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Dynamic linkages between BRIC[1] equities and global financial assets using Auto-regressive Distributed Lag Model

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Abstract

The study examines the dynamic linkages among BRIC (Brazil, Russia, India, and China) stock markets and key global financial assets: gold, Bitcoin, U.S. Treasury bonds, and the CBOE Volatility Index (VIX). During financial turbulence, investors often divert their investments towards safe-haven assets, but empirical research on dynamic linkages of these variables with BRIC equity markets is limited. Using secondary data from 2015 to 2025, this study addresses this gap employing the Auto-regressive Distributed Lag (ARDL) framework, to study both short-run and long-run dynamics between the MSCI BRIC index (dependent variable) and global assets (Bitcoin, VIX, gold, and bonds as explanatory variables). The results confirm a long-run co-integrating relationship between the dependent (BRIC) and explanatory variables (bitcoin, VIX, gold and bonds). The VIX has a significant negative impact on BRIC stock indices in both the short and long run. U.S. Treasury bonds also show a negative long-run relationship, consistent with flight-to-safety behaviour. Conversely, gold has a significant positive long-run impact, with both gold and bonds showing a positive short-run effect. These findings highlight the importance of balanced portfolios, the hedging abilities of gold, and the stabilizing role of bonds in risk management for emerging markets.

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1. There is a distinction between BRIC (before South Africa joined) and BRICS (after South Africa joined) in this article and it is not a spelling error.

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1. Introduction

Investors often use hedging tools or diversify their portfolios to protect their investments. During financial turbulence, they frequently reallocate capital toward safe-haven assets such as gold, Bitcoin and U.S. Treasury bonds (Aloui et al., 2018; Baur & Lucey, 2010). The theory of a safe-haven asset was introduced by Baur and Lucey (2010), who defined it as an asset that is negatively correlated or uncorrelated with other asset during periods of market turmoil. Gold, long regarded as a store of value, provides hedging benefits (Chkili, 2016; Dey & Sampath, 2018), but its role has been questioned during various crises, such as the Global Financial Crisis (2008), COVID-19 pandemic and the Russia-Ukraine war. Studies provide mixed evidence of gold's interrelationships, stronger in crises but weaker in stable periods, with gold–equity links varying across studies. Some studies found positive association (Singhal et al., 2019) while as others report weak/negative correlations (Dong et al., 2012; Gokmenoglu & Fazlollahi, 2015).

More recently, Bitcoin has gained global attention, being the first decentralized digital asset. Often referred to as "digital gold", it operates independently of central banks, exhibits hedging ability and has been widely studied for its safe-haven capacity, particularly in relation to traditional assets like the U.S. dollar, crude oil and gold (Dyhrberg, 2016; Wei et al., 2023). Some studies found evidence of a strong co-movement between gold and Bitcoin (Bouoiyour et al., 2019), whereas others reported weaker or no co-movement (Baur et al., 2018; Ibrahim & Basah, 2022). Another strand of research showed that both gold and Bitcoin continued to act as safe-haven assets during the COVID-19 outbreak and maintained significant relationship with financial markets (Ji et al., 2020; Salisu et al., 2021), while others (Conlon et al., 2020; Akhtaruzzaman et al., 2021) highlighted their declining linkages.

In addition to traditional assets, investors are often drawn to U.S. Treasury bonds, which play a crucial role in global financial markets. These bonds are widely recognized as fixed-income securities and become particularly attractive during times of crisis. A negative correlation between BRIC bonds (Brazil and Russia) and equity markets was reported during crises, while India's bonds remain unaffected (Bianconi et al., 2013).

Beyond that, investors typically create a diversified basket of assets to enhance profitability. Among these, one of the most important variables is the CBOE Volatility Index (CBOE VIX), commonly known as the "fear index". The VIX measures the short-term volatility of S&P 500 options (Prasad et al., 2022) and is widely used to gauge market sentiment. It serves as an essential tool for risk management and portfolio diversification in capital markets (Bantwa, 2017; Chandra & Thenmozhi, 2015). However, other researchers emphasize its role primarily as a fear gauge, reflecting perceived risk in the market

(Whaley, 2000; Giot, 2005). Rising fluctuations in the VIX indicate shift in risk perception, often linked to global market shocks and broader macroeconomic factors (Le et al., 2019; Su et al., 2019). Existing studies have explored the relationship between gold and the VIX across both crises and stable periods (Hood & Malik, 2013; Choudhry et al., 2015), while others have examined how stock markets respond to increases in the VIX (Giot, 2005; Chang et al., 2018; Shahzad et al., 2022).

Against this backdrop, the selection of BRIC countries provides an interesting research ground to examine dynamic interactions amongst the emerging economies and safe-haven assets. The reason of incorporating BRIC countries is that, their share of global GDP rose from 8% in 2001 to 25% in 2019 (Zhang & Giouvris, 2022), highlighting their importance in shaping global financial markets. BRIC markets, characterized by elevated risk-premiums, information imbalances and volatility clustering impact the herding in investors behavior (Adu et al., 2015; Huang et al., 2015). The studies reveal time-varying correlations and hedging effectiveness (Chkili, 2016; Shahzad et al., 2022; Aloui et al., 2023) and gold outperforms Bitcoin as a safer hedge during market stress (Belguith et al., 2025).

Despite an exhaustive literature focused on safe-haven assets, studies primarily examined the volatility indices, precious metals and cryptocurrencies individually or in limited combinations. However, selected studies focus on the dynamic and joint interactions of financial assets with emerging BRIC markets.

This study has contributed to the existing literature in three important ways. Firstly, it offers a comprehensive analysis of among BRIC markets and global financial assets like gold, Bitcoin, the CBOE VIX and U.S. Treasury bonds. Secondly, the choice of emerging economies provides insights into how precious metals, fixed income securities and cryptocurrency behave in markets defined by structural differences and high volatility compared to developed markets. Thirdly, the study employs the Auto-regressive Distributed Lag (ARDL) approach to measure both short-run and long-run dynamics, offering a deep analysis of the dynamic interactions among the asset classes.

