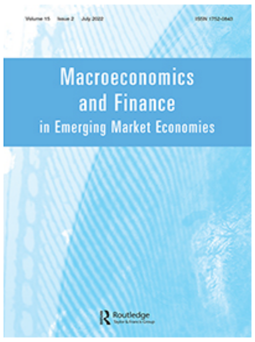

Macroeconomics and Finance in Emerging Market Economies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/reme20

Macroeconomic variables and stock market performance: a PMG/ARDL approach for BRICS economies

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MACROECONOMICS AND FINANCE IN EMERGING MARKET ECONOMIES
https://doi.org/10.1080/17520843.2021.1983704

Macroeconomic variables and stock market performance: a PMG/ARDL approach for BRICS economies

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ABSTRACT

The present study seeks to examine the impact of select macroeconomic variables on stock market performance in the BRICS economies. The study has used monthly data over the period 2011–2021. The study has employed both ARDL bounds testing model and PMG/ARDL model to measure the short and long-run relationships. Both the models provide the confirmatory results regarding short as well as long-run relationships for all the BRICS economies excluding South Africa. Also, the variables have been found to be causally related with each other during the sample period. The study has implications for policymakers, regulators, academia and investors.

ARTICLE HISTORY
Received 11 August 2021
Accepted 18 September 2021

KEYWORDS
Macroeconomic variables; stock market performance; BRICS; PMG/ARDL

1. Introduction

The standard equity valuation model states that the price of a stock is equal to the present value of the future expected cash flows discounted at a required rate of return called capitalization rate. The changes in macroeconomic state variables effectively represent the systematic risk, which influences the investors' preferences over time and consequently affects the captilization rate, the firm's ability to generate future cash flows, and also the dividend pay-out ratio (Chen, Roll, and Ross 1986). It is, therefore, through this mechanism that macroeconomic variables take the shape of systematic risk factors and eventually affect the stock prices. In this context, several theoretical and empirical research works have been conducted to establish a link between the macroeconomic variable and stock market (e.g. Fama 1981, 1990; Chen, Roll, and Ross 1986; Hamao 1988; Asprem, 1989; Chen 1991; Mukherjee and Naka 1995; Cheung and Ng 1998; Nasseh and Strauss 2000). Although the majority of the work has been conducted in the developed or industrialized economies, however, there are similar studies that have been conducted in emerging market economies too (e.g. Mookerjee and Yu, 1997; Maysami and Koh 2000; Wongbangpo and Sharma 2002).

The emerging market economies, contrary to their developed counterparts, possess distinguishing features so far as their political and economic structures and risk and return profiles are concerned. Further, emerging market economies are yet to explore their true economic potential, which will lead to more efficient capital market operations. Moreover, studies like Errunza (1983), Claessens and Naude (1993) and Harvey (1995) observe that

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emerging market economies present more investment avenues to foreign investors resulting in massive capital inflows into such economies. Thus, analysing the dynamic linkages between the stock market and macroeconomy in the emerging markets, especially Brazil, Russia, India, China, and South Africa (BRICS), will help policymakers, regulators, academia, and most importantly, the investors in designing their investment strategies efficiently.

The present study gains importance from the fact that not many studies have discussed the role of macroeconomic variables in predicting stock market returns in the emerging economies during the post-US sub-prime crisis period. Moreover, a more robust pooled mean group panel estimation method within the ARDL framework has been employed which has not been used by any prior study in the context of the theme of the present study. Also, the study intends to analyse the effect of macroeconomic variables on the price discovery of BRICS stock markets through a structure of lags of the macroeconomic variables. As such, addressing the issue of transmission mechanism through which macroeconomic policies reflect in the stock market performance, as well as addresses the possible problems of endogeneity which are inherent in most of the economic models.

The rest of the paper is structured as follows: Section 2 highlights the need for the present study. Section 3 explores the existing literature to highlight the relationship between the select macroeconomic variables and stock market performance. Section 4 highlights the data issues, model specifications, and estimation technique. Section 5 discusses the empirical findings and finally, Sections 6 and 7 present the limitations and scope for future research and conclusion and implications of the study, respectively.

2. Need for the study

The present study seeks to extend the extant literature by testing the long-run stability and short-run dynamics between the macroeconomic variables and the stock market in the BRICS setting by applying pooled mean group-autoregressive distributive lag (PMG/ARDL) model.

Moreover, the behaviour of stock markets in BRICS countries is supposed to exhibit varied responses given the unique macroeconomic environment in which each stock market operates. Therefore, the present study attempts to predict the differential responses of stock markets to macroeconomic variables in the respective BRICS economies, which could be different from the existing research works on a similar theme.

Lastly, the financial crisis (like Asian Currency Crisis, 1997; Global Financial Crisis, 2007–08; Euro Debt Crisis, 2009) have affected the stock markets and yielded results different from what were achieved in periods prior to such crisis. Therefore, the present study attempts to re-examine the dynamics between the macroeconomic variables and the stock market performance post-financial crisis period.

3. Review of literature

3.1. Across different economies

The relationship between macroeconomic variables and the stock market has been one of the focal points both in the developed and the developing economies in the recent past. However, the subject has been extensively researched in developed economies, especially in the US, UK, Japan, among others (Fama 1981, 1990; Geske and Roll 1983; Chen, Roll, and Ross 1986; Schwert 1990; Poon and Taylor 1991; Hamao 1988; Brown and Otsuki 1990; Mukherjee and Naka 1995). Fama (1981) investigates the relationship between stock returns and select macroeconomic variables. The study documents an anomalous negative relationship between stock returns and inflation which is proxied by the positive relationship between real activity and stock returns and the negative relationship between real activity and inflation. Geske and Roll (1983), supporting the views of Fama (1981), observe a reverse causality between the two, meaning thereby stock returns signal inflationary expectations. Further, Kaul (1987) established that negative stock return-inflation stems from money demand and counter-cyclical money supply effects. James, Koreisha, and Partch (1985) examine the causal link between the stock returns, real activity, money supply, and expected inflation. The empirical evidence of the study supports the reverse causality proposition. Further, Chen, Roll, and Ross (1986) investigate the link between stock return and select macroeconomic state variables by analysing whether the innovations in the macroeconomic variables are the risks and whether they are being rewarded in the stock market. The study observes that macroeconomic state variables represent systematic risks and are significantly priced by stock returns as per their exposures except for the oil prices. Gjerde and Sættem (1999) examine the link between stock and select macroeconomic variables in the Norwegian market. Interestingly, the study finds the results from major economies like the US and Japan are valid in the small and open economy of Norway despite having undeveloped financial markets.

Further, a study conducted by Flannery and Protopapadakis (2002) finds that real economic activity has no causal link with stock returns. Moreover, Kyereboah-Coleman and Agyire-Tettey (2008) examine the impact of macroeconomic variables on the Ghana Stock Exchange and observe that lending rates and inflation exert an adverse impact on the stock market. Mazuruse (2014), using the canonical correlation analysis (CCA), observes that maximization of returns on the Zimbabwe Stock Market (ZSE) is found to be mostly caused by macroeconomic variables. Rafay, Naz, and Rubab (2014) analyse the causal link between Karachi Stock Exchange (KSE) and select macroeconomic variables and conclude that there exists a bi-directional relationship between interest rate and KSE 100 index; however, exchange and imports are having a uni-directional relationship with KSE 100 index and no causal link exists between CPI and KSE 100 index. More recently, Ullah et al. (2017) analysed the impact of select macroeconomic variables on the stock markets of SAARC countries. The study observes that exchange rate, foreign currency reserves, and interest rate have statistical significance in explaining stock returns. There is another interesting study by Balagobei (2017), which investigates the link between the macroeconomic variables and Sri Lankan stock returns. The study finds that interest rate and factory industry production influence stock returns negatively while inflation and exchange rate have a positive impact on the latter. Moreover, Kalam (2020) studies the effects of macroeconomic variables on the Malaysian stock market performance. The empirical analysis reveals that macroeconomic variables both in short and the long run have a significant relationship with the stock returns.

