RUB_RET, ZAR_RET				
Sample: 2006M01 2026M03				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-52.0150	0.0000	10	2409
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-46.6521	0.0000	10	2409
ADF - Fisher Chi-square	1104.35	0.0000	10	2409
PP - Fisher Chi-square	1104.68	0.0000	10	2409
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

*Author's own calculation using Eviews10

The panel unit root results clearly show that all BRICS stock returns and exchange rate returns are stationary at level ($I(0)$).

Both types of tests—common unit root (Levin, Lin & Chu) and individual unit root (Im, Pesaran and Shin, ADF-Fisher, PP-Fisher)—strongly reject the null hypothesis of a unit root, as all p-values are 0.0000. This means there is no unit root problem in the data.

In simple terms, the return series of BOVESPA, BSE, FTSE, MOEX, Shanghai, and currencies (BRL, CNY, INR, RUB, ZAR) are stable over time, with constant mean and variance.

Economically, this is expected because financial returns are usually stationary, unlike price levels. It implies that shocks in these markets are temporary and do not persist in the long run.

Thus, the data is suitable for VAR analysis without differencing, and results from models based on these series will be reliable and not spurious.

4.3 Lag Order Selection Criteria

Table no.4 Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6217.648	NA	7.78e+10*	53.45620*	53.60432*	53.51593*
1	-6131.873	163.4501	8.80e+10	53.57831	55.20756	54.23530
2	-6060.046	130.7065	1.13e+11	53.82014	56.93052	55.07438
3	-6001.627	101.2941	1.63e+11	54.17705	58.76856	56.02856
4	-5913.101	145.8973	1.83e+11	54.27554	60.34818	56.72430
5	-5855.652	89.74870	2.73e+11	54.64079	62.19456	57.68680
6	-5788.457	99.20510	3.82e+11	54.92238	63.95729	58.56566
7	-5677.688	154.0308	3.75e+11	54.82994	65.34598	59.07048
8	-5569.814	140.7455*	3.89e+11	54.76235	66.75953	59.60015
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

*Author's own calculation using Eviews10

The VAR lag selection results suggest that lag 0 is the optimal choice for the model. This is because all major criteria—**AIC, SC, HQ, and FPE**—select lag 0 (indicated by *).

In simple terms, this means that including past values (lags) of the variables does not significantly improve the model's explanatory power. The current values of the BRICS stock indices and exchange rates are sufficient to explain their relationships.

Although the Likelihood Ratio (LR) test shows significance at higher lags (especially lag 8), information criteria are generally more reliable for model selection, particularly in large systems like this with many variables.

Economically, this result suggests weak dynamic interdependence among the BRICS markets in the short run. Most interactions appear to be contemporaneous (same period) rather than driven by past values.

Therefore, a VAR(0) or very low-lag structure is appropriate for further analysis.

4.4 Johansen Cointegration Test

Table no. 5 - Johansen Cointegration Test (Both Trace and Eigenvalue)

Date: 03/20/26	Time: 22:49
Sample (adjusted): 2006M03 2026M02	
Included observations: 240 after adjustments	
Trend assumption: No deterministic trend (restricted constant)	

Series: BOVESPA_RETN BSE_RETN FTSE_RETN MOEX_RETN SHAN_RETN BRL_RETN RUB_RETN INR_RETN CNY_RETN ZAR_RETN

Lags interval (in first differences): No lags				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.667894	1666.943	251.2650	1.0000
At most 1 *	0.608200	1402.391	208.4374	0.0000
At most 2 *	0.564084	1177.509	169.5991	0.0001
At most 3 *	0.525461	978.2362	134.6780	0.0001
At most 4 *	0.491292	799.3375	103.8473	0.0001
At most 5 *	0.488866	637.1262	76.97277	0.0001
At most 6 *	0.452106	476.0565	54.07904	0.0001
At most 7 *	0.412108	331.6551	35.19275	0.0000
At most 8 *	0.355312	204.1643	20.26184	0.0001
At most 9 *	0.337474	98.80701	9.164546	0.0001
Trace test indicates 10 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.667894	264.5522	65.30016	0.0001
At most 1 *	0.608200	224.8812	59.24000	0.0000
At most 2 *	0.564084	199.2731	53.18784	0.0000
At most 3 *	0.525461	178.8987	47.07897	0.0000
At most 4 *	0.491292	162.2113	40.95680	0.0000
At most 5 *	0.488866	161.0697	34.80587	0.0001
At most 6 *	0.452106	144.4014	28.58808	0.0000
At most 7 *	0.412108	127.4907	22.29962	0.0000
At most 8 *	0.355312	105.3573	15.89210	0.0000
At most 9 *	0.337474	98.80701	9.164546	0.0001
Max-eigenvalue test indicates 10 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**Mackinnon-Haug-Michelis (1999) p-values				