This study contributes to the literature on safe-haven assets and offers practical insights for investors, policymakers, and institutions in developing effective risk management and diversification strategies. The study is divided into six parts. The second section contains the literature review. Section three discusses conceptual framework and section fourth discusses the data and methodology. The five section explains the analysis. The conclusion is presented in the last section.

2. Literature review

The growing integration of emerging markets, particularly the BRIC economies into global financial systems has raised concerns about their

vulnerability to external shocks. This has highlighted the role of alternative assets in maintaining financial stability. Extensive research has studied the interlinkages among assets like gold, Bitcoin, volatility index (VIX), and crude oil, each suggesting different implications for risk management and portfolio diversification.

2.1. Gold–stock market relationship

Periods of heightened fear index typically coincide with downturns in stock markets, prompting investors to shift from high-risk assets to those offering safe-haven properties, such as gold. Gold, historically regarded as a store of value, provides both hedging and diversification benefits (Baur & Lucey, 2010; Chkili, 2016; Dey & Sampath, 2018).

Empirical evidence further shows that the role of gold becomes more pronounced during distress periods (Wen & Cheng, 2018; Kinateder et al., 2021; Akhtaruzzaman et al., 2024), like during the Global Financial Crisis (2008), COVID-19 pandemic and the Russia-Ukraine war. During these events, it often tends to exhibit a negative correlation with equity markets (Jain & Biswal, 2016).

In the BRICS bloc, Chkili (2016) employed DCC[1] models and found that correlations between gold and stocks fluctuate from low to negative during stress periods. Similar findings were reported for India (Dey & Sampath, 2018). However, Dar and Maitra (2017) found relatively stable gold–stock relationships in India and the U.S.

The evidence on gold's relationship with equities is therefore mixed, i.e., stronger in times of crisis but weaker in stable periods, highlighting the importance of time-varying analysis in BRIC markets. The cross-market analyses also suggest inconsistent gold–stock relationships: some studies highlight a positive association (Singhal et al., 2019), while others suggest weak or negative correlations depending on time, country, and methodology (Dong et al., 2012; Gokmenoglu & Fazlollahi, 2015).

2.2. Interactions among VIX, gold and equity markets

The VIX is widely recognised as a barometer to measure investor fear and forecasting stock market volatility (Whaley, 2000; Giot, 2005). During crises, gold and VIX share positive correlation. When VIX increases, investors often buy more gold, which drives an upward price movement. Conversely, in stable periods, as the uncertainty index decreases and investor fear subsides, gold may lose its value compared to other assets that have fixed interest rates, like bonds. However, the interrelationship between the two is not linear, as other factors such as currency movements and interest rates also influence gold prices (Hood & Malik, 2013).

Choudhry et al. (2015) examine the nonlinear dynamic co-

1. Dynamic Conditional Correlation

movements between gold and equities, finding that the relationship strengthens during crises periods. Their results also reveal a bidirectional linkage between gold–stock returns and the volatility index. Chai et al. (2021), and Yatie (2022) found gold prices are positively influenced through fluctuations in the VIX and crude oil markets, with crude oil being the dominant factor. Among forecasting approaches, the STL-ETS model provided the best predictive performance compared to neural network and Bayesian models.

Interestingly, gold acts as a reliable hedge against stock returns and volatility in stable conditions. Fakhfekh et al. (2023) highlight that VIX holds the most dominant influence with stock market indices, compared to cryptocurrencies and gold. Empirical evidence further shows that stock returns decrease with VIX shocks in U.S. and European markets (Chang et al., 2018), while sharp spikes in the VIX may reflect market recovery (Giot, 2005). Moreover, Shahzad et al. (2022) reported time-varying interrelationships between VIX-BRICS markets. Similarly, Sharma and Malik (2022) found that higher VIX, COVID-19 deaths and reduce in oil prices had a negative impact on BRIC markets in short run. All countries recovered in long run—except Russia, due to heavy dependence on oil. Other studies also explored the interplay between VIX and commodities, currencies and fixed income securities (Boscaljon & Clark, 2013).

2.3. Relationship between bitcoin and gold

Bitcoin, often categorised as "digital gold" (Baur & Hoang, 2021; Jareño et al., 2020), exhibits some behavioural patterns akin to gold (Dyhrberg, 2016). However, the evidence is mixed. While some studies suggest stronger correlations (Bouoiyour et al., 2019), others report weaker or even absent correlations (Baur et al., 2018; Ibrahim & Basah, 2022).

Aloui et al. (2023), using NARDL[1], found a positive association of cryptocurrencies with G7 and BRICS stock indices, the VIX, gold, and oil both before and during the pandemic. Both gold and Bitcoin demonstrate hedging properties and stronger linkages; however, Belguith et al. (2025), applying copula approach highlights that gold offers greater hedging effectiveness than Bitcoin during market downturns, particularly in BRICS-plus economies. The literature is not limited to static correlations, researchers also explored dynamic interrelationships using DCC model and wavelet coherence Kang et al. (2019) and spillover effects utilizing SVAR Aliu et al. (2024), highlighting mixed results on the relationships of Bitcoin-gold.

2.4. Financial markets and alternative assets during crisis periods

Recent studies have explored the performance of gold,

[1]. Nonlinear Autoregressive Distributed Lag

cryptocurrencies, or other alternative assets during turbulent periods such as COVID-19. Dutta et al. (2020), via a conditional correlation model (DCC), found out gold maintains a stronger correlation with crude oil, compared to bitcoin. Similar conclusion was provided by Kristoufek (2020), who employed a quantile correlation approach.

Liu et al. (2023), employing asymmetric co-integration and Granger causality tests, reported significant nonlinear relationships between gold, oil, the U.S. dollar, and Bitcoin both pre and post COVID-19 outbreak. Specifically, before the outbreak, gold prices were influenced by Bitcoin, while after the outbreak, a decline in crude oil prices led to a fall in Bitcoin prices, highlighting the changing dynamics brought about by COVID-19.

