Economic Change and Restructuring
https://doi.org/10.1007/s10644-021-09339-3

Asymmetric response of cpi inflation to exchange rates in oil-dependent developing economy: the case of Nigeria

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Received: 16 March 2021 / Accepted: 14 June 2021

Abstract

The question of whether domestic prices respond to either official exchange rate or parallel exchange rate movement is a key research issue especially in an oil-dependent developing country like Nigeria with rising fiscal pressures and a vibrant parallel market. Also from the monetary authority perspective, it is imperative to know if prices respond symmetrically and/or asymmetrically to both official and parallel exchange rates movement. Consequently, this study examines the response of domestic prices to both official and parallel exchange rates movement for the period 1995Q1-2019Q1 with the Shin et al. (In: Horrace WC, Sickles RC (eds) Festchrift in Honour of Peter Schmidt. Springer, New York, pp 281–414, 2014) nonlinear ARDL approach. The results provide support for prices responding symmetrically to parallel rates than the official rate especially in periods of large exchange rate premium. However, prices only respond differently to depreciation and appreciation of the official exchange rate in Nigeria. Consequently, the government needs to ensure some levels of fiscal austerity and possible exchange rate unification when the premium gets large if the intention is to insulate domestic prices from fiscal pressures. Also, the Central Bank of Nigeria needs to take cognizance of possible asymmetric relationship in their decisions to ensure price stability so as not to distort monetary policy effect.

Keywords General consumer price · Food price · Official exchange rate · Parallel exchange rate · Nonlinear ARDL

I wish to express my deep appreciation to the African Economic Research Consortium (AERC) for the financial support to this study. I am also grateful to the resource persons and members of AERC's thematic group B for various comments and suggestions that shaped the evolution of this study from its inception to completion. The guidance and comments of Akpan Ekpo and Dick Duravall as to the direction of the study have been valuable and I am grateful for that also. The findings made and opinions expressed in this paper are exclusively those of the author. The author is also solely responsible for content and any errors.

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Published online: 19 June 2021

JEL Classifications C32 · E31 · F31

1 Introduction

A good understanding of the dynamics of inflationary pressures is imperative to ensuring not only proper policy direction but also the effectiveness of monetary policy stance in an oil-dependent developing economy. In the literature, two prominent approaches dominate in explaining this dynamics-the Phillip Curve and the quantity theory (Duravall et al. 2013). Now, most studies in Sub-Sahara Africa pay more attention to the use of the quantity theory with focus on the excess money supply as the driver of inflation due to large informal sector and alarming unemployment rate (see, Duravall et al. 2013). However, the role of foreign prices and exchange rate as a nominal anchor is recently considered in the literature in modeling inflationary dynamics (See, Olubosye and Oyaromade 2008; Delatte et. al. 2012; Duravall et al. 2013; Baharumshah et al. 2017). Thus, providing an understanding of the response of domestic prices (both general and food) to the dynamics of the nominal exchange rate is critical to the monetary policy decision especially when the primary objective of the Central Bank is price stability in an oil-dependent developing economy (Delatte et al. 2012). This is the main thrust of the study on Nigeria.

The Nigerian economy operates multiple exchange rate windows but the most prominent ones are the official and parallel exchange rates.[1] Over the years, the gap between these two exchange rates become large especially in periods where there is negative oil price shock as the government treats positive oil price shocks as permanent thus resulting in procyclical fiscal shocks. Oil accounts for about 90% of export earnings and foreign exchange in Nigeria and the country is a major importer of both consumables and capital goods. In fact, non-oil imports accounts for roughly 91% of import consequently, a possible pass-through effect on domestic prices. This sometimes explains the reason for persistence external imbalances due to global oil price shock that may affect domestic prices via exchange rate. The government, however, imposes exchange rate controls with the intention of isolating inflation from fiscal pressures as the parallel rate is expected to absorb this pressure. But, balance of payment adjustment responds to real exchange rate via the exchange rate pass-through channel (Delatte et al. 2012). This necessitates the need to consider the exchange rate pass-through to domestic prices in Nigeria's case especially with the existence of both official and parallel market rates.

Additionally, the intention of the government is to maintain the role of the official exchange rate as a nominal anchor so as to isolate domestic prices from fiscal pressures. However, available evidence showed that when the exchange rate premium gets large, the isolation of domestic prices from fiscal pressure breaks down

[1] Official exchange rate is the rate announced by the Central Bank of Nigeria for official government transactions such as government foreign revenue calculations while parallel exchange rate is the exchange rate in a dual system especially with Nigeria having more than one window. It can also refer to black market rate in a black market system.

(Kaufmann and O'Connell 1999; Kiguel and O'Çonnell 1995). Nigeria is basically a net seller of foreign exchange to the private sector mainly from the oil export earnings. It is evident from the existing studies that devaluing the official exchange rate when the exchange rate premium is large could curtail the fiscal pressure but on the other hand, rising parallel rate might spur inflation (Pinto, 1990; Morris, 1995; Kiguel and O'Connell 1995). The question then is, how domestic prices (general and food) respond to the movement in both the official rate and parallel rates. While studies exist on the response of inflation to exchange rate but the response to both official and parallel rates in providing policy direction has received less or little attention in Nigeria. More importantly, previous studies assumed a symmetric long-run connection between price levels and the exchange rate but this assumption looks restrictive and might distort the effectiveness of monetary policy (Delatte et al. 2012). With the existence of these two prominent exchange rates in Nigeria, it is imperative to pursue further and show not only the symmetric response but also the asymmetric response of domestic price levels (general and food) to these two exchange rates in providing empirical support for monetary policy decisions in Nigeria.

