Exchange rate pass-through to Inflation: Symmetric and Asymmetric Effects of Monetary Environment in Nigeria

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Abstract: This study investigates symmetric, asymmetric, and structural models of exchange rate pass-through to inflation in Nigeria over the monthly period of 2000: Month 01- 2021: Month 05. The percentage change in the price of import-competing goods (traded goods) that is ascribed to a particular percentage change in the exchange rate (which is the price of one country's currency in terms of another country's currency) is referred to as exchange rate pass-through. This paper is set out to examine the impact of monetary environment in exchange rate pass-through to inflation in Nigeria using monthly time series data. The method adopted included inter-alia the use of both the Augmented Dickey-Fuller (ADF) unit root test and the Breaking point unit root test for relative comparison. The results of unit root tests from both ends indicate the existence of both stationary and non-stationary variables which made adoption of bounds cointegration test plausible and Nonlinear Autoregressive Distributed Lag(NARDL) methodologies applicable, this method allows the incorporation of possible asymmetric effects of positive and negative changes in explanatory variables on dependent variable unlike the conventional Autoregressive Distributed Lag (ARDL) models where the possible impact of explanatory variable changes remain unaccounted for on dependent variable. Further, the results from cointegration test confirm the existence of short-run situations among the variables of interest in all the models considered. Also, three models were estimated under the framework of linear and nonlinear Autoregressive Distributed Lag (ARDL) models. The model estimate findings revealed that inflation modeling in Nigeria is both autoregressive and adaptive in character. In the short run, pass-through estimates are larger, though declining, due to asymmetric behaviours of exchange rate changes as confirmed by Wald test. This justifies the existence of asymmetric effect in the behavour of exchange rate over times. It was also discovered that inflation is seldom a monetary phenomenon in this new normal as industrial production index was found to reduce consumer prices drastically and exchange rate found to explain inflation better than money supply. However, structural policy of land border closure exerts positive but insignificant pressure on inflation in Nigeria during the period under investigation, this may be because of lag effect between the policy stance and reaction of economic agents in the economy. Finally, by policy recommendation, Nigerian government is thus advised to invest heavily in productive sectors of economy, specifically, by building capacities of local producers.

Keywords: Exchange rate pass-through; Inflation; Money supply; Land border closure; Non-linear ARDL

JEL Classification: F31; E31; E51; C01

1. INTRODUCTION

The percentage change in the price of import-competing goods (traded items) that is ascribed to a particular percentage change in the exchange rate (which is the price of one country's currency in terms of another country's currency) is referred to as exchange rate pass-through. The exchange rate pass-through (ERPT) mechanism works along the pricing chain from import to domestic prices. Purchasing Power Parity (PPP) compares exchange rates between nations based on the comparable prices of a basket of products. Though the absolute and relative forms of PPP hold that PPP applies to both traded and non-traded products, implying that exchange rate pass-through affects all types of goods, traded and non-traded; the generalized version of PPP, which distinguishes between traded and non-traded goods, countered this argument by stating that prices of traded goods are determined by international competition, while prices of non-traded goods are determined by domestic demography. As a result, pass-through is exclusively connected with traded commodities, such as import-competing goods/import substitutes (see Pilbeam, 2006). Invariably, the rate of exchange rate pass-through is likely/expected to be imperfect in the short run while complete in the long run since both import and consumer prices fully respond to a change in exchange rate.

Nigeria is currently witnessing exchange rate depreciation owing to the demand pressure on foreign exchange (the US dollar to be precise), declining oil prices in the global market, land border closure, Coronavirus disease of 2019 (Covid-19) induced economy, and an increase in inflation rate. Though there are so many fundamentals of inflation in the country, ranging from demand, supply factors to structural factors, exchange rate fluctuations are regarded to play a significant influence (Sanusi, 2010). Also, measures limiting the movement of goods, labour and services put in place by government to curtail the spread of Covid-19 during the pandemic coupled with trade restrictions over land border closure are likely to cause fluctuations and instabilities in exchange rate movement as importers struggled for other means of transportation, majorly through sea and air, which are considered highly expensive and capable of impacting on consumption basket of Nigeria and prices (imported inflation) thereby triggering exchange rate fluctuations. Narayan (2020) observed that movement of goods and labour restrictions during pandemic causes instability in exchange rate movements between the Japanese Yen and US dollar. And that “one of the most affected asset prices due to COVID-19 is the exchange rate” (Iyke, 2020).

