

# Coherence of Growth & Inflation in BRICS: ARDL Bound Test Approach

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## ABSTRACT

**Purpose:** The present study deals with the link between economic growth and inflation for BRICS nations.

**Methodology:** The study applied autoregressive distributed lag model (ARDL) for long term relationship and granger causality test to check the direction of short term and long-term causal relationship.

**Findings:** After employing different statistical and econometric measures, the findings reveal that BRICS has significant relationship in terms of inflation (CPI) and economic growth (GDP). The study found different types of causal relationships in long run and short run as well. The ARDL cointegration approach also revealed the long run bond between these two variables for BRICS nations. It is also suggested that being a regional grouping BRICS must work for economic development and cooperation in Trade and Tariff with effective policies. Cumulative sum of squares (CUSUMSQ) also organized the stability and goodness of the model for shortrun and long run as well.

**Value:** The study offers long term equipoise relationships of selected variables in the context of BRICS nations for 28 years (1991-2018). The study is an effort to identify short run and long run causal effects along with ARDL testing of cointegration

**Keywords:** ARDL, BRICS, Economic growth, GDB Inflation, Time series..

JEL Classification: E00, E3, E6, E31, E56

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## INTRODUCTION

The second half of the twentieth century has witnessed the spread of turbulent literature about the relationship between inflation and economic growth. The BRICS economy is expected to transform the global economy in the future. The BRICS is a grouping acronym that refers to the countries of Brazil, Russia, India, China and South Africa. All BRICS members have their own strengths and characteristics, high growth rates, economic potential and demographic developments were going to put BRICS further in a lead position. (BRICS Report, 2012). While the developed economies have confronted different downturns in recent past, the major players India and China have incessant evolution even in times of financial instability. Achieving high and sustainable growth in production with low and stable inflation rates is the main goal of macroeconomic policy (Kan and Omay, 2010). Inflation is one of the key economic structures, dazzling constant rise in wide-

ranging price level of goods and services. Every country practices it during the process of its growth and development. In an era of globalization, inflation is irrefutable, and one of the prominent and vibrant macroeconomic problems which plague almost every developing economy of the world (Basu, 2011). Economic growth is a prerequisite for improving the living standards and life opportunities of the “average” citizen of the developing world (Rodrik, 2013).

### **Theoretical Framework**

Inflation is measured as the percentage rate of change in the price index of a country. There are several measures of inflation that depend on various sectors of the economy. The well-known measure of inflation, used in almost all countries and for which inflation indices are reported, is the consumer price index (CPI). CPI measures prices of selected goods and services that affect consumers (Economy watch, 2010). There is an excessive amount of economic prose concerning with the question of what causes inflation and what type of effects it has. Adam Smith and David Hume proposed a quantity theory of inflation for money (Smith, 1776). Economic growth is an increase in the market value of goods and services adjusted for inflation over time. Conventionally, it is measured as a percentage of real gross domestic product growth or real GDP (IME 2012). Over the time, many theories and empirical studies have generated different investigative aspects of economic growth [Solow (1956), Barro (1991), Mankiw et al. (1992), Romer (1990); Aghion and Howitt (1997) and Barro and Sala-i-Martin (2004)].

With the view of those theories this study inspects the inflation - growth bond in the BRICS countries. The importance of studying the connection between inflation and economic growth in this province stems from the belief that the member countries have common goals and close relationships. These are the two motivational factors to conduct this study. First, there are many recent developments taking place in the growing economies to meet the standards of globalization.

For this, the developing economies must employ few important strategies to control inflation and boost their GDPs. Second, effects of Inflation on an economy are numerous and can be concurrently positive and negative. The relationship may differ from country to country. This study is an effort to find out those relationships and their impact. The study adds insights into the economy, reinforcing the perception of the relationship of inflation and growth in the BRICS countries. Hereinafter, the rest of the paper is divided in different sections; (i) Literature Review, (ii) Research Methodology, (iii) Analysis and Findings; (iv) Conclusion.

