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ORIGINAL

Temporal Dynamics of BRIC-A and US Stock Indices: Pre-, During-, and Post-Pandemic Analysis

Dinámica temporal de los índices bursátiles de BRIC-A y EE. UU: Análisis antes, durante y después de la pandemia

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ABSTRACT

Introduction: global financial markets exhibit varying degrees of interdependence, which can shift during systemic disruptions such as the COVID-19 pandemic. Understanding these dynamics is crucial for investors, policymakers, and risk managers.
Objectives: to examine the evolving interdependence between the US stock market and BRIC-A stock markets (Brazil, Russia, India, China, and South Africa) across three distinct periods: pre-pandemic, pandemic, and post-pandemic.
Method: the Johansen cointegration framework was used to test for the presence and stability of long-run relationships, and the Granger causality test identified short-run directional linkages among the markets during the three phases.
Results: the analysis revealed that the long-run equilibrium between the US and Indian markets remained stable throughout, while structural shifts were observed in the relationships with China and Russia, indicating heterogeneous market responses to systemic shocks. In the short run, bidirectional linkages between the US and all BRIC-A markets existed before the pandemic; however, post-pandemic, these persisted only with India's BSE and China's SSE indices.
Conclusions: global crises can recalibrate financial market integration, reducing linkages among major markets and reshaping interdependencies. These findings have significant implications for portfolio diversification strategies, contagion risk management, and international policy coordination during periods of systemic disruption.

Keywords: COVID-19; Johansen Cointegration; Granger Causality; BRIC-A; Financial Market Integration; Systemic Shocks.

RESUMEN

Introducción: los mercados financieros globales presentan diversos grados de interdependencia, los cuales pueden cambiar durante las disrupciones sistémicas, como la pandemia de COVID-19. Comprender estas dinámicas es crucial para inversionistas, responsables de políticas y gestores de riesgos.

Objetivos: examinar la evolución de la interdependencia entre el mercado bursátil de Estados Unidos y los mercados bursátiles BRIC-A (Brasil, Rusia, India, China y Sudáfrica) en tres periodos distintos: pre-pandemia, pandemia y post-pandemia.
Método: se utilizó el marco de cointegración de Johansen para probar la presencia y estabilidad de relaciones a largo plazo, y la prueba de causalidad de Granger para identificar vínculos direccionales a corto plazo entre los mercados durante las tres fases.
Resultados: el análisis reveló que el equilibrio a largo plazo entre los mercados de Estados Unidos e India se mantuvo estable en todo momento, mientras que se observaron cambios estructurales en las relaciones con China y Rusia, lo que indica respuestas heterogéneas de los mercados ante choques sistémicos. A corto plazo, existieron vínculos bidireccionales entre Estados Unidos y todos los mercados BRIC-A antes de la pandemia; sin embargo, después de la pandemia, estos persistieron únicamente con los índices BSE de India y SSE de China.
Conclusiones: las crisis globales pueden recalibrar la integración de los mercados financieros, reduciendo los vínculos entre los principales mercados y reconfigurando las interdependencias. Estos hallazgos tienen implicaciones significativas para las estrategias de diversificación de carteras, la gestión del riesgo de contagio y la coordinación de políticas internacionales durante períodos de disrupción sistémica

Palabras clave: COVID-19; Cointegración de Johansen; Causalidad de Granger; BRIC-A; Integración del mercado financiero; Choques sistémicos.

INTRODUCTION

Financial markets have repeatedly been subjected to severe disruptions, including Black Monday in 1987, when the Dow Jones Industrial Average plunged over 22 % in a single day.[1] the Asian financial crisis of 1997–1998, which triggered deep recessions in Thailand, Indonesia, and South Korea.[2] Russia's 1998 debt default and subsequent collapse.[3] the 2008 global financial crisis, rooted in the US subprime mortgage market and leading to a worldwide recession.[4] and the Eurozone debt crisis of 2009, which particularly affected Greece, Ireland, and Portugal.[5] These episodes underscore the inherently interconnected nature of global financial systems, where shocks in one region can propagate rapidly across borders, impacting economies and markets worldwide. The COVID-19 pandemic brought this interconnectedness into sharp focus, as the initial outbreak in China disrupted global supply chains, triggered volatility, and intensified correlation among global markets.[6,7] Such events highlight the necessity for continuous monitoring and analysis of financial linkages, particularly during systemic crises.

