FREQUENCY DOMAIN APPROACH TO CAUSALITY AMONG FISCAL DEFICIT, INTEREST RATES AND INFLATION IN NIGERIA

Olusola Joel Oyeleke*

Department of Economics, Redeemer's University, P. M. B. 230, Ede, Osun State, Nigeria

*Corresponding author's email: oyelekej@run.edu.ng

Abstract

Using quarterly data from 1993:q1-2018:q1, this paper examines causal relationship among budget deficit, interest rates and inflation in Nigeria in a multivariate causality setting. Instead of time domain causality methods commonly used in existing studies, this study adopts a frequency domain causality approach (FDCA) that allows differentiating causal relationships in the short-, medium- and long-term. After testing for stationarity and cointegration of variables, the results show that fiscal deficit Granger causes interest rate only in medium-term in the study period. However, Granger causality results could not provide evidence that, both in the short run and long run, there was causality between fiscal deficit and inflation in one hand and interest rate and inflation rate on the other hand. This paper concludes that fiscal deficit is a significant driver of interest rate in Nigeria.

Keywords: Causality; Fiscal deficit; Frequency domain; Inflation; Interest rates

JEL Classification: H2, C6, E3, E4

Introduction

From theoretical stand point, frequent government borrowing requirements to finance fiscal deficit generally have tendency to expand credit demands in an economy, thereby reducing national savings. It follows that as many economic agents compete for the funds available in the national cover, the interest rate is driven upward, leading to crowding out of private investments (Chaudhry & Munir, 2010; Javid & Arif, 2014). With the private investments being crowded out, the effect will lead to the reduction in aggregate production in the economy (i.e. shortage in volume of goods and services available for transactions), and thereby leading to the shortage in supply of output against aggregate demand, hence increase in price level (Tiwari, Tiwari & Pandey, 2012; Abu & Karim, 2015). Inflation is a persistent rise in general price level (Olaniyi, 2020), fiscal deficit is the shortage in public revenues relative to its spending plus total interest payment on debts in a fiscal year (Awe & Olalere, 2012; Bakare, Adesanya, & Bolarinwa, 2014), while interest rate is the cost of capital.

Although the conventional economic wisdom is not explicit on the period in which the causality occurs among fiscal deficit, interest rate and inflation, however the issues surrounding the direction and the period of causality among fiscal deficit, interest rate and inflation are of great importance for effective policy formulation. Validating the theoretical view with datasets to produce empirical evidence which are great importance for policy developments, numerous studies (see Şahin, 2019; Nwakobi, Echekoba & Ananwude, 2018; Nwakoby, Okaro & Ananwude, 2016; Tiwari, Bolat & Koçbulut, 2015; Erkam & Çetinkaya, 2014; Jalil, Tariq & Bibi, 2014; Koyuncu, 2014; Odionye & Uma 2013, among others) have investigated the direction of causality, pairing either fiscal deficit and interest rate, fiscal deficit and inflation or interest rate and inflation though without combining the three variables and even with varied outcomes. While most, if not many, of these studies concentrate on investigating the direction of causality between the variables, the period in which the causality occurs has not attracted research interest especially in developing countries like Nigeria. Meanwhile, understanding the period (whether short run, medium run or long run) in which the causality occurs between the variables is so important to the policy makers if the policies intended to address the fluctuations of any of the variables

would not be rendered ineffective. Therefore, apart from the fact that empirical evidence on the period in which the causality occurs among fiscal deficit, interest rate and inflation are scanty across economic structures including Nigeria, no study known to us has focused on tri-variate causal relationship among the variables for investigation exclusively in Nigeria, using frequency domain approach. This study attempted to fill this gap.

While other studies focus on time domain methodology to investigate the causality between the variables, this study, therefore, differs from existing studies by using frequency domain approach which presents the opportunity to examine the frequencies and timings of causality among fiscal deficit, interest rate and inflation in Nigeria. Our results show that fiscal deficit Granger causes interest rate in Nigeria in the medium term which has implication for domestic private investment growth, and then whole economic growth. In which case, fiscal deficit is the lead variable while interest rate is the lag variable in the fiscal deficit and interest rate interactions in Nigeria. Remaining paper is organised as follows: the next section highlights the trends of fiscal deficit, interest rate and inflation and follow by literature review. Section 3 deals with data description and sources. Section 4 and 5 describe methodology as well as discussion of results, while section 6 concludes with policy recommendation.

Trends of Fiscal Deficit, Interest Rate and Inflation in Nigeria

From Figure 1, the curve depicting the movements of inflation drifted upward from the beginning of 1993 second quarter and continued to rise until first quarter of 1996 before it drifted downward. The high inflation rates recorded in the economy between 1993 and 1995 could be attributed to a general election conducted in 1993 but later annulled same year. The annulment was greeted with mass protests from civil societies and labour strike that almost plunged the country into another round of civil war. The movements supported the evidence of crises that engulfed the economic activities of Nigeria during the period. However, there was sharp drop in movements in interest rates as depicted by its curve. The development could be ascribed to mass exist of manufacturing companies from Nigeria to some neighbouring countries for fear of war. More importantly, financial market performance equally suffered setbacks because foreigners could not access the market offshore. After 1996, inflation rate continued to fluctuate around 10% to 20% though it was as low as 0% in 1999. On average, over the period under review, inflation rate maintained two digit. Comparing the movements of inflation with that of interest rate during the period, it was discovered that interest rate was relatively stable because its volatility was not conspicuous like that of inflation. Also, fiscal deficit curve did not conspicuously drift away from hundreds from 1993 to 2008, indicative of mild deficit period. Precisely, in 1995 and 1996, the fiscal deficit curve was slightly above zero, a development that designated a fiscal surplus in state finance for those two years. However, from first quarter of 1997 till second quarter of 2010 while fiscal deficit curve continued to dip down, inflation and interest rate were still fluctuating around positive values. Again, from 2011 till first quarter of 2018, federal government finance has been in mess with regards to deficit as shown by its curve. The curve movements revealed that fiscal deficit continued to oscillate, though around negative values, but got to its peak in the first quarter of 2018.