*Author's own calculation using Eviews10

Although the variables are stationary (I(0)), researchers sometimes still apply the Johansen cointegration test as a robustness check. In theory, cointegration is relevant only for non-stationary (I(1)) series. However, applying it to stationary data helps verify whether there exist stable long-run relationships or common equilibrium patterns among variables.

In such cases, results (like full cointegration) mainly reflect that the series are already stationary rather than true long-run equilibrium behaviour. Therefore, the test is used for confirmation and consistency, not as primary evidence of cointegration.

The Johansen cointegration test results for BRICS stock and forex returns (Jan 2006–Mar 2026) indicate very strong long-run integration among all variables.

Both the Trace test and Maximum Eigenvalue test reject the null hypothesis at every level (from “none” to “at most 9”), confirming 10 cointegrating equations at the 5% significance level. This implies that all variables—stock indices (BSE, Bovespa, FTSE, MOEX, Shanghai) and exchange rates (INR, BRL, RUB, CNY, ZAR)—are tied together by **stable long-run equilibrium relationships**.

Economically, this suggests that despite short-run fluctuations, BRICS financial markets move together in the long run, driven by common factors such as trade integration, commodity price cycles, and global financial shocks. Events like the Global Financial Crisis and COVID-19 pandemic likely strengthened this co-movement.

Overall, the results highlight strong long-run financial integration within BRICS, supporting the existence of interconnected stock and currency markets.

4.5 Granger Causality Test

Pairwise Granger Causality Tests

Sample: 2006M01 2026M03

Lags: 2

Table no. 6 – Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
BSE_RETN does not Granger Cause BOVESPA_RETN	240	0.39640	0.6732
BOVESPA_RETN does not Granger Cause BSE_RETN		1.49382	0.2266
FTSE_RETN does not Granger Cause BOVESPA_RETN	239	0.48446	0.6166
BOVESPA_RETN does not Granger Cause FTSE_RETN		0.53766	0.5848
MOEX_RETN does not Granger Cause BOVESPA_RETN	240	2.94293	0.0547
BOVESPA_RETN does not Granger Cause MOEX_RETN		0.65690	0.5194
SHAN_RETN does not Granger Cause BOVESPA_RETN	240	1.48423	0.2288
BOVESPA_RETN does not Granger Cause SHAN_RETN		0.86275	0.4233
BRL_RETN does not Granger Cause BOVESPA_RETN	240	0.25751	0.7732
BOVESPA_RETN does not Granger Cause BRL_RETN		1.92850	0.1477
CNY_RETN does not Granger Cause BOVESPA_RETN	240	0.80009	0.4505
BOVESPA_RETN does not Granger Cause CNY_RETN		0.72889	0.4835
INR_RETN does not Granger Cause BOVESPA_RETN	240	1.04691	0.3527
BOVESPA_RETN does not Granger Cause INR_RETN		2.53018	0.0818
RUB_RETN does not Granger Cause BOVESPA_RETN	240	0.70556	0.4949
BOVESPA_RETN does not Granger Cause RUB_RETN		0.14907	0.8616
ZAR_RETN does not Granger Cause BOVESPA_RETN	240	0.45770	0.6333
BOVESPA_RETN does not Granger Cause ZAR_RETN		2.26793	0.1058