Modern Portfolio Theory, pioneered by Markowitz.[8] emphasizes the value of diversification reducing investment risk through the combination of assets with low or negative correlations. However, empirical evidence has shown that during crises, correlations between markets tend to increase, undermining the effectiveness of traditional diversification strategies.[9] This study focuses on the BRIC-A countries Brazil, Russia, India, China, and Argentina and their evolving relationships with the US stock market across pre-pandemic, pandemic, and post-pandemic periods. The inclusion of Argentina alongside the BRIC nations is justified by its status as a significant emerging market with considerable growth potential and geopolitical influence in Latin America.[10] Despite the strategic importance of these economies, comparative empirical research on their interactions with the US market, especially in the context of COVID-19, remains limited.[7]

Recent studies provide important insights into the nature and dynamics of these linkages. For example, volatility spillover analysis using multivariate GARCH-BEKK models has shown significant contagion effects among BRIC markets and with the US during COVID-19, with Russia demonstrating high sensitivity to US market movements.[11] Kumar and Gupta.[12] employing a DCC-GARCH framework, found that India and China acted as both key transmitters and receivers of financial stress across multiple asset classes during the pandemic. Research into BRICS term-structure connectedness using time-varying parameter vector autoregression (TVP-VAR) models has revealed shifting patterns of interdependence, with Brazil and South Africa serving as net transmitters and China and India as net receivers of interest rate shocks during pandemic waves.[13] Time-frequency spillover analyses between BRIC and G7 markets have further demonstrated short-term contagion during geopolitical stress, though COVID-19 did not produce exceptional volatility spillovers in every case.[14] Studies on market efficiency and multifractality indicate that the pandemic's effects were heterogeneous, with China improving in post-pandemic efficiency while Brazil became more inefficient. Collectively, these findings reveal that crisis-driven changes in correlations and spillovers can erode diversification benefits, that emerging markets often play pivotal roles in absorbing or transmitting financial shocks, and that advanced econometric techniques such as BEKK, DCC-GARCH, TVP-VAR, and multifractal analysis are critical for capturing the evolving complexity of global market linkages.

Against this backdrop, the present study applies both long-run (Johansen cointegration) and short-run (Granger causality) methodologies to assess the stability and evolution of US–BRIC-A financial linkages across distinct pandemic phases. By including Argentina in the BRIC framework, this research addresses a gap in comparative studies of emerging market behavior during global crises. The findings are expected to offer significant implications for investors seeking to optimize diversification strategies, for policymakers aiming to mitigate contagion risks, and for scholars interested in the evolving patterns of financial integration under systemic shocks.

METHOD

This study utilizes daily closing price data spanning a decade from April 1, 2013, to June 30, 2023 to provide a comprehensive temporal framework for analyzing inter-market linkages and their evolution surrounding the COVID-19 pandemic. This period was selected to balance the dual imperatives of historical depth and contemporary relevance, encompassing pre-pandemic stability, pandemic-induced market turmoil, and the subsequent recovery phase.

The study focuses on six principal stock indices representing the BRIC-A countries and the US, as detailed in table 1.

Table 1. Selected Stock Market Indices of the Sample Countries

S.No	Country	Index Selected
1	Brazil	BOVESPA
2	Russia	RTSI
3	India	SENSEX
4	China	SSE
5	Argentina	S&P MERVAL
6	US	S&P 500

The daily closing prices were sourced from investing.com and the official Bombay Stock Exchange (BSE) website, ensuring data reliability and consistency. For analytical rigor, logarithmic returns were computed as:

$$r_t = (logP_t - logP_{t-1)} * 100$$

where r_t represents the return at time t, P_t is the closing price index on day t, and P_{t-1} is the price index on day t−1. The use of logarithmic returns is consistent with financial econometrics best practices, providing symmetry and stationarity essential for subsequent time-series analysis.[15]

Addressing missing data due to asynchronous trading holidays across different exchanges, the study employs a pragmatic approach inspired by Occam's razor principle.[16] wherein missing values are imputed by carrying forward the preceding day's price. This approach is theoretically justified as non-trading days convey no new market information, thus minimizing bias in correlation and cointegration analyses.