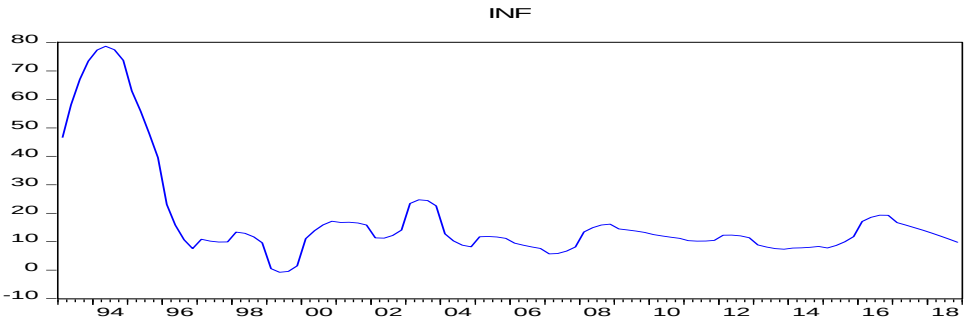


Fig. 1. Trends of inflation in Nigeria (1993:q1-2018:q1)
Source: Author's computation, 2020

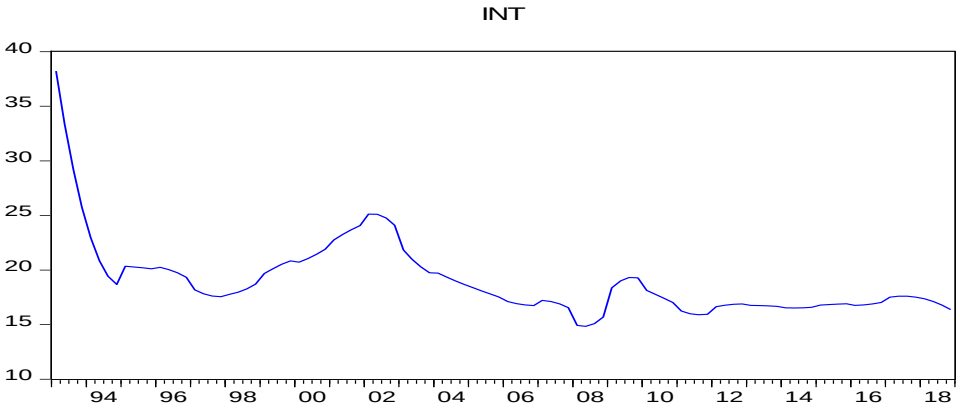


Fig. 2. Trends of interest rates in Nigeria (1993:q1-2018:q1)
Source: Author's computation, 2020

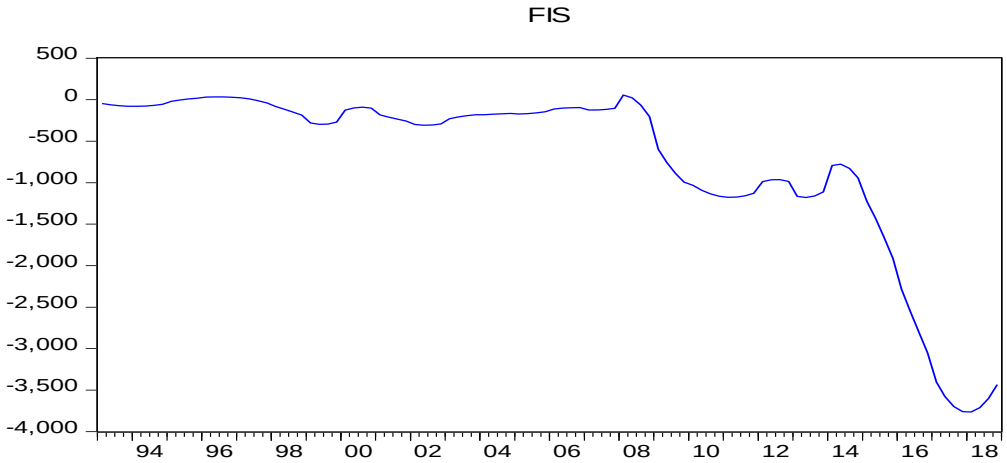


Fig. 3. Trends of fiscal deficits in Nigeria (1993:q1-20018:q1)
Source: Author's computation, 2020

Literature review

Pairing either fiscal deficit and interest rates, interest rates and inflation or fiscal deficit and inflation, several studies have brought investigation of causality between the two variables into focus. For instance in Nigeria, Odionye and Uma (2013) examined connection between budget deficit and interest rate in Nigeria from 1970-2010, using VECM. With the evidence of long run relationship, the outcomes showed that high budget deficit had been raising interest rate in the economy. Oladipo and Akinbobola, (2011) explored the direction of causality between fiscal deficit and inflation in Nigeria. Using pairwise causality method, the results provided the evidence of a uni-directional causality running from fiscal deficits to inflation in the economy of Nigeria. Similarly, Nwosa and Ibas (2014) investigated whether fiscal deficits affected long- and short-term interest rates differently in Nigeria from 1970-2011. The study was mainly devoted to three subjects i.e. the causality between fiscal deficit and interest rates, impact of fiscal deficit on interest rates as well as reaction of interest rates to shocks from fiscal deficit. Results indicated there was no evidence of causation between fiscal deficit and interest rates, while shocks to fiscal deficit produced instantaneous positive rise in long term interest rate. Again, Egbulonu and Wobilor (2016) studied effect of fiscal policy on inflation in Nigeria from 1970-2013. After edging out trends from variables, ECM method was employed. Findings indicated a statistically insignificant relation between public expenditure; tax revenue and inflation in Nigeria, while public debt is positive and statistically significant. It is clearly understood that most of these extant literature shared common shortcoming because they used time domain causality methods that did not allow differentiating causal relationships in the short-, medium- and long-term. It is equally observed that none of these studies has sought to investigate the causality among fiscal deficit, interest rate and inflation, putting these three variables together in a study. Using bootstrap simulation with leverage adjustments on quarterly data, Olaniyi, (2020) examined the symmetric and asymmetric nexus between fiscal deficits and inflation in

Nigeria from 1981Q1 to 2016Q4. The outcomes show that there was neither symmetric nor asymmetric causality between fiscal deficits and inflation in Nigeria, suggesting that the fiscal deficits were not inflationary and vice versa.

Devapriya and Ichihashi (2012) explored nexus between budget deficits and inflation in Sri Lanka, employing data from 1950-2010. The study employed VAR method and the results revealed that budget deficit and inflation had positive association, while causality analysis showed a bi-directional causal structure from budget deficit to inflation. Tiwari *et. al* (2012) examined the path of causality among fiscal deficit, public expenditure, money supply and inflation in India, employing Dolado and Lukepohl (DL) (1996) and granger-causality techniques. The approaches presented variant results for same economy. Based on DL technique, the study found public spending and monetary base granger-caused fiscal deficit, while standard granger causality results showed only public expenses granger-caused fiscal deficit. Khumalo (2013) used the quarterly data from 1980–2012 to survey direction of causality between budget deficit and inflation in South Africa. Using VAR method leaned on impulse response functions, the findings revealed causality ran from budget deficit to inflation and evidence of long run relation was discovered.