The literature is mixed on the symmetric connection. For instance, Ndulu and Hyuha (1990), Azam (1999), and Rustasitara (2004) found parallel exchange rate to explain domestic prices, Canetti and Greene (1992), Hyuha (1992), Kuijs (1998), Olubusoye and Oyaromade (2008), Imimole and Enoma (2011) provided evidence of domestic prices responding to official exchange rate while Chhibber and Shafik (1992), Barungi (1997), Bada et al. (2016) showed evidence of anti-inflationary effect from official exchange rate. Also, Durevall et al. (2013) showed domestic prices responding to foreign prices. On the asymmetric connection, recent studies like Zhu and Chen (2019), Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) showed asymmetric effect of exchange rate on domestic prices. On exchange rate regimes, fixed regimes can ensure low inflation if there is adherence to prudent fiscal policy. On the other hand, floating exchange rates have also been found to ensure stable inflation with prudent fiscal policy (Siklos 1996; Toulaboe and Terry 2013). Toulaboe and Terry (2013) opined that the credibility of fixed regimes can be abused with the pursuit of expansionary policy. Also, deteriorating tax collection has the tendency to manifest in macroeconomic disequilibrium resulting into unrealistic exchange rate, deteriorating BOP, monetization of fiscal deficits and growing external debt arrears (Toulaboe and Terry 2013). Barungi (1997) and Rustasitara (2004) opined that the relevant exchange rate for traded goods and portfolio shift when exchange rate is overvalued is the parallel rate in countries where the parallel market exists with such economic structure. But devaluation of the official exchange rate could translate into improving budgetary resources and reducing foreign exchange demand thereby reducing the upward pressure on price level (Barungi 1997).

This study contributes to the literature by gauging not only the symmetric connection but also the asymmetric response of both general and food price levels to both official and parallel exchange rates in an oil-dependent economy-Nigeria. The Nigeria case is not only understandable but also imperative based on recent experiences due to slump in oil price coupled with rising debt profile as this will provide a guide

to countries with similar experiences. This study in examining this connection pays specific attention to periods where the exchange rate premium becomes large and the government also maintained some level of exchange rate controls. To the best of our knowledge, except for Zhu and Chen (2019), Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) studies, previous studies always assumed symmetric long-run relationship between domestic prices and exchange rate. This is with a rigid and restrictive assumption that both depreciation and appreciation have the same effect on price level. Consequently, a distortionary effect of monetary policy may ensue with the omission of asymmetric effect (Delatte and Lopez-Villavicencio 2012). Prices are sticky downward and price adjustment to exchange rate depreciation and appreciation depends on the underlying fiscal and monetary policies. When a country is unable to curtail spending amidst depreciation or devaluation as the need arise due to deteriorating BOP position, the aftermath effect is inflationary pressure especially in the case of import and oil-dependent economy (Pinto 1990; Morris 1995; Kiguel and O'Çonnell 1995; Kaufmann and O'Çonnell 1999). This study is different from the works of Zhu and Chen (2019), Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) because both official and parallel exchange rates are considered. Also, the study controlled for periods of widening exchange rate premium in an oil-dependent developing country.

2 Brief literature review

A country where the official and parallel exchange rates exists, the government most times imposes exchange controls so as to isolate the inflation rate from fiscal pressures with the intention that the parallel rate will absorb the pressures while retaining the nominal anchor role of the official exchange rate (Kaufmann and O'Connell 1999; Kiguel and O'Çonnell 1995). However, when the premium becomes large, the insulation of prices from fiscal pressures might break down. The literature showed that when a country is a net seller of foreign exchange (from oil exporting earnings) to the private sector, devaluing the official rate when the parallel premium is large will actually reduce inflation, while increases in the parallel rate will spur inflation (Pinto 1990). On exchange rate regimes, it is postulated that during periods of depleting foreign reserves and the inability to meet foreign exchange demand, the fixed policy results in overvalued exchange rate that makes the export sector uncompetitive and with an active parallel market which rate is determined by market forces, the relevant rate of exchange for portfolio shifts and traded goods is the parallel market rate, since it is the marginal cost of foreign exchange (see, Barungi 1997). The implication is that instead of the fixed policy to maintain price stability, the reverse might be the case in such situation. Thus, the response of domestic price to the official and parallel exchange rate might differ and there is also the possibility of the asymmetric response.