The delineation of the pandemic period follows a considered synthesis of official timelines and prior academic definitions.[17] Although the initial COVID-19 cases emerged in December 2019, the World Health Organization's designation of the outbreak as a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, and its classification as a pandemic on March 11, 2020, provide key reference points. The resumption of regular international flights by the Indian Civil Aviation Ministry on March 27, 2022, marking a return to pre-pandemic mobility conditions, frames the end of the pandemic period for this study. Consequently, the timeline is partitioned into three distinct phases for analysis:

1. Pre-Pandemic: October 1, 2013 – January 29, 2020 (1784 trading days)
2. Pandemic: January 30, 2020 – March 8, 2022 (549 trading days)
3. Post-Pandemic: March 9, 2022 – September 30, 2023 (343 trading days)

This stratification enables a granular investigation of stock market interdependencies across temporally heterogeneous regimes, capturing structural breaks and regime shifts induced by the pandemic's unprecedented economic impact.[18]

The study employs a multi-stage econometric approach to assess inter-market linkages across the selected stock indices. Initially, descriptive statistics and correlation analysis are conducted to evaluate the fundamental characteristics of returns and to examine pairwise relationships among markets in each sub-period. To ensure the validity of subsequent modeling, stationarity testing is performed using the Augmented Dickey–Fuller (ADF)

and Phillips–Perron (PP) tests, confirming the integration order of the series. The Johansen Cointegration Test is then applied to identify the presence of long-run equilibrium relationships among the indices. To capture both short-run and long-run causal dynamics, Granger causality analysis is implemented within a Vector Error Correction Model (VECM) framework. Finally, Impulse Response Functions (IRFs) and Variance Decomposition are employed to investigate the dynamic interactions and the transmission of shocks across markets.

RESULTS

The empirical findings from correlation analysis, unit root tests, cointegration tests, and Granger causality provide insights into the dynamic interdependencies among the selected stock markets across pre-pandemic, pandemic, and post-pandemic periods

Table 2. Correlation among Indices (Pre pandemic Period)

	BRAZIL	RUSSIA	INDIA	CHINA	ARGENTINA	US
BRAZIL	1,000					
RUSSIA	0,02*	1,000				
INDIA	0,907*	0,303*	1,000			
CHINA	0,036	-0,439*	0,246*	1,000		
ARGENTINA	0,927*	0,380*	0,938*	0,194*	1,000	
US	0,934*	0,398*	0,971*	0,218*	0,963*	1,000

Note: * Significant at 0,05

The correlation matrices reveal varying degrees of interdependence across the three sub-periods. During the pre-pandemic period, most indices exhibited strong positive correlations with the US market, particularly India (0,971) and Argentina (0,963), while China showed weak association (0,218), table 3.

Table 3. Correlation among Indices (pandemic Period)

	BRAZIL	RUSSIA	INDIA	CHINA	ARGENTINA	US
BRAZIL	1,000					
RUSSIA	0,668*	1,000				
INDIA	0,692*	0,802*	1,000			
CHINA	0,751*	0,672*	0,855*	1,000		
ARGENTINA	0,462*	0,652*	0,902*	0,721*	1,000	
US	0,703*	0,796*	0,973*	0,863*	0,902*	1,000

Note: * Significant at 0,05

In contrast, the pandemic period marked a substantial increase in correlation across all markets, with the US-India pair showing the highest value (0,973) and China (0,863) also aligning closely with global trends, table 3.

Table 4. Correlation among Indices (Post pandemic Period)

	BRAZIL	RUSSIA	INDIA	CHINA	ARGENTINA	US
BRAZIL	1,000					
RUSSIA	-0,281*	1,000				
INDIA	0,625*	-0,423*	1,000			
CHINA	-0,350*	0,054	-0,110*	1,000		
ARGENTINA	0,457*	-0,348*	0,843*	0,018	1,000	
US	0,602*	-0,349*	0,576*	0,172*	0,577*	1,000

Note: * Correlation is significant at 0,05

However, in the post-pandemic phase, correlation values declined markedly, and some pairs, such as Russia-Brazil (–0,281) and China–Brazil (–0,350), even turned negative, indicating structural decoupling, table 4.

Results from the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests confirm that all return series are non-stationary at level but become stationary at first differences, satisfying the I(1)I(1)I(1) property required for cointegration analysis, tables 5 and 6.

