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# Impact of Exchange Rate on Inflation in Nigeria: Symmetric and Asymmetric Analyses

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**Abstract**

*Inflation is a variable that is of importance to any economy. It can causes distortion in economic planning and development. Due to its key roles in the economy, government needs to consistently put it under checks so as to avoid economic fluctuations. Therefore, this study investigated the aggregated impact of exchange rate as one of the determinants of inflation rate in Nigeria. The study employed Non-Linear ARDL estimation technique to examine the positive and negative impact of exchange rate on inflation rate, using monthly time series data that cover the period of January, 1996 and December, 2020. It was found in the study that expected inflation or lag of inflation has positive impact on inflation in the short-run in Nigeria. It is also found that exchange rate has symmetric impact on inflation rate in the short-run in Nigeria while it has positive impact on food inflation (FINF) and head-line Inflation (HLINF) in the short-run. It is also found in the study that the impact of rainfall on inflation rate is negative in the short-run in Nigeria. Then, the study recommends that the study recommend that authority should put in place exchange rate and price harmonization institution that will ensure that exchange rate pass-through occurs at the time when Naira appreciates and depreciates. This is to control the producers from charging excessive prices, especially when the cost of production has fallen due to appreciation of Naira.*

***Key Words:*** *Exchange rate, Inflation, Time series, Non-linear ARDL and Nigeria.*

## Introduction

One of the major issues of Nigerian economy is how to control inflation rate. The control of it has been linked to the monetary policy and fiscal policy as shown in a number of budget and policy statements in Nigeria (Egwaikhide, Chete & Falokun, 1994). The level of inflation dated back to 1970, when the revenue accruing to the government from the oil resource, rose consistently. With the increase in public expenditure, due to increase in oil revenues, there was vast expansion in aggregate demand. With the inelastic supply of domestic output, inflation inevitably resulted (Egwaikhide et al. 1994). Viewing it from another perspective, as Nigeria is notably an import-dependent economy, prices of domestically produced goods changes as a result of changes in exchange rate of Naira to US Dollars in

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foreign exchange market. It is generally believe that when Naira depreciates in value compared to US Dollars, prices of local commodities increases. But, when the value of Naira appreciates in foreign exchange market, the prices of domestic commodities should come down, as the appreciation of Naira should bring about a fall in cost of production to producers, who import raw materials from abroad. The fall in cost of production will lead to increase in profit of producers. Consequently, the producer will