### **LITERATURE REVIEW**

There are some of the reviews of the studies which have been previously undertaken in the related area of research and enlightened the thought of prospective researchers. Mishra, A. et.al. (2016) assessed the relationship of growth and inflation for short run using lag distribution model. Behera, J. (2014) explored the relationship of rising inflation in seven

countries in South Asia, using advanced panel integration technology. The study displayed that there is a negative relationship between inflation and economic growth for all countries. The findings suggested the existence of long-term relationship between inflation and economic growth for all countries, and unidirectional causality for inflation for economic growth for all countries. Keskek and Orhan (2010) investigated the power of monetary policy regarding the relationship between inflation and inflation uncertainty, using data from Turkish inflation. The results of the GARCH-M models showed that high rates of inflation are directly related to higher inflation. The impact of inflation on growth was considered negative mainly due to stabilization motives controlling the opportunistic incentives of the financial authorities. Researchers established strong evidence to counter the prospects that inflationary monetary policy has the power to reduce inflation persistence and eliminate ambiguity. Patra and Ray (2010) assessed that the prospect of inflation plays a significant role in setting and implementing monetary policy in modern India. The researchers also showed that incorrect information about the intentions of the central bank was one of the sources of apathy in the formation of inflation expectations. Patnaik (2010) has tried to recognize the determinants of inflation in India, made an empirical conclusion in a single integrated system VAR. The researcher also used an error correction mechanism for cointegrated variables. The impulse response function of the cointegrated VAR system indicates that the inflation response is lagging behind changes in other variables in the VAR system. Decomposition with a fixed error showed that inflation in India is a combination of supply and demand factors. Dua and Gaur (2009) inspected fortitude of inflation in the framework of an open economy activist as well as predictable retrospective Phillips curve for eight Asian countries - Japan, Hong Kong, Korea, Singapore, Philippines, Thailand, China Mainland and India. They found that the output gap, and at least one measure of global competitiveness to be significant in explaining the inflation rate in almost all the countries.

Additionally, agriculture related supply distresses were created to be major in determining inflation in developing countries. For all countries, the avant-garde Phillips curve provides an enhanced fit compared to the backward looking variant. Erbaykal and Okuyan (2008) examined the cointegration association between the inflation and the economic growth in Turkey. The results indicated that there was no statistically significant long-term relationship, but a negative and statistically significant short-term relationship between inflation and economic growth. Stilianos et. al (2006) scrutinized the contributory connection among nominal insecurity, real indecision and macroeconomic performance measured by the inflation and growth rates and using a bivariate comprehensive autoregressive conditionally heteroskedastic (GARCH) model of inflation and growth. The study found that, inflation cause negative interests' effects, both directly and indirectly. In some countries, more inflation uncertainty provides an incentive to Central Banks to shock the public by raising inflation suddenly; and more inconsistency in the business cycle leads to more output growth. John (2003) has used post-liberalization data to study causality between monetary aggregates and exchange rates. The researcher used Vector Autoregressive (VAR) to find out which monetary aggregate best explained inflation. However, the study could not provide a clear rationale for which monetary aggregates

explained inflation in a best manner. The result of the VAR model showed sufficient reasons to believe that broad money (M3) is the best measure to explain changes in inflation. Nachane and Lakshmi (2002) attempted a P - Star model for India by using both annual and quarterly data for the period 1955-1995. To build up a model for measuring inflationary pressures in the economy, the researchers have used co- integration techniques, as the velocity in India was found to be trend stationary. The model was found to be best fitted to the data, and in the out-of-sample forecasts, it significantly outperformed a seasonal ARMA benchmark model. Canetti and Greene (1991) used Granger's causality tests to test the role of matrimonial money on inflation changes for six African countries. They found that the expansion of the money supply and the alleged exchange rate had a significant effect on inflation.

Keeping in mind existing literature, the present study is an effort to focus on principal macroeconomic determinant and impact of inflation in BRICS countries.