Erkam and Çetinkaya (2014) investigated existence of causality between inflation and budget deficit in Turkey. Granger-causality tests were employed on monthly budget deficit and inflation data which covered two sub-periods; (1987:1-2003:6; 2005:1-2013:6). The study found that causality ran from budget deficit to inflation during high inflation period, while the reverse held during the low inflation period. Verifying the plausibility of FTPL in Pakistani economy, Jalil, Tariq and Bibi (2014) examined nexus between inflation and budget deficits from 1972-2012. The study employed ARDL framework and found fiscal deficit was a crucial component of inflation with other variables like public debts, interest rates and private borrowing. In another development, Brima and Mansaray-Pearce (2015) investigated nexus between budget deficit and some macroeconomic variables in Sierra Leone, using data from 1980-2014. The study employed VECM and granger causality tests as methodologies. Findings revealed that, in the long run, exchange rate, money stock and GDP negatively associated with budget deficits, though interest rates and inflation had a positive one. However, in short run, only exchange rate deviated and granger causality test confirmed causal tie between exchange rates, GDP, inflation, monetary stock and budget deficit. In another study, Tiwari, Bolat and Kocbulut (2015) revisited time and frequency domain analysis of budget deficits and inflation in nine European Union (EU) countries from 1990-2013. Engaging quarterly data, study found long run causality existed, running from inflation to budget deficits in Belgium only, but frequency causality ran in France.

Similarly, Rani and Kumar (2016) examined effect of budget deficits on real interest rates in India from 1980-2014. Using ARDL bound testing method of cointegration and VECM model for casualty, results confirmed evidence of equilibrium between fiscal deficits and interest rates, but there was unidirectional causality running from inflation to real interest rates in short run. Bhunia (2016) investigated effect of inflation and interest rates on India's GDP. Built on annual data from 1992-2015, VECM and granger causality methods were used. Results authenticated the existence of long run causality from GDP to inflation and interest rates. Khumalo, Mutambara and Assensoh-Kodua (2017) revisited the association of inflation and interest rate in Swaziland from 2010-2014. Using quarterly data, descriptive technique was employed for the analysis. The results revealed there was bidirectional causality between interest rates and inflation in economy of Swaziland.

Methodology

Model specification

This study adopts Breitung and Candelon (2006)'s frequency domain approach to analyse the causality among fiscal deficit, interest rates and inflation in Nigeria from 1993:q1-2018:q1. This is with a view to improving on existing studies that have employed time domain analysis which produce results at a point in time. A particular interest developed in this study is the use of frequency domain approach to causality because the approach allows differentiating timing of causality among variables. In this case, the short-, medium- and long-term causalities are possibilities under the frequency domain approach,

but are not available under the time domain technique. Also, according to Bouri, Kachacha, Lien and Raubaud (2017), frequency domain approach as a technique helps to overcome main weaknesses of time domain methods which duel on 'restricted assumption that only one single statistical measure can be used to explain the relation among the examined variables at all frequencies (at an infinite time horizon)'. In addition, relative to the time domain analysis, the frequency Granger causality helps identifying the lead and lag variables. Other study that have used frequency domain causality approach in the past include Ozer and Kamisli (2016) to investigate relations between financial markets in Turkey, Bouri, Kachacha, Lien and Roubaud (2017) to explore short, medium and long-run causal nexus among crude oil, wheat, and corn markets in US, Tiwari and Kyophilavong (2017) to investigate the association between international reserves and exchange rate in India, Huang *et al.* (2018) to examine impact of oil price on tourist for US and nine EU countries and Olasehinde-Williams, (2020) to explore whether US policy uncertainty was strong enough to explain volatility in global output, among others. Modelling bivariate frequency domain begins with time domain model as:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{t-I} + \sum_{i=1}^{p} \mu_i \Delta Z_{t-I} + \mathcal{E}_{1t} \quad (1)$$

$$\Delta X_t = \phi_0 + \sum_{i=1}^{p} \phi_i \Delta X_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta Y_{t-I} + \sum_{i=1}^{p} \alpha_i \Delta Z_{t-I} + \mathcal{E}_{2t} \quad (2)$$

$$\Delta Z_t = \Omega_0 + \sum_{i=1}^{p} \Omega_i \Delta X_{t-1} + \sum_{i=1}^{p} \pi_i \Delta Y_{t-I} + \sum_{i=1}^{p} \theta_i \Delta Z_{t-I} + \mathcal{E}_{3t} \quad (3)$$

According to Olayungbo (2019), Vector Autoregression (VAR) is amended to produce frequency domain of bivariate and two-dimensional causal model of two non-random variables Y_t and X_t. The model becomes;

$$\Theta(L)\begin{pmatrix} Y_t \\ X_t \\ Z_t \end{pmatrix} = \begin{pmatrix} \Theta_{11}(L) & \Theta_{12}(L) & \Theta_{13}(L) \\ \Theta_{21}(L) & \Theta_{22}(L) & \Theta_{23}(L) \\ \Theta_{31}(L) & \Theta_{32}(L) & \Theta_{33}(L) \end{pmatrix}\begin{pmatrix} Y_t \\ X_t \\ Z_t \end{pmatrix} = \begin{pmatrix} \mathcal{E}_{1t} \\ \mathcal{E}_{2t} \\ \mathcal{E}_{3t} \end{pmatrix} \quad (4)$$

Where $\Theta(L)$ represents 1- $\Theta_1(L) - \Theta_2(L^2) - \Theta_3(L^3) \ldots - \Theta_p(L^\rho)$ and 3 by 3 lag polynomial of order p with $L^j X_t$ equals X_{t-j}, while $L^j Y_t$ equals Y_{t-j} respectively. Vector of disturbance term $\mathcal{E}_t$ equal $(\mathcal{E}_{1t}, \ \mathcal{E}_{2t}, \mathcal{E}_{3t})'$, taken to be stationary and its E($\mathcal{E}_t$) equal zero. Again, E($\mathcal{E}_{1t}, \ \mathcal{E}_{2t}, \mathcal{E}_{3t})'$equal Σ, and Σ is both asymmetric and positive definite. Using Cholesky decomposition, G\G equal Σ^{-1} and G denotes lower triangular matrix, while G' is upper triangular matrix. Matrix presentation of the eqn. (4) is given as;

$$\begin{pmatrix} Y_t \\ X_t \\ Z_t \end{pmatrix} = \Phi(L)\begin{pmatrix} \eta_t \\ \eta_t \\ \eta_t \end{pmatrix} = \begin{pmatrix} \Phi_{11}(L) & \Phi_{12}(L) & \Phi_{13}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) & \Phi_{23}(L) \\ \Phi_{31}(L) & \Phi_{32}(L) & \Phi_{33}(L) \end{pmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \\ \eta_{3t} \end{pmatrix} \quad (5)$$