Recently, in the literature (Adekunle, Tiamiyu and Odugbemi 2019; Dube, 2016; Razafimahefa, 2012; Lopez-Villavicencio and Mignon, 2016; Bada, Olufemi, Tata, Peters, Onwubiko, and Onyowo (2016); Borensztein and Heideken, 2016; Sanusi, 2010 and Mushendami and Namakalu, 2016), there have been new findings and conclusions, that ERPT in Nigeria is now partial/incomplete and declining along the price chain contrary to the prior findings that ERPT was much higher in developing economies than developed ones. However, all these recent works do not adequately account or provide reasons for the presence of such incomplete and declining ERPT especially within Nigerian context. The main question is, can recent developments

in Nigeria explain the presence of such phenomenon (incomplete and declining ERPT)? The present study intends to provide answers to the impending question.

Furthermore, according to Taylor (2000), exchange rate pass-through rates are endogenous to a country's monetary policy and monetary stability; that is, the smaller the amount of exchange rate pass-through, the more stable a country's monetary policy and the lower inflation. Despite the fact that most of the writers argued that inflation targeting, and monetary policy credibility determine the degree of pass-through, there is no agreement on the conditions that lead to a low pass-through. However, the fear of floating (a situation in which small and open economies are relatively more susceptible to exchange rate pass-through effects) can partially explain the adoption of inflation targeting in both developing and emerging market economies; the goal would be to dampen the effect of exchange rate fluctuations on inflation.

Recent events in the history of the Nigerian economy (such as Covid-19, border closures, and so on) are thought to be powerful enough to alter or change inflation modeling projections in Nigeria; thus, the need to factor in structural issues in inflation modeling to avoid making or drawing incorrect conclusions about the Nigerian economy. This remark becomes critical in light of the fact that, during land border closures, for example, importers were forced to convert to other modes of transportation, namely sea and air, which are deemed highly expensive and capable of affecting Nigeria's consumption basket and prices (imported inflation). Furthermore, the lockdown policy implemented during Covid-19 exacerbated some panic buying, which has a strong propensity to alter the degree of pass-through in the process. As a result, structural breaks are seen as significant and are thus taken into consideration in our inflation modeling equation.

In addition, following the findings of Ogundipe and Egbetokun (2013) in their investigation of exchange rate pass-through to consumer prices in Nigeria that exchange rate has been more important in explaining Nigeria's inflation phenomenon than actual money supply between 1970 and 2008, it becomes critical to challenge the findings by confirming or ascertaining truly if exchange rate has been more important in explaining Nigeria's inflation phenomenon than actual money supply or not.

Consequently, the urge to carry out this study, following from the above submission, is, therefore, anchored on the following distinct reasons namely:

(1.) To investigate the extent of exchange rate pass-through to inflation in Nigeria so as to know whether inflation in Nigeria is significantly driven by changes in exchange rate or not.

(2.) To verify symmetric, asymmetric and structural model-models of exchange rate pass-through to inflation in Nigeria

(3.) To confirm or determine if the exchange rate has been more relevant in explaining Nigeria's inflationary phenomena than the much-lauded money supply.

(4.) To Capture and validate the impact of recent events in the Nigerian setting, particularly in relation to the land border closure and the covid-19 epidemic.

Such research will aid monetary authorities in their responsibility to stabilize prices, as well as traders and investors in their desire to maximize profits. According to Oyinlola and Babatunde (2009), research of this kind helps to understand the process of price determination in Nigeria and, as a result, ensures a strong formulation of monetary policy targeted at reducing inflation.

Unlike previous studies, this is the first to consider linear/symmetric, asymmetric, and structural models of exchange rate pass-through to inflation in Nigeria, with a particular focus on assessing the impact of the Covid-19 pandemic and land border closure policy on the degree of exchange rate pass-through to inflation. The remaining part of this article is thus organized as follows: Section two explores empirical review; Section three includes a review of the empirical literature; Section four delves into technique and data issues; Section five includes empirical analysis results; and Section six ends.

2. Empirical Review

Colavecchio and Rubene(2020) discovered that after one year, big changes in the exchange rate have an effect on import prices and headline HICP eurozone inflation, although tiny changes do not. Accounting for the role of the global financial crisis in Mozambique, Aisen, Manguinhane, and Simione (2019) discovered that the financial crisis only temporarily impacted the amount of the ERPT. Although the ERPT surged during the financial crisis, it eventually returned to its long-run equilibrium. Similarly, Narayan (2020) investigated exchange rate resistance to the Covid-19 pandemic between the Japanese Yen and the US dollar and concluded that constraints on goods transportation and labor during the epidemic generate volatility in exchange rate movements. Iyke (2020) discovered that the exchange rate was the hardest hit variable (asset price) during the Covid-19 epidemic. For the exchange rate movements of selected Asian economies, Salisu et al (2021) investigate the predictive content of uncertainty related to pandemics and epidemics (UPE). They revealed evidence of a UPE-based predictive model's greater out-of-sample predictability over a benchmark model, and that UPE predictability is stronger before the COVID-19 pandemic than after the epidemic.