## **RESEARCH METHODOLOGY**

The study aims to explore nexus between Growth and Inflation in BRICS nations. The study considered Consumer Price Index (CPI) as indicator of inflation (Behera 2014; Mishra 2016) and Gross Domestic Product (GDP) as indicator of growth (Faridul et al. 2012; Koonthar et al. 2018). Both variables are converted in natural logarithms (Mishra 2016). Data for selected variables has been taken for the time of 1991 to 2018 as per the availability of data. For study, required secondary data has been collected from Reports, Working papers, Newspapers and Statistical data base of IMF and World Bank. Some information has also been gathered from official websites Government/ Central Banks of BRICS countries. Different statistical and econometrical measures; descriptive analysis, unit root test (ADF), Granger Causality, ARDL Bound Test and Cumulative Sum Squares Test (CUSUMQ) were applied.

## **ANALYSIS AND FINDINGS**

The pragmatic data used in present study included annual time series of inflation and growth for Brazil, Russia, India, China and South Africa. The summary of basic descriptive of selected variables for BRICS presented in Table 1 (Annexure).

Descriptive statistics include the Mean, Median, Maximum, Minimum, Standard Deviation (Std. Dev.), Skewness and Kurtosis of all variables for BRICS. The result of St. Deviation shows that about 68% of scores fall within 1S.D. for both variables of BRICS. Further, Skewness is a measure of asymmetry of the distribution of the series around its mean. Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long-left tail (Levin, 2000). The findings of skewness reveal that CPI and GDP are positively skewed and have long right tail as per the distribution in different countries. In case of Brazil, India and South Africa both variables are negatively skewed. After descriptive statistics, researcher employed Unit Root test to judge the null hypothesis (Ho) that the variable contains a unit root (non-stationary).

Augmented Dickey-Fuller (ADF) test is the most popular unit root test to test the stationarity. Augmented Dickey Fuller (ADF) test for unit root for checking the favor of stationary was developed by Dickey and Fuller (1979), ADF model is:

$$\Delta y_t = \alpha + \beta y_{t-1} + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + \dots + \gamma_k \Delta y_{t-k} + \epsilon_t$$

Where,  $k$  is the number of lags,  $y_t$  is the time series data under consideration. The test is based on the null hypothesis ( $H_0$ ) that the variable contains a unit root or non-stationary, and alternative hypothesis ( $H_1$ ) is that the variables are generated by a stationary process. This test requires a negative sign and significant test statistic, for rejecting the null hypothesis. (Dougherty, 2007). The tests for integration of order (1) and I (0) are carried out. The findings of ADF test are depicted in Table 2 (Annexure). According to the results of ADF test, it is apparent that all series are first difference stationary I (1). Hence, researcher has rejected the null hypothesis of unit root at 5% level of significance for all countries. The next stage of analysis includes the testing of long run relationship between economic growth and inflation within a bivariate framework. As per the available literature, the recent popular methodology to find out long run relationship is single cointegration approach by using Auto Regressive Distributed Lag Model (ARDL) also known as ARDL Bound Testing (Pesaran et al. 2001). Model can be expressed as follows

$$y_t = \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta x_t + \beta_3 y_{t-1} + \beta_4 x_{t-1} + \beta_5 \Delta y_{t-1} + \beta_6 \Delta x_{t-1} + \beta_7 \Delta y_{t-2} + \beta_8 \Delta x_{t-2} + \beta_9 \Delta y_{t-3} + \beta_{10} \Delta x_{t-3} + \epsilon_t$$

This model can be applied in both conditions when series are I(0) and I(1). The unrestricted error correction model is used for both variables. In Bound test for exploring the long run relationship F statistic is used. The test offers two critical values; I(0) and I(1). These bounds need to be compared with F statistics and when F statistics is more than upper bound [I (1)] then null hypothesis can be rejected. The possible selection of lag order is based on the Akaike's information criteria (AIC). Table 3 portrays the results of ARDL Bound Test for BRICS. The results of Bound test shows that long run relationship exist in case of Brazil and India when both the variables (CPI and GDP) have been taken as dependent variable. F statistics are 9.808131, 10.29324 for Brazil which are higher than the lower bound value I(0) and upper bound value I(1) 4.94, 5.73 at 5% level of significance respectively. Hence, researcher reject the null hypothesis of no long run relationship. In the data considered for India, F statistics are 12.99404 and 6.795143. These are higher than the critical values of lower and upper bound. So that, the null hypothesis of no long run relationship is rejected. In case of Russia, F statistics (3.588601, 2.334718) are less than I(0) and I(1) critical values. Researcher accepted the null hypothesis of no long run relationship for both cases when CPI and GDP are taken as dependent variable. For China, the null hypothesis of ARDL bound test is accepted when CPI is taken as a dependent variable. As the F statistic (2.962912) for this case is less than critical bound of I(0) 4.94. In case of South Africa, the test revealed that there is no long run relationship when GDP is taken as dependent variable. Whereas when CPI taken as the dependent variable the null hypothesis of bound test is rejected at 5% level of significance.