Where $\Phi(L)$ equal $\Theta(L)^{-1}G^{-1}$, while $\begin{pmatrix} \eta_t \\ \eta_t \end{pmatrix}'$equal G($\mathcal{E}_{1t}, \ \mathcal{E}_{2t}, \mathcal{E}_{3t})'$, then cov($\eta_{1t}, \ \eta_{2t}$) is equal to zero, and var(η_{1t}) = var(η_{2t}) = var(η_{3t}) equal to one. Eqn. (4) implies that X_t is the sum of two uncorrelated matrix processes. It is the total of a central element compelled by past shocks in X_t and Z_t while a component comprising causal elements of the variable Y_t. The causal element of Y_t at each frequency *w* can be derived by associating causal elements of the spectrum with the central element at frequency. Y_t does not granger cause X_t and Z_t at frequency *w* though the causal element of the spectrum of X_t and Z_t at frequency *w* is equal to zero. According to Olayungbo (2019), the measure of causality is demarcated as

$$M_{y \to x}(\omega) = log\left[1 + \frac{\left|\phi_{12}(e^{-i\omega})\right|^2}{|\phi_{11}(e^{-i\omega})|^2} \ and \ 1 + \frac{\left|\phi_{13}(e^{-i\omega})\right|^2}{|\phi_{11}(e^{-i\omega})|^2}\right] \quad (6)$$

This measure of causality is ratio of total spectrum and intrinsic component of the spectrum. This is stated as $M_{y\to x}(\omega)$ equal to zero, suppose $\left|\phi_{12}(e^{-i\omega})\right|^2$ and $\left|\phi_{13}(e^{-i\omega})\right|^2$ equal to zero. Given that $\left|\phi_{12}(e^{-i\omega})\right|^2$ and $\left|\phi_{13}(e^{-i\omega})\right|^2$ equal to zero offers absence of causality at frequency *w*. According to Breitung and Candelon (2006), absence of causality at frequency *w* could be depicted in a regular linear restriction on coefficient of elements of VAR model in eqn. (2)

$$\Delta X_t = \sum_{i=1}^{p} \Theta_{11i}\Delta X_{t-1} + \sum_{i=1}^{p} \Theta_{12i}\Delta Y_{t-I} + \sum_{i=1}^{p} \Theta_{13i}\Delta Z_{t-I} + \mathcal{E}_{1t} \qquad (7)$$

Where Θ_{11i}, Θ_{12i} and Θ_{13i} represent coefficients of lag polynomial of $\Phi_{11}(L)$, $\Phi_{12}(L)$ and $\Phi_{13}(L)$ respectively. For absence of causality, the necessary and sufficient conditions at frequency *w* could be presented thus,

$$\begin{cases} \sum_{i=1}^{p} \Theta_{11i}\sin(i\omega) = 0 \\ \sum_{i=1}^{p} \Theta_{12i}\sin(i\omega) = 0 \\ \sum_{i=1}^{p} \Theta_{13i}\sin(i\omega) = 0 \end{cases} \qquad (8)$$

In this case, the linear restriction on coefficients in eqn. (8) could be verified by standard F-test distributed as F (3, T – 3ρ), where T is the number of observations employed to estimate VAR model of order p and 3 is the number of restrictions. Similarly, incremental R-squared test could be used to test the linear restrictions in eqn. (8). It determines the proportion of explained variation of X_t lost owing to imposition of the two restrictions in eqn. (8). Incremental R-squared test is the difference between R-squared test of unrestricted equation in eqn. (7) and R-squared test of equation estimated in eqn. (8). Therefore, incremental R-squared can be presented thus:

Incremental $R^2 = R^2 - R_*^2$ (9)

The power of causality from Y_t to X_t at frequency *w* is the incremental R-squared test which lies between 0 and 0.1. The plot of the incremental R-squared of the frequencies is between 0 and ρ that denotes the power of causality in the frequency domain (0, ρ). Null hypothesis of no causality at the frequency *w* is rejected at significance level α given thus:

Incremental $R^2 > F_{(2,T-2\rho,1-\alpha)}\frac{2}{T-2\rho}(1 - R^2)$ (10)

$F_{(2,T-2\rho,1-\alpha)}$ is the α upper critical value of F-distribution as 2 and T-2ρ degree of freedom.

Data description and source

Data used in this study start from first quarter of 1993 to first quarter of 2018. Apart from difficulty posed by availability of fiscal deficit in quarterly data from 1993, the base year for this study (1993) is crucial in political annals of Nigeria. It is the year the country witnessed first annulment of general elections that almost culminated in civil war. The civil unrest ensued from the annulment drove away many non-oil multinational companies from Nigeria's shore and, therefore, reduced the tax base of government. Also, the annulment attracted several severe economic sanctions from developed economies around the world against Nigeria, plunging the economy in near disarray. Variables employed include fiscal deficit, real interest rate and inflation. Fiscal deficit is measured as government total revenues net government total expenditure. Real interest rates is measured as nominal interest rates net of inflation. Inflation rate is measured using the consumer price index (CPI). All data are sourced from Central Bank of Nigeria Statistical Bulletin (2018).

Descriptive analysis

The descriptive statistics as presented in Table 1 shows average values of ₦165.39 billion, 17.24% and 13.6% for fiscal deficit, inflation rate and interest rate respectively. It is clear that there have been remarkable changes in the variables over the period of study. The minimum value of fiscal deficit during the period under consideration is ₦2 trillion, an amount that could be considered so huge, given the level of economic performance. In the same vein, there is a huge difference between the minimum value of 2.13% for inflation rate and its maximum value of 73.1%. The interest rate also records variations in value during the period i.e. 1993:q1-2018:q1. As shown in Table 1, while the minimum value interest rate is 6%, its highest value is 20.7%. In general, given the perpetual oscillation in the values of fiscal deficit and the fluctuations in interest rate and inflation rate, it can be argued that there is a relationship among the variables of interest.

Table 1. Descriptive statistics

	fiscal deficit	inflation rate	interest rate
Mean	-165.388	17.238	13.569
Median	-50.68	11.200	13.500
Maximum	0.000	73.100	20.700
Minimum	-2007.72	2.137	6.000
Std. Dev.	297.003	16.572	3.629
Jarque-Bera	1299.195	121.77	1.669
Probability	0.00	0.00	0.43
Observation	101	101	101

Source: Author's computation, 2020

Empirical Results and Discussion

Unit root tests

In Table 2, unit root test results are presented, using both augmented Dickey Fuller (ADF, 1979), Philip Perron (PP, 1988) and Kwiatkowsi-Phillips-Schmidt-Shin (KPSS) to determine the order of integration of the variables so as to achieve efficient estimates and avoid spurious results. The ADF results suggest that all the variables are non-stationary at levels, that is I(1) processes, while only fiscal deficit is stationary at levels, that is I(0) for PP test. Precisely in Table 2a, the ADF and PP's results are presented.