Zeng et al. (2023) explored the dynamic correlation between gold, Bitcoin, developed and regional equity markets through TVP-VAR and Vine-Copula approach. They found spillover effect from Bitcoin to the Pakistani and Chinese stock markets.

Another study by Amoako et al. (2022) employed wavelet technique, and highlighted positive correlation among commodities, VIX and equities in long run. Except Russia, other countries in BRICS were more suspectable to external shocks.

Frikha et al. (2024) examined the co-movements among equities, gold, Bitcoin, oil, wheat and carbon futures. The study found time varying interrelationships increased during COVID-19 outbreak, while as declined in the Russia-Ukraine war. However, a short-run negative correlation was seen between VIX and equities.

2.5. Research gap and contribution of the study

Overall, the literature reveals mixed and time-varying evidence on interrelationships of gold, Bitcoin, and the VIX, particularly within BRICS economies. While gold maintains a stronger and more consistent linkage during crises, Bitcoin exhibits weaker connections than gold. However, the VIX stands out as a key indicator of market dynamics, but its relationship with equities and gold is context-dependent and non-linear.

Despite the growing literature on global financial markets and assets, several gaps exist. Firstly, many studies focus on static or bivariate relationships, such as gold–stock, VIX–gold, stock–VIX, or Bitcoin–gold, and some even consider triple-asset linkages. However, few studies explicitly examine the joint role of riskier assets, fixed-income securities, volatility indices, and equities in shaping stock market dynamics. Secondly, most studies focus towards the developed nations, leaving emerging markets particularly (BRIC) unexplored. Thirdly, prior research falls short in addressing both the short and long run dynamics that are crucial for capturing the complexity of global financial markets.

3. Conceptual framework

The theoretical background of this study explains the relationship between global financial assets and BRIC markets (Figure 1). During periods of financial stress, alternative instruments such as gold and bitcoin are often considered as safe-haven and hedging assets. Similarly, U.S Treasury bonds characterised by fixed-income and low risk are attractive investments during crisis, while the CBOE VIX index represents market volatility and investor sentiment. So, change in these variables jointly might influence the BRIC markets behaviour with the help of risk-management strategies and portfolio allocation. Therefore, this study examines the intricate relationship of BRIC equity markets and global financial indicators.

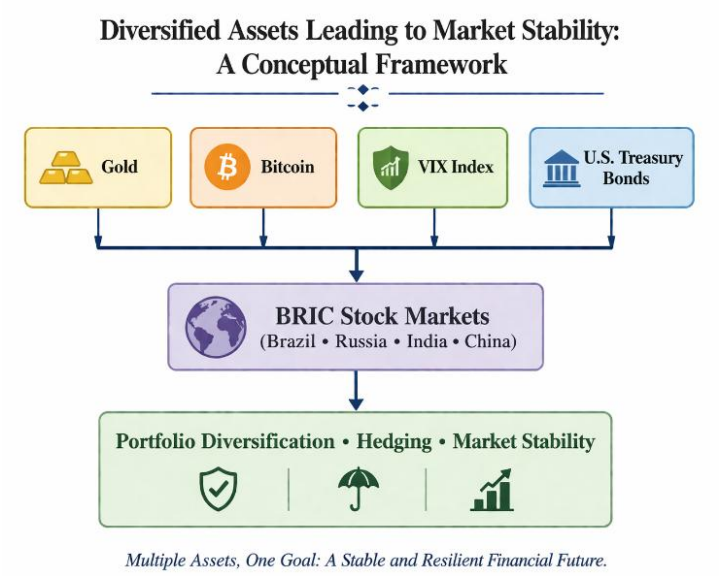

Figure 1. Conceptual framework

4. Data and Methodology

Secondary data has been used in the study covering the reference period from 01-01-2015 to 15-08-2025. The data for the variables namely Bitcoin, Volatility Index, Gold prices, U.S. Treasury bond yield and MSCI (Morgan Stanley Capital International) BRIC index, has been taken from Investing.com. MSCI BRIC index is the dependent variable for this study whereas Bitcoin, Volatility Index, Gold prices and U.S. Treasury bond yield are the explanatory or independent variables.

The first step in the econometric methodology adopted in the present study was a descriptive statistical analysis conducted to understand the behaviour of data. Mean and standard deviation were the summary statistical measures used to describe the general behaviour of data in the study. After performing the descriptive analysis of data, the pairwise correlation analysis was performed to ascertain the degree of linear

relationship between dependent and independent variables using coefficient of correlation, the value of which ranges from -1 to +1.

It is important to check the stationarity of variables in any econometric analysis and in this study, we have used the standard unit root test for time series data known as Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1981). Stationarity in a data set indicates that its statistical properties, like mean, variance and covariance, have remained constant and not changed over time. In order to check the stationarity of our time-series data set employing the ADF test, the following null hypothesis was tested:

Null Hypothesis (H_o): A unit root is present in the time series data.

In order to assess the long-run and short-run relationship between the dependent and explanatory variables, the present study uses Auto-regressive Distributed Lag (ARDL) model (Pesaran & Shin, 1999). ARDL model puts a limitation of strict stationarity bounds as results get invalidated if variables are integrated of order (2), however, the use of ARDL model is justified on the basis of the results of stationarity test as ARDL model requires variables to be stationary at level, I(0) or integrated of order 1, I(1), or mix of I(0) and I(1) and also due to its superiority over traditional methods. Moreover, the ARDL model is considered as a robust method to assess the dynamic linkages and the short-run and long-run relationship among variables (ibid).