FTSE_RETN does not Granger Cause BSE_RETN	239	1.51347	0.2223
BSE_RETN does not Granger Cause FTSE_RETN		0.81053	0.4459
MOEX_RETN does not Granger Cause BSE_RETN	240	4.23468	0.0156
BSE_RETN does not Granger Cause MOEX_RETN		4.64567	0.0105
SHAN_RETN does not Granger Cause BSE_RETN	240	5.63809	0.0041
BSE_RETN does not Granger Cause SHAN_RETN		0.16049	0.8518
BRL_RETN does not Granger Cause BSE_RETN	240	1.43264	0.2408
BSE_RETN does not Granger Cause BRL_RETN		2.28959	0.1036
CNY_RETN does not Granger Cause BSE_RETN	240	0.21829	0.8041
BSE_RETN does not Granger Cause CNY_RETN		1.03884	0.3555
INR_RETN does not Granger Cause BSE_RETN	240	0.83637	0.4346
BSE_RETN does not Granger Cause INR_RETN		0.77354	0.4625
RUB_RETN does not Granger Cause BSE_RETN	240	3.86133	0.0224
BSE_RETN does not Granger Cause RUB_RETN		0.13472	0.8740
ZAR_RETN does not Granger Cause BSE_RETN	240	1.28090	0.2797
BSE_RETN does not Granger Cause ZAR_RETN		2.41162	0.0919
MOEX_RETN does not Granger Cause FTSE_RETN	239	0.06530	0.9368
FTSE_RETN does not Granger Cause MOEX_RETN		0.82196	0.4408
SHAN_RETN does not Granger Cause FTSE_RETN	239	1.13257	0.3240
FTSE_RETN does not Granger Cause SHAN_RETN		0.54805	0.5788
BRL_RETN does not Granger Cause FTSE_RETN	239	1.38452	0.2525
FTSE_RETN does not Granger Cause BRL_RETN		1.58971	0.2062
CNY_RETN does not Granger Cause FTSE_RETN	239	0.85790	0.4254
FTSE_RETN does not Granger Cause CNY_RETN		0.71915	0.4882
INR_RETN does not Granger Cause FTSE_RETN	239	2.10881	0.1237
FTSE_RETN does not Granger Cause INR_RETN		2.87220	0.0586
RUB_RETN does not Granger Cause FTSE_RETN	239	0.36871	0.6920
FTSE_RETN does not Granger Cause RUB_RETN		0.25256	0.7770
ZAR_RETN does not Granger Cause FTSE_RETN	239	2.62083	0.0749