The final stage of analysis includes the formation of standard Granger-type causality tests with auto regressive lag distribution. For this approach of Granger Causality there must be existence of co-integration relationship between the variables. After establishing a long-term relationship, ECM (error correction model) can be estimated (Engle-Granger, 1987). Table 4 depicts the results of causality tests with ARDL approach. The short term causality can be judged on the basis of F statistics and for long run ECM t statistics to be used (Islam, 2012). The results shows that there is no causality between the two selected variables in short run for Brazil, where as in long run a bidirectional causality exists between CPI and GDP, ECM t values are -2.443, -3.211 and these are significant at 5% level of significance. In case of Russia, unidirectional causality exist from CPI to GDP in long run but in short run there is no causal relationship exist. For India, direction of this causal relationship is bidirectional for long run but in short run this is unidirectional from GDP to CPI as F statistics is 4.17192 significant at 5% level of significance. Results for China depicts that there is unidirectional causality present in long run and short run as well. ECM t statistics is - 3.357 (significant at 5% level) for CPI to GDP in long run and F statistics is 3.14175 for short run. In case of last country of this block, researcher found unidirectional causality in short run whereas researcher accept the null hypothesis of no causality in long run. With this Granger causality & ARDL approach the study revealed the directions of causal relationships.

Further, researcher applied CUSUMQ test for stability and goodness of model. The CUSUM test (Brown, Durbin, and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines (EViews User guide). CUSUMSQ charts fall into two critical lines at a 5% significance level for all countries. Which means that the long run and short run coefficients are stable and model applied for results are best fit. (See annexures)

## **CONCLUSION**

For the steady development of trade and industry, a certain amount of inflation is important for wheel lubrication (Temple, 2000).The study investigated the connection between inflation and economic growth in BRICS. The ADF test results of both variables were integrated of order one I (1). The results of ARDL Bound Test to co-integration for long run relationship and modified Causality test with ECM suggested significant relationship between GDP and CPI. ECM t statistics with 5% level of significance revealed long term causality of unidirectional, bidirectional and exogeneity for different countries. These results are in line with the suggested findings given by Behera 2014; Mishra 2016; Faridul et al. 2012. The researcher employed CUSUMQ test to check stability and goodness of model. The results found that long run and short run coefficients are stable and model applied for results are best fit. The study further suggested that for regional development, this trade bloc should work to grow together with innovations, technological advances, and \_ political relations that will develop in the economies of the world.

## **IMPLICATIONS**

The current study has certain implications for theory as well as for practice. The study adds to the existing literature on economic growth and inflation. The results obtained from the estimation of the ARDL short run and long run test revealed that both short run and long run relationships exist among the variables of the study. These results have important implications for those responsible for national policies; policymakers and for development partners. Results imply that controlling inflation is a necessary condition to promote economic growth. Therefore, government should focus on keeping inflation low. This study has some practical implications for investors also. For stock market investors, inflation is the driver to take the greatest risk of investing in the stock market with the hope of obtaining the highest real rates of return. While inflation is moderate, the stock market offers the best opportunities for high returns. As BIRCS is a trade block having common trade goals. Hence, GDP is one of the main factors which influence the trade percentage. Generally, trade growth is much more volatile than GDP growth at the global level although both tend to rise and fall together. (WTO, Review Report, 2017)

In this regard, this study will be an addition to the existing body of literature which will help to boost the economic development by drawing a picture of selected economic block.