3.2. In BRICS economies

The BRICS economies have grown rapidly and are becoming increasingly integrated with the developed world through trade and investment. They cover more than a quarter of the world's land area, more than 40% of the world's population, and roughly 15% of global GDP (Mensi et al. 2014). The current and projected growth rate of BRICS has substantial implications for the capitalization of their stock markets, as well as their financial interconnection with other stock markets (Mensi et al. 2014). The stock markets of BRICS economies have grown both in terms of size and volume of investment, and as such, have attracted much attention from domestic as well as international investors (Mensi et al. 2014). Moreover, BRICS stock markets have consistently produced high returns, which has lured the investors to form internationally diversified portfolios. Koze and Ozturk (2014) observe that the growth rate in BRICS economies will be much higher than the growth rate of developed and other developing economies by 2030. Considering the importance and the critical role played by the BRICS economies in global economics and financial development, the present study has taken BRICS countries as its sample. In this context, reviewing the extant literature concerning the BRICS economies would not only help to assess the present state of research work but also identify the possible research gaps to be addressed by the present study.

Several research works have investigated the link between the macroeconomic variables and the stock market in the BRICS economies, like (Gay 2008; Tripathi and Kumar 2015a, 2015b; Hsing 2011; Chandrashekar, Sakthivel, Sampath, and Chittedi 2018). The study of Gay (2008) examines the impact of macroeconomic variables on stock returns in four emerging economies of BRIC (Brazil, Russia, India, and China) by employing the Box-Jenkins methodology. The empirical analysis of the study reveals that there is no significant influence of exchange rate and international oil prices on the respective stock market indices in the BRIC economies. Moreover, Hsing (2011) evaluates the influence of select macroeconomic variables on the South African stock market by using the exponential GARCH model. The study establishes a positive impact of GDP and monetary aggregates on the stock returns and a negative impact of government deficit ratio to GDP, real interest rate, nominal exchange rate, and inflation on stock returns. Further, Tripathi and Kumar (2015a) analyses the impact of macroeconomic variables on stock returns in BRICS countries. The study finds that stock returns in individual BRICS economies are not significantly affected by GDP and inflation. Moreover, the study observes that interest rate, exchange rate and international oil prices have a significant negative impact on stock returns while money supply has a positive effect on the same. In another study by Tripathi and Kumar (2015b), a unidirectional causality running from stock returns to GDP, inflation, exchange rate, and money supply has been found. Chandrashekar et al. (2018) in their study, use the panel least square regression to evaluate the impact of macroeconomic factors on stock prices in emerging market economies, including India and Brazil. The study establishes a long-run relationship and unidirectional causality between several macroeconomic factors and stock prices.

There is another strand of literature that has examined the link between oil prices changes and stock returns. In this context, Fang and You (2014) investigate, by altering the procedure suggested by Kilian and Park (2009), the impact of oil price shocks on the stock market returns in China, India, and Russia using the structural VAR (or SVAR)

Table 1. Expected sign of the relationship between select macroeconomic variables and stock market indices of BRICS economies.

Macroeconomic Variable	Notation	Expected Sign of relationship
Index of Industrial Production	IIP	+
Interest Rates	IR	-
Consumer Price Index	CPI	+
Exchange Rate	EXR	±
International Oil Prices	OIL	±

approach. The study establishes the mixed results and observes that oil prices always negatively influence India's economy as long as they are not driven by India's increasing oil consumption. Further, the study observes that in the case of Russia, only oil-specific supply shocks have a significant influence on the stock returns. Finally, given China being low on the energy efficiency front, stock returns in the Chinese market are significantly affected by the oil-specific demand shocks. More recently, a critical study by Ji and Zhang (2019) analyses the relationship between Oil futures and stock returns in China. The study establishes that oil futures exhibited substantial volatility during early sessions and also had a significant impact on stock return volatilities during the same time. Further, the study of Ji, Liu, Zhao, and Fan (2020) examines the spillover effects from oil shocks to stock markets in BRICS economies. The empirical findings of the study suggest the dependence between stock returns and oil price shocks. Moreover, the study establishes that such dependence is mostly positive and time-varying. Interestingly, oil-specific demand shocks are more in magnitude compared to supply shocks which are also almost insignificant.

On the basis of the finance theory and the review of literature on the subject, the priori expectations about the signs of the relationship between various macroeconomic variables and stock market prices/returns have been presented in Table 1:

4. Data and methodology

4.1. Data

The use of time-series data allows to examine the development of casual relations over time (Hondroyiannis, Lolos and Papapetrou, 2005; Rousseau and Wachtel 1998). However, pooled/panel data facilitates the evaluation of common effects as well as the individual effects within a dataset. In this context, the present study uses both the time series and the panel data on a monthly basis from January 2012 to May 2021. Based on the objectives of the study, stock index prices along with the select macroeconomic variables related to the BRICS economies have been employed, the details of which along with their respective sources are presented in Table 2.

Figure 1 gives the graphical representation of the monthly stock index prices data of BRICS economies from January 2012 to May 2021. Visually, the stock index prices are seen to follow a random walk behaviour. It is evident that almost all the BRICS economies have witnessed stability in their respective stock markets during the sample period, with China stock index prices exhibiting relatively a higher trending behaviour. Further, the movement

Table 2. Details of variables and data source.

Variables	Notation	Notation for 1st differenced form	Country	Source
Stock Index Prices	SIP	Returns	BRICS	Morgan Stanley Composite Index
Index of Industrial Production	IIP	IIP-Growth	Brazil, Russia, South Africa	Organization for Economic Cooperation & Development
			India	Reserve Bank of India
			China	National Bureau of Statistics, China
Interest Rate	IR	IR-Change	BRICS	International Financial Statistics, IMF
Consumer Price Index	CPI	IFL	BRICS	Organization for Economic Cooperation & Development
Exchange Rate	EXR	EXR-Change	BRICS	World Bank
West Texas Intermediate Oil Price Index	OIL	OIL-Change	BRICS	U.S. Energy Information Administration

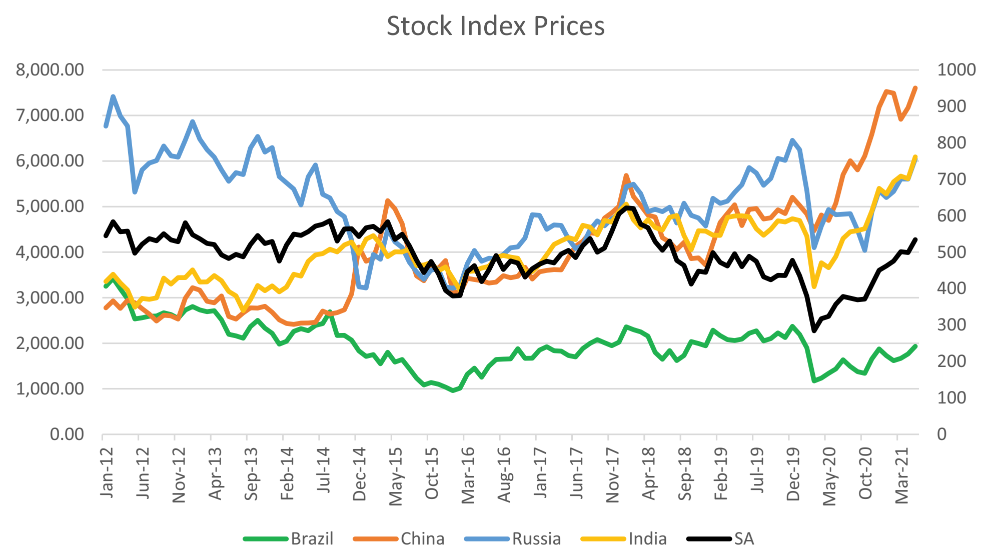

Figure 1. Stock Index Prices of BRICS Economies

of stock index prices seems to be efficiently incorporating and reflecting the information emerging on account of the COVID-19 pandemic outbreak in the latter part of the sample period (i.e. from Febuary 2020 onwards).

Descriptive statistics of all the variables of the study are reported in Table 3. The following inferences can be drawn: From Panel-A of Table 3, it is evident that Brazil, Russia, and South Africa stock markets have on an average generated negative return; however, India and China markets have generated positive returns during the sample period. Also, Brazil's stock market has been found to be riskier compared to its BRICS counterpart markets.