When data analysis is conducted on a time series data and the model of regression includes both present and past or lagged values of the explanatory variables or regressors, it is known as distributed-lag model and as an extension to this, when regression model includes the past or lagged values of the dependent variable as well, it is called an autoregressive model. An autoregressive distributed-lag (ARDL) model is the one where it is assumed that the dependent variable is a function of both its past or lagged value as well as the present and past or lagged values of the independent variables (Equation 1).

$$Yt = \alpha + \beta 0Xt + \beta 1Xt-1 + \beta 2Xt-2 + \varepsilon_t \quad (1)$$

Whereas, Equation (2) represents an autoregressive model.

$$Yt = \alpha + \beta Xt + \gamma Yt-1 + \varepsilon_t \quad (2)$$

The ARDL model in the study aims at testing the following null hypotheses:

H_{01}: There exists no long-run co-integration between the dependent (BRIC) and explanatory variables (bitcoin, VIX, gold and bonds).

H_{02}: The explanatory variables (bitcoin, VIX, gold and bonds) exert no short-run impact on dependent variable (BRIC).

H_{03}: The explanatory variables (bitcoin, VIX, gold and bonds) exert no long-run impact on dependent variable (BRIC).

The ARDL model used to test the long-run and short-run relationship between the variables in the present study is specified by Equation (3).

$$\Delta BRIC_t = \phi + \theta_1 BRIC_{t-1} + \theta_2 bitcoin_{t-1} + \theta_3 VIX_{t-1} + \theta_4 gold_{t-1} + \theta_5 bonds_{t-1} + \sum_{i=1}^{p} \alpha\Delta\ BRIC_{t-i} + \sum_{i=0}^{q1} \beta\ \Delta bitcoin_{t-i} + \sum_{i=0}^{q2} \gamma \Delta LVIX_{t-i} + \sum_{i=0}^{q3} \delta \Delta Lgold_{t-i} + \sum_{i=0}^{q4} \sigma \Delta Lbonds_{t-i} + \varepsilon_t \quad (3)$$

where Δ denotes the 1st difference operator, ϕ stands for the drift component, $\theta_1, \ldots, \theta_8$ indicate the long-run multipliers and ε_t is the error term.

5. Empirical results and discussion

The starting point of our analysis is to check the behaviour of data using descriptive analysis. The summary statistics presented in Table 1 indicate the mean and standard deviation of variables used in the study.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
BRIC	2,676	547.1976	98.92281	309.86	843.36
Bitcoin	2,676	25075.02	28773.69	164.9	123323.4
VIX	2,676	18.38837	7.234427	9.14	82.69
Gold	2,676	1701.533	532.2191	1049.6	3501.8
Bonds	2,676	2.59945	1.122315	0.512	4.99

After checking the summary statistics (Table 1), we perform the correlational analysis to test the degree of linear relationship between dependent and explanatory variables (Table 2).

Table 2. Correlation

	BRIC	Bitcoin	VIX	Gold	Bonds
BRIC	1.0000				
Bitcoin	0.4976	1.0000			
	0.0000				
VIX	0.1063	0.0570	1.0000		
	0.0000	0.0032			
Gold	0.4539	0.9249	0.1840	1.0000	
	0.0000	0.0000	0.0000		
Bonds	-0.1131	0.5536	-0.2239	0.5449	1.0000
	0.0000	0.0000	0.0000	0.0000	

As shown in Table 2, there exists a significant positive correlation between BRIC and bitcoin (0.4976), BRIC and VIX (0.1063), BRIC and gold (0.4539) at 1% level of significance. However, BRIC index has a significant negative correlation with bonds (-0.1131) at 1% level of significance. Bitcoin exhibits a weak positive correlation with VIX (0.0570), strong positive correlation with gold (0.9249) and a moderate positive correlation with bonds (0.5536) at 1% level of significance. Volatility index (VIX) has a weak positive correlation with gold (0.1840) and a weak negative correlation with bonds (-0.2239) with bonds at 1% significance level. Moreover, gold has a moderate positive correlation with bonds (0.5449) at 1% significance level.

Due to high correlation between gold and Bitcoin, we test for multi-collinearity which is an important assumption of regression because presence of multicollinearity among variables makes the regression coefficients unstable and standard errors inflated and meaningless. Multi-collinearity is present in the variables if the Variance Inflation Factor (VIF) value is more than 10 (Gujarati, 2007). The results of multicollinearity test given in Table 3 which show that there is no multicollinearity as the mean VIF value (4.74) is less than 10.

Table 3. Multicollinearity

Variable	VIF	1/VIF
Gold	8.32	0.120133
Bitcoin	7.63	0.130989
Bonds	1.69	0.593253
VIX	1.32	0.758716
Mean VIF	4.74	

Another assumption of classical linear regression states that error terms or disturbances should be serially correlated with each other. In order to test for this auto-correlation in this study, we have used Durbin-Watson test. In case the value of Durbin-Watson statistics is found to be less than 1.75 or more than 2.25, the presence of auto-correlation is established. The autocorrelation test results (Table 4) reveal that there is no auto-correlation between the variables, as D-Watson statistics is less than 2.25.

Table 4. Auto-correlation

D-statistics (9, 2675)	1.99

The classical linear regression model assumes the presence of homoscedasticity, which means that the variance of disturbance, conditional upon the value of the independent variables, is always constant. In the present study, we have used Breusch-pagan heteroscadasticity test the null hypothesis of which is presence of homoscedasticity. The P-value is 0.0000 (Table 5) which leads to rejection of null hypothesis and establishes presence of

heteroscedasticity which the model addresses using robust standard errors.

Table 5. Breusch–Pagan test for heteroscedasticity

Test	Chi^2	$Prob.>Chi^2$
H_0: Constant variance		
Breusch-Pagan test for heteroscedasticity	36.14	0.0000

Next, the data was checked for stationarity by conducting ADF unit root test (Table 6). It was found that the variable namely VIX (Volatility index) is stationary at level rejecting the null hypothesis of presence of unit root in the data series, whereas, all other variables, BRIC, bitcoin, gold and bonds are stationary at first difference.