Table 2a. Unit root Test

	Augmented Dickey Fuller			Philip Peron			
Variables	levels	first diff.	Status	Variables	level	first diff.	status
fiscal deficit	0.2039	-15.0985	I(1)	fiscal deficit	-3.1929		I(0)
inflation rate	-2.7004	-4.8434	I(1)	inflation rate	-2.3453	-9.8863	I(1)
interest rate	-1.9877	-9.6812	I(1)	interest rate	-1.9878	-9.6812	I(1)

Note**:** Critical values of both Augmented Dickey Fuller (ADF) and Phillips Perron (PP) methods are 1% level (-3.6156), 5% level (-2.9411) 10% level (-2.6091) and 1% level (-3.6055), 5% level (-2.9369) and 10% level (-2.6069).

Source: Author's computation, 2020.

Given the contradictory results between ADF and PP on fiscal deficit's stationarity and its order of integration, we move a step forward to conduct another unit root test with different technique. Therefore, KPSS method of unit root test is employed and the results are presented in Table 2b. The results show that all series are I(1) processes. Therefore, we conclude that all the series are first difference variables.

Table 2b. Unit root Test

Variable	KPSS		
	Level	First Difference	Order of Integration
fiscal deficit	0.31385	0. 88029*	I(1)
Inf	0.08233	0.45941**	I(1)
Int	0.30598	0.76199*	I(1)

Note: *and *** denoted 1% and 10% significance levels respectively based on Mackinnon critical values.

Source: Author's computation, 2020

Cointegration test

Now that the variables of interest are I(1) series, we test for cointegration among the variables. The Johansen (1988) cointegration test is employed to test the presence or otherwise of cointegration. The advantage of the Johansen cointegration method over other single equation cointegration tests such as Engle and Granger (1987) and Pesaran, Smith and Shin (2001) cointegration bound testing is that, it is a vector autoregressive (VAR) model that allows for dynamic interactions among choice variables. Specifically, a bivariate linear combination of the variables is done to test for cointegration which is in line with the bivariate frequency domain causality test. The cointegration test uses the values of the eigenvalue and the trace statistics to determine the presence of cointegration. If the values of the eigenvalue and the trace statistics are greater than critical value at 5 percent significance level, than the null hypothesis of no cointegration is rejected. The cointegration model can be written in a VAR process with lag k as:

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots + A_k Z_{t-k} + \varepsilon_t \quad (11)$$

With a bivariate linear combination of our variables, fiscal deficit, inflation rate and interest rate, then $Z_t = (\text{fscd, inf}), (\text{fscd, int})$ and (int, inf) are 2×1 endogenous variables. Where fscd, inf and int signify fiscal deficit, inflation rate and interest rate respectively. Writing Eq. (1) in a cointegrating relationship gives:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots + \Gamma_{k=1} \Delta Z_{t-k-1} + \Pi Z_{t-1} + u_t \quad (12)$$

Where $\Pi = \alpha\beta^{'}$ matrix that contains information about the cointegrating relationship between our bivariate models. When Π has a reduced rank (i.e. $r \leq n-1$), where r is the number of cointegrating vector and n is the number of variables, then there are $r \leq (n-1)$ cointegration relationships. This cointegration condition is equivalent to when the trace and eigen statistics are than their critical values. The optimal lag length of 1 is chosen for the cointegration tests following the Schwarz criterion (SC). The lag length results are presented in Appendix. It can be observed from Table 4 that there is presence of cointegration among our variables. For inflation rate and interest rate for instance, the null hypothesis that the cointegration rank is equal to zero ($r \leq 0$) can be rejected because the critical value of 15.49 is greater than eigen value and trace statistic value of 7.15 and 11.88 respectively. On the other hand, the null hypothesis that the cointegration rank is equal to one ($r \leq 1$) can be accepted at 5% significance level. This outcome implies the presence of at least one cointegration relationship between inflation rate and interest rate. The same is true for the cointegrating relationship between inflation rate and fiscal deficit and the cointegrating relationship between fiscal deficit and interest rate.

Table 4. Johansen unrestricted Cointegration Result

Coint. Rank	Eigen value	Critical value	Prob	Trace Stat.	Critical value	Prob
Inflation rate and interest rate						
$r \leq 0$	7.15	15.49	0.47	11.88	15.49	0.16
$r \leq 1$	4.73	3.84	0.03**	4.73	3.84	0.03**
Inflation rate and fiscal deficit						
$r \leq 0$	8.33	14.26	0.34	15.13	15.49	0.05
$r \leq 1$	6.8	3.84	0.00***	6.8	3.84	0.00***
Fiscal deficit and interest rate						
$r \leq 0$	4.99	14.26	0.74	9.96	15.49	0.28
$r \leq 1$	4.95	3.84	0.03**	4.96	3.84	0.03**

Note: *** and ** are significance level at 1% and 5% respectively
Source: Author's computation, 2020

Lag length selection

Selection of lag length is based on Schwarz Information Criterion (SC) and Akaike information Criterion (AIC), given its importance to causality test. Where the lag length criterion are contradictory, the SC prevails over the other criterion. In our analysis, optimal lag length of 1 was chosen for both the

cointegration tests and the frequency domain causality tests. The results of the lag length are presented at the Appendix.