From the empirics, the literature is still very scanty on the effect of parallel market rate but more is done on official exchange rate and exchange rate policy on inflation. However, most of the studies on exchange rate policy are more on panel data studies with combinations of developing countries. For instance, Ndulu and Hyuha (1990),

Camen (1994), Azam (1999) and Rutasitara (2004) found parallel exchange rate to influence inflation. Surprisingly, Canetti and Greene (1992), Hyuha (1992), Kuijs (1998), Imimole and Enoma (2011) found official exchange rate to also influence inflation while Chhibber and Shafik (1992), Barungi (1997), Bada et al. (2016) found it to be anti-inflationary. On exchange rate policy, Ghosh et al. (1997), Rogoff et al. (2003), Domac et al. (2004), Bleaney and Francisco (2007), Sokolov and Mark (2011), Toulaboe and Terry (2013) found fixed exchange rate regime to be less inflationary than flexible policy. But, Levy-Yeyati and Sturzenegger (2000) found inflation rates to be similarly correlated with fixed and pure floating policies but it is higher for intermediate policy. Olubusoye and Oyaromade (2008) found petroleum prices, money growth and exchange rate to significantly explain inflation but output was insignificant. However, Ghanem (2010) found fixed regime to be unsuccessful in maintaining low and stable inflation with de jure classification but found inflation to be considerably lower under de facto classification. Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) showed with an asymmetric cointegration model that exchange rate depreciations are pass-through to prices more than appreciations. Durevall et al. (2013) found domestic prices to respond to foreign food and goods prices in the long-run while at the short agricultural supply shock explained food inflation and money supply growth affected non-food inflation.

On exchange rate unification due to its perceived effect on money growth and inflation, Pinto (1990) showed that if government is a net seller of foreign exchange, unification imposes a fiscal shock that triggers money creation and inflation in the long-run except there is concerted efforts by the government to ensure fiscal austerity. Morris (1995) revealed, on the other hand, the case where Pinto (1990) results can be reversed. Accordingly, if money creation is not ensued, unification is not inflationary otherwise, it is inflationary. And if the foreign exchange account is in surplus, unification should not be inflationary but if it is in deficit, then unification is inflationary. Kiguel and O'Çonnell (1995) identified illegal trade and prices as the two channels through which the existence of parallel exchange rate transmit into the economy. According to them, it promotes the diversion of exports from official to the unofficial and the reverse is the case for imports and this undermines trade tax revenue. The study stressed further that domestic prices of imported goods are determined by the world price and the parallel exchange rate. And that government mostly in developing countries responds to external imbalance by tightening and/or exchange control instead of contractionary fiscal policy and devaluation or both. Consequently, fiscal indiscipline amidst devaluation or depreciation results in inflation tax to service the debt obligation. Kaufmann and O'Çonnell (1999) later revealed that there was no economic benefit for delaying or gradual unification when there are serious macroeconomic woes. In fact, the study showed that a more aggressive attempt for unification will engender fiscal bonus and curtail money growth and inflationary pressures.

3 Data and methodology

In modeling the dynamics of inflation in Nigeria, the study followed Durevall et al. (2013) framework that can allow one to test various hypotheses without restrictions and also able to account for specific peculiarities of an oil-dependent developing economy. The framework is based on the quantity theory focusing on the role of money and demand as against the Phillips curve due to low degree of labor-market organization, extensive underemployment and large informal sector even as this is the case also for Nigeria. In the Durevall et al. (2013) framework, the long-run determinants of the domestic price level are of the fact that inflation is usually anticipated to originate from the monetary and foreign sectors in an open economy case via the money demand and purchasing power parity arguments.

Consequently, Durevall et al. (2013) opined that variation in the domestic price can be explained by deviations from the steady-state equilibrium in the monetary and external sectors thus:

$$\log\left(m/p\right) = \alpha_0 + \alpha_1 y + \alpha_2 r \tag{1}$$

$$p = \vartheta_1 e + \vartheta_2\, wp - \vartheta_4 t_1 \tag{2}$$

$$pf = \gamma_1 e + \gamma_2 wfp - \gamma_4 t_2 \tag{3}$$

where m/p = real money balance, y = log of real output, r = rate of returns, p and pf = log of general domestic price and food price, e = log of the exchange rate, wp and wfp are log of world price and world food prices, t_1 and t_2 are trends in prices. Equations (2) and (3) indicate purchasing power parity (PPP) relationship for the long-run external market equilibrium for general domestic and food sectors. Equations (2) shows that general domestic consumer prices are assumed to adjust to world consumer prices and the exchange rate in the long-run, while Eq. (3) indicates that domestic food prices adjust to world food prices and the exchange rate. Durevall et al. (2013) estimated Eqs. (1)-(3) separately and included their long-run deviations in explaining four prices in single-equation ECMs though with variations to account for specific other drivers. Agricultural goods through supply shock affect food inflation and several other drivers were included such as exchange rate changes, energy price, imported inflation and world-fertilizer price. Since the framework is not restrictive and allows testing for several hypotheses, this study adopts it with modification to account for our variables of interest (official and parallel market exchange rate changes). The main thrust of this study is the short-run and long-run asymmetric response of general CPI inflation and food inflation to exchange rate changes.