Moreover, PANEL-B, C, D, E & F of Table 3 highlight the descriptive statistics of the select macroeconomic variables. With regards to IIP-Growth, it can be seen that only Brazil has witnessed negative growth while as rest of the BRICS economies have experienced varying but positive levels of growth. The IR-Change on average has been found to be negative across all the BRICS economies. Moreover, it is observed that China has seen the lowest inflation among all the BRICS economies during the

Table 3. Descriptive statistics.

Desc. Stats.	Mean	Median	Max.	Min.	SD	Skew	Kurt	JB
PANEL-A: Returns								
Brazil	−0.0046	−0.0018	0.2649	−0.4823	0.1005	−0.7334	6.5157	67.7240*
Russia	−0.0010	−0.0027	0.2055	−0.2737	0.0785	−0.5419	5.0441	4.9831*
India	0.0053	0.0065	0.1495	−0.2933	0.0611	−0.9309	6.9404	88.6388*
China	0.0089	0.0048	0.2887	−0.1943	0.0707	0.3057	4.7848	16.6126*
South Africa	−0.0002	0.0029	0.1584	−0.2886	0.0675	−0.7122	4.7030	23.0047*
PANEL-B: IIP-Growth								
Brazil	−0.0009	0.0000	0.1283	−0.1328	0.0273	−0.3032	12.3600	410.5664*
Russia	0.0028	0.0032	0.0523	−0.0971	0.0201	−1.1760	8.4458	164.2189*
India	0.0029	0.0019	0.1157	−0.1391	0.0320	−0.7906	9.9650	238.0617*
China	0.0058	0.0059	0.0227	−0.0283	0.0045	−3.3440	31.2095	3922.3630*
South Africa	0.0003	0.0020	0.0551	−0.0956	0.0206	−0.8390	6.6389	74.9369*
PANEL-C: IR-Change								
Brazil	−0.0034	−0.0022	0.2256	−0.1949	0.0402	0.7284	15.3790	725.0276*
Russia	−0.0033	−0.0107	0.4219	−0.0948	0.0521	4.9689	41.0180	7205.9420*
India	−0.0017	0.0000	0.0052	−0.0324	0.0059	−3.7669	17.0919	1191.6080*
China	−0.0036	0.0000	0.0456	−0.0689	0.0147	−2.5051	11.1006	423.3820*
South Africa	−0.0022	0.0000	0.0571	−0.1213	0.0204	−3.1070	19.7513	1489.7070*
PANEL-D: IFL								
Brazil	0.0046	0.0042	0.0134	−0.0038	0.0034	0.3861	3.1648	2.9099*
Russia	0.0051	0.0043	0.0377	−0.0054	0.0050	3.2246	19.7698	1506.5010*
India	0.0050	0.0047	0.0337	0.0337	0.0071	0.3937	5.1663	24.7937*
China	0.0015	0.0009	0.0157	−0.0123	0.0054	0.1917	3.0806	0.7164
South Africa	0.0040	0.0034	0.0138	−0.0060	0.0037	0.3599	3.2650	2.7463*
PANEL-E: EXR-Change								
Brazil	0.0098	0.0090	0.1446	−0.1042	0.0480	0.2066	3.2280	1.0401
Russia	9.13E-05	−0.0010	0.0435	−0.0336	0.0112	0.9232	6.0204	58.4857*
India	0.0033	0.0024	0.0855	−0.0603	0.0218	0.3483	5.6760	35.6844*
China	0.0079	0.0032	0.2034	−0.1198	0.0508	0.9232	5.9757	57.2338
South Africa	0.0050	−0.0014	0.1404	−0.0987	0.0441	0.4715	3.4750	5.2036***
PANEL-F: OIL-Change								
WTI	−0.0038	0.0113	0.5456	−0.5681	0.1245	−0.8326	11.5136	351.1891*

Source: Authors' Compilation.
Note: *,**and*** indicate statistical significance at 1, 5 and 10% respectively.

sample period. In the case of EXR-change, it is noticed that the Russian (Rubel/USD) exchange rate is minimum, while as Brazilian (Real/USD) exchange rate has been found to be highest. Finally, the OIL-change has undergone negative change during the sample period, which approximately ranges between −57% and −55%.

Table 4 summarizes the correlation between returns and select macroeconomic variables for all the BRICS economies, as well as the cross-correlation between the macroeconomic variables within each BRICS economies. This primarily provides insights into the relationship between various macroeconomic variables and stock market returns and confirm the expectations in the literature. It is also evidently clear that the pair-wise correlations between the select macroeconomic variables have been found to be less than 0.5 with varying signs across all the BRICS economies. This indicates that there will not be any issue of multicollinearity with macroeconomic variables.

Table 5 presents the summary of the unit root test for the individual stock index prices and the select macroeconomic variables across all BRICS economies. The Augmented Dickey-Fuller (ADF) test reveals that all the variables are either integrated of order zero I (0) or integrated of order one I (1) except for CPI in the case

Table 4. Pairwise correlation matrix.

Variables	Returns	IIP-Growth	IIP-Growth	IFL	EXR-Change	OIL-Change
PANEL-A: BRAZIL						
Returns	1.000					
IIP-Growth	0.204**	1.000				
IR-Change	0.073	0.024	1.000			
IFL	0.024	0.014	0.312*	1.000		
EXR-Change	−0.824*	−0.148	−0.110	−0.087	1.000	
OIL-Change	0.432*	0.008	−0.041	0.061	−0.325	1.00
PANEL-B: RUSSIA						
Returns	1.000					
IIP-Growth	−0.006	1.000				
IR-Change	−0.233**	0.034	1.000			
IFL	−0.070	−0.004	0.496*	1.000		
EXR-Change	−0.223**	−0.122	0.001	−0.024	1.000	
OIL-Change	.393*	0.272*	−0.235**	−0.261*	−0.115	1.000
PANEL-C: INDIA						
Returns	1.000					
IIP-Growth	0.195**	1.000				
IR-Change	−0.092	−0.111	1.000			
IFL	0.155	0.044	−0.043	1.000		
EXR-Change	−0.742*	0.002	0.026	0.034	1.000	
OIL-Change	.192**	.160***	0.110	0.125	−0.114	1.000
PANEL-D: CHINA						
Returns	1.000					
IIP-Growth	0.168**	1.000				
IR-Change	−0.022	0.001	1.000			
IFL	−0.013	−0.237**	0.088	1.000		
EXR-Change	−0.226**	−0.149	−0.309*	0.019	1.000	
OIL-Change	0.115	0.119	0.168**	0.101	−0.468*	1.000
PANEL-E: SOUTH AFRICA						
Returns	1.000					
IIP-Growth	−0.115	1.000				
IR-Change	0.068	0.053	1.000			
IFL	0.062	−0.031	0.286*	1.000		
EXR-Change	−0.819*	0.097	−0.094	−0.144	1.000	
OIL-Change	0.311*	−0.045	0.236**	0.136	−0.311*	1.000

Source: Authors' compilation.
Note: *, **and*** indicate statistical significance at 1, 5 and 10% respectively.

of Russia, China, and South Africa, which has been found to be integrated of order two I (2). These results are necessary for the application of the ARDL model and suggest that CPI cannot be incorporated in the ARDL model for Russia, China, and South Africa.

Table 6 reports the estimation results of the panel unit root tests. The present study uses both first- and second-generation panel unit tests. The underlying assumption for the first-generation test that is Levin, Lin, and Chu (2002) test is that the cross-sectional units are independent and, as such, check the common unit root process. However, the second-generation tests, including Im, Pesaran, and Shin's (2003) test, ADF-Fisher Chi-square, and PP-Fisher Chi-square, assume the dependence of cross-sectional units and thus check the individual unit root processes within the panel data. It is evident that all the panel data variables have been found to be integrated of order one I (1).

Table 5. Augmented Dickey Fuller (ADF) test.