Table 5. Unit Root Test

	Different periods at Total Period		level Pre pandemic Period		Pandemic Period		Post Pandemic Period	
Index	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
BRAZIL	-1,050	-1,163	0,477	0,733	-1,356	-1,656	-2,141	-2,264
RUSSIA	-2,476	-2,625	-1,094	-1,128	-1,225	-1,356	-2,746	-2,711
INDIA	-0,035	-0,050	-0,921	-0,885	-0,734	-0,779	-1,221	-1,326
CHINA	-2,808	-2,866*	-2,263	-2,178	-1,886	-1,876	-3,018*	-2,963*
ARGENA	7,931	5,307	-0,726**	-0,764**	-0,240	-0,282	0,649	0,751
US	-0,870	-0,828	-0,377	-0,299	-0,991	-1,002	-2,007	-2,007

Note: *Significant at 1 %; **Significant at 5 %

Table 6. Unit Root Test

	Different Periods at 1st difference							
Index	**Total Period**		**Pre pandemic Period**		**Pandemic Period**		**Post Pandemic Period**	
	ADF	**PP**	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
BRAZIL	-56,603*	-56,327*	-42,318*	-42,479*	-28,701*	-28,136*	-18,740*	-18,692*
RUSSIA	-51,887*	-51,938*	-39,430*	-39,421*	-25,958*	-25,824*	-16,829*	-16,784*
INDIA	-21,318*	-50,292*	-38,433*	-38,394*	-23,754*	-23,782*	-19,448*	-19,463*
CHINA	-48,257*	-48,287*	-18,601*	-37,642*	-23,126*	-23,127*	-20,951*	-21,141*
ARGEN	-8,174*	-39,779*	-45,870*	-45,811*	-22,147*	-22,132*	-15,134*	-15,378*
US	-15,814*	-56,460	-40,938*	-41,002*	-6,792*	-28,463*	-20,149*	-20,154*

Note: *Significant at 1 %; **Significant at 5 %

Table 7. Co integration Test Results Total Period

Indices	Eigenvalue	Trace Statistic	Prob,	Cointegrated
US - Brazil	0,003110	9,273246	0,3407	No
US - Russia	0,003499	10,62289	0,2358	No
US - India	0,005206	15,08479	0,0501*	Yes
US - China	0,002695	7,854993	0,4810	No
US - Argentina	0,001236	4,523478	0,8571	No

The Johansen cointegration results suggest a limited presence of long-run relationships. For the total sample, only the US–India pair demonstrates cointegration (p = 0,0501), table 7.

A similar pattern persists in the pre-pandemic period, table 8.

Table 8. Co integration Test Results Pre Pandemic Period

Indices	Eigenvalue	Trace Statistic	Prob,	Cointegrated
US - Brazil	0,008004	13,42125	0,1002	No
US - Russia	0,005138	8,794853	0,3847	No
US - India	0,009184	16,46935	0,0356*	Yes
US - China	0,002885	4,912391	0,8181	No
US - Argentina	0,005873	11,31592	0,1928	No

Table 9. Co integration Test Results Pandemic Period

Indices	Eigenvalue	Trace Statistic	Prob,	Cointegrated
US - Brazil	0,008676	6,455628	0,6416	No
US - Russia	0,002781	1,985527	0,9952	No
US - India	0,035198	21,13492	0,0063*	Yes
US - China	0,027514	16,56943	0,0343*	Yes
US - Argentina	0,007141	4,579543	0,8517	No

Table 10. Co integration Test Results Post Pandemic Period

Indices	Eigenvalue	Trace Statistic	Prob,	Cointegrated
US - Brazil	0,015615	10,20756	0,2651	No
US - Russia	0,027312	15,18810	0,0501*	Yes
US - India	0,012243	16,997493	0,0439*	Yes
US - China	0,018977	11,39387	0,1884	No
US - Argentina	0,015621	6,355648	0,6535	No

Table 11. Pair wise Granger Causality Test Results - Pre Pandemic Period

Null Hypothesis	F statistics	Prob.
US does not Granger Cause Brazil	1,463	0,231
Brazil does not Granger Cause US	3,186	0,042**
US does not Granger Cause Russia	22,920	2,E-10*
Russia does not Granger Cause US	0,415	0,659
US does not Granger Cause India	46,287	3,E-20*
India does not Granger Cause US	2,692	0,0680
US does not Granger Cause China	19,259	5,E-09*
China does not Granger Cause US	0,681	0,505
US does not Granger Cause Argentina	3,157	0,0428**
Argentina does not Granger Cause US	9,853	0,605