Therefore, based on the Durevall et al. (2013) framework in Eqs. (1)-(3) informing their empirical specification and the Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) specifications that specifically account for asymmetric exchange rate pass-through to domestic price, we specify our ARDL equation accounting for the ECMs of Eqs. (1)-(3):

$$\Delta p_t = \vartheta + \sigma_p p_{t-1} + \sigma_e e_{t-1} + \sigma_o op_{t-1} + \sigma_{m2} m2_{t-1} + \sigma_w wp_{t-1} + \sigma_m ecm\_mb_{t-1} + \sum_{k=1}^{n} \beta_k^{'} \Delta p_{t-k} + \sum_{k=0}^{n} (\gamma_k^{'} \Delta e_{t-k} + \alpha_k^{'} \Delta Op_{t-k} + \delta_k^{'} \Delta m2_{t-k} + \varphi_k^{'} \Delta wp_{t-k}) + \sigma_D PreDum_t + \sigma_t trend_t + {}_{1t} \tag{4}$$

$$\Delta pf_t = \vartheta + \sigma_p pf_{t-1} + \sigma_e e_{t-1} + \sigma_o op_{t-1} + \sigma_{m2} m2_{t-1} + \sigma_w wfp_{t-1} + \sigma_m ecm\_mb_{t-1} + \sum_{k=1}^{n} \beta_k^{'} \Delta pf_{t-k} + \sum_{k=0}^{n} (\gamma_k^{'} \Delta e_{t-k} + \alpha_k^{'} \Delta Op_{t-k} + \delta_k^{'} \Delta m2_{t-k} + \varphi_k^{'} \Delta wfp_{t-k}) + \sigma_D PreDum_t + \sigma_t trend_t + {}_{2t} \tag{5}$$

Equations (4) and (5) are the ARDL specification for the general domestic price and food price Eqs. (2) and (3), where *ecm_mb* = error correction mechanism of the real money balance Eq. (1) as a measure of excess money supply:

$$ecm\_mb = \log\left({}^{m}/_{p}\right) - \alpha_1 y - \alpha_2 r \tag{6}$$

Oil price is later added to the specification because Nigeria's main budgetary assumption is oil price and it is evident that during periods of declining oil prices, the country experiences negative revenue shock that widens the country's deficit thereby putting pressure on domestic prices (CBN, 2019). Also, movement in oil price has effect on foreign reserves via export earnings thus transmitting into exchange rate pass-through to domestic prices via import. In fact, the premium between the official rate and parallel rate gets larger in periods of negative oil price shock. The inclusion of oil price is also supported by the inclusion of oil price by Baharumshah et al. (2017) and Durevall et al. (2013) and energy prices by Durevall et al. (2013) and Delatte and Lopez-Villavicencio (2012) in their final estimations. The study also controls for widening exchange rate premium. A dummy variable (PreDum) accounting for periods of widening exchange rate premium is also included. It takes the value of one for periods of widening premium and zero otherwise. This is also an indication of the periods where the government decides to allow exchange rate controls as negative oil price ensued.

Equations (4) and (5) are the Pesaran et al. (2001) symmetric ARDL specification. The focus variable of interest is e_t (log of exchange rate both at the parallel and official), ϵ_{1t} and ϵ_{2t} *are iid* process. Equations (4) and (5) are the ARDL specification and they allows both short-run and long-run analyses with either I(1) or I(0) series or both. The study adopts both the Banerjee et al. (1998) and Pesaran et al. (2001) approaches for testing symmetric long-run relationships. For the Banerjee et al. (1998) approach (t_{BDM}), if $\sigma_p = 0$ it means there is symmetric no long-run relationship using the t-statistics. However, with the Pesaran et al. (2001) approach (F_{pp}), the joint F-statistics test is computed as against the Pesaran et al. (2001) critical values taking from the lower and upper bounds depending on whether the regressors are I(1) or I(0), if the computed f-statistics is above

upper critical values, there is symmetric long-run relation, if it lies below the lower critical values, there is no evidence of long-run relationship.

The purpose of this study is to allow for asymmetric response hence as also used by Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012), the study adopts the asymmetric long-run relationship model (Nonlinear ARDL) by Shin et al. (2014).

The study employs the Shin et al. (2014) nonlinear ARDL approach which is an extension of the Pesaran et al. (2001) ARDL approach. This is to ascertain if the effect of rising parallel or official exchange rates on inflation (both general and food) is different from that of declining rates both at official and parallel markets. The main thrust of this is to account for the different effects of appreciation (declining) and depreciation (rising) of both parallel and official exchange rates on both headline and food inflation in Nigeria. Consequently, the movement of exchange rate is decomposed into its positive (depreciation) and negative (appreciation) partial sums being the starting point in Eqs. (7) & (8):

$$\log E_t = \log E_0 + \log E_j^+ + \log E_j^- \tag{7}$$

$$\begin{cases} e_t^+ = \sum_{j=1}^{t} \Delta \log E_j^+ = \sum_{j=1}^{t} \max\left(\Delta \log E_j, 0\right) \\ e_t^- = \sum_{j=1}^{t} \Delta \log E_j^- = \sum_{j=1}^{t} \min(\Delta \log E_j, 0) \end{cases} \tag{8}$$

Equation (8) is used to calculate the partial sum variables and thus replace exchange rate variable to examine the nonlinear effect. Consequently, Eqs. (4) and (5) can be modified to account for asymmetric relationship thus:

$$\begin{aligned} \Delta p_t = {} & \vartheta + \sigma_p p_{t-1} + \sigma_e^+ e_{t-1}^+ + \sigma_e^- e_{t-1}^- + \sigma_o op_{t-1} + \sigma_{m2} m2_{t-1} + \sigma_w wp_{t-1} + \sigma_m ecm\_mb_{t-1} \\ & + \sum_{j=1}^{n} \beta_j' \Delta P_{t-j} + \sum_{k=0}^{n} (\gamma_k^{+\prime} \Delta e_t^+ + \gamma_k^{-\prime} \Delta e_t^- + \alpha_k' \Delta op_{t-k} + \delta_k' \Delta m2_{t-k} + \varphi_k' \Delta wp_{t-k}) \\ & + \sigma_D PreDum_t + \sigma_t trend_t + {}_{1t} \end{aligned} \tag{9}$$