Discussion of findings

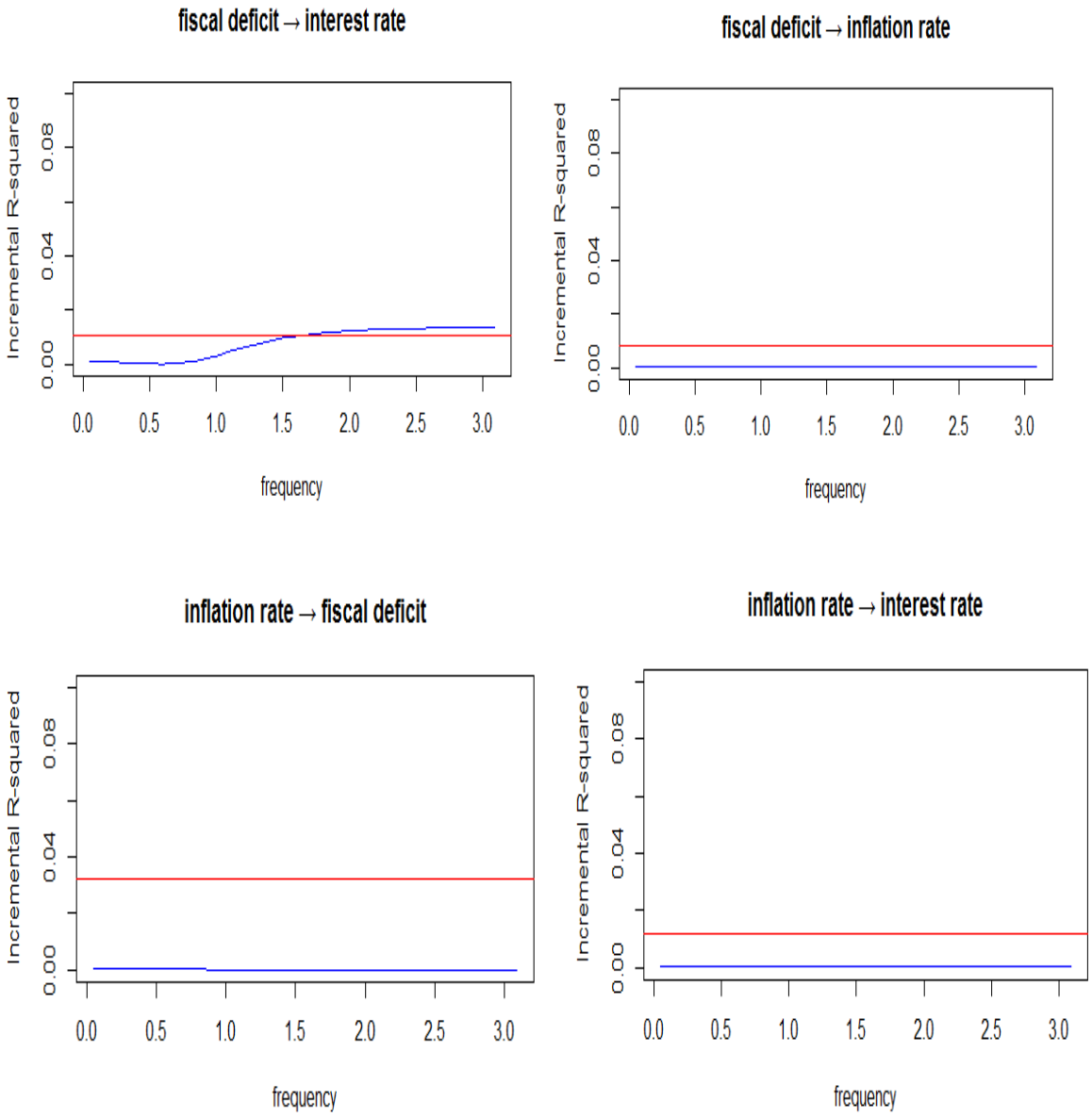
In this study, we determined the order of integration of fiscal deficit, interest rate and inflation rate, and found that not all of them were stationary at level, but first difference. Therefore, the non-stationary process at level of all the series necessitated the test for cointegration, and the null hypothesis of no cointegration was rejected at 5 percent significance level for our variables. Fig 4 showed the incremental R-squared for frequency domain Granger causality for the various frequencies ω in $(0,\pi)$. The frequency were measured in quarterly frequencies ω. The short term causality was represented by the frequency range of 0 to 1.4, while frequency range of 1.5 was medium term causality and frequency range from 1.6 to 2.0 indicated long term causality.

In the frequency analysis, we explored the possible dynamic relationship among the variable of interest. The frequency domain causality results as presented in Fig 4 showed that causality existed only from fiscal deficit to interest rate in the first section of Figure 2 to the left at 0.01 incremental R-squared with the frequency value of 1.5. This revealed that the causal frequency from fiscal deficit to interest rate in Nigeria was a medium term. The frequency could be expressed by $S = \pi / 2\omega$. Where S represented the frequency period, π was given as 3.1416 and ω equaled 1.5 years. The frequency ω of 1.5 years was equivalent to 17 months, which was 1 year and 5 months. This was interpreted to mean that fiscal deficit significantly affected interest rate at every 1 year 5 months. However, the frequency domain Granger causality results showed that, both in the short run and long run, there was no causality between fiscal deficit and inflation in one hand and between interest rate and inflation rate on the other hand. Moreover, it could be equally observed that no causality ran from fiscal deficit to inflation in Nigeria. This result was consistent with Olaniyi, (2020) who got the evidence that fiscal deficit was not inflationary in Nigeria, but in contrast with Oladipo and Akinbobola, 2011 which found that fiscal deficit was a key factor in inflation determination in Nigeria.

The implication of the frequency causal timing is that fiscal policy makers, ministry of budget and planning in Nigeria, should pursue a medium term planning for the effectiveness of fiscal responsibility on macroeconomic performance. The frequency timing of 1 year 5 months also suggests that policy makers should monitor within the period government deficit behaviour in relation to interest rate response for effective macroeconomic performance. This result stems from the Keynesian theory that increase in government deficit from the domestic saving usually crowd out the private investment. The competition for the few available funds among the private investors drove the interest rate up with the resultant effects on low private investment.

The outcome of the causal relationship between fiscal deficit and interest rate shows that, in the medium term, budget deficit is the lead variable while interest rate is the lag variable. This finding is consistent with previous studies done for Nigeria, such as Odionye and Uma (2013) and Nwosa and Ibas (2014). The result supports the Nigeria's experience given the increase in government deficit from ₦278.10 billion in 2012 to ₦713.38 billion in 2015 with double digit interest rate (BudgIT, 2019). By 2018, the government deficit increased to ₦1.64 trillion with 793 billion sourced from the domestic source and 849 billion from the foreign source. The incessant increase in government spending in Nigeria has reduced the available funds for private investors and being the major source of increase in interest rate in the country. Nigeria usually attaches her yearly budget spending to the expected bench mark of oil price. And whenever the oil price falls short of the expected bench mark, the country either resort to mopping up the available funds for the private sector or borrow from external sources. The peculiarity of government spending in Nigeria is the sole reliance on the oil revenue to finance the economy. As a consequence, the debt to revenue ratio in Nigeria is around is on the increase, such that Nigeria now spends 80 percent of her revenue to debt payment (Centre for the Study of the Economies of Africa, 2019). Lastly, there is no causality from budget deficit to inflation rate and vice versa. The absence of the frequency causal relationship between fiscal deficit and inflation rate supports the earlier work of

Tiwari *et al.* (2015) on frequency Granger causality for nine European Union countries. In the same vein, no causality was found between interest rate and inflation rate in the frequency analysis.