FTSE_RETN does not Granger Cause ZAR_RETN 4.57353 **0.0113**

SHAN_RETN does not Granger Cause MOEX_RETN 240 3.63582 **0.0279**

MOEX_RETN does not Granger Cause SHAN_RETN 2.65139 **0.0727**

BRL_RETN does not Granger Cause MOEX_RETN 240 0.96037 0.3842

MOEX_RETN does not Granger Cause BRL_RETN 2.28313 0.1042

CNY_RETN does not Granger Cause MOEX_RETN 240 1.31127 0.2714

MOEX_RETN does not Granger Cause CNY_RETN 0.56896 0.5669

INR_RETN does not Granger Cause MOEX_RETN 240 0.59164 0.5542

MOEX_RETN does not Granger Cause INR_RETN 2.34597 **0.0980**

RUB_RETN does not Granger Cause MOEX_RETN 240 3.72074 **0.0257**

MOEX_RETN does not Granger Cause RUB_RETN 0.87262 0.4192

ZAR_RETN does not Granger Cause MOEX_RETN 240 1.85755 0.1583

MOEX_RETN does not Granger Cause ZAR_RETN 2.13207 0.1209

BRL_RETN does not Granger Cause SHAN_RETN 240 0.43822 0.6457

SHAN_RETN does not Granger Cause BRL_RETN 0.40596 0.6668

CNY_RETN does not Granger Cause SHAN_RETN 240 0.84912 0.4291

SHAN_RETN does not Granger Cause CNY_RETN 0.38341 0.6820

INR_RETN does not Granger Cause SHAN_RETN 240 1.38503 0.2524

SHAN_RETN does not Granger Cause INR_RETN 3.74912 **0.0250**

RUB_RETN does not Granger Cause SHAN_RETN 240 0.40602 0.6668

SHAN_RETN does not Granger Cause RUB_RETN 0.98881 0.3736

ZAR_RETN does not Granger Cause SHAN_RETN 240 1.24427 0.2900

SHAN_RETN does not Granger Cause ZAR_RETN 1.37822 0.2541

CNY_RETN does not Granger Cause BRL_RETN 240 1.50515 0.2241

BRL_RETN does not Granger Cause CNY_RETN 0.06744 0.9348

INR_RETN does not Granger Cause BRL_RETN 240 4.15061 **0.0169**

BRL_RETN does not Granger Cause INR_RETN 1.59245 0.2056

RUB_RETN does not Granger Cause BRL_RETN 240 0.79757 0.4516

BRL_RETN does not Granger Cause RUB_RETN 0.09614 0.9084

ZAR_RETN does not Granger Cause BRL_RETN	240	1.75035	0.1760
BRL_RETN does not Granger Cause ZAR_RETN		1.13380	0.3236
<hr/>			
INR_RETN does not Granger Cause CNY_RETN	240	1.17023	0.3121
CNY_RETN does not Granger Cause INR_RETN		0.75342	0.4719
<hr/>			
RUB_RETN does not Granger Cause CNY_RETN	240	4.28834	0.0148
CNY_RETN does not Granger Cause RUB_RETN		1.07367	0.3434
<hr/>			
ZAR_RETN does not Granger Cause CNY_RETN	240	0.27977	0.7562
CNY_RETN does not Granger Cause ZAR_RETN		0.91246	0.4030
<hr/>			
RUB_RETN does not Granger Cause INR_RETN	240	1.31842	0.2695
INR_RETN does not Granger Cause RUB_RETN		0.37715	0.6862
<hr/>			
ZAR_RETN does not Granger Cause INR_RETN	240	0.14123	0.8684
INR_RETN does not Granger Cause ZAR_RETN		0.63264	0.5321
<hr/>			
ZAR_RETN does not Granger Cause RUB_RETN	240	0.81512	0.4438
RUB_RETN does not Granger Cause ZAR_RETN		0.68362	0.5058

*Author's own calculation using Eviews10

The pairwise Granger causality results for BRICS stock indices and currency returns (Jan 2006–Mar 2026) reveal a limited but selective transmission of return spillovers, with stronger intra-market (stock–stock) linkages than cross-market (stock–currency) effects.

First, among stock markets, a bidirectional causality exists between BSE Sensex and MOEX Russia Index ($p < 0.05$), indicating strong financial integration between India and Russia. This may be attributed to energy trade linkages and geopolitical alignment, especially post-2014 and after the Russia-Ukraine conflict, which increased India–Russia economic interactions.

Unidirectional causality is observed from Shanghai Composite Index and MOEX to BSE, suggesting that India's equity market is influenced by external shocks from China and Russia, reflecting their roles as major trading partners. Conversely, BSE does not significantly influence these markets, implying asymmetric dependence.

Second, the Bovespa Index appears largely exogenous, with no strong causal linkages except weak evidence from MOEX (10% level). This suggests relative segmentation of Latin American markets from Asian and European BRICS economies, possibly due to geographic and structural differences.

Third, currency–stock interactions are generally weak. Most exchange rates (BRL, CNY, INR, RUB, ZAR) do not Granger-cause stock returns, indicating that equity markets are not strongly driven by short-term currency fluctuations. However, some exceptions exist:

- Indian Rupee → BRL ($p < 0.05$), suggesting spillover from Indian macroeconomic conditions to Brazil.

- Russian Ruble → CNY ($p < 0.05$), reflecting energy-price and trade channel effects between Russia and China.
- INR → Shanghai Composite (reverse direction significant), implying feedback from China to India's currency, possibly through trade imbalances.

Fourth, some weak (10% level) causalities—such as Bovespa → INR and FTSE → ZAR—indicate episodic spillovers during global shocks like the Global Financial Crisis and COVID-19 pandemic.

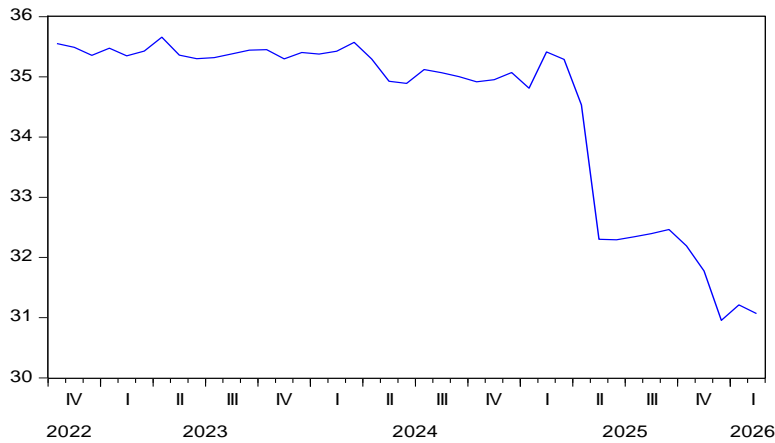
Overall, the findings suggest that BRICS financial markets are partially integrated, with stronger equity market interdependence (especially India–Russia–China) and relatively weak currency-driven spillovers. This supports the view that real economic linkages (trade, commodities, geopolitics) dominate financial transmission channels rather than exchange rate dynamics in the BRICS bloc.