	Level		1st Differenced		
Test	Intercept	Trend & Intercept	Intercept	None	Decision
PANEL-A: BRAZIL					
Index Price	−2.8555***	−2.6402	−9.7531*	−9.7475*	I (1)
IIP	−1.2155	−1.2316	−10.181*	−10.181*	I (1)
IR	−2.8133***	−0.6964	−4.2708*	−4.2804*	I (1)
CPI	−0.1302	−2.5935	−4.1301*	0.0358	I (1)
EXR	−0.6070	−2.2325	−10.448*	−10.168*	I (1)
Index Price	−2.8555***	−2.6402	−9.7531*	−9.7475*	I (1)
PANEL-B: RUSSIA					
Index Price	−2.9839**	−2.6778	−7.9339*	−7.9669*	I (0)
IIP	−0.2901	−5.5785*	−8.8565*	−8.2074*	I (0)
IR	−1.3539	−1.9576	−5.7703*	−5.7871*	I (1)
CPI	−0.7128	−1.8378	−2.5144	−0.9596	I (2)
EXR	−1.6941	−1.7868	−7.7776*	−7.8137*	I (1)
PANEL-C: INDIA					
Index Price	−0.7482	−2.5684	−10.7235*	−10.6654*	I (1)
IIP	0.9905	1.7036	−5.1592*	−2.9919*	I (1)
IR	−0.6872	−2.8672	−10.6753*	−3.6981*	I (1)
CPI	−0.3371	−1.5208	−6.7734*	−1.0453*	I (1)
EXR	−2.1778	−3.3919**	−10.805*	−10.5904*	I (0)
PANEL-D: CHINA					
Index Price	0.3665	−2.0856	−9.0311*	−8.8400*	I (1)
IIP	0.8511	−2.5653	−6.0450*	−1.7912*	I (1)
IR	−1.0631	−1.3935	−4.575*	−3.2277*	I (1)
CPI	−0.0296	−2.2225	−2.8433***	−1.3195	I (2)
EXR	−1.3133	−1.7668	−7.4899*	−7.2755*	I (1)
PANEL-E: SOUTH AFRICA					
Index Price	−2.5228	−2.6997	−11.1413*	−11.1897*	I (1)
IIP	−3.2467**	−3.3828**	−14.333*	−14.3963*	I (1)
IR	−0.9574	−0.8738	−4.7682*	−4.7492*	I (1)
CPI	−0.9493	−2.0479	−2.7028***	−0.1693	I (2)
EXR	−1.9755	−2.0601	−11.1080*	−11.0495*	I (1)
PANEL-F: OIL PRICES					
WTI	−2.2937	−2.4166	−6.7310*	−7.1038*	I (1)

Source: Authors' compilation.
Note: *, **and*** indicate statistical significance at 1, 5 and 10% respectively.

4.2. Econometric methodology

4.2.1. ARDL bounds testing method

On the basis of the discussion in the previous sections, the study has considered the following model to assess the long-run relationship between the stock market and macroeconomic variables in BRICS economies;

$$LnY_{i,t} = \alpha_0 + \beta_1 LnIIP_{i,t} + \beta_2 LnIR_{i,t} + \beta_3 LnCPI_{i,t} + \beta_4 LnEXR_{i,t} + \beta_5 OIL_t + \varepsilon_{i,t} \quad (1)$$

where, LnY_t, $LnIR_{i,t}$, $LnCPI_{i,t}$, $LnEXR_{i,t}$ represent the stock index prices, index of industrial production, consumer price index, and exchange rate vis-à-vis US dollar respectively for BRICS economies and OIL_t represents the international crude oil prices. The Johansen approach to cointegration can be used when all the variables are integrated of the same order (Johansen 1991). However, the Autoregressive Distributed Lag (ARDL) approach, which the present study has used, can be applied even when the variables are integrated of different order. Thus, if some of the variables are integrated of zero-order I(0), and some of the variables are integrated of order one I

Table 6. Panel unit root test.

Variables			Index Prices	IIP	IR	CPI	EXR
Levin, Lin & Chut	Level	Intercept	2.2814	1.4704	−1.1167	−0.8003	−0.2466
		Trend & Intercept	2.4441	0.9883	0.5185	−0.0568	2.2126
	1st Differenced	Intercept	−5.6130*	−2.3693*	−4.2417*	−5.8564*	−6.4407*
		None	−11.0913*	−6.1625*	−8.3992*	−4.6454*	−10.2615*
Im, Pesaran and Shin W-stat	Level	Intercept	0.6848	2.0310	0.3591	2.5889	0.5555
		Trend & Intercept	0.3188	−1.4425	1.6433	−0.1926	0.1390
	1st Differenced	Intercept	−8.9734*	−9.5487*	−6.1401*	−9.4262*	−8.2738*
		None	-	-	-	-	-
ADF – Fisher Chisquare	Level	Intercept	7.6257	6.7393	6.2209	1.2888	5.6508
		Trend & Intercept	6.3912	16.6940***	3.1277	9.1380	6.8547
	1st Differenced	Intercept	100.027*	109.252*	59.602*	108.207*	88.9869*
		None	−11.0913*	127.529*	83.444*	52.0591*	117.352*
PP – Fisher Chisquare	Level	Intercept	14.0552	15.3002	4.7070	1.1699	8.1364
		Trend & Intercept	9.7568	55.2721*	2.7336	11.9439	10.254
	1st Differenced	Intercept	313.142*	279.601*	260.53*	204.855*	298.665*
		None	1094.08*	1075.26*	646.68*	181.664*	974.516*
Decision			I (1)	I (1)	I (1)	I (1)	I (1)

Source: Authors' compilation.
Note: *, **and*** indicate statistical significance at 1, 5 and 10% respectively.

(1), the ARDL model provides long-run estimates along with the short-run dynamics, which can be relied upon (Pesaran 1997). However, none of the variables should be integrated of order two or I(2). The other advantage of using the ARDL model is that it can be used for small samples as it provides robust results for the same (Ghatak and Siddiki 2001). The use of appropriate lags within the ARDL model corrects the autocorrelation as well as the indigeneity problem (Pesaran, Shin, and Smith 2001). The present study has used the AIC to select the lag order of the ARDL model.

The ARDL model specification allows for transforming the long-run model in Equation (1) into an unrestricted vector error correction model (VECM), which provides both the long-run and short-run dynamics, which in our case may be reproduced as;

$$\Delta LnY_{i,t} = \alpha_0 + \sum_{j=1}^{p} \theta_1 \Delta LnY_{t-j} + \sum_{j=0}^{q} \theta_2 \Delta LnIIP_{t-j} + \sum_{j=0}^{r} \theta_3 \Delta LnIR_{t-j} + \sum_{j=0}^{s} \theta \Delta LnCPI_{t-j} + \sum_{j=0}^{t} \theta_5 \Delta LnEXR_{t-j} + \sum_{j=0}^{v} \theta_{6,} \Delta LnOIL_{t-j} + \beta_1 LnY_{t-1} + \beta_2 LnIIP_{t-1} + \beta_3 LnIR_{t-1} + \beta LnCPI_{t-1} \beta_5 LnEXR_{t-1} + \beta_6 LnOIL_{t-1} + \varepsilon_{i,t} \tag{2}$$

where, α_0 is the intercept, β's are the long-run coefficients, θ's are the short-run coefficients, t represents time dimension, and ε_t is the random disturbance term.

Further, the study employs the bounds testing approach to test the presence of a long-run relationship between the variables, as mentioned in Pesaran, Shin, and Smith (2001). The absence of a long-run relationship between the variables is tested by the joint null hypothesis of the coefficients of the lagged variables, which are θs, under Wald test statistics;

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7$

Against the alternate hypothesis:

H_1: $\beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0, \beta_5 \neq 0, \beta_6 \neq 0, \beta_7 \neq 0$

The first step in the bounds testing approach includes estimating the Ordinary Least Squares (OLS) regression for the ARDL specification of unrestricted vector error correction model (VECM). After this, the joint significance of the long-run coefficients β's under the F-statistic is tested. The calculated F-statistic under the null hypothesis of no cointegration is compared with upper and lower critical bounds. If the computed F-statistic falls above the upper critical bound value, then the null hypothesis of absence of cointegration is rejected. Once the presence of long-run relationship is confirmed, then the study proceeds to estimate the long-run relationship between stock prices and macroeconomic variables for each BRICS country under the ARDL framework, which is as;

$$LnY_t = \alpha_0 + \beta_1 LnIIP_t + \beta_2 LnIR_t + \beta_3 LnCPI_t + \beta_4 LnEXR_t + \beta_5 LnOIL_t + \varepsilon_t \tag{3}$$