$$\begin{aligned} \Delta pf_t = {} & \vartheta + \sigma_p pf_{t-1} + \sigma_e^+ e_{t-1}^+ + \sigma_e^- e_{t-1}^- + \sigma_o op_{t-1} + \sigma_{m2} m2_{t-1} + \sigma_w wfp_{t-1} \\ & + \sigma_m ecm\_mb_{t-1} + \sum_{j=1}^{n} \beta_j' \Delta Pf_{t-j} + \sum_{k=0}^{n} (\gamma_k^{+\prime} \Delta e_t^+ + \gamma_k^{-\prime} \Delta e_t^- + \alpha_k' \Delta op_{t-k} \\ & + \delta_k' \Delta m2_{t-k} + \varphi_k' \Delta wfp_{t-k}) + \sigma_D PreDum_t + \sigma_t trend_t + {}_{2t} \end{aligned} \tag{10}$$

Equations (9) and (10) are the standard Shin et al. (2014) nonlinear ARDL specification and the sign cum size of the partial sum coefficients is used to determine general and food inflations response to exchange rate (either official or parallel asymmetries). From Eqs. (9) and (10), asymmetric long-run cointegration test can be performed using the Banerjee et al. (1998) (t_{BDM}), and the Pesaran et al. (2001)

Table 1 Variable definition and sources

Variables	Name	Measurement	Source
p_t	Consumer price index to capture inflation	Price Index	CBN
p_{ft}	Food price index to capture food inflation	Price Index	CBN
m_2	Money supply to capture quantity theory		CBN
op	Oil price	Crude oil Price per barrel	CBN
gdp_t	Domestic output to capture aggregate demand	Nominal	CBN
e_{ot}	Official exchange rate	Nominal	CBN
e_{pt}	Parallel exchange rate	Nominal	CBN
e_t^+	Positive exchange rate movement to capture depreciation of both official (e_{ot}^+) and parallel (e_{pt}^+)rates	Nominal	Asymmetric measurement
e_t^-	Negative exchange rate movement to capture appreciation of both official (e_{ot}^-) and parallel (e_{pt}^-) rates	Nominal	Asymmetric measurement
r	Interest rate (lending rate)	Nominal	CBN
ecm_mb	Excess money supply		Generated with Eq. (6)
$PreDum$	Exchange rate premium dummy for periods of widening premium	Dummy variable	1 for periods of widening period; 0 for otherwise
wp_t	World consumer price Index to capture world prices	Price index	IMF-IFS
wfp_t	World food price index	Price index	IMF-IFS

CBN Central Bank of Nigeria, *IMF-IFS* International Monetary Fund International Financial Statistics

Source: Author's compilation

Table 2 Unit root test results

Variables	Unit root without break point					Unit root with break point				
	ADF		PP			ZA test				
	I(0)	I(1)	I(0)	I(1)	rmk	I(0)	BP	I(1)	BP	rmk
p_t	−0.61	−9.88*	−1.66	−14.15*	I(1)	−1.55	2015Q4	−10.56*	2005Q3	I(1)
p_{ft}	0.13	−10.32*	0.15	−10.34*	I(1)	−1.04	2008Q1	−10.52*	2003Q1	I(1)
e_{ot}	−1.64	−9.27*	−1.63	−9.27*	I(1)	−5.87*	1998Q4	–	–	I(0)
e_{pt}	−0.24	−4.79*	−0.13	−6.59*	I(1)	−2.88	2014Q4	−7.02*	2016Q3	I(1)
m_2	−2.24	−10.56*	−2.46	−10.56*	I(1)	−3.08	1994Q4	−12.34*	2008Q1	I(1)
op	−1.49	−8.00*	−1.58	−7.86*	I(1)	−3.36	2003Q4	−9.46*	2008Q4	I(1)
gdp_t	−0.05	−0.29	−2.21	−10.72*	I(1)	−3.15	2016Q2	−10.75*	1998Q2	I(1)
$Agdp_t$	0.18	−4.57*	−6.32*	–	I(0)	−5.98*	1998Q1	–	–	I(0)
e_{ot}^{+}	−0.57	−6.02*	−0.39	−5.98*	I(1)	−3.81	2007Q2	−11.22*	2007Q4	I(1)
e_{ot}^{-}	0.11	−8.41*	0.01	−8.37*	I(1)	−2.39	2014Q4	−11.58*	2016Q2	I(1)
e_{pt}^{+}	0.94	−8.22*	0.75	−8.23*	I(1)	−3.44	2016Q3	−34.05*	2017Q2	I(1)
e_{pt}^{-}	0.73	−5.85*	1.02	−6.05*	I(1)	−3.36	2015Q3	−11.31	2016Q3	I(1)
wp_t	1.14	−4.64*	0.45	−7.98*	I(1)	−2.33	2007Q1	−8.32*	1996Q2	I(1)
wfp_t	−1.61	−1.67	−1.09	−3.51**	I(1)	−2.33	1998Q1	−4.22**	2009Q1	I(1)

P_{ft} food price, e_{ot} official exchange rate, e_{pt} parallel exchange rate, gap_G output gap, gap_A agricultural output gap, *BP* break point, * and ** indicates 1% and 10% significance levels, respectively, *ADF* Augmented Dickey Fuller, *PP* Phillips-Perron, *ZA* Zivot and Andrew Unit Root test

approach (F_{pp}), approaches. Data for study cover the period 1995Q1-2019Q1 as shown in Table 1.