Table 12. Pair wise Granger Causality Test Results -Pandemic Period

Null Hypothesis	F statistics	Prob,
US does not Granger Cause Brazil	1,345	0,261
Brazil does not Granger Cause US	0,834	0,434
US does not Granger Cause Russia	13,277	2,E-06*
Russia does not Granger Cause US	0,782	0,457
US does not Granger Cause India	36,414	1,E-15*
India does not Granger Cause US	5,313	0,005*
US does not Granger Cause China	10,087	5,E-05*
China does not Granger Cause US	0,237	0,788
US does not Granger Cause Argentina	1,083	0,339
Argentina does not Granger Cause US	0,165	0,847

Table 13. Pair wise Granger Causality Test Results- Post Pandemic Period

Null Hypothesis	F statistics	Prob.
US does not Granger Cause Brazil	0,635	0,530
Brazil does not Granger Cause US	0,575	0,563
US does not Granger Cause Russia	0,476	0,621
Russia does not Granger Cause US	1,784	0,169
US does not Granger Cause India	37,533	1,E-15*
India does not Granger Cause US	0,261	0,770
US does not Granger Cause China	7,420	0,001*
China does not Granger Cause US	1,466	0,232
US does not Granger Cause Argentina	0,181	0,833
Argentina does not Granger Cause US	1,404	0,246

During the pandemic, both US–India and US–China pairs show significant long-run linkages ($p < 0,05$), reflecting heightened global integration, table 9.

Post-pandemic, cointegration persists between the US and India, and a new relationship emerges with

Russia, table 10.

Granger causality tests reveal strong unidirectional causality from the US to most markets in all periods, especially towards India (F = 46,287, p < 0,01 pre-pandemic; F = 36,414, p < 0,01 pandemic; F = 37,533, p < 0,01 post-pandemic), confirming the US as a dominant transmitter of shocks, tables 11–13. Reciprocal causality is minimal, with a few exceptions during the pandemic, such as India influencing the US (p = 0,005).

DISCUSSION

The graphical analysis of the pandemic period reveals pronounced volatility in the stock markets of India, Argentina, and Brazil, contrasting sharply with the comparatively muted fluctuations observed in the indices of China, Russia, and the United States. Notably, within approximately two months following the onset of pandemic-induced lockdowns, the most volatile markets Brazil's BOVESPA, Argentina's S&P MERVAL, and India's Sensex plummeted to their respective nadirs. The trajectories of subsequent recoveries diverged markedly, reflecting heterogeneous market resilience and macroeconomic conditions. India's Sensex required an extended recovery horizon of nearly ten months to reclaim pre-pandemic valuation levels, indicative of enduring economic and systemic shocks. In contrast, Argentina's S&P MERVAL exhibited a relatively swift rebound within five months, suggesting more agile market adjustments or differing pandemic impacts. Brazil's BOVESPA endured the most protracted recuperation phase, spanning approximately fifteen and a half months, underscoring structural vulnerabilities and perhaps the compounded effects of policy responses and external shocks. These disparities in recovery durations underscore the complex interplay of economic fundamentals, fiscal and monetary policy efficacy, and investor sentiment across emerging markets during systemic crises, thereby emphasizing the importance of contextualizing financial resilience within country-specific institutional frameworks, as indicated in figure 1.