Razafimahefa (2012) examined the exchange rate pass-through to local pricing and discovered that it is insufficient. The pass-through is greater after a currency decline than after a currency appreciation. It is lower in nations with more flexible exchange rate regimes and in higher-income countries. A smaller pass-through is connected with a low inflation environment, cautious monetary policy, and a sustainable fiscal policy. Since the mid-1990s, the degree of pass-through has decreased across the SSA area, owing to significant changes in the macroeconomic and political conditions. This is consistent with Taylor (2000), as well as Lopez-Villavicencio and Mignon (2016). However, Ca'Zorzi et al. (2007) refuted the notion that exchange

rate pass-through is higher in developing nations than in developed countries by stating that emerging countries with single-digit inflation rates had low rates of exchange rate pass-through, which is comparable to the developed.

Adekunle, et al (2019) accounted for asymmetric effect of exchange rate pass-through in their study and confirmed the presence of asymmetric effects of exchange rate changes as well as imported inflation in Nigeria. Also, in the short run, partial/incomplete pass-through was confirmed. Bello and Sanusi (2019) estimated a nonlinear augmented New Keynesian Philips Curve for Nigeria by partitioning inflation into food and energy inflation in a bid to capture non-linearity and imported inflation and empirically found out asymmetry in the behavior of exchange rate and the case of imported inflations were reported. Maka (2013) also confirms Ghana's uneven reaction to changes in the nominal currency rate between 1990 and 2011. Adekunle et al. (2019), Bello and Sanusi (2019), and Maka (2013) share some of the same findings as Razafimahefa (2012), and Mignon (2016). They all agreed that exchange rate fluctuations had an unbalanced effect on inflation, imported inflation, and decreased pass-through.

With the exception of Adekunle et al (2019), all research on exchange rate pass-through in Nigeria (Adetiloye, 2010; Adelowokan, 2012; Ogundipe and Egbetokun, 2013; Oyinlola and Babatunde, 2009; Zubair et al, 2013; Bada et al, 2016 and Sanusi et al, 2009) used quarterly or annual data. The current study also varies from earlier studies in that it takes into account monthly data on the variables used. To the best of our knowledge, this is the only research of its sort in the literature that studies symmetric, asymmetric, and structural model-models of currency rate pass-through to inflation in Nigeria from 2000:M01 to 2021:M05.

3. Theoretical Framework

The current analysis is based on a framework that incorporates and adapts the absolute versions of the law of one price (LOP) and the purchasing power parity theory (PPP). According to the law of one price, "in the absence of frictions, such as shipping fees and taxes, the price of a product when translated into a common currency, such as the US dollar, using the spot exchange rate, is the same in every nation" (Maurice, 2005).

In algebraic terms, the law of one price holds when

$_{qi} = Eq_i$*.....(3.8)

where $_{qi}$ denotes the home price of good i, say car; q_i* denotes the foreign price of the same good i, say car; E represents nominal exchange rate measured as units of domestic currency per unit of foreign currency.

If the law of one price applies to all items between two nations, then the absolute purchasing power parity (PPP) theory of exchange rates would apply between both countries, as shown in algebraic terms below:

$q = Eq^*$ .....(3.9)

Because purchasing power parity (PPP) assumes the absence of transaction costs such as transportation costs and trade barriers (tariff and non-tariff), identical demand across countries, and identical baskets of goods in the calculation of price indices, all of which are unrealistic, the absolute version of PPP as stated in eq (3.9) would be transformed to near relative terms by taking the natural log of the expression in eq (3.9) to account for all the above-mentioned factors (The relative version of PPP goes further by taking the time-derivative of the log-levels of the expression so that we have, domestic inflation rate equals the sum of percentage change in exchange rate and foreign inflation rate). The near-relative version of PPP is given as

In q = In E + In q* .....(3.10)

In relation to exchange rate pass-through, eq.(3.10) implies that the domestic price level responds fully or completely to changes in exchange rate, what is referred to in the literature as " full or complete exchange rate pass-through".

Goldberger and Knetter (1997) created the following framework for explaining price adjustments to exchange rate fluctuations and deviations from the law of one price in order to validate the validity of the law of one price and purchasing power parity theory.

$$Qt = \beta + \phi t + \Theta Et + \delta Ht + \varepsilon t \qquad 3.11$$

where subscript t denotes time; all variables are in logs; Q is the local-currency import price; ϒ is a control variable measuring the exporter's cost; E is the nominal exchange rate (defined as units of domestic currency per unit of foreign currency, so that an increase implies depreciation while a decrease appreciation) and H is a variable controlling for shifts in import demand, such as, output/income of the importing country, among others. The coefficient of main importance is Θ which captures the degree of exchange rate pass-through (ERPT): full/complete exchange rate pass-through is depicted by Θ = 1 and incomplete/partial exchange rate pass-through occurs when Θ < 1; ε is the error term.