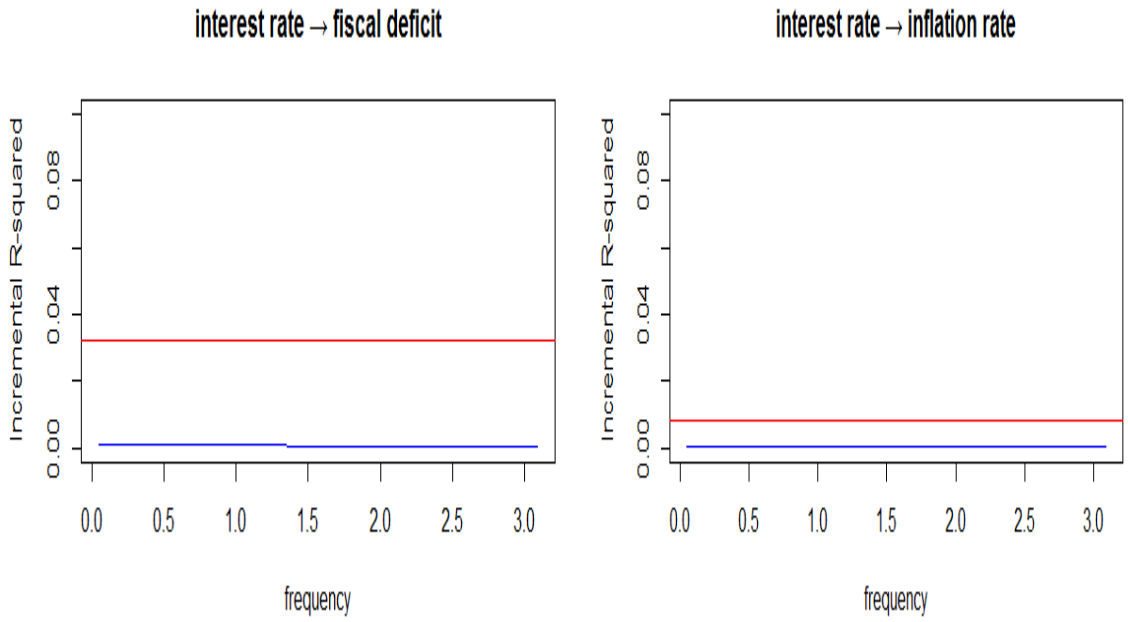


Fig.4. Frequency Granger causality of fiscal deficit, interest rate and inflation rate in Nigeria
Source: Author's computation, 2020

Conclusion

This paper investigated the dynamic causal relationship among fiscal deficit, inflation rate and interest rate in Nigeria. We used data from the first quarter of 1993 to the first quarter 2018. After testing for stationarity and cointegration, the frequency domain Granger causality result showed that, both in the short run and long run, there was no causality between fiscal deficit and inflation in one hand and between interest rate and inflation rate on the other hand. We, however, found medium term causality running from fiscal deficit to interest rate. The conclusion of this study was that fiscal deficit was a leading variable and a major driver of interest rate in Nigeria. The policy implications of these findings are; that government of Nigeria needs to be fully committed to improving business environment via reduction in its borrowing requirements which have tendencies to increase interest rates in the economy. The monetary authority should consider issuance of seignoirage to absorb public debts instead of mounting undue pressures on interest rates through financial market in the economy. Finally, fiscal authorities should pursue a medium-term planning as fiscal policy rule for sound fiscal responsibility and discipline.

Reference

Abu, N., & Abd Karim, M. Z. (2015). The non-linear relationship between fiscal deficits and inflation: evidence from Africa. *South East European Journal of Economics and Business, 10 (2),* 102-112.

Awe, A. A., & Olalere, S. S. (2012). The nexus between budget deficit and inflation in the Nigerian economy (1980–2009). *Research Journal of Finance and Accounting, 3(10),* 78–92.

Bakare, I. O. A., Adesanya, O. A., & Bolarinwa, S. A. (2014). Empirical investigation between budget deficit, inflation and money supply in Nigeria. *European Journal of Business and Social Sciences, 2(12),* 120–134.

Barror R. (1987). Government spending, interest rates, prices, and budget deficits in the United Kingdom, 1701-1918.*Journal of Monetary Economics, 20(2),* 221-47; http://doi.org/10.1016/03043932(87)90015-8.

Bhat, S. A., & Laskar, M. R. (2016). Interest rate, inflation rate and gross domestic product in India. *International Journal of Technical Research & Science, 1(9),* 284-288.

Bhunia, A. (2016). How inflation and interest rates are related to economic growth? A case of India. *Journal of Finance and Accounting, 4(1),* 20-26; DOI:10.12691/jfa-4-1-3

Bouri, E., Kachacha, I., Lien, D., & Roubaud,D. (2017). Short- and long-run causality across the implied volatility of crude oil and agricultural commodities. *Economics Bulletin*, 37(2), 1077-1088

Breitung, J., & Candelon, B. (2006). Testing for short and long-run causality: a frequency domain approach. *Journal of Econometrics, 132,* 363-378. http://dx.doi.org/10.1016/j.jeconom.2005.02.004

Brima, S., & Mansaray-Pearce, E. A. (2015). Budget deficit and macroeconomic variables in Sierra Leone: an econometric approach. *Journal of Economics and Sustainable Development, 6(4),* 38-51.

BudgIT (2019) http://yourbudgit.com Accessed 25th July, 2019

Centre for Study of Economies of Africa 2019. 4 Dep. Street off Danube Street, Maitama, Abuja, FCT, Nigeria. Available online: www.cseaafrica.org accessed on the 26th July, 2019.

Croux, C., & Reusens. P. (2013). Do stock prices contain predictive power for the future economic activity? A Granger causality analysis in the frequency domain. *Journal of Macroeconomics, 35,* 93–103.

Davapriya, T. N. K.P.N., & Ichihashi, M. (2012). *How does the budget deficit affect inflation in Sri Lanka*. IDEC Discussion Paper 2012, Hiroshima University, 1-38.

Dickey, D.A., & Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a Unit root, *Journal of the American Statistical Association, 74,* 427-431; doi.org/10.1080/01621459.1979.10482531

Dolado, J. J. & Lütkepohl, H. (1996) Making wald tests work for cointegrated VAR systems, *Econometric Reviews, 15(4),* 369-386; DOI: 10.1080/07474939608800362

Egbulonu, K. G., & Wobilor, A. K. (2016). Impact of fiscal policy on inflation in Nigeria. *International Journal of Innovative Development & Policy Studies 4(3),* 53-60.

Engle, R. E., & Granger, C.W.J. (1987). Cointegration and error correction: representation, estimation and testing, *Econometrica, 55,* 251-276; http://doi.10.2307/1913236

Erkam, S., & Çetinkaya, M. (2014). Budget deficits and inflation: evidence from Turkey. *The Macrotheme Review 3(8),* 12-22

Huang, X., Silva, E., & Hassani. H. (2018). Causality between oil prices and tourist arrivals. *Stats.* 1, 134–54; doi:10.3390/stats1010010

Jalil, A., Tariq, R., & Bibi, N. (2014) Fiscal deficit and inflation: new evidences from Pakistan using a bounds testing approach. *Economic Modelling, 37,* 120-126; http://dx.doi.org/10.1016/j.econmod.2013.10.029

Javid, Y. A., & Arif, U. (2014). Fiscal and monetary regime identification for price stability in case of Pakistan economy. *Journal of Economic Cooperation and Development, 35(3),* 43-70.