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ANNEXURE

Table 1: Descriptive Statistics (BRICS)

Countries	Variables	Mean	Median	St. Deviation	Skewness	Kurtosis	Minimum	Maximum
BRAZIL	GDP	.5269	.1618	0.80583	-.049	-1.029	-1.07	1.78
	CPI	2.6833	1.9077	1.97839	1.822	1.989	1.17	7.99
RUSSIA	GDP	.8854	.5353	0.89807	.204	-1.746	-.30	2.31
	CPI	2.3937	2.3283	1.60501	.867	1.538	0.00	6.77
INDIA	GDP	1.6069	1.8961	0.84492	-.990	.312	0.00	3.17
	CPI	1.8345	1.8532	0.57062	-1.231	2.511	0.00	2.63
CHINA	GDP	2.0645	2.2178	0.62214	-2.784	7.978	0.00	2.66
	CPI	1.0143	.9555	0.96767	.419	.077	-.92	3.18
SOUTH AFRICA	GDP	.7845	.9898	0.69059	-.620	-.638	-.66	1.72
	CPI	1.7529	1.7840	0.66253	-1.247	2.074	0.00	2.73

Source: Empirical data calculated by IBM SPSS 20.

Table 2: Augmented Dickey Fuller Unit Root Test

Countries	Variables	I (0)		I (1)	
		Constant	Constant & Trend	Constant	Constant & Trend
BRAZIL	LNGDP	-4.431831* (0.0017)	-4.388079* (0.0090)	-6.163481* (0.0000)	-5.214405* (0.0017)
	LNCPPI	-2.747169 (0.0799)	-3.152267 (0.1166)	-3.459851* (0.0178)	-3.577683* (0.0051)
RUSSIA	LNGDP	-2.078668 (0.2541)	-1.967599 (0.5920)	-5.605315* (0.0001)	-5.617675* (0.0006)
	LNCPPI	-2.721731 (0.0835)	-2.836062 (0.1975)	-5.362939* (0.0002)	-5.463953* (0.0008)
INDIA	LNGDP	-3.144088* (0.0351)	-3.617258* (0.0471)	-8.185100* (0.0000)	-8.218221* (0.0000)
	LNCPPI	-5.899272* (0.0001)	-5.809228* (0.0007)	-7.115898* (0.0000)	-6.411245* (0.0001)
CHINA	LNGDP	-4.493838* (0.0015)	-4.082253* (0.0177)	-5.069084* (0.0004)	-5.561056* (0.0006)
	LNCPPI	-2.482234 (0.1307)	-2.784578 (0.2144)	-4.987903* (0.0005)	-4.852207* (0.0033)
SOUTH AFRICA	LNGDP	-2.768269 (0.0762)	-2.837356 (0.1971)	-4.966720* (0.0005)	-5.427751* (0.0009)
	LNCPPI	-4.322462* (0.0022)	-5.027234* (0.0021)	-7.027733* (0.0000)	-6.714023* (0.0000)

Notes: (i) [\*] denotes rejection of null hypothesis at 5% significance level respectively.  
(ii) Akaike Information Criterion (AIC) & SIC used for lag order selection.  
(iii) Parentheses “()” shows related P values.

Source: Data calculated by STATA SE 12.

Table 3: Auto Regressive Distributed Lag Model (ARDL)

Countries	Null Hypothesis	F statistics		Critical Value Bound <sup>c</sup>		Conclusion (H <sub>0</sub> )
		GDP <sup>a</sup>	GDP <sup>b</sup>	I (0)	I (1)	
Brazil	No long-run relationships exist	—	9.808131	4.94	5.73	Rejected
	No long-run relationships exist	10.29324	—	4.94	5.73	Rejected
Russia	No long-run relationships exist	—	3.588601	4.94	5.73	Accepted
	No long-run relationships exist	2.334718	—	4.94	5.73	Accepted
India	No long-run relationships exist	—	12.99404	4.94	5.73	Rejected
	No long-run relationships exist	6.795143	—	4.94	5.73	Rejected
China	No long-run relationships exist	—	2.962912	4.94	5.73	Accepted
	No long-run relationships exist	9.812761	—	4.94	5.73	Rejected
South Africa	No long-run relationships exist	—	9.913584	4.94	5.73	Rejected
	No long-run relationships exist	3.701909	—	4.94	5.73	Accepted

Note: (i) "a" denotes when GDP taken as dependent variable.  
(ii) "b" denotes when CPI taken as dependent variable.  
(iii) Critical value bound [I (0) and I (1)] given for 5% level of significance.  
Source: Data calculated by EVIEWS 10.