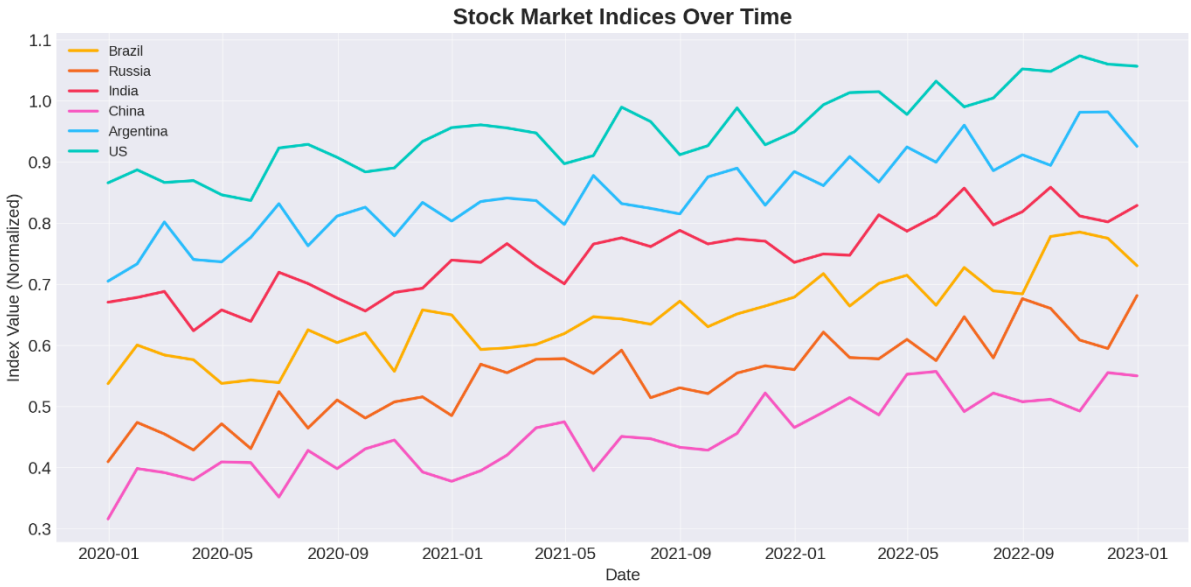

Figure 1. BRIC-A Nations stock indices movement during the pandemic Period

Empirical observations extend beyond pandemic-era volatility to shed light on recent market behavior, revealing contrasting dynamics across emerging and developed economies. Brazil's BOVESPA continues to reflect underlying macroeconomic stress and elevated inflation Brazil recorded one of the most pronounced inflation surges during 2021–2022 contributing to sustained market responsiveness to policy uncertainty and external shock. Argentina's S&P MERVAL, having surged 42 % in US dollar terms in 2022 amid a fragile economic and political backdrop, remains emblematic of stop-and-start recoveries under persistent inflation and currency instability. India's SENSEX, despite crossing its historic 80,000 mark by mid-2024, has displayed notable intra-year swings; in 2025, the index suffered a drop of nearly 12 % over just four months amidst capital outflows and global uncertainty.[18] Conversely, stock indices in China, Russia, and the United States though not immune to global macro shocks have exhibited relatively muted volatility during the same period. This divergence underscores the heterogeneous resilience of stock markets: developed and heavily state-influenced economies have benefited from deeper liquidity, policy buffers, and investor confidence, whereas emerging markets continue to grapple with structural vulnerabilities such as inflationary pressures, currency volatility, and investor sentiment shifts illuminating the asymmetric recovery pathways and the importance of tailored policy and investment strategies.

In the pre-pandemic phase, correlation patterns largely reflect entrenched market linkages shaped by long-standing trade relationships, capital flows, and macroeconomic synchronisation. The onset of the pandemic marked a structural break, with heightened uncertainty and synchronous global sell-offs amplifying correlation coefficients—a phenomenon consistent with the "flight-to-safety" effect and contagion literature. This convergence of market movements underscores the dominance of systemic shocks over idiosyncratic factors during periods of acute crisis.

The post-pandemic phase reveals a more heterogeneous pattern: while certain correlations revert towards pre-crisis levels, others display newly strengthened or weakened linkages. These shifts are indicative of differential recovery trajectories, policy interventions, and evolving investor perceptions of risk across economies. Such reconfigurations in market co-movements not only highlight the dynamic nature of financial integration but also point to the possibility of lasting structural changes in the architecture of global equity interdependence.

In the pre-pandemic period, as detailed in table 2 most countries exhibited positive correlations, with the notable exception of China and Russia, which demonstrated a negative relationship. Both China and Russia maintained only weak positive correlations with the US. India showed a particularly strong positive correlation with the US, Brazil, and Argentina, while its linkages with Russia and China were modest but still positive. These patterns suggest that, prior to the pandemic, India's stock market was more closely synchronized with the US and Latin American markets, whereas China and Russia followed more independent trajectories.

During the pandemic period, as detailed in table 3 all examined markets displayed positive and statistically significant correlations at the 5 % level, with no evidence of negative relationships. This convergence reflects a heightened degree of global market synchronization, as equity indices worldwide moved almost in lockstep declining sharply during the initial outbreak and subsequently recovering in parallel as policy interventions and economic reopening gained momentum. The pronounced co-movement underscores the globalized nature of modern capital markets, where systemic shocks, such as COVID-19, can override regional market idiosyncrasies and produce near-uniform responses. Notably, India and Argentina maintained particularly strong positive correlations with the US, indicating a closely aligned reaction to pandemic-induced volatility and subsequent recovery phases.