Table 6. ADF test of stationarity

Variables	ADF unit root test				Decision
	Level		1st difference		
	t-statistics	p-value	t-statistics	p-value	
BRIC	-1.68	0.438	-47.62	0.000	Stationary at 1st difference
Bitcoin	0.96	0.993	-53.07	0.000	Stationary at 1st difference
VIX	-7.08	0.000	-	-	Stationary at level
Gold	1.66	0.998	-53.00	0.000	Stationary at 1st difference
Bonds	-0.83	0.810	-53.32	0.000	Stationary at 1st difference

Based on the results of ADF unit root test, the Auto-regressive Distributed Lag (ARDL) model is found to be suitable for this study as ARDL model requires variables to be stationary at level, I(0) or integrated of order 1, I(1), or mix of I(0) and I(1) (Pesaran & Shin, 1999). The latter is true in our case and therefore, we use ARDL model to test the short-run and long-run impact of explanatory variables on the dependent variable. The ARDL test results are presented in Table 7 and the visual representation is also depicted in Figures 2 & 3. It is found that the error correction term (ECT), also known as speed of adjustment, used to ascertain the long-run co-integration between the variables shows the presence of a long-run co-integrating relationship at 1% level of significance ($P<.01$) between the dependent (BRIC) and explanatory variables (bitcoin, VIX, gold and bonds). This implies that any deviation from the long-run equilibrium would be corrected at -0.0047 speed of adjustment as it falls within the benchmark limit (i.e., negative value between 0 to -2). However, it depicts a slow convergence towards the long-run equilibrium following a market shock. The results of ARDL bounds test also confirms co-integration between variables as the F-statistic is 6.78 which is more than I(1) upper bound 4.35 (Table 8).

Table 7. Results of ARDL model

(1)			
D.BRIC			
ECT			
L.BRIC			-0.00480** (-2.91)
LR			
Bitcoin	-0.00672 (-1.72)	VIX	-30.00** (-2.82)
Gold	0.700** (2.64)	Bonds	-150.7*** (-3.42)
SR			
D.VIX	-0.954*** (-15.31)	D.Gold	0.0378*** (5.61)
D.Bonds	9.497*** (4.16)	cons	2.299 (1.82)
N	2675		

t statistics in parentheses
* *P* <0.05, ** *P* <0.01, *** *P* <0.001

Table 8. ARDL bounds test

* Output: F(5, 2661) = 6.78 * Prob > F = 0.0000

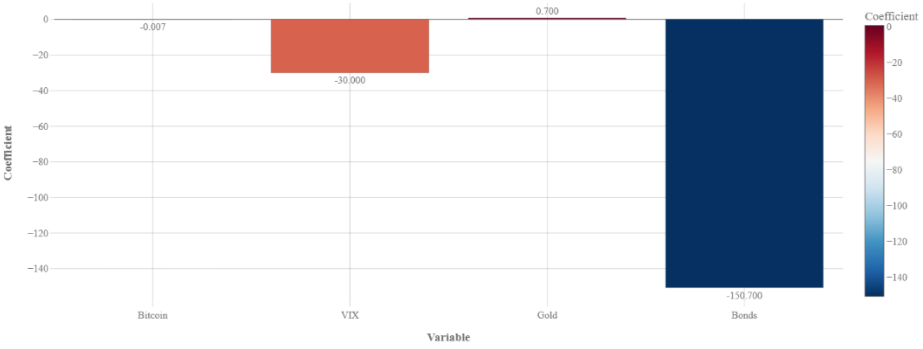

Figure 2. Long-run coefficients (ARDL model)

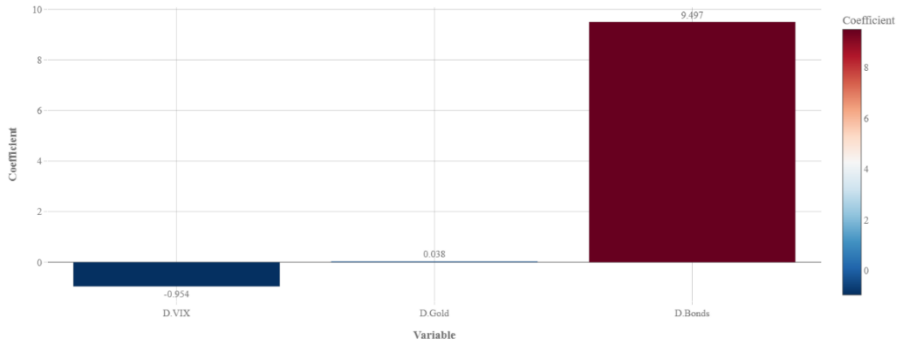

Figure 3. Short-run coefficients (ARDL model)

Moreover, the ARDL test results reveal that except bitcoin, the explanatory variables namely VIX (-30) and bonds (-150.7) have a statistically significant negative long-run impact on BRIC index at 10% and 1% significance level respectively whereas gold (0.70) is found to have a statistically significant positive long-run impact on BRIC index at 10% significance level. The negative value of Volatility Index indicates that the BRIC markets are sensitive to global uncertainty. As risk aversion increases globally in the long-run (i.e., a higher value of VIX), there is a tendency of capital to squeeze out of emerging markets like the BRIC countries toward safe-haven assets. The higher bond yields make the long-run BRIC index face a pressure downwards which reflects the shift in the interest rate environment, favouring fixed-income assets more than the emerging market equities. The significant positive coefficient for gold reveals that BRIC markets move in line with the prices in commodity markets. Since many BRIC economies, especially Brazil and Russia, are main commodity exporters, gold acts as a broader "commodity boom" proxy supporting their equity markets.

The short-run ARDL test results reveal that VIX (-0.954) exerts a statistically significant negative short-run impact on BRIC index at 1% significance level, however, gold (0.037) and bonds (9.497) exhibit a statistically significant positive short-run impact on BRIC index at 1% significance level. The negative short-run impact of VIX implies the vulnerability of BRIC economies to sudden spikes facing sell-offs in rising volatility situations. Positive coefficient in gold prices is seen as promising for BRIC equity investors, which reinforces the "risk-on" sentiment related to the strength of the commodity. The positive coefficient for bond reveals that rising bond yields might give a liquidity boost to emerging economies in the short-run, even if there exists an inverse long-run relationship.