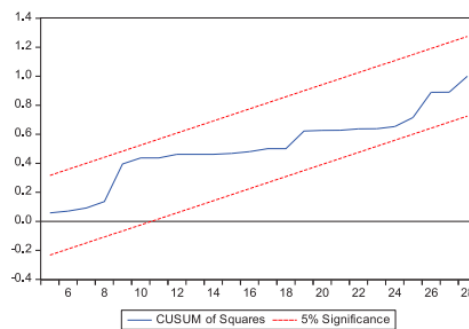
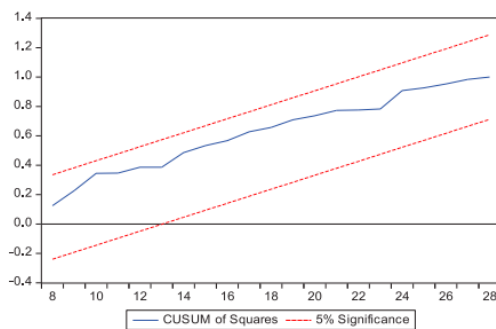
Table 4: Result Specification of Granger Causality Test

Countries	Short Run Causality - F statistics		Long Run Causality - ECM t statistics		Short run decision	Long run decision
	H <sub>0</sub> : GDP does not granger cause CPI	H <sub>0</sub> : CPI does not granger cause GDP	H <sub>0</sub> : GDP does not granger cause CPI	H <sub>0</sub> : CPI does not granger cause GDP		
Brazil	0.40525 (0.6719)	0.45123 (0.6429)	-2.443* (0.0201)	-3.211* (0.008)	Exogeneity	Bidirectional
Russia	0.14774 (0.8635)	3.80433* (0.0089)	-1.198 (0.1062)	-1.211 (0.8330)	CPI-GDP	Exogeneity
India	4.17192* (0.0032)	2.74146 (0.0875)	-2.119* (0.006)	-3.421* (0.0130)	GDP-CPI	Bidirectional
China	3.14175* (0.0018)	1.75328 (0.4831)	-3.552 (0.7140)	-3.357* (0.005)	GDP-CPI	Unidirectional
South Africa	0.02045 (0.9798)	6.33919* (0.0162)	-1.118 (0.4062)	-1.225 (0.7430)	CPI - GDP	Exogeneity

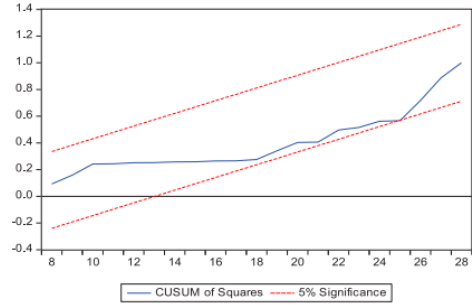
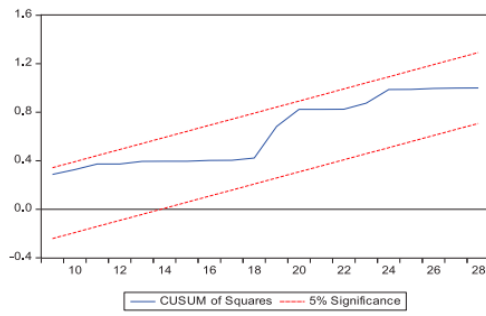
Notes: (i) [\*] denotes rejection of null hypothesis at 5% significance level respectively.  
(ii) Parentheses "()" shows related P values.  
(iii) ECM stands for Error Correction Model.  
Source: Data calculated by EVIEWS 10.