4 Empirical analysis

4.1 Unit root test

In an ARDL framework, it does not matter the order of integration of the regressors that is, whether the regressors are I(0) or I(1) or a combination of them. But it is imperative to test for the unit root status in the series to avoid the inclusion of I(2) regressor(s). This is because according to Pesaran et al. (2001) bound testing cointegration approach, the lower and upper bound critical values assume series to be I(0) and I(1), respectively. Consequently, the study employs unit root tests without breakpoint (ADF and PP) and with breakpoint and the results are reported in Table 2.

A cursory look at the table shows that all the variables are integrated of order (1) except for the agricultural output gap which was found to be integrated of order (0) with a confirmation from both breakpoint and without breakpoint tests. However, for official exchange rate, the unit root test with breakpoint confirmed an integration of order (0) as against the integration of order (1) being confirmed for same series in the case of unit tests without breakpoint.

Table 3 Symmetric and asymmetric ARDL cointegration tests

Models	Symmetric case			Asymmetric case			LR coefficients		
	t_{BDM}	F_{PP}	k	t_{BDM}	F_{PP}	k	α_1	α_1^+	α_1^-
CPI with official exchange rate	−0.27***	4.92***	4	−0.26***	6.45***	5	0.04	0.08	−0.15
CPI with parallel exchange rate	−0.34***	5.97***	4	−0.37*	3.72	5	0.18	0.005	0.003
Food Price with official exchange rate	−0.19***	12.24***	4	−0.04***	9.16***	5	0.11	0.25	−0.5
Food Price with parallel exchange rate	−0.36***	4.64***	4	−0.06*	3.60	5	0.19	0.05	0.02
Monetary Sector	−0.22***	7.45***	2	–	–	–	–	–	–

t_{BDM} indicates Bonerjee et al.(1998) test, F_{PP} indicates Pesaran approach,1 α_1; α_1^+ and α_1^- stand for corresponding long-run coefficients associated with total, positive (depreciation) and negative (appreciation) exchange rate changes, ***; ** and * stand for 1%; 5% and 10% significance levels, *LR* Long-run.

4.2 Symmetric and asymmetric ARDL long-run relationship test

After establishing the order of integration, the next step is to estimate the equations and test for the existence of both symmetric and asymmetric long-run relationship between prices (CPI inflation and food inflation) and exchange rates as well as for the monetary sector. The Banerjee et al. (1998) test (t_{BDM}) and the Pesaran et al. (2001) F-test (F_{PP}) as reported in Table 3 were used. The results provide support for the existence of both symmetric long-run relationship for all the models, but asymmetric long-run relationship could only be confirmed for the models with official exchange rate. This implies that parallel exchange rate only had symmetric long-run relationship with both general and food price levels while official exchange rate had both symmetric and asymmetric long-run relationship with both general and food price levels in Nigeria. For the monetary sector, a long-run relationship was also established using the symmetric case and the Johansen test (see "Appendix" A1).

This confirms the need for modeling exchange rate asymmetric effect to inform policy decision as neglected in previous studies in Nigeria. Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012) found similar results. In the step that followed, the symmetric short-run and long-run tests were performed to establish the existence of asymmetric response of prices to both official and parallel exchange rate movements using the Wald test as reported in Table 4.

The Wald test results show that both general and food prices responded asymmetrically to official exchange rate both at the short-run and long-run but this could not be confirmed for parallel exchange rate in Nigeria. This implies that only official exchange rate had asymmetric effect on prices in Nigeria and not parallel exchange rate.

Table 4 Short-run and long-run symmetric tests

Models	Short-run Wald test	Long-run Wald test
CPI inflation with official exchange rate	3.05 (0.00)	7.26 (0.00)
CPI inflation with parallel exchange rate	–	1.72 (0.18)
Food inflation with official exchange rate	3.66(0.00)	9.58 (0.00)
Food inflation with parallel exchange rate	–	1.88 (0.17)

Short-run Wald test is for additive symmetric testing the null hypothesis $\sum_{k=0}^{n} \gamma_k^{+\prime} = \sum_{k=0}^{n} \gamma_k^{-\prime}$ in Eq. (9), long-run Wald test is testing the long-run symmetric null hypothesis $\alpha_1^{+} = {\sigma_e^{+}}/{-\sigma_p} = \alpha_1^{-} = {\sigma_e^{-}}/{-\sigma_p}$ in Eq. (9), *p*-values in parenthesis

4.3 Empirical result

The result of the monetary sector as specified with the money demand function shows that the coefficients had the correct signs and a long-run relationship is also established (see "Appendixes" A1 and A2). Tables 5 and 6 present the symmetric and asymmetric ARDL estimation results, respectively. One significant thing to note is that the exchange rate premium dummy was found to positively influence prices in Nigeria indicating that allowing for large premium undermines the plan of government to isolate inflation from fiscal pressures. At the symmetric case, the parallel exchange rate was found to have a positive and significant effect on prices (general and food prices) but the official exchange rate had a weak positive effect in Nigeria. In fact, the symmetric long-run effects of parallel and official exchange rates on general price level were estimated to be 0.18 and 0.04, respectively, while the symmetric long-run effect of parallel and official exchange rates on food price were estimated to be 0.19 and 0.11, respectively. From the results in Table 5, it is clear that the response of prices to the official exchange rate is weak compared to the parallel exchange rate in Nigeria. This implies that the parallel exchange rate had a more pronounced positive effect on prices compared to the official exchange rate. At the short-run, only official exchange rate had a negative and significant effect on prices. The intuition is that generally, a rise in parallel exchange rate had a long-run effect to facilitate higher prices than official rate especially when the premium becomes large.