The findings of the study reveal a significant positive correlation between the BRIC index and Bitcoin, VIX and gold, while bonds share a negative correlation. However, the results of ARDL confirm a long-run co-integration among the variables, with gold exerting positive long-run impact on BRIC markets, whereas VIX and bonds showing negative impacts. These findings align with Damodaran (2025) and Singhal et al. (2019), which observed a positive gold and equity relationship, exhibiting gold's role as diversifier.

Similarly, Sharma and Malik (2022), and Frikha et al. (2024) found that VIX had a negative short-run impact on BRIC markets. The negative long-run bond and equity relationship corroborate with Molenaar (2024), Adrian et al. (2025), Boscaljon and Clark (2013), and Bianconi et al. (2013) during crises.

6. Conclusion

The present study investigates the dynamic interlinkages among BRIC stock markets and the global financial assets—gold, Bitcoin, U.S.

Treasury bonds, and the CBOE volatility index—over the period from 2015 to 2025. The findings of ARDL test reveal that the volatility index exerts a significant negative impact on BRIC stock indices in both the short and long run, which confirms the role of VIX in investor fear and uncertainty associated with markets. U.S. Treasury bonds also show a significant negative association with BRIC index in the long run, which aligns with the flight-to-safety behaviour which is seen particularly during market downturns.

An important finding from the ARDL co-integration test confirms the long-run equilibrium linkages among the variables, underscoring a consistent impact of shifts in global risk sentiment and cryptocurrency dynamics on the equities of emerging markets. The ARDL short-run results highlight the influence of gold and bonds in giving buffers during volatility spikes. The error correction term reveals that the BRIC markets do converge to the equilibrium, however, slow convergence suggests that the "memory" of shocks remains for some period and this slow adjustment suggests use of dynamic capital buffers among other macro-prudential tools to enhance the post-shock convergence. However, these findings underscore the importance of having a balanced portfolio that comprises the traditional safe-haven assets, despite the growing popularity of digital assets like cryptocurrency.

Policymakers can also gain insights about short-long run dynamics from global assets and ways to examine financial market stability. The results suggests that gold has important hedging abilities, whereas the predictive power of volatility index and the stabilizing impact of bonds are significant for risk management in emerging market economies. Resilience should be prioritized by the policymakers in BRIC economies against global volatility, owing to the negative VIX coefficient signalling capital flight in times of uncertainty. Also, sovereign wealth funds can be developed that are linked to gold to act as a buffer for commodity-dependent countries like Brazil and Russia. The BRIC policymakers should work toward addressing the bond divergence—positive short-run versus negative long-run—by promoting the bond markets for possible liquidity inflows while mitigating the outflows which are yield-driven. The joint bond funds can be developed by the governments of BRIC countries to coupe up with the international fixed-income shifts and stabilize the stock valuations.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. This article was not authored by artificial intelligence.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

References

Adrian T, Kiff J, Montes M. (2025). *Global Financial Stability Report, October 2025*. International Monetary Fund. https://www.imf.org/en/publications/gfsr/issues/2025/10/14/global-financial-stability-report-october-2025.

Adu G, Alagidede P, Karimu A. (2015). "Stock return distribution in the BRICS". *Review of Development Finance*. 5(2): 98-109. https://doi.org/10.1016/j.rdf.2015.09.002.

Akhtaruzzaman M, Banerjee AK, Le V, Moussa F. (2024). "Hedging precious metals with impact investing". *International Review of Economics & Finance*. 89: 651-664. https://doi.org/10.1016/j.iref.2023.07.047.

Akhtaruzzaman M, Boubaker S, Sensoy A. (2021). "Financial contagion during COVID–19 crisis". *Finance Research Letters*. 38: 101604. https://doi.org/10.1016/j.frl.2020.101604.

Aliu F, Asllani A, Hašková S. (2024). "The impact of bitcoin on gold, the volatility index (VIX), and dollar index (USDX): analysis based on VAR, SVAR, and wavelet coherence". *Studies in Economics and Finance*. 41(1): 64-87. https://doi.org/10.1108/SEF-04-2023-0187.

Aloui C, Jammazi R, Hamida HB. (2018). "Multivariate co-movement between Islamic stock and bond markets among the GCC: A wavelet-based view". *Computational Economics*. 52(2): 603-626. https://doi.org/10.1007/s10614-017-9703-7.

Aloui M, Hamdi B, Tiwari AK, Jeribi A. (2023). "The impact of cryptocurrencies on the gold, WTI, VIX index, G7 and BRICS index before and during COVID-19: a quantile regression and NARDL analysis". *International Journal of Law and Management*. 65(6): 485-510. https://doi.org/10.1108/IJLMA-04-2022-0083.

Amoako GK, Asafo-Adjei E, Mintah Oware K, Adam AM. (2022). "Do volatilities matter in the interconnectedness between world energy commodities and stock markets of BRICS?". *Discrete Dynamics in Nature and Society*. 2022(1): 1030567. https://doi.org/10.1155/2022/1030567.

Bantwa A. (2017). "A study on India volatility index (VIX) and its performance as risk management tool in Indian Stock Market". *Paripex-Indian Journal of Research*. 6(1). https://ssrn.com/abstract=3732839.

Baur DG, Dimpfl T, Kuck K. (2018). "Bitcoin, gold and the US dollar–A replication and extension". *Finance Research Letters*. 25: 103-110. https://doi.org/10.1016/j.frl.2017.10.012.

Baur DG, Hoang LT. (2021). "A crypto safe haven against Bitcoin". *Finance Research Letters*. 38: 101431. https://doi.org/10.1016/j.frl.2020.101431.

Baur DG, Lucey BM. (2010). "Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold". *Financial Review*. 45(2): 217-229. https://doi.org/10.1111/j.1540-6288.2010.00244.x.

Belguith R, Alnafisah H, Snene Manzli Y, Jeribi A. (2025). "Can bitcoin and gold have dynamic hedging and safe haven capabilities against the BRICS plus stock

market indices during global crises? An evidence from a time-varying copula approach". *Emerging Markets Finance and Trade.* 1-24. https://doi.org/10.1080/1540496X.2025.2486677.