4.2.2. VECM and causality test

Additionally, we estimate the restricted VECM under the ARDL framework using the lagged residuals from the long-run model (3). The model may be parameterized as;

$$\begin{aligned}\Delta LnY_t = \alpha_0 &+ \sum_{j=1}^{p} \theta_1 \Delta LnY_{t-j} + \sum_{j=0}^{q} \theta_2 \Delta LnIIP_{t-j} + \sum_{j=0}^{r} \theta_3 \Delta LnIR_{t-j} + \sum_{j=0}^{s} \theta_4 \Delta LnCPI_{t-j} \\ &+ \sum_{j=0}^{t} \theta_5 \Delta LnEXR_{t-j} + \sum_{j=0}^{v} \theta_{6,} \Delta LnOIL_{t-j} + \mu ECT_{t-1} + \varepsilon_{i,t}\end{aligned} \tag{4}$$

The ECT from the models (3) and (4) can be expressed as;

$$\begin{aligned}ECT_t = LnY_t - \alpha_0 &- \sum_{j=1}^{p} \beta_{1,j} LnY_{t-j} - \sum_{j=0}^{q} \beta_{2,j} LnIIP_{t-j} - \sum_{j=0}^{r} \beta_{3,j} LnIR_{t-j} - \sum_{j=0}^{s} \beta_{4,j} LnEXR_{t-j} \\ &- \sum_{j=0}^{t} \beta_{5,j} LnCPI_{t-j} - \sum_{j=0}^{v} \beta_{6,j} LnOIL_{t-j}\end{aligned} \tag{5}$$

According to the Granger representation theorem (Granger 1986), in the case of the existence of a cointegrating relationship between the variables, there exists at least a unidirectional causal relationship between them. The following VECM in the matrix form can be estimated to capture both the long-run as well as the short-run causal relationship between the variables;

$$\begin{bmatrix} \Delta LnY_t \\ \Delta LnIIP_t \\ \Delta LnIR_t \\ \Delta LnCPI_t \\ \Delta LnEXR_t \\ \Delta LnOIL_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{bmatrix} + \sum\nolimits_{j=1}^{n} \begin{bmatrix} \theta_{11} & \theta_{12} & \theta_{13} & \theta_{14} & \theta_{15} & \theta_{16} \\ \theta_{21} & \theta_{22} & \theta_{23} & \theta_{24} & \theta_{25} & \theta_{26} \\ \theta_{31} & \theta_{32} & \theta_{33} & \theta_{34} & \theta_{35} & \theta_{36} \\ \theta_{41} & \theta_{42} & \theta_{43} & \theta_{44} & \theta_{45} & \theta_{46} \\ \theta_{51} & \theta_{52} & \theta_{53} & \theta_{54} & \theta_{55} & \theta_{56} \\ \theta_{61} & \theta_{62} & \theta_{63} & \theta_{64} & \theta_{65} & \theta_{66} \end{bmatrix} \begin{bmatrix} \Delta LnY_{t-j} \\ \Delta LnIIP_{t-j} \\ \Delta LnIR_{t-j} \Delta LnCPI_{t-j} \\ \Delta LnEXR_{t-j} \\ \Delta LnOIL_{t-j} \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_1 \\ \mu_1 \\ \mu_1 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_t \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \end{bmatrix} \ldots \tag{6}$$

where, α_1 to α_6 represent the constant terms; θ_{11} to θ_{66} represent the short-run estimates of the VECM model, μ_1 to μ_6 represent the error correction coefficients and ε_1 to ε_6 represent the white noise terms. The long-run causal relationship between the variables can be verified by testing the null hypotheses $H_0 : \mu_{i's} = 0$, while as the short-run causality between the variables can be established through the lagged β_{mn} coefficients by jointly testing the null hypotheses $H_0 : \beta_{mn,1} = \beta_{mn,2} = \ldots = \beta_{mn,j} = 0$.

4.2.3. PMG/Panel ARDL model

The heterogeneous characteristics of the estimators can be more appropriately understood with the panel estimation technique. Among others, the panel ARDL model is one of the most popular methods for estimating cross-sectional heterogeneity. The mean group (MG), as well as pooled mean group (PMG) estimators, can be used while estimating the panel ARDL method. However, to ensure the validity of the MG estimators, a large time period for each cross-sectional unit (Pesaran 2015), as well as sufficient lagged cross-sectional averages, are required (Arnold, Javorcik, and Mattoo 2011).

The most widely used approach for estimating the panel ARDL model as an alternative to MG is the PMG estimator. The PMG approach to the panel ARDL modelling estimates long-run coefficients using the maximum likelihood procedure while restricting them to be homogenous across cross-sectional units (Odugbesan and Rjoub 2019). Once the long-run coefficients are estimated, the PMG approach estimates the intercepts, short-run slope coefficients, and the error correction terms on a unit-by-unit basis using the maximum likelihood procedure, allowing them to vary across cross-sectional units (Odugbesan and Rjoub 2019, 2020). Additionally, the residuals resulting from the VECM should be serially uncorrelated since the panel ARDL model does not address the cross-sectional dependence.

The panel ARDL model within the PMG estimator approach takes the following long-run form:

$$LnY_{i,t} = \alpha_i + \beta_1 LnIIP_{i,t} + \beta_2 LnIRi_{,t} + \beta_3 LnCPI_{i,t} + \beta_4 LnEXR_{i,t} + \beta_5 LnOIL_{i,t} + \varepsilon_{i,t} \tag{7}$$

where, α_i represents common effects.

The above long-run model (7) can be reparametrized in VECM specification of the following form;

$$\Delta LnY_{i,t} = \alpha_0 + \sum_{j=1}^{p} \theta_{1i,j} \Delta LnY_{t-j} + \sum_{j=0}^{q} \theta_{2i,j} \Delta LnIIP_{t-j} + \sum_{j=0}^{r} \theta_{3i,j} \Delta LnIR_{t-j} + \sum_{j=0}^{s} \theta_{4,ij} \Delta\, LnCPI_{t-j} + \sum_{j=0}^{t} \theta_{5i,j} \Delta LnEXR_{t-j} + \sum_{j=0}^{v} \theta_{6i,j} \Delta LnOIL_{t-j} + \mu_i ECTi,_{t-1} + \varepsilon_{i,t} \tag{8}$$

where, i represents cross-sectional units, t represents time-series dimension and $Y_{i,t}$ represents stock market index price for each cross-sectional unit i at time t. All the θ_{is} and μ_i are allowed to vary across cross-sectional units.

$$ECT_{i,t} = LnY_{i,t} - \alpha_0 - \sum_{j=1}^{p} \beta_{1i,j} LnY_{i,t-j} - \sum_{j=0}^{q} \beta_{2i,j} LnIIP_{i,t-j} - \sum_{j=0}^{r} \beta_{3i,j} LnIR_{i,t-j} - \sum_{j=0}^{s} \beta_{4i,j} LnCPI_{i,t-j} - \sum_{j=0}^{t} \beta_{5i,j} LnEXR_{6i,-j} - \sum_{j=0}^{v} \beta_{6i,j} LnOIL_{i,t-j} \tag{9}$$

In Equation (6), μ_i represents the error correction coefficient signifying the long-run relationship with β_{is} in Equation (8) representing the long-run coefficients.

5. Empirical findings

5.1. Long-run relationship and cointegration test using ARDL model and bounds testing approach

The long-run cointegration relationship between the stock index prices and the select macroeconomic variables across all the BRICS economies is reported in Table 7 (see Appendix A for AIC results). Panel-A of the table provides the results of the ARDL bounds test showing that a long-run relationship exists in all the BRICS economies except South Africa. Panel-B of Table 7 reveals that none of the select macroeconomic variables significantly influence the Brazilian stock prices in the long run, while the majority of the macroeconomic variables of the rest of the BRICS economies influence their respective stock index prices in the long run. With respect to IIP, in the case of Russia and India, stock

Table 7. ARDL bounds testing and long-run form.