Furthermore, in accordance with the asymmetry literatures arising from pricing to market behavior of exporters that characterize exporters' decision to either adjust or not adjust their mark-ups in response to exchange rate changes, the generic model developed by Golberger and Knetter (1997) given by eq. (3.11) is transformed as follows:

The exchange rate term (E) is decomposed into a partial sum of exchange rate changes so that

$E_t = E_t^+ + E_t^-$.....(3.12)

Now, substituting eq.(3.12) into eq.(3.11) gives

$Q_t = \beta + \phi\Upsilon + \theta(E_t^+ + E_t^-) + \delta Ht + \varepsilon t$

$Qt = \beta + \phi\Upsilon_t + \theta^+E^+ + \theta^-E^- + \delta Ht + \varepsilon t$……..3.13

Moreover, considering that commodities and movement restrictions that translated to lockdown measures during Covid-19, as well as trade restrictions caused by land border closure, might considerably contribute to lower/higher exchange rate pass-through to the economy. In his research of Covid-19 and exchange rate resilience to shocks, Narayan (2020) concluded that mobility of products and labor constraints during pandemics promote volatility in exchange rate fluctuations. Iyke (2020) also emphasizes that the currency rate is one of the most affected asset prices as a result of COVID-19. Hence, the transformed equation of (3.13) is further modified to capture and control for the impact of Covid-19 and land border closure respectively using dummy variables:

$$Qt = \beta + \phi\Upsilon_t + \theta^{+}E_t^{+} + \theta^{-}E_t^{-} + \delta Ht + \lambda Dt + \pi E * Dt + \varepsilon_t \quad \text{.....(3.14)}$$

where Dt is a dummy capturing impact of Covid-19/land border closure. The dummy variable takes the value of 1 for the period of covid-19 pandemic/for the period of land border closure; the interactive term between exchange rate and dummy variable captures; (1) the extent of ERPT that occurs as a result Covid-19 pandemic, (2) the contribution of land border closure on the change of ERPT, in two separate occasions. λ and π respectively represent the coefficients of Covid-19/land border restriction and interactive terms; E_t^{+} and E_t^{-} denote positive changes in exchange rate (representing exchange rate depreciation) and negative changes in exchange rate (representing exchange rate appreciation), respectively; θ^{+} and θ^{-} are, respectively, the pass-through coefficients associated with exchange rate depreciation and appreciation terms (that is, E_t^{+} and E_t^{-}). The restrictions that $0 \leq \theta^{+} < 1$ indicates incomplete/partial pass-through following exchange rate depreciation (implying that the exporters absorb fully or partially the rise in exchange rate so as to retain their market shares) and $\theta^{-} = 1$ indicates complete or full pass-through following exchange rate appreciation (implying that exporters transfer fully the fall in exchange rate to importers so as to avoid a decline in their profits). All other variables remain as defined above.

Eq.(3.14) serves as a building block for the models specified later in the study and warrants the choice of Non-linear autoregressive distributed lag model (NARDL) developed by Shin, Yu, and Greenwood-Nimmo (2014).

3.1 Model Specification and Methodology

The present study adopts and modifies the model of Rajan and Ghosh (2007) who studied exchange rate pass-through (ERPT) into India's consumer price index (CPI) over the period 1980:Q1-2006:Q4 and its possible macroeconomic determinants. Specifically, the authors estimated the following model:

$$\ln(CPI)^{India} = \alpha_0 + \alpha_1 \ln(E^{India/US}) + \alpha_2 \ln(PPI/CPI)^{US} + \alpha_3 \ln(IP)^{India} + \varepsilon_t \quad \text{.....3.4.6}$$

Where all variables are in natural logs; $E^{India/US}$ is the bilateral exchange rate defined as the number of units of the Indian rupee per unit of the US dollar. The authors control for shifts in aggregate demand in India by using the overall industrial production index (IP) of India (because quarterly GDP data for India was not available). For cost conditions in the exporting nation, the authors used US producer

price index (PPI) and US consumer price index (CPI) in separate specifications. The exchange rate pass-through (ERPT) elasticity is given by the coefficient α_1. If $\alpha_1 = 1$, then we have full/complete pass-through, while if $\alpha_1 < 1$, we have partial/incomplete pass-through. To this end, this study modifies the model of Rajan and Ghosh (2007) stated above as follows:

(A) Symmetric-Effect Models (Model 1)

$$In(NCPI_t) = \beta_{12} + \beta_{13}In(EXC_t) + \beta_{14}In(UPPI_t) + \beta_{15}In(IPI_t) + \beta_{16}In(IMP_t) + \beta_{17}In(MS_t) + e_{3t} \quad (3.4.7)$$

(B) Asymmetric-Effect Models (Model 2)

$$In(NCPI_t) = \alpha_{10} + \gamma_4^{+} In(EXC_t^{+}) + \gamma_4^{-} In(EXC_t^{-}) + \alpha_{11}In(UPPI_t) + \alpha_{12} In (IPI_t) + \alpha_{13}In(IMP_t) + \alpha_{14}In(MS_t) + e_{4t} \quad (3.4.8)$$

(C) Structural Effect (Land Border Closure and Covid-19-Effect) Models (Model 3)

$$In(NCPI_t) = \beta_{18} + \beta_{19}In(EXC_t) + \beta_{20}In(UPPI_t) + \beta_{21}In(IPI_t) + \beta_{22}In(IMP_t) + \beta_{23}In(MS_t) + \beta_{24}(CLOSURE_t * In(EXC_t)) + e_{4t} \quad (3.4.9)$$

$$In(NCPI_t) = \beta_{25} + \beta_{26}In(EXC_t) + \beta_{27}In(UPPI_t) + \beta_{28}In(IPI_t) + \beta_{29}In(IMP_t) + \beta_{30}In(MS_t) + \beta_{31}(COVID_t * In(EXC_t)) + e_{5t} \quad (3.4.10)$$

where

In = Natural logarithm (log)
NCPI = Nigeria's consumer price index;
UPPI = United States' producer price index or wholesale price index, WPI (a proxy for cost conditions in the exporting country, in this case US);
EXC = Naira/dollar exchange rate;
EXC^{+} = Positive change in exchange rate (an indication of exchange rate depreciation);
EXC^{+} = Negative change in exchange rate (an indication of exchange rate appreciation);
IPI = industrial production index;
IMP = import price index;
MS = money supply
CLOSURE = dummy variable on land border closure;
COVID = dummy variable on Covid-19 pandemic;
CLOSURE* EXC = interactive terms of land border closure and exchange rate
COVID* EXC = interactive terms of Covid-19 and exchange rate

A priori Expectations

$\beta_{19}, \beta_{26} > 0$; $\beta_{20}, \beta_{27} >$ or < 0; $\beta_{21}, \beta_{28} >$ or < 0; $\beta_{22}, \beta_{29} > 0$; $\beta_{24}, \beta_{31} >$ or < 0; β_{17}, $\beta_{23}, \beta_{30} > 0$ $\gamma_4^{+} > 0$; $\gamma_4^{-} > 0$; $\alpha_{11} >$ or < 0; $\alpha_{12} >$ or < 0; $\alpha_{13} > 0$; $\alpha_{14} > 0$

Given the series' mix of stationary and integrated character, as well as the existence of a short-run connection between variables as demonstrated by the Bound test, the

estimate technique applicable for this model is Non-linear Autoregressive distributed lag model (NARDL).

3.2 Data Description and Sources

Monthly data are collected on six variables including Nigeria's consumer price index (CPI), exchange rate (₦/$), United States' producer price index (PPI) or wholesale price index (WPI), industrial production index (IPI), money supply (MS) and import price index (IMP). For the purpose of analysis, all variables are transformed into their natural logs so that they become percentages irrespective of their original units of measurement. The data on Nigeria's CPI, exchange rate and money supply (MS) were collected from the CBN Statistical Bulletin (various years). The data on import price index were collected from National Bureau of Statistics (NBS). The data on US WPI were collected from US Bureau of Labour Statistics (BLS)'s website. Lastly, the data on industrial production index were obtained from IMF's International Financial Statistics (IFS).

4. Empirical Analysis

4.1 The Unit Root Test Result

From Table 1, on the part of ADF unit root test. Only three variables including positive and negative changes in exchange rate, and log of Nigeria's CPI are stationary at levels, and hence are said to be integrated of order zero, that is, I(0). The remaining five variables including the natural logs of import prices, US WPI, exchange rate, money supply and industrial production index become stationary only after first differencing, and hence are said to be integrated of order one, that is, I(1). However, as compared to the conventional unit root test, the results of Breaking point unit root test show that NIGCPI, IPI and USWPI are not at levels with their respective break point dates 2010M08, 2008M12, and 2020M 04 respectively. However, the remaining variables: exchange rate, money supply, import price, and both positive and negative exchange rate are all at levels at 2016M05, 2006M02, 2016M12, 2016M12, 2016M07, 2007M11 respectively.