Bianconi M, Yoshino JA, De Sousa MOM. (2013). "BRIC and the US financial crisis: An empirical investigation of stock and bond markets". *Emerging Markets Review*. 14: 76-109. https://doi.org/10.1016/j.ememar.2012.11.002.

Boscaljon B, Clark J. (2013). "Do large shocks in VIX signal a flight-to-safety in the gold market?". *Journal of Applied Finance*. 23(2): 120-131. https://www.proquest.com/openview/8e5d90c2b6a9f9b06a1e76c9a739eca4/1?cbl=26518&pq-origsite=gscholar.

Bouoiyour J, Selmi R, Wohar ME. (2019). "Bitcoin: competitor or complement to gold?". *Economics Bulletin*. 39(1): 186-191. http://www.accessecon.com/Pubs/EB/2019/Volume39/EB-19-V39-I1-P51.pdf.

Chai J, Zhao C, Hu Y, Zhang ZG. (2021). "Structural analysis and forecast of gold price returns". *Journal of Management Science and Engineering*. 6(2): 135-145. https://doi.org/10.1016/j.jmse.2021.02.011.

Chandra A, Thenmozhi M. (2015). "On asymmetric relationship of India volatility index (India VIX) with stock market return and risk management". *Decision*. 42(1): 33-55. https://doi.org/10.1007/s40622-014-0070-0.

Chang CL, Hsieh TL, McAleer M. (2018). "Connecting VIX and stock index ETF with VAR and diagonal BEKK". *Journal of Risk and Financial Management*. 11(4): 58. https://doi.org/10.3390/jrfm11040058.

Chkili W. (2016). "Dynamic correlations and hedging effectiveness between gold and stock markets: Evidence for BRICS countries". *Research in International Business and Finance*. 38: 22-34. https://doi.org/10.1016/j.ribaf.2016.03.005.

Choudhry T, Hassan SS, Shabi S. (2015). "Relationship between gold and stock markets during the global financial crisis: Evidence from nonlinear causality tests". *International Review of Financial Analysis*. 41: 247-256. https://doi.org/10.1016/j.irfa.2015.03.011.

Conlon T, Corbet S, & McGee RJ. (2020). "Are cryptocurrencies a safe haven for equity markets? An international perspective from the COVID-19 pandemic". *Research in International Business and Finance*. 54: 101248. https://doi.org/10.1016/j.ribaf.2020.101248.

Damodaran A. (2025). "A golden year (2025): Gold's price surge - The signal in the noise". *Substack*. https://aswathdamodaran.substack.com/p/a-golden-year-2025-golds-price-surge.

Dar AB, Maitra D. (2017). "Is gold a weak or strong hedge and safe haven against stocks? Robust evidences from three major gold-consuming countries". *Applied Economics*. 49(53): 5491-5503. https://doi.org/10.1080/00036846.2017.1310998.

Dey S, Sampath A. (2018). "Dynamic linkages between gold and equity prices: Evidence from Indian financial services and information technology companies". *Finance Research Letters*. 25: 41-46. https://doi.org/10.1016/j.frl.2017.10.002.

Dickey DA, Fuller WA. (1981). "Likelihood ratio statistics for autoregressive time series with a unit root". *Econometrica*. 49(4): 1057-1072. https://doi.org/10.2307/1912517.

Dong J, Pan HP, Yao YY, Li CG. (2012). "Empirical study on the correlation of oil, stock and gold markets based on DCC-MVGARCH model". *Forecasting*. 31(4): 53-57.

Dutta A, Das D, Jana RK, Vo XV. (2020). "COVID-19 and oil market crash: Revisiting the safe haven property of gold and Bitcoin". *Resources Policy*. 69: 101816. https://doi.org/10.1016/j.resourpol.2020.101816.

Dyhrberg AH. (2016). "Hedging capabilities of bitcoin. Is it the virtual gold?". *Finance Research Letters*. 16: 139-144. https://doi.org/10.1016/j.frl.2015.10.025.

Fakhfekh M, Jeribi A, Ghorbel A, Hachicha N. (2023). "Hedging stock market prices with WTI, Gold, VIX and cryptocurrencies: a comparison between DCC, ADCC and GO-GARCH models". *International Journal of Emerging Markets*. 18(4):

978-1006. https://econpapers.repec.org/scripts/redir.pf?u=https%3A%2F%2Fdoi.org%2F10.1108%252FIJOEM-03-2020-0264;h=repec:eme:ijoemp:ijoem-03-2020-0264.

Frikha W, Béjaoui A, Bariviera AF, Jeribi A. (2024). "What matters for comovements among gold, bitcoin, CO_2, commodities, VIX and international stock markets during the health, political and bank crises?". *Risks*. 12(3): 47. https://doi.org/10.3390/risks12030047.

Giot P. (2005). "Relationships between implied volatility indexes and stock index returns". *Journal of Portfolio Management*. 31(3): 92. http://dx.doi.org/10.3905/jpm.2005.500363.

Gokmenoglu KK, Fazlollahi N. (2015). "The interactions among gold, oil, and stock market: Evidence from S&P500". *Procedia Economics and Finance.* 25: 478-488. https://doi.org/10.1016/S2212-5671(15)00760-1.

Gujarati DN. (2007). *Basic Econometrics.* 4th ed. New York: McGraw-Hill.

Hood M, Malik F. (2013). "Is gold the best hedge and a safe haven under changing stock market volatility?". *Review of Financial Economics*. 22(2): 47-52. https://doi.org/10.1016/j.rfe.2013.03.001.

Huang TC, Lin BH, Yang TH. (2015). "Herd behavior and idiosyncratic volatility". *Journal of Business Research*. 68(4): 763-770. https://doi.org/10.1016/j.jbusres.2014.11.025.