In contrast, the post-pandemic period, table 4 revealed a substantial fragmentation in market relationships. Negative correlations emerged in multiple pairings, with Russia exhibiting inverse movements against four other countries, suggesting heightened geopolitical and economic divergence. India's relationships with Russia and China turned negative, while it preserved strong positive linkages with Brazil, Argentina, and especially the US. This shift signals that while some market interdependencies remained intact, others realigned potentially due to evolving trade relations, geopolitical tensions, and differentiated recovery trajectories following the pandemic.

Unit root test results from table 5 and 6 confirm that all return series are stationary after first differencing, indicating integration of order one.[14] While Chinese and Argentine indices showed weak evidence of stationarity at level form, most indices required differencing to achieve stationarity. This reinforces the necessity of differencing in order to avoid spurious regression results in time-series modeling, as emphasized by Dickey and Fuller.[19]

Co-integration analysis from table 7-10 offers deeper insight into long-term market linkages. Across the total study period, only the US–India pairing exhibited a statistically significant long-run equilibrium relationship, suggesting a sustained structural connection between the two markets. Disaggregating by time periods, however, reveals that these linkages were not static. During the pandemic, the US was co-integrated not only with India but also with China, implying that the crisis fostered a temporary structural alignment between the US and Chinese markets—a relationship absent in both pre- and post-pandemic contexts. This transient alignment may reflect shared exposure to global demand shocks, synchronized policy responses, or capital flow patterns influenced by investor risk aversion.

In the post-pandemic period, co-integration emerged between the US and Russia a pairing that had shown no such long-term relationship in earlier phases alongside the persistent US–India connection. This suggests that post-pandemic geopolitical and commodity price dynamics, particularly in energy markets, may have deepened US–Russia financial linkages despite political tensions.

From a present-day perspective, these findings have critical implications for international investors, policymakers, and risk managers. The pandemic not only amplified short-term market synchronization but also altered the long-run integration structure among major emerging and developed markets. Such structural changes may affect portfolio diversification benefits, as markets that once moved independently may now exhibit stronger co-movements, particularly in response to global shocks. Furthermore, the emergence and disappearance of specific co-integrating relationships highlight the fluid nature of global financial interdependencies, suggesting that correlation and co-integration structures should be continuously monitored rather than assumed to be stable over time.

The empirical investigation employs a two-stage approach to examine both short-run and long-run interdependencies between the US stock market and the BRIC-A equity markets across three distinct phases—pre-pandemic, pandemic, and post-pandemic. Short-run relationships are captured through cross-correlation analysis of log-transformed index values, which helps stabilize variance and allows for more reliable comparisons of percentage changes. Long-run linkages are assessed using Johansen's co-integration framework, which identifies the presence of equilibrium relationships beyond transient fluctuations.[20,21]

In the pre-pandemic period, most markets exhibited strong positive correlations, reflecting relatively stable and integrated global equity dynamics. India demonstrated the highest degree of alignment with the US, Brazil, and Argentina, whereas its connections with China and Russia were modest yet still positive. China and Russia, however, shared a negative correlation with each other, indicating divergent market behavior prior to the crisis.

During the pandemic, correlations intensified across most markets, consistent with contagion effects and synchronized responses to global uncertainty. Brazil's BOVESPA, Argentina's MERVAL, and India's Sensex recorded the highest volatility, hitting their troughs within two months of the initial lockdowns. Recovery trajectories varied Argentina rebounded in just five months, India in ten months, while Brazil took over fifteen months reflecting differences in economic resilience, policy interventions, and investor sentiment. The US maintained strong correlations with most BRIC-A markets during this phase, although short-run linkages with some markets weakened as the crisis evolved.

In the post-pandemic period, correlation patterns partly reverted to pre-crisis configurations but with notable shifts, suggesting that recovery policies, sectoral adjustments, and altered capital flows have reshaped short-run interdependencies.[22]

Johansen co-integration results reveal deeper structural changes in market relationships. Across the entire study period, the US and Indian stock indices displayed a statistically significant co-integrating vector, indicating a persistent equilibrium relationship that withstands short-term volatility. This underscores the structural integration of these two markets, where shocks in one are likely to have enduring effects on the other.