4.6 Spillover Table

Table no. 7- Spillover Table

Spillover (Connectedness) Table											
	bovespa_retn	moex_retn	bse_retn	shan_retn	ftse_retn	brl_retn	rub_retn	inr_retn	cny_retn	zar_retn	From Others
bovespa_retn	97.6	0.0	0.1	0.0	0.5	0.2	0.0	0.7	0.1	0.6	2.4
moex_retn	25.1	69.2	0.6	1.1	0.0	0.5	3.1	0.1	0.0	0.2	30.8
bse_retn	36.9	6.3	54.3	0.2	0.0	0.1	0.0	0.6	0.5	1.1	45.7
shan_retn	13.3	0.9	2.6	79.6	0.1	1.0	0.1	1.9	0.1	0.4	20.4
ftse_retn	34.1	4.1	3.1	2.2	55.0	0.0	0.1	0.3	0.1	1.0	45.0
brl_retn	45.1	1.8	0.1	0.1	0.2	51.6	0.2	0.5	0.0	0.2	48.4
rub_retn	12.8	2.0	0.5	1.0	0.1	1.9	80.0	0.6	0.2	0.8	20.0
inr_retn	19.8	2.4	13.1	0.7	0.3	6.2	1.0	55.8	0.6	0.1	44.2
cny_retn	4.9	0.6	0.1	0.7	6.3	0.6	0.4	2.8	83.2	0.5	16.8
zar_retn	40.2	1.9	2.1	0.5	3.1	5.6	0.5	1.8	5.3	39.1	60.9
Contribution to others	232.2	20.0	22.3	6.6	10.7	16.1	5.5	9.3	7.1	4.7	334.4
Contribution including own	329.8	89.2	76.6	86.2	65.7	67.7	85.4	65.1	90.3	43.9	Spillover Index=33.4%

*Author's own calculation using Eviews10



*Author's own calculation using Eviews10 **Figure no.1 Spillover Graph**

The Diebold–Yilmaz Spillover Index results for BRICS stock and currency returns (January 2006–March 2026) indicate a **moderate level of interconnectedness**, with a **total spillover index of 33.4%**. This suggests that about one-third of forecast error variance is driven by cross-market shocks, while the remaining portion is explained by own-market dynamics.

The diagonal elements (own variance shares) are relatively high for most variables—such as Bovespa (97.6%), CNY (83.2%), and RUB (80.0%)—indicating that domestic factors dominate return behavior. However, some markets like South Africa (ZAR, 39.1%) and India (INR, 55.8%) exhibit lower own shares, implying greater external vulnerability.

In terms of directional spillovers, **Brazilian markets (Bovespa and BRL)** emerge as the **largest net transmitters**, with a very high contribution to others (232.2). This highlights Brazil's central role in transmitting shocks across BRICS. Conversely, **South Africa (ZAR)** is the **largest net receiver**, with the highest “from others” value (60.9), indicating strong susceptibility to external influences.

Among stock markets, **India (BSE) and the UK-linked FTSE (South Africa proxy)** show substantial spillover reception (45.7 and 45.0 respectively), suggesting exposure to global and intra-BRICS shocks. **China (Shanghai and CNY)** displays relatively low spillover dependence, reinforcing its more insulated financial structure.

Currency markets show mixed dynamics: **BRL and INR** are more interconnected, while **CNY and RUB** remain relatively insulated. This reflects differences in exchange rate regimes and capital controls.

Overall, the findings suggest **partial financial integration within BRICS**, with clear asymmetry: a few dominant transmitters (especially Brazil) and several vulnerable receivers (notably South Africa and India). The moderate spillover level also implies **scope for diversification**, though contagion risks remain significant, especially during periods of global financial stress.