Khumalo, L. C., Mutambara, E., & Assensoh-Kodua, A. (2017). Relationship between inflation and interest rates in Swaziland revisited. *Bank and Banks System, 12(4),* 218-226; http://dx.doi.org/10.21511/bbs.

Koyuncu F. T. (2014), Causality network between budget deficit, money supply and inflation: an application to Turkey. *International Journal of Business and Social Science, 10(1),* 225-235.

Nwakobi, P. C., Echekoba, F. N., & Ananwude, A. C. (2018). Fiscal deficit in an oil dependent revenue country and selected macroeconomic variables: a time series analysis from Nigeria (1981-2015). *European Journal of Economic and Financial Research, 3(1),* 126-166; doi:10.5281/zenodo.12857

Nwakoby, C. N. I., Okaro, C. S. O., & Ananwude, A. C. (2016). Fiscal deficit and inflation in an oil rich exporting country: evidence from Nigeria. *Journal of Policy and Development Studies, 10(3),* 140-155.

Nwosa, P.I., & Ibas, C. K. (2014). Does budget deficit affect short and long term interest rates differently? *International Journal of Economics and Business Research, 8(4),* 399-414.

Odionye, J. C., & Uma K. E. (2013). The relationship between budget deficit and interest rate: evidence from Nigeria. *European Journal of Business and Social Sciences, 2(1),* 158-167.

Oladipo, S. O., & Akinbobola, T. O. (2011). Budget deficit and inflation in Nigeria: a causal relationship. *Journal of Emerging Trends in Economics and Management Sciences (JETEMS), 2 (1),* 1-8.

Olaniyi, (2020). Application of bootstrap simulation and asymmetric causal approach to fiscal deficit-inflation nexus. *Global Journal of Emerging Market Economies,* 1-18.DOI: 10.1177/0974910120919021

Olasehinde-Williams, G. (2020). Is US trade policy uncertainty powerful enough to predict global output volatility? *The Journal of International Trade & Economic Development,* DOI: 10.1080/09638199.2020.1806912

Olayungbo, D. O. (2019). Effects of global oil price on exchange rate, trade balance and reserve in Nigeria. *Journal of Risk Financial Management, 12*(1), 43 doi:10.3390/jrfm12010043

Perron, P. (1989). The great crash, the oil price shock and the unit root hypothesis. *Econometrica, 57,* 1361-1401; DOI: 10.2307/1913712

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001) Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics 16(3),* 289–326; https://doi.org/10.1002/jae.616

Phillips P.C.B, & Perron P. (1988). Testing for a unit in time series regression. *Biometrica, 75,* 335–346; https://doi.org/10.1093/biomet/7.52.335.

Rani, R., & Kumar, N. (2016). Does fiscal deficit affect interest rate in India? An empirical investigation. *Jindal Journal of Business Research, 5(2),* 87–103; https://doi.org/10.1177/2278682116680925.

Şahin, B. E. (2019). Analysis of the relationship between inflation, budget deficit and money supply in Turkey by ARDL approach: 1980-2017. *Journal of Life Economics, 6(3),* 297-306; doi.org/10.15637/jlecon.6.018

Tiwari, A.K., Bolat, S., & Koçbulut, Ö. (2015) Revisit the Budget Deficits and Inflation: Evidence from Time and Frequency Domain Analyses. *Theoretical Economics Letters, 5,*357-369; http://dx.doi.org/10.4236/tel.2015.53041

Tiwari, A.K., & Kyophilavong, P. (2017). Exchange rates and international reserves in India: a frequency domain analysis. *South Asian Economic Journal, 18(1),* 76-93; https://doi.org/10.1177/1391561416684237

Tiwari, A.K., Tiwari, A.P., & Pandey, B. (2012) Fiscal Deficit and Inflation: What causes what? The case of India. *Journal of International Business and Economy, 13,* 57-81.

Ozer, M., & Kamisli, M. (2016). Frequency domain causality analysis of interactions between financial markets of Turkey. *International Business Research, 9(1),* 176-186; http://dx.doi.org/10.5539/ibr.v9n1p176

Appendix

Table A1. VAR lag order selection criteria. Endogenous variables: inflation rate and interest rate.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−622.87	NA	2350.35	13.43	13.43	30.3
1	−462.30	310.78	81.07*	10.07*	10.07*	25.6*
2	−461.87	0.81	87.56	10.14	10.14	25.5
3	−461.01	1.59	93.70	10.21	10.22	25.4
4	−459.15	3.35	98.18	10.26	10.26	25.48
5	−453.64	9.71*	95.14	10.22	10.22	25.54
6	−451.68	3.38	99.54	10.27	10.27	25.59
7	−451.39	0.47	108.04	10.35	10.35	25.66
8	−450.20	1.94	115.08	10.41	10.41	25.72

LR—likelihood ratio, FPE—final prediction error, AIC—Akaike information criterion, SC—Schwarz information criterion, HQ—Hannan–Quinn information criterion. * signifies optimal lag length.
Source: Author's computation, 2020

Table A2. VAR lag order selection criteria. Endogenous variables: inflation rate and fiscal deficit.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−542.59	NA	418.17	11.71	11.76	11.73
1	−425.09	227.41	36.42	9.27	9.43*	9.33
2	−418.96	11.61*	34.79*	9.22*	9.49	9.33*
3	−417.73	2.28	36.94	9.28	9.66	9.43
4	−415.23	4.52	38.18	9.31	9.80	9.51
5	−410.27	8.75	37.43	9.29	9.89	9.53
6	−408.40	3.21	39.25	9.34	10.04	9.62

7	−405.42	4.99	40.20	9.36	10.18	9.69
8	−404.61	1.31	43.17	9.43	10.35	9.80

LR—likelihood ratio, FPE—final prediction error, AIC—Akaike information criterion, SC—Schwarz information criterion, HQ—Hannan–Quinn information criterion. * signifies optimal lag length.

Table A3. VAR lag order selection criteria. Endogenous variables: fiscal deficit and interest rate rate.

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	−433.88	NA	40.37	9.37	9.42	9.39
1	−313.73	232.54	3.32	6.87	7.03	6.94
2	−307.27	12.24	3.15	6.82	7.09	6.93
3	−304.91	4.38	3.26	6.85	7.23	7.01
4	−304.30	1.09	3.51	6.93	7.42	7.12
5	−300.78	6.20	3.55	6.94	7.54	7.18
6	−296.95	6.58	3.57	6.95	7.65	7.23
7	−295.47	2.50	3.78	7.00	7.81	7.33
8	−293.29	3.55	3.93	7.04	7.96	7.41

LR—likelihood ratio, FPE—final prediction error, AIC—Akaike information criterion, SC—Schwarz information criterion, HQ—Hannan–Quinn information criterion. * signifies optimal lag length.
Source: Author's computation, 2020