Country	Brazil	Russia	India	China	South Africa
PANEL-A: Bounds Test					
Bounds Test F-Value	3.3251	3.4487	3.4259	4.3218	2.0826
Degrees of Freedom	5	4	5	4	4
Critical values					
10%	10%	10%	10%	10%	10%
5%	5%	5%	5%	5%	5%
1%	1%	1%	1%	1%	1%
PANEL-B: Long run form					
LOG(IIP)	14.5370	−0.018344	−1.7541***	2.6062*	-
LOG(IR)	11.8410	−0.294055*	−2.6610	1.9229**	-
LOG(CPI)	−35.4604	-	3.6883*	-	-
LOG(EXR)	22.1732	1.168496***	−3.1018*	−0.0441	-
LOG(WTI)	9.0464	0.406562*	0.2442**	−0.4297***	-
Constant	−7.0688	3.323919	15.3202**	−5.7324***	-

Source: Authors' Compilation.
Note: *,**and*** indicate statistical significance at 1, 5 and 10% respectively.

prices are negatively influenced in the long run; however, a statistically significant relationship is established only in the Indian context. These results are consistent with Ibrahim and Musah (2014), according to which investors are induced to borrow funds while anticipating an improvement in the future real economic activity. This leads to a corresponding increase in interest rates resulting in a fall in stock prices. Further, in the case of China, IIP is found to influence the stock prices positively, which is significant at the 1% level. The results are in line with the economic expectations about the relationship between the two variables. The intuition here, as is supported by an overwhelming number of studies including (Chen, Roll, and Ross 1986; Chatrath, Ramchander, and Song 1996; Mookerjee and Yu 1997; Wongbangpo and Sharma 2002), is that the corporate earnings increase as real economic activity increases which results in higher stock prices. So far as IR is concerned, the results suggest that stock prices are negatively affected in the case of Russia and India; however, a statistically significant relationship is established only in the case of Russia. The underlying explanation for such a relationship, as discussed in detail in Wongbangpo and Sharma (2002), lies in the fact that the stock and the debt markets exist as competitive investment alternatives. Thus, an increase in the interest rates leads to a shift iin investment from the stock market to the debt market, consequently reducing stock prices. Contrastingly, IR has been found to have a significantly positive influence on Chinese stock prices supporting the earlier results of Suhaibu, Harvey and Amidu (2017). As far as the relationship between CPI and stock index prices is concerned, India is the only BRICS economy where the CPI coefficient shows a significant positive association with stock index prices which is consistent with the Fisher effect hypothesis (see Fisher 1930).

Moreover, the relationship between EXR and stock index prices is evidenced across all BRICS economies except Russia. In the case of India and China, EXR is negatively related to stock index prices; however, in the Indian context, stock index prices are significantly affected. The results favour the net importer hypothesis, as in the case of India, as per which domestic currency depreciation is associated with falling stock prices (see Kim 2003). In the case of Russia, stock prices are having a significant positive relationship with EXR supporting the flow approach given by Dornbusch (1980) as per which when depreciation of domestic currency sets in, exports become more competitive which consequently lead to an increase in output and a subsequent increase in stock prices. Finally, the relationship between international crude oil prices and stock index prices is seen to exist positively across all the BRICS economies except China. In this context, Brazil, Russia, and India exhibit a positive association between the two; however, it is significant only in the case of Russia and India. So far as China is concerned, crude oil prices are negatively and significantly influencing the stock index prices.

5.2. Short-run relationship and causality test

The short-run dynamics and the causal relationship between the variables are presented in Table 8, wherein the error correction model is used in the case of those BRICS economies where cointegration has been established (see Panel-A of Table 7), and the VAR model is used in the case of South Africa. The empirical analysis of the results reveals that all the short-run coefficients in the case of South Africa are insignificant in explaining the stock return movements. Further, the autoregressive coefficients for Brazil, India, and

Table 8. Error correction and causality test.

Countries	Brazil (4, 1, 4, 1, 3, 2)	Russia (1, 1, 3, 1, 2)	India (2, 1, 0, 0, 1, 0)	China (2, 0, 1, 1, 2)	South Africa (2, 2, 2, 2, 2)
PANEL-A: Error correction and short-run coefficients					
Returns (−1)	−0.3217*	-	−0.1126***	0.1653***	0.1002
Returns (−2)	−0.4411*	-	-	-	−0.0344
Returns (−3)	−0.1122**	-	-	-	-
IIP-Growth	0.3334***	−0.5150***	0.2123***	0.7798	-
IIP-Growth (−1)	-	-	-	-	0.0887
IIP-Growth (−2)	-	-	-	-	0.3448
IR-Change	−0.0294	−0.4084*	−0.3877	−0.6423	-
IR-Change (−1)	0.3115**	−0.0151		-	−0.4877
IR-Change (−2)	0.1127	0.2951*		-	0.2862
IR-Change (−3)	0.2977**	-		-	-
IFL	−2.3663***	-	1.1336*	-	-
EXR-Change	−1.7224*	−1.3211**	−2.1087*	−0.4311*	-
EXR-Change (−1)	−0.6362	-	-	-	0.2767
EXR-Change (−2)	−0.7600*	-	-	-	−0.0214
OIL-Change	0.1371*	0.3190*	0.0586***	−0.0749	-
OIL-Change (−1)	0.0879***	−0.1300**	-	0.1203**	0.0818
OIL-Change (−2)					−0.0393
ECT (−1)	0.0053*	−0.3281	−0.1355*	−0.1811*	-
BG Serial Correl. LM Test:	0.0349	0.1115	0.1195	0.2235	1.9443
PANEL-B: Pair-wise Granger causality summary					
Returns & IIP-Growth	←	←→	●	←	●
Returns & IR-Change	←	←→	→	←→	→
Returns & IFL	→	●	←	●	●
Returns & EXR-Change	→	→	←→	●	●
Returns & OIL-Change	←→	←→	←→	←	→

Source: Authrs' Compilation.
Note: *, **and*** indicate statistical significance at 1, 5 and 10% respectively.
→ represents unidirectional causality from returns to macroeconomic variables, ← represents unidirectional causality from macroeconomic variables to returns, ←→ represents bidirectional causality between returns and macroeconomic variables and ● represents absence of causality.

China are statistically significant, implying market inefficiency (Fama 1991). Similarly, IIP-Growth is seen to explain returns in the short-run for all the BRICS countries, while as in the case of Russia, the same is found to be negative, a result contrary to the stock valuation hypothesis, however consistent with the earlier findings of Ibrahim and Musah (2014). Moreover, it is evident from the ARDL model for all the BRICS countries that changes in industrial production are reflected in the stock returns without any lags. The dynamics of IR-Change show that contemporaneously IR-Changes are negatively related to the stock returns of all the BRICS countries, which is explained by Mishkin (2007) in the form of the denominator effect in the Gordon growth model as per which, when interest rates increase debt investments become more attractive in comparison to equity investments given the increase in the required rate of return on the part of equity investors, thus resulting in an increase in stock returns. However, the lagged IR-Changes show a significant positive impact on returns, which is counterintuitive and support the findings of Suhaibu, Harvey, and Amidu (2017). The IFL is seen to have a negative impact on stock returns in the case of Brazil, establishing the proxy effect hypothesis (Fama 1981), while the same has been found to confirm the generalized Fisher effect in the case of India. Further, EXR-change dynamics are reported to influence stock returns negatively in the case of all BRICS economies except South Africa. Since on average EXR-change has been found to be positive for all the BRICS countries (see Panel-E of Table 3), implying depreciation of respective home currencies viz-a-viz the US dollar and thus should impact stock returns negatively in case of net importer countries (see Morley 2002), which actually is the case with Brazil, Russia and India in the present study. However, in the case of China, the results are counterintuitive as China being the net exporter with almost negative imports. Moreover, it is evident that oil has witnessed a negative change over the sample period (see Panel-F of Table 3), as a result of which the returns in net oil-importing countries will increase as is the case with all the BRICS economies except China, a result which is again counterintuitive as China is the world's largest oil importer. Also, the error correction term (ECT) reveals the speed of adjustment with which the long-run equilibrium relationship is maintained between the variables. The lagged ECTs provide information about the long-run causality running from the macroeconomic variables to the stock returns. As is evident from Panel-A of Table 8, the ECT has been found to be negative and significant for Russia, India and China, indicating that long-term causality runs from macroeconomic variables to stock returns. In the case of Brazil, the same has been found to be positive, a result contrary to the earlier findings of cointegration in the context of Brazil (see Panel-A of Table 7).