Ibrahim J, Basah MYA. (2022). "A study on relationship between crypto currency, commodity and foreign exchange rate". *The Journal of Muamalat and Islamic Finance Research.* 1-12. https://jmifr.usim.edu.my/index.php/jmifr/article/view/457.

Jain A, Biswal PC. (2016). "Dynamic linkages among oil price, gold price, exchange rate, and stock market in India". *Resources Policy*. 49: 179-185. https://doi.org/10.1016/j.resourpol.2016.06.001.

Jareño F, de la O González M, Tolentino M, Sierra K. (2020). "Bitcoin and gold price returns: A quantile regression and NARDL analysis". *Resources Policy*. 67: 101666. https://doi.org/10.1016/j.resourpol.2020.101666.

Jeribi, A., Ghorbel, A., & Hachicha, N. (2023). Hedging stock market prices with WTI, Gold, VIX and cryptocurrencies: a comparison between DCC, ADCC and GO-GARCH models. *International Journal of Emerging Markets*, *18*(4), 978-1006.

Ji Q, Zhang D, Zhao Y. (2020). "Searching for safe-haven assets during the COVID-19 pandemic". *International Review of Financial Analysis*. 71: 101526. https://doi.org/10.1016/j.irfa.2020.101526.

Kang SH, McIver RP, Hernandez JA. (2019). "Co-movements between Bitcoin and Gold: A wavelet coherence analysis". *Physica A: Statistical Mechanics and its Applications*. 536(1): 120888. https://doi.org/10.1016/j.physa.2019.04.124.

Kinateder H, Campbell R, Choudhury T. (2021). "Safe haven in GFC versus COVID-19: 100 turbulent days in the financial markets". *Finance Research Letters*. 43: 101951. https://doi.org/10.1016/j.frl.2021.101951.

Kristoufek L. (2020). "Grandpa, grandpa, tell me the one about Bitcoin being a safe haven: New evidence from the COVID-19 pandemic". *Frontiers in Physics*. 8: 296. https://doi.org/10.3389/fphy.2020.00296.

Le TMH, Zhihong J, Zhu Z. (2019). "Impact of macroeconomic variables on stock price index: Evidence from Vietnam stock market". *Research Journal of Finance and Accounting*. 10(12): 28-29. https://doi.org/10.5296/ajfa.v12i1.17092.

Liu Y, Naktnasukanjn N, Tamprasirt A, Rattanadamrongaksorn T. (2023). "Comparison of the asymmetric relationship between bitcoin and gold, crude oil, and the US dollar before and after the COVID-19 outbreak". *Journal of Risk and Financial Management*. 16(10): 455. https://doi.org/10.3390/jrfm16100455.

Molenaar R. (2024). "Empirical evidence on the stock-bond correlation". *Economic Modelling.* 132: 106-123. https://doi.org/10.1080/0015198X.2024.2317333.

Pesaran MH, Shin Y. (1999). "An autoregressive distributed-lag modelling approach

to cointegration analysis". *Econometrics and Economic Theory in the 20th Century*. 371-413. https://doi.org/10.1017/CCOL521633230.011.

Prasad A, Bakhshi P, Seetharaman A. (2022). "The impact of the US macroeconomic variables on the CBOE VIX Index". *Journal of Risk and Financial Management*. 15(3): 126.

Salisu AA, Raheem ID, Vo XV. (2021). "Assessing the safe haven property of the gold market during COVID-19 pandemic". *International Review of Financial Analysis*. 74: 101666. https://doi.org/10.1016/j.irfa.2021.101666.

Shahzad SJH, Bouri E, Rehman MU, Roubaud D. (2022). "The hedge asset for BRICS stock markets: Bitcoin, gold or VIX". *The World Economy*. 45(1): 292-316. https://doi.org/10.1111/twec.13138.

Sharma S, Malik K. (2022). "Comovement of fear index, stock returns, brent oil prices in BRIC countries: The case of COVID-19". *The Indian Economic Journal*. 70(4): 559-576. https://journals.sagepub.com/doi/abs/10.1177/00194662221082188.

Singhal S, Choudhary S, Biswal PC. (2019). "Return and volatility linkages among international crude oil price, gold price, exchange rate and stock markets: Evidence from Mexico". *Resources Policy*. 60: 255-261. https://doi.org/10.1016/j.resourpol.2019.01.004.

Su Z, Fang T, Yin L. (2019). "Understanding stock market volatility: What is the role of US uncertainty?". *The North American Journal of Economics and Finance*. 48: 582-590. https://doi.org/10.1016/j.najef.2018.07.014.

Wei L, Lee MC, Cheng WH, Tang CH, You JW. (2023). "Evaluating the efficiency of financial assets as hedges against Bitcoin risk during the COVID-19 pandemic". *Mathematics*. 11(13): 2917. https://doi.org/10.3390/math11132917.

Wen X, Cheng H. (2018). "Which is the safe haven for emerging stock markets, gold or the US dollar?". *Emerging Markets Review*. 35: 69-90. https://doi.org/10.1016/j.ememar.2017.12.006.

Whaley RE. (2000). "The investor fear gauge". *Journal of Portfolio Management*. 26(3): 12. https://doi.org/10.3905/jpm.2000.319728.

Yatie A. (2022). "Failure of Gold, Bitcoin and Ethereum as safe havens during the Ukraine-Russia war". *Bordeaux Economics Working Paper*. Bordeaux School of Economics (BSE). https://ideas.repec.org/p/grt/bdxewp/2022-07.html.

Zeng H, Lu R, Ahmed AD. (2023). "Dynamic dependencies and return connectedness among stock, gold and Bitcoin markets: Evidence from South Asia and China". *Equilibrium. Quarterly Journal of Economics and Economic Policy*. 18(1): 49-87. https://doi.org/10.24136/eq.2023.002.

Zhang H, Giouvris E. (2022). "Measures of volatility, crises, sentiment and the role of US 'Fear'Index (VIX) on herding in BRICS (2007–2021)". *Journal of Risk and Financial Management*. 15(3): 134. https://doi.org/10.3390/jrfm15030134.