Intuitively, the rationale behind breaking point unit root test is that it prevents the test from producing a biased result in favor of rejecting the null hypothesis; it identifies when a structural break occurred; and it provides valuable information for determining whether a structural break on a specific variable is associated with a specific government policy, economic crises, war, regime shifts, or other factors. For instance, the break point in USWPI is attributed to Covid-19 pandemic.

Table 1: Results of Unit Root Test

Conventional ADF Unit Root Test				Breakpoint Unit Root Test			
Variable	**Level**	**Fist Difference**	**(d)**	**Level**	**Fist Difference**	**(d)**	**Break Dates**
LNIGCPI	-3.309763*[A]	----------†	I(0)	-2.174835[t]	-16.39735***[i]	I(1)	2010M08
LEXCR	-1.7158297[A]	-6.948760***[C]	I(1)	-6.301051[t]	----------	I(0)	2016M05
LMS	-1.851701[A]	-16.91517***[C]	I(1)	-5.038835[i]	----------	I(0)	2006M02
LIPI	-2.332356[A]	-3.721844***[C]	I(1)	-3.499300[t]	-4.535642**[i]	I(1)	2008M12
LIMPR	-2.933175[A]	-21.01319***[C]	I(1)	-7.709507[t]	----------	I(0)	2016M12
LUSWPI	-2.028637[A]	-9.955910***[C]	I(1)	-3.70958[t]	-11.19563[i]	I(1)	2020M04
PLEXCR	-6.744672***[C]	----------†	I(0)	-13.93923[i]	----------	I(0)	2016M07
NLEXCR	-10.78685***[C]	----------†	I(0)	-15.06320[i]	----------	I(0)	2007M11

The symbol ***, **, * denote the rejection of the null hypothesis of a unit root at 1%, 5% and 10%, respectively; †implies that a series that is stationary at levels does not require its first difference being reported; Superscripts A, B and C denote model with intercept and trend, model with intercept only and model with none, respectively; Superscripts i and t represent break specification for intercept only and trend only. The break dates were determined endogenously using Dickey-Fuller t-stat.

4.2 Bounds Test Results

The table 2 below shows the result of Bounds Cointegration test: in all the three models, the results show that there exist only short run phenomenon among the variables given the fact that F-statistics of each model falls below the lower critical bounds values at every percent level of significance. Hence, only short-run specifications are specified for the study.

Table 2: Result of Bounds Test for Cointegration

	Model 1	Model 2	Model 3
F-statistics	2.259922	1.599272	1.393887
		Critical Values	
Significant level		Lower Bound	Upper Bound
10%		2.26	3.35
5%		2.62	3.79
2.5%		2.96	4.18
1%		3.41	4.68

Note: Model 1 equals symmetric modelling, Model 2 asymmetric while model 3 represents structural modelling of inflation.
***Source**: Author's Computation from Eviews 9, 2021*

4.3 Regression results of the Models

The following observations were noted over the course of the investigation and are depicted in table 3:

- Money supply (MS) was discovered to be the most volatile series, whereas exchange rate appreciation term was discovered to be the least variable;
- The model estimate findings revealed that inflation modeling in Nigeria is both autoregressive and adaptive in character;

- Regardless of the specifications used, whether symmetric, asymmetric, or structural, there is evidence of a positive association between USWPI and inflation in Nigeria;
- When just the symmetric model was investigated, the case of imported inflation was identified; however, when both the asymmetric and structural models were evaluated, the situation faded away. As a result, when both asymmetric and structural models are evaluated, the case of imported inflation cannot be justified. It follows that the policy impact of land border closure was intriguing for the time period studied;
- When the asymmetric effect was studied in comparison to the symmetric effect, the pass-through estimates increased due to asymmetric behaviours of exchange rate changes as confirmed by Wald test. The inclusion of structural modifications such as Covid-19 and land border closure, on the other hand, has no substantial effect on pass-through estimations;
- In Model 1, 2 and 3 also, there is an inverse relationship between demand condition (industrial production index) and inflation in Nigeria as expected. The associated coefficient (-0.03237) implies that for every 1% increase in industrial production index, consumer prices decreases on average by -0.03237% keeping US wholesale prices, exchange rate constant, import prices, money supply and interactive term constant. Since the impact coefficents of industrial production index are statistically significant at 1% level across all the models, it indeed shows that Nigerian production sector is rising. We can only hope it is sustainable;
- There is an expected positive relationship between money supply and Nigerian inflation across all models, as evidenced by its coefficient, which states that for every one percent increase in money supply, Nigerian inflation rises by 0.007645 percent on average, while holding US wholesale prices, exchange rate appreciation and depreciation, import prices, and the industrial production index constant. It is, however, insignificant at the 10% threshold of significance, indicating that money supply is no longer the new norm. It does not explain inflation as well as the exchange rate.
- Across all of the three models given (symmetric, asymmetric, and structural), the industrial production index stays statistically significant, although the money supply falls behind. The consequence is that money supply is no longer the norm, which means that inflation is seldom a monetary occurrence in this new normal; this result is reinforced by variance decomposition analysis, which reveals that the exchange rate explains inflation better than the money supply. This observation is consistent with the findings of Ogundipe and Egbetokun (2013);
- In Nigeria, the interactive terms of exchange rate and border closure correlate positively with inflation (i.e. exerts positive pressure on inflation), although their effects are not statistically different. This suggests that the