Further, Panel-B of Table 8 summarizes the causal relationship between stock index returns and macroeconomic variables. The Granger causality results within the Wald statistic framework establish unidirectional causality running from IIP-Growth to stock returns in the case of Brazil and China, which imply that past values of IIP-Growth have predictive power for current and future stock returns (see Abdullah and Hayworth 1993; Dhakal, Kandil, and Sharma 1993; Pesaran and Timmermann 1995 for similar results); however, bidirectional causality has been established in the case of Russia and the same is consistent with Choudhry, Papadimitriou, and Shabi (2016) who have established bidirectional causality between the two variables in case of the USA, Canada, Japan and UK. In the case of India and South, Africa IIP-Growth is not causing returns and vice-versa. Moreover, a unidirectional causality is running from returns to IR-Change in the case of India and South Africa, while a unidirectional causality running from IR-Change to returns has been confirmed in the case of Brazil. For the remaining BRICS countries, returns and IR-Change are bi-directionally causing each other confirming the results of Suhaibu, Harvey, and Amidu (2017). In the case of Brazil, reverse causality is reported indicating that causality is running from returns to inflation which indicates that lagged stock returns contain significant information for predicting current and future inflation rates, confirming the results of Geske and Roll (1983). However, in the case of India, a unidirectional causality from inflation to returns is evidenced, a result consistent with Islam and Goyal (2017). Moreover, analysing the causal relationship between returns and EXR-change, it is evident that unidirectional causality running from returns to EXR-change is established in the case of Brazil and India. These results are contrasting the findings of (Gavin 1989; Abdalla and Murinde 1997; Ajayi, Friedman, and Mehdian 1998) who find and contend that the transmission mechanism runs from exchange rate to stock returns. However, bidirectional causality exists in the case of

India, results which are consistent with the early findings of Bahmani-Oskooee and Sohrabian (1992) who have established a two-way causal relationship between exchange rate and stock returns in the US market. Moreover, Granger, Huangb and Yang (1986) have revealed a strong bi-directional causal relationship between the two variables in the case of Hongkong, Malaysia, Singapore, Thailand, and Taiwan which substantiate the results of the present study. Also, the results reveal the absence of any causal relationships in the case of China and South Africa. Finally, with regard to causality between oil prices changes and returns, Brazil, Russia and India report bidirectional causality. However, in the case of China and South Africa, a unidirectional causality is reported running from returns to oil price changes and from oil prices changes to returns, respectively.

The study conducted a BG serial correlation LM test which reveals that there is no serial correlation in the residuals of respective ARDL models of BRICS economies except Brazil. However, the study has employed serial correlation consistent standard errors in the case of Brazil (see Panel-A of Table 8). Further, the study performed stability diagnostic tests, including CUSM and CUSM of squares tests which have revealed the stability of BRICS ARDL models (see Appendix B).

5.3. Dynamic PMG/ARDL model estimation

Panel-A of Table 9 presents the PMG/ARDL estimation results of the common effects of all macroeconomic variables across all the BRICS countries together on the stock index prices as well as returns. The long-run coefficients reveal that IIP, IR, and CPI cause BRICS stock prices while EXR is seen to have no effect. Also, the common effects of macroeconomic variables across all the BRICS countries reveal that only IR-Change and EXR-change are significantly explaining changes in the BRICS stock returns. Moreover, the negative coefficient of ECT signifies that long-run causality runs from the macroeconomic variables to stock returns; however, the low coefficient of ECT implies that the BRICS stock returns take a longer time to adjust in the short-run to maintain the long-run equilibrium. Further, the Panel-B results of Table 9 help in identifying the individual effect of macroeconomic variables of BRICS countries on their respective stock returns. In this context, the results of the individual effects model for all the BRICS countries, excluding South Africa, are in conformity with the findings of the short-run dynamic ARDL model (see Panel-A of Table 8). However, on account of robustness, the PMG/ARDL model identifies the short-run dynamics in the case of South Africa, which the simple ARDL model fails to capture. Thus, the PMG/ARDL coefficients of individual effects related to South Africa reveal that the IIP-Growth and EXR-change have a significant and negative impact on the stock market returns. Moreover, the ECTs for all the individual effect models are negative and statistically significant, which points to the fact that the variables in question are related to each other in the long-run, with causality running from macroeconomic variables to stock returns. Finally, the confidence ellipse plots (see Appendix C) reveal the absence of significant serial correlation between the long-run coefficients (see Panel-B of Table 8), which establishes the independence of the estimates, as such confirming the absence of multicollinearity.

Table 9. PMG/ARDL test.

Country	Variables	Coefficient	t-statistic	p-value
PANEL-A: Common Effects				
Long-run Form				
BRICS-Panel	IIP	1.7428	4.0391	0.0001
	IR	−0.3393	−2.6908	0.0074
	CPI	−1.3595	−5.0005	0.0000
	EXR	0.0523	0.2672	0.7893
Short-run Form				
BRICS-Panel	ECT	−0.0863	−2.1619	0.0311
	IIP-Growth	0.4723	1.0833	0.2791
	IR-Change	−0.2676	−2.0165	0.0442
	IFL	−0.4265	−0.7204	0.4716
	EXR-Change	−1.3557	−4.5587	0.0000
	Constant	0.4870	2.2909	0.0224
PANEL-B: Individual Effects				
BRAZIL	ECT	−0.0146	−31.261	0.0001
	IIP-Growth	0.2978	7.7366	0.0045
	IR-Change	−0.0212	−1.0876	0.3563
	IFL	−1.7378	−0.5963	0.5929
	EXR-Change	−1.7010	−134.14	0.0000
	Constant	0.1226	4.9767	0.0156
RUSSIA	ECT	−0.2327	−41.610	0.0000
	IIP-Growth	−0.2573	−2.1877	0.1165
	IR-Change	−0.2927	−12.933	0.0010
	IFL	−1.1715	−0.3885	0.7235
	EXR-Change	−1.4255	−3.7161	0.0339
	Constant	1.2434	3.6495	0.0355
INDIA	ECT	−0.0200	−34.060	0.0001
	IIP-Growth	0.3399	26.954	0.0001
	IR-Change	−0.4002	−1.0880	0.3562
	IFL	1.40234	5.6064	0.0112
	EXR-Change	−2.0921	−78.849	0.0000
	Constant	0.1023	7.0097	0.0060
CHINA	ECT	−0.1036	−54.583	0.0000
	IIP-Growth	2.1489	1.0254	0.3806
	IR-Change	−0.6788	−3.1395	0.0517
	IFL	0.5137	0.3510	0.7488
	EXR-Change	−0.3111	−17.437	0.0004
	Constant	0.6432	6.0872	0.0089
SOUTH AFRICA	ECT	−0.0608	−97.685	0.0000
	IIP-Growth	−0.1677	−5.6462	0.0110
	IR-Change	0.0551	1.5824	0.2117
	IFL	−1.1395	−1.1841	0.3216
	EXR-Change	−1.2491	−185.55	0.0000
	Constant	0.3236	13.502	0.0009

Source: Authors' Compilation.

6. Limitations and future research

The study has two major limitations that offer the potential for future research. First, the study has been conducted with the assumption of linearity in the underlying relationship between the variables. However, the underlying relationship can be non-linear in structure which offers potential for future research and can be modelled using non-linear econometric models like Non-linear ARDL. Second, the study has taken the cross-sectional sample wherein there are possibilities of volatility spillovers and thus may impact the results. Therefore, the present study can be extended further by analysing the cross-sectional volatility spillovers by employing multivariate volatility models like DCC-GARCH or GARCH-BEKK.

7. Conclusion and policy implications

The present study has been conducted to investigate the impact as well as the dynamic linkages between macroeconomic variables and stock market performance in the BRICS set-up. The study has identified relevant select macroeconomic variables on the basis of the intuitive financial theory, which includes IIP, IR, CPI, EXR, and WTI, and the stock market prices as a proxy for its performance. The study has used both the ARDL bounds testing model and PMG/ARDL model to measure the short and long-run relationships given the time dimension and pooled data, respectively. Both the models provide confirmatory results regarding short as well as long-run relationships for all the BRICS countries, excluding South Africa. Also, the variables have been found to be causally related to each other during the sample period. Moreover, based on the data analysis, it is observed largely that macroeconomic variables hold predictive power for stock returns in BRICS countries.