CUMULATIVE SUM SQUARES (Goodness of Model Fit)

1. Brazil (GDP & CPI)

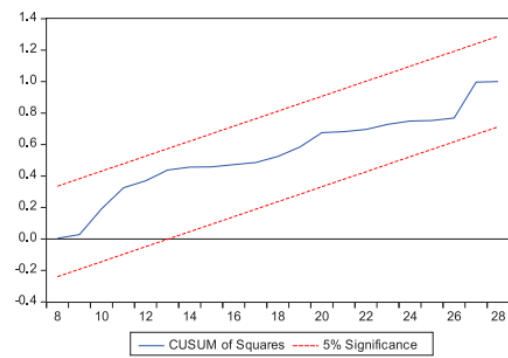
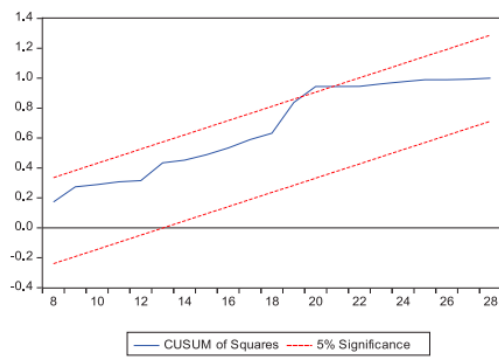


### 3. Russia (GDP & CPI)

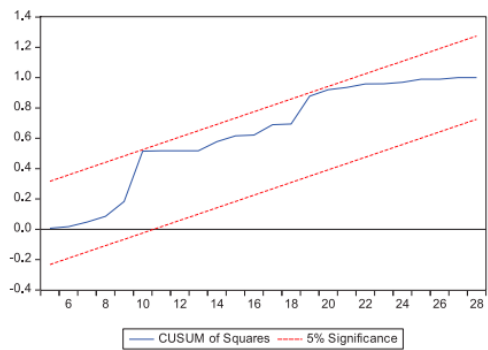
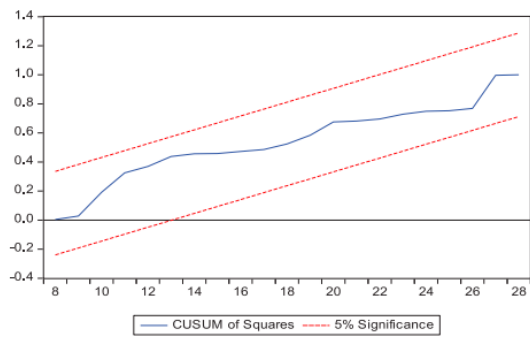


Source: Author's Calculation; EViews

### 3. India (GDP & CPI)



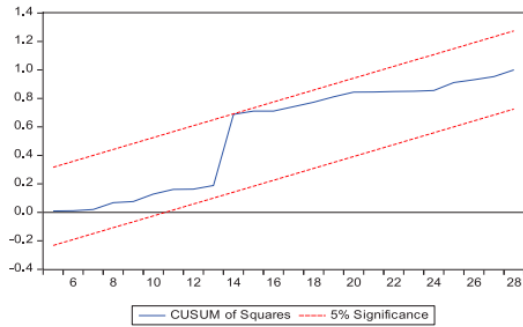
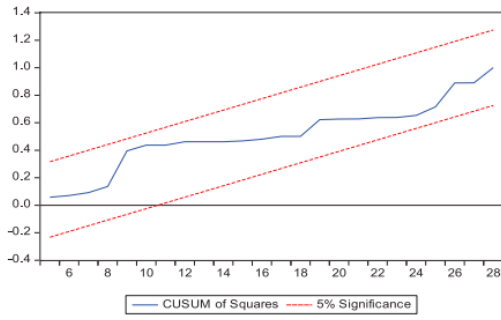
### 4. China (GDP & CPI)



Source: Author's Calculation; EViews

Source: Author's Calculation; EViews

5. South Africa (GDP & CPI)



LAG SELECTION CRITERIA

Akaike Information Criteria