Nigerian government softened the blow; Unlike the border closure impact, the relationship of interaction terms of exchange and Covid-19 on inflation in Nigeria is quite negative, meaning that the more severe the pandemic, the lower the rate of inflation in Nigeria. This is feasible and might be related to the absence of market activity during this time period.

Table 3: Symmetric, Asymmetric, and Structural Models Estimates of Inflation

Dependent Variable	LNCPI		
	Model 1	Model 2	Model 3
$LNCPI_{t-1}$	0.965918*** (0.015768)	0.991115***(0.007907)	0.964597***(0.016951)
LUSWPI	0.034353 (0.030020)	0.009768(0.025783)	0.035627(0.031427)
LEXCR	0.025149**(0.011976)		0.025942**(0.012904)
$LEXC_t^+$		-0.004836(0.02684)	
$LEXC_t^-$		0.347849*(0.190906)	
$LIPI_t$	-0.032257***(0.012278)	-0.038962***(0.012830)	-0.031237***(0.012731)
$LIMP_t$	-0.001412(0.003251)	-0.002715(0.0003360)	-0.001246(0.003228)
LMS_t	0.011781(0.007478)	0.007645(0.007165)	0.011972(0.007478)
CLSR_LEXCR			0.000233(0.000396)
COVID_LEXCR			-6.49E-05(0.000400)
C	-0.169663 (0.135416)	0.071245(0.055521)	-0.182698(0.152035)
Adj. R^2	0.999577	0.99980	0.999276
F-stat	100384.3[0.0000]	85043.76[0.0000]	85727.48[0.0000]
Ramsey RESET linearity test	0.288377[0.5917]	0.975896[0.335]	0.240808[0.6241]
Jarque-Bera normality test	660.7697[0.0000]	654.9836[0.0000]	661.264[0.0000]
Breusch-Godfrey serial correlation LM test	0.069884[0.9325]	0.118919[0.8879]	0.070423[0.9320]
Breusch-Pagan Godfrey heteroscedasticity test	2.771147 [0.0126]	2.538143[0.0154]	2.373334[0.2230]
Wald test for short-run asymmetry		3.335243[0.0678]	

Note: Model 1 equals symmetric model estimation, Model 2 asymmetric while model 3 represents structural model estimation of inflation. The symbols ***, **, * denote statistical significance of coefficients at 1%, 5%, and 10%, respectively; the numbers in parentheses and block brackets represent the standard errors and probability value, respectively.
***Source**: Author's Computation from Eviews 9, 2021*

4.4 Analysis of Inflation Responses to Exchange rate and Money supply

Figure A.1 in Appendix A depicts the impulse response graphs of inflation to the exchange rate, money supply, and other factors, and it can be shown visually that money supply dissipates with time, but the exchange rate never breaks at any point. Dissecting this event will offer a clear picture of their separate effect. This breakdown is shown in Table A.1. In period 2, for example, inflation drives itself more than other factors since inflation shocks account for around 98% of inflation

shocks. Aside from inflation shocks, money supply has a minimal influence relative to the exchange rate throughout the period: for example, in period 3, the total shock to inflation is caused by 0.13 percent money supply shocks against 0.18 percent exchange rate shocks. In period 3, the exchange rate is responsible for 1.02 percent of the shocks, whereas the money supply is responsible for 0.42 percent of the shocks. The exchange rate contributes for 2.3 percent of the total in period 7, while the money supply accounts for 0.82 percent. Similarly, in period 12, the exchange rate exerts 5.6 percent while the money supply exerts just 1.9 percent. When one looks closely, one may observe that the share of shocks explained by money supply compared to exchange rate is less. As a result, the exchange rate outperforms the money supply in explaining Nigerian inflation. This conclusion is consistent with the findings of Ogundipe and Egbetokun (2013)

5. Conclusion

The study has so investigated symmetric, asymmetric and structural model-models of exchange rate pass-through to inflation in Nigeria over the monthly period of 2000:M01- 2021:M05. Both Augmented Dickey-Fuller (ADF) unit root test and Breaking point unit root test were conducted for relative comparison. The results of unit root tests from both ends indicate the existence of both stationary and non-stationary variables which made adoption of bounds cointegration test plausible and NARDL methodologies applicable. Moreover, the results from cointegration test confirm the existence of short-run situations among the variables of interest in all the models considered. Also, three models were estimated under the framework of linear and nonlinear Autoregressive Distributed Lag (ARDL) models.