The study has implications for academia, policymakers, regulators, and investors in general, and the same are enumerated as below:

(i) The study is expected to facilitate academia to draw a more meaningful conclusion and also extend the present study by applying more advanced and comprehensive econometric models.

(ii) The existence of a cointegrating relationship between the macroeconomic variables and stock market prices signals towards the efficient price discovery mechanism in the stock markets of BRICS countries. This indicates that the information in macroeconomic variables is efficiently reflected by the respective stock markets of the BRICS economies. Thus, investors enjoy a greater advantage in forming their investment policies within a set of variables prevalent in the macroeconomy.

(iii) In many cases, bi-directional causality has been established between macroeconomic variables and stock market prices which implies that stock markets do not merely operate as casinos where at a throw of dice fortunes are made or lost, but indeed represent well-structured and mature institutions which signal or make valuable predictions about the macroeconomic scenario. These results have implications regarding the extent of development of the financial markets in general and stock markets in particular and thus indicate the extent of allocational efficiency.

(iv) The distributive lag structure within the ARDL framework highlights that the macroeconomic variables impact the stock market with certain lags, which is obvious due to the transmission mechanism through which policies affect the asset prices. In this context, the study will help policymakers and regulators while devising the economic policies and ensuring proper regulation in the system.

(v) Also, it is evident that each of the BRICS economies operates within a unique macroeconomic environment, and as such, it can be seen that the macroeconomic variables impact their respective stock markets differently across BRICS countries. Thus, the study will help domestic as well as international investors to devise their portfolio investment strategies for maximizing their benefits across different markets.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

There is no funding for this research work.

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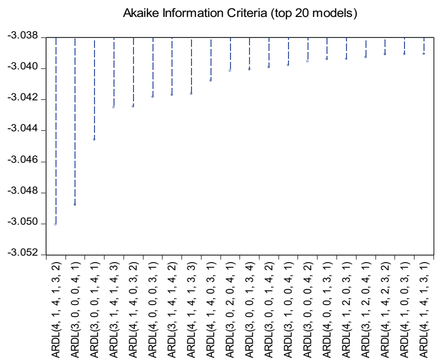
Appendix A. Lag-length selection based on AIC



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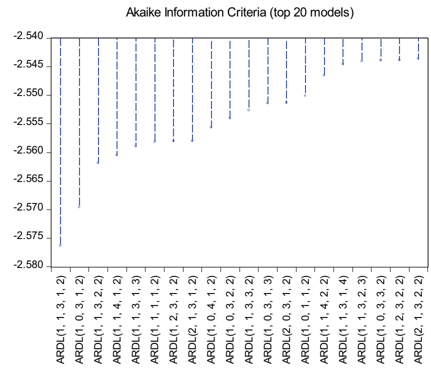
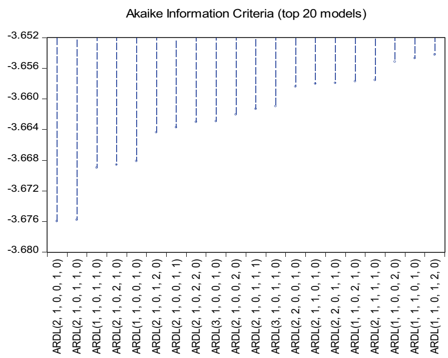


RUSSIA



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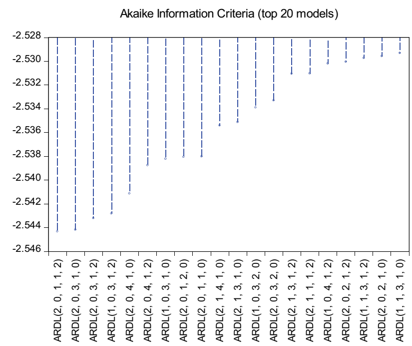
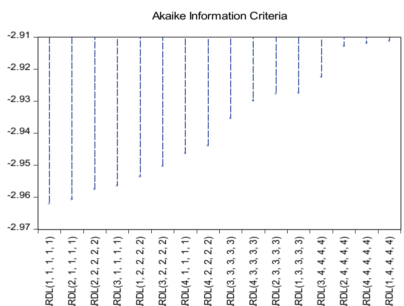
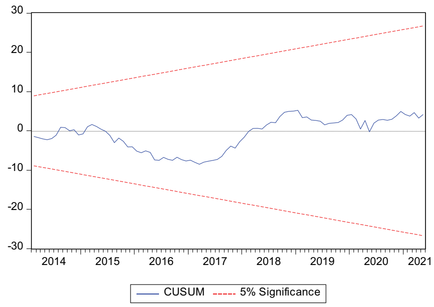


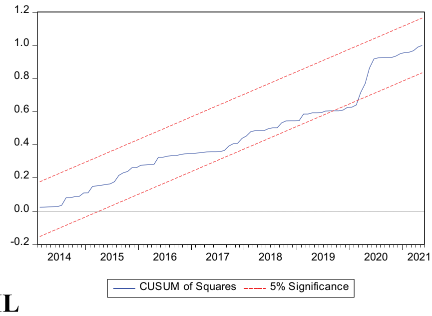
CHINA



BRICS-Panel

Appendix B. CUSUM and CUSUM of squares test for stability





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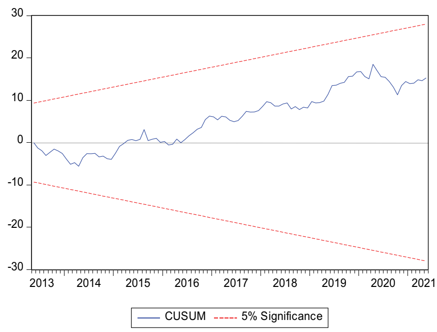

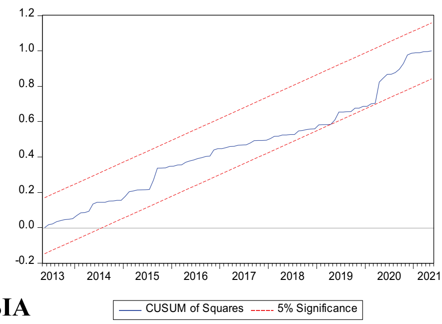

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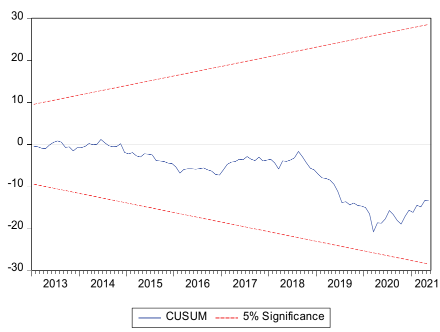

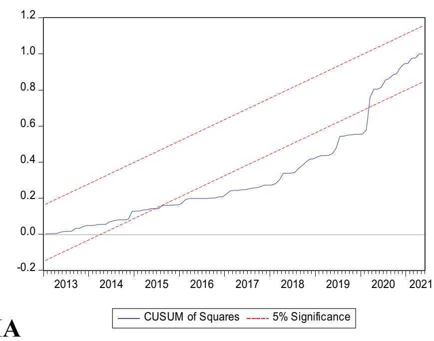

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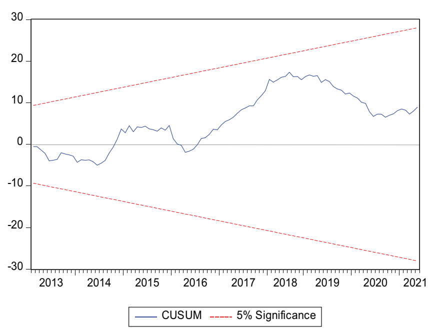

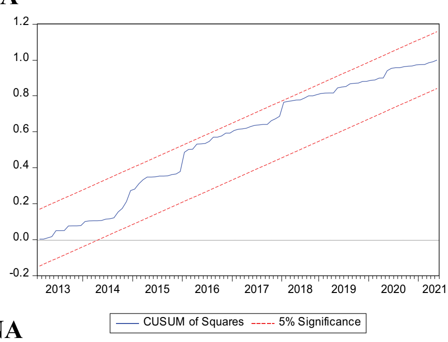

CHINA

Appendix C. PMG/ARDL coefficient confidence ellipse plots