When examined by sub-periods, notable shifts emerge. During the pandemic, a new long-run linkage developed between the US and Chinese markets a relationship absent both before and after the crisis. This temporary integration may be explained by globally synchronized macroeconomic policies, simultaneous exposure to pandemic-related supply and demand shocks, and parallel investor sentiment under systemic uncertainty.[23]

In the post-pandemic phase, the US and Russian markets exhibited a newly established co-integration relationship, likely reflecting changes in global commodity trade patterns, particularly in energy markets, and shifts in cross-border capital allocation in the aftermath of the pandemic. Together, the correlation and co-integration analyses present a nuanced picture of global market interconnectedness. Short-run linkages reveal the rapid transmission of shocks and volatility spillovers during periods of heightened uncertainty, while long-run linkages highlight more enduring structural connections that can emerge, disappear, or reconfigure in response to major global events. The pandemic acted as a structural break, temporarily integrating certain markets (US–China) and fostering new post-crisis linkages (US–Russia), while reinforcing already strong ties (US–India).

For policymakers, these findings underline the importance of monitoring both short-run contagion channels and long-run structural interdependencies, as each has distinct implications for financial stability and crisis management. For investors, the evolving nature of these relationships underscores the limits of diversification in times of global systemic shocks and the necessity of dynamic portfolio strategies.

The Granger causality as indicated in table 11 and 13, framework within a bivariate VAR model is applied to examine the short-run predictive relationships among the US and BRIC-A stock indices across different time horizons. Prior to estimation, all series are transformed to their first differences to achieve stationarity, ensuring the validity of the inference. The analysis is conducted at the 5 % significance level.

Results indicate that Brazil's stock market exerted unidirectional causality over the US market, suggesting that fluctuations in Brazilian stock prices had predictive power over subsequent US market movements. Conversely, the US market displayed unidirectional causality toward the stock indices of China, Argentina, India, and Russia, implying that changes in US stock prices were systematically followed by corresponding movements in these markets.

The causal structure shifted significantly during the pandemic. The US market maintained unidirectional causality over Russia and China, reflecting the transmission of pandemic-induced shocks and global investor sentiment from the US to these economies. A notable exception was the emergence of a bidirectional causal relationship between the US and India, indicating a feedback loop where changes in one market reciprocally influenced the other. This suggests that during the height of the crisis, US–India market linkages intensified, possibly due to synchronized policy responses, capital flow volatility, and parallel sectoral vulnerabilities.

In the recovery phase, the US market continued to exert unidirectional causality over China and India, demonstrating the persistence of US influence on these markets in the short run. However, the earlier

bidirectional causality with India dissipated, indicating a partial reversion to pre-pandemic dynamics. No bidirectional causal links were observed in this phase, suggesting a return to more conventional, asymmetric causality patterns.

These results reveal that the pandemic acted as a structural shock, temporarily altering the direction and intensity of short-term market dependencies. While the US market has historically maintained a dominant predictive role over BRIC-A markets, the pandemic period saw a unique phase of reciprocal causation with India, underscoring the heightened interconnectedness during global crises. For policymakers, such findings highlight the need for coordinated market surveillance in periods of systemic stress. For investors, they underscore the limits of decoupling strategies during crisis-induced contagion.

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CONCLUSION

The COVID-19 pandemic introduced structural shifts in financial linkages between BRIC-A markets and the US, a key global financial hub. Johansen co-integration tests confirm a persistent long-term relationship between the US and India across all periods, indicating resilience in bilateral integration despite systemic shocks, consistent with Singh et al. [21]

This stability contrasts with other markets, where co-integration patterns were transient US–China linkages strengthened only during the pandemic, aligning with Zhang , while US–Russia co-integration appeared post-pandemic, reflecting geopolitical and commodity market dynamics, as noted by Kinateder & Papavassiliou.

Short-run dynamics, as revealed by the Granger causality test, further support these structural shifts. Pre-pandemic, the US exerted unidirectional influence on all BRIC-A markets, reflecting its dominant role in global capital flows. During the pandemic, a unique bidirectional causality emerged between the US and India, signaling heightened interdependence during global uncertainty. Post-pandemic, the US influence narrowed primarily to India and China, while previous linkages with Brazil and Argentina weakened, pointing to evolving regional capital flow dynamics.

The findings highlight the contingent nature of global financial integration, which strengthens during crises and reconfigures as conditions normalize. These results carry implications for portfolio diversification and risk management, emphasizing that systemic shocks can trigger both temporary and lasting changes in market interdependencies. Future research should incorporate high-frequency data and sector-level analysis to better capture contagion mechanisms and the role of policy interventions.

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CONFLICT OF INTEREST

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