The model estimate findings revealed that inflation modeling in Nigeria is both autoregressive and adaptive in character. In the short run, pass-through estimates are larger, though declining, due to asymmetric behaviours of exchange rate changes as confirmed by Wald test. This justifies the existence of asymmetric effect in the behavour of exchange rate over times. It was also discovered that inflation is seldom a monetary occurrence in this new normal as industrial production index was found to reduce consumer prices drastically and exchange rate found to explain inflation better than money supply. However, structural policy of land border closure exerts positive but insignificant pressure on inflation in Nigeria during the period under investigation.

Finally, despite the fact that the models suffer from non-normality of the residuals in general, the results of the other three tests (linearity, serial correlation, and heteroscedaticity tests) confirmed the models' suitability for policy prescription, and the regression estimates are considered BLUE. By policy recommendation; Nigerian government is thus advised to invest heavily in productive sectors of economy, specifically, by building capacities of local producers.

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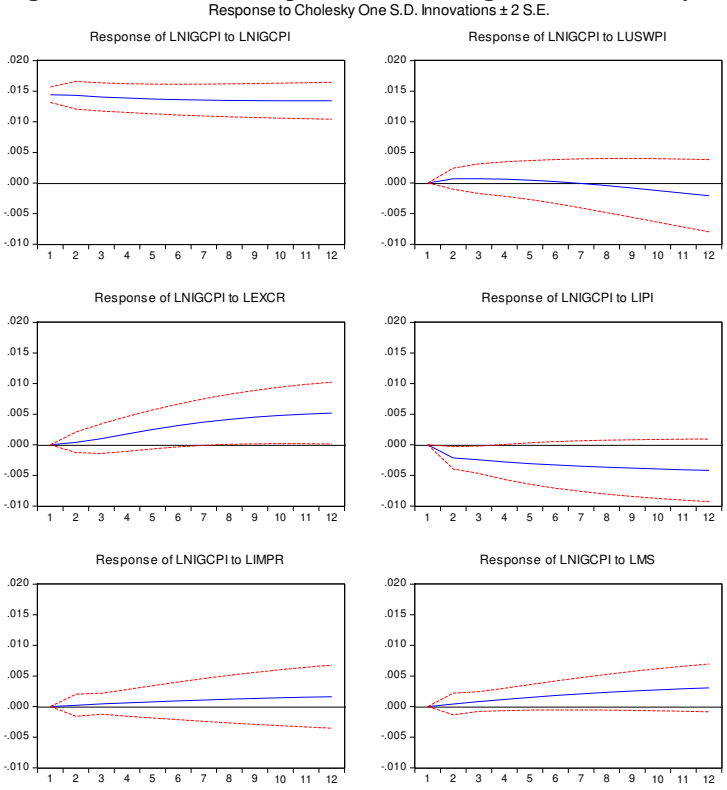
APPENDIX A

Figure A.1: Inflation Responses to Exchange rate and Money Supply



***Source**: Author's Computation from Eviews 9, 2021*

Table A.1: Variance Decomposition of Inflation

Period	S.E.	LNIGCPI	LUSWPI	LEXCR	LIPI	LIMPR	LMS
1	0.014421	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.020449	98.70155	0.114787	0.036477	1.095657	0.010113	0.041421
3	0.024973	97.78621	0.156451	0.187618	1.696365	0.038976	0.134379
4	0.028794	96.75558	0.166044	0.517546	2.226376	0.071735	0.262724
5	0.032190	95.59043	0.154486	1.017563	2.696217	0.114052	0.427257
6	0.035308	94.33017	0.132752	1.642890	3.114394	0.163147	0.616647
7	0.038228	93.01471	0.113593	2.339906	3.491508	0.217851	0.822428
8	0.041001	91.68303	0.109584	3.060707	3.833442	0.276402	1.036833
9	0.043658	90.36377	0.131790	3.768660	4.144994	0.337048	1.253739
10	0.046219	89.07627	0.188750	4.438611	4.429782	0.398101	1.468489
11	0.048702	87.83241	0.286027	5.055118	4.690705	0.458042	1.677697
12	0.051115	86.63885	0.426230	5.610191	4.930140	0.515582	1.879009

***Source**: Author's Computation from Eviews 9, 2021*