After establishing the response of how inflation responds to both official and parallel exchange rates, it is imperative to go a step further to know if these relationships are asymmetric. This is because recent studies (Zhu and Chen 2019; Baharumshah et al. 2017; Delatte and Lopez-Villavicencio 2012) have underscored the need to examine the asymmetric relationship. It is also imperative for Nigeria because the main objective of the Central Bank is price stability and omission of asymmetric effect if it exists may cause distortionary effect of monetary policy. Thus, the asymmetric ARDL result is reported in Table 6 where asymmetric relationship was only confirmed for the official exchange. At the long-run, positive movements (depreciation) of official exchange rate had a positive and significantly impact on prices (CPI and food prices) but negative

Table 5 Symmetric ARDL empirical results

Variables	Dependent variable: CPI inflation				Dependent variable: food inflation			
	Model 1		Model 2		Model 1		Model 2	
	Coeff	*t*-values	Coeff	*t*-values	Coeff	*t*-values	Coeff	*t*-values
c	0.19	0.15	− 3.37	− 2.47	2.45	2.80	0.48	1.20
p_{t-1}	− 0.27	− 3.44	− 0.34	− 4.68	− 0.19	− 5.87	0.36	− 3.69
e_{t-1}	0.01	1.63	0.06	3.29	0.02	1.72	0.07	2.25
op_{t-1}	− 0.02	− 1.93	-0.02	− 1.82	− 0.03	− 2.34	− 0.04	− 1.97
wp_{t-1}	0.15	1.87	0.22	2.87	–	–	–	–
wfp_{t-1}	–	–	–	–	0.13	4.01	0.14	3.12
ecm_mb_{t-1}	0.02	1.51	0.06	2.75	0.12	2.50	0.07	1.88
Δe_t	–	–	–	–	–	–	–	–
Δe_{t-1}	-0.05	-3.05	–	–	–	–	–	–
Δe_{t-2}	-0.03	-1.99	–	–	–	–	–	–
Δe_{t-4}	–	–	–	–	-0.18	-6.02	–	–
Δop_{t-1}	–	–	–	–	0.19	5.59	–	–
Δop_{t-2}	–	–	–	–	0.17	4.33	–	–
Δp_{t-1}	0.16	1.61	0.25	2.59	0.64	3.99	0.23	2.13
Δp_{t-4}	0.25	3.08	–	–	0.71	4.80	0.25	2.33
PremDum	0.01	1.96	0.02	4.31	0.01	1.63	0.03	1.96
Trend	0.01	3.04	0.003	1.62	0.03	5.17	0.01	3.11
R^2	0.91		0.90		0.89		0.88	
LM	1.63	(0.19)	1.14	(0.31)	1.97	(0.14)	1.65	(0.17))

Lags in ARDL are chosen based on general-to-specific procedure; Model 1 indicates model with official exchange rate. Model 2 indicates model with parallel exchange rate; all variables as earlier defined. *LM* Breusch–Godfrey LM test for serial correlation, brackets indicate *p*-values. Optimal lag order was selected using the Schwarz Bayesian Criterion with maximum lag of 4

Source: author's estimation result

movements (appreciation) of the official exchange rate was confirmed to have negative impact.

The long-run effects of official exchange rate depreciation on CPI and food prices were estimated to be 0.08 and 0.25, respectively, while that of its appreciation were found to have − 0.15 and − 0.5 on both prices. Similar findings were confirmed by Zhu and Chen (2019), Baharumshah et al. (2017) and Delatte and Lopez-Villavicencio (2012). The economic intuition is that prices respond differently to depreciation and appreciation of the official exchange rate. Intuitively, the Nigerian government has always pursued expansionary fiscal policy and exchange rate controls amidst the need for devaluation or floating the exchange rate to ensure unification which imposes a fiscal shock that increases money growth and invariably prices in the long-run. Also, the country had always delayed in allowing exchange rate adjustment that portends some fiscal cost in spurring money growth and inflation.