Section 5: Discussion

The empirical findings provide important insights into the nature of interlinkages among BRICS stock and foreign exchange markets over the period 2006–2026. The VAR lag selection results indicate an optimal lag length of zero, implying that past values do not significantly influence current movements. This suggests that interactions are largely contemporaneous, meaning that shocks are transmitted within the same period. Economically, this reflects high market efficiency and rapid information transmission across BRICS financial systems.

The Johansen cointegration results show full cointegration among all variables. However, since the data are stationary ($I(0)$), this outcome should not be interpreted as true long-run equilibrium relationships. Instead, it reflects the stable and consistent behavior of the series over time. Thus, while the variables move together, this does not necessarily imply deep structural integration. The Granger causality analysis reveals selective and asymmetric relationships. Stronger linkages are observed among stock markets, particularly between India, Russia, and China. India appears to be more influenced by external markets, especially Russia and China, highlighting its exposure to global and regional economic developments. In contrast, Brazil shows relatively weak connections, indicating partial segmentation from other BRICS economies.

Currency–stock interactions are generally weak, suggesting that exchange rate movements do not strongly affect stock returns in the short run. This may be due to domestic policy controls, managed exchange rate regimes, or the dominance of internal economic factors. However, a few significant relationships point to the role of trade and commodity linkages in transmitting shocks. The spillover analysis confirms moderate interconnectedness, with a total spillover index of 33.4%. While cross-market effects are present, domestic factors remain dominant. Brazil emerges as a major transmitter of shocks, while South Africa and India are more vulnerable to external influences. China appears relatively insulated, likely due to regulatory controls and limited capital account openness.

Overall, the findings suggest that BRICS financial markets are partially integrated, with uneven linkages and limited influence of currency markets on equities.

Section 6: Conclusion

This study provides a comprehensive analysis of the interrelationships between BRICS stock markets and foreign exchange markets using multiple econometric techniques. The results offer a nuanced understanding of both short-run and long-run dynamics within these emerging economies.

The absence of significant lag effects in the VAR model indicates that past values do not play a major role in explaining current market behavior. Instead, financial markets respond quickly to new information, leading to contemporaneous interactions. This highlights the increasing efficiency and responsiveness of BRICS financial systems in the modern globalized environment. Although the Johansen cointegration test suggests the presence of multiple long-run relationships, this result is primarily driven by the stationary nature of the data rather than genuine long-term equilibrium linkages. It indicates stability and co-movement rather than deep structural dependence among markets.

The Granger causality results reveal that interdependence within BRICS is selective and asymmetric. Stock markets exhibit stronger linkages compared to exchange rates, with India, Russia, and China forming a relatively interconnected group. India's market, in particular, appears more sensitive to external influences, reflecting its growing integration with global and regional economies. On the other hand, Brazil's relative isolation suggests that geographic and structural factors still limit full integration within BRICS.

The spillover analysis further reinforces these findings by showing moderate interconnectedness. With a spillover index of 33.4%, the results indicate that while cross-market shocks are important, they do not dominate market behaviour. Domestic factors continue to play a crucial role in shaping financial dynamics. The presence of key transmitters (such as Brazil) and major receivers (such as South Africa and India) highlights the asymmetric nature of financial integration within the BRICS group (Chakraborty et.al 2025).

From an economic perspective, these findings suggest that BRICS financial markets are in a transitional phase of integration. While there is evidence of growing interconnectedness, particularly among equity markets, the overall system remains fragmented. Differences in economic structure, policy frameworks, and levels of financial development contribute to this uneven integration.

Importantly, the moderate level of spillovers implies that diversification opportunities still exist for investors within BRICS markets. However, the presence of interconnectedness also means that shocks can spread across markets, especially during periods of global financial stress. Therefore, both opportunities and risks coexist in the BRICS financial landscape.

In summary, the study concludes that BRICS financial markets are partially integrated, with stronger equity market linkages, weak currency-driven effects, and significant asymmetry in shock transmission. The findings emphasize the need for a balanced approach to financial integration that promotes stability while enhancing connectivity among member economies.

Section 7: Policy Implications

Policymakers should focus on improving financial coordination among BRICS countries, especially to manage cross-border shocks. Strengthening financial stability frameworks is important for more vulnerable economies like India and South Africa. At the same time, maintaining stable exchange rate policies and promoting gradual financial integration can help reduce asymmetry and enhance resilience.

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