Table 6 Asymmetric ARDL Empirical Results

Variable	Dependent variable: CPI inflation				Dependent variable: food inflation			
	Model 1		Model 2		Model 1		Model 2	
	Coeff	$t-$Values	coeff	$t-$values	Coeff	$t-$values	Coeff	$t-$values
C	−2.27	−2.21	−4.50	−3.15	3.17	5.47	1.62	5.09
p_{t-1}	−0.26	−4.41	−0.37	−1.74	−0.04	−6.52	−0.06	−1.81
e^{+}_{t-1}	0.02	4.61	0.002	1.50	0.01	4.54	0.003	1.53
e^{-}_{t-1}	−0.04	−3.13	0.001	1.48	−0.02	−4.17	0.001	1.49
op_{t-1}	−0.02	−1.57	−0.04	−1.82	−0.07	−4.20	−0.05	−2.32
wp_{t-1}	0.12	2.49	0.09	3.64	–	–	–	–
wfp_{t-1}	–	–	–	–	0.08	1.65	0.06	1.75
ecm_mb_{t-1}	0.20	1.54	0.05	1.68	0.23	1.73	0.04	1.66
Δe^{+}_{t}	0.001	2.54	–	–	–	–	–	–
Δe^{+}_{t-1}	−0.001	−3.17	–	–	−0.001	−2.85	–	–
Δe^{+}_{t-2}	−0.001	−2.26	–	–	−0.001	−1.93	–	–
Δe^{-}_{t}	0.01	1.86	–	–	–	–	–	–
Δe^{-}_{t-1}	–	–	–	–	0.01	2.22	–	–
Δe^{-}_{t-2}	–	–	–	–	0.01	1.93		
Δe^{-}_{t-4}	−0.02	−2.49	–	–	–	–		
Δp_{t-1}	0.47	2.67	–	–	0.59	3.97	0.50	2.99
Δp_{t-2}	–	–	–	–	0.56	4.45	0.43	4.06
Δp_{t-3}	–	–	–	–	–	–	0.22	1.86
Δop_{t}	−0.04	−1.68			–	–		
Δop_{t-2}	−0.13	−2.77	–	–	–	–	–	–
Δwp_{t-1}	0.11	1.77	–	–	–	–	–	–
PremDum	0.01	1.74	0.02	3.17	0.03	2.08	0.02	2.26
Trend	0.02	1.56	0.002	1.91	0.02	2.12	0.02	1.99
R^2	0.98	–	0.98	–	0.97	–	0.97	–
LM	0.52	(0.46)	0.41	(0.56)	0.53	(0.43)	0.49	(0.51)

Lags in ARDL are chosen based on general-to-specific procedure, Model 1indicates model with official exchange rate; Model 2 indicates model with parallel exchange rate; all variables as earlier defined. *LM* Breusch–Godfrey LM test for serial correlation; brackets indicate *p*-values. The Optimal lag order was selected using the Schwarz Bayesian Criterion with maximum lag of 4

Source: author's estimation result

5 Conclusion

The intention of government to maintain the role of the official exchange rate as a nominal anchor so as to isolate domestic prices from fiscal pressures through the parallel exchange rate may break down especially when the premium gets larger. This poses the question of whether domestic prices respond to either official exchange rate or parallel exchange rate movement in an oil-dependent developing country like Nigeria with rising fiscal pressures and a vibrant parallel market. Thus, this study examines the

response of domestic prices to the official and parallel exchange rates' movements in Nigeria. Using both the linear and nonlinear ARDL models selected based on general-to-specific approach and controlling for periods of large exchange rate premium in the estimation, interesting findings are established for policy implications. First, the presence of both symmetric and asymmetric long-run relationships were confirmed for the official exchange rate but only symmetric long-run relationship could be confirmed for the parallel rate in Nigeria. The policy implication is that when the Central Bank of Nigeria is taking decision on price stability in the long-run, the asymmetric effect of the official exchange rate is plausible and must be reflected in their decision. Second, the results also underscore domestic prices to respond to parallel exchange rate than official exchange rate especially when the exchange rate premium becomes large at the symmetric case. By implication, the intention of government to retain the nominal anchor role of the official exchange rate with a bid to isolate domestic prices from fiscal pressures always fails when the premium gets large. Consequently, the parallel exchange rate in such condition transmits the fiscal pressures on domestic prices. Third, prices only respond differently to appreciation and depreciation of the official exchange rate. This implies that a depreciation of the official exchange rate spurs rising prices while an appreciation is a disincentive for prices' increase in Nigeria. This confirms the need not to neglect the asymmetric relationship so as not to distort monetary policy effect in Nigeria. The government should ensure some level of fiscal austerity and possible unification when the premium gets large if the intention is to insulate prices from fiscal pressures. Since exchange rate may not all explain domestic prices in Nigeria, further studies may consider fiscal drivers due to possible procyclical policies in Nigeria.

Appendix A1: Monetary sector cointegration result

Series: LOG(M2/P) LOG(Y) LOG(R)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
None *	0.252947	43.67186	42.91525	0.0419
At most 1	0.110550	16.25972	25.87211	0.4719
At most 2	0.054294	5.247429	12.51798	0.5612

Source: Author's Estimation result.

Appendix A2: Monetary sector FMOLS result

Dependent Variable: LOG(M2/P)				
Method: Fully Modified Least Squares (FMOLS)				
Variable	Coefficient	Std. Error	*t*-Statistic	Prob
LOG(Y)	0.580736	0.030613	18.97014	0.0000
LOG(R)	−0.252195	0.223662	−1.127575	0.2624
C	−0.314814	0.673518	−0.467417	0.6413
R-squared	0.934480	Mean-dependent var		3.977959
Adjusted R-squared	0.933071	S.D.-dependent var		0.715224
S.E. of regression	0.185033	Sum squared resid		3.184068
Long-run variance	0.118703			

Source: Author's estimation result.

Declarations

Conflict of interest There is no conflict of interest with regard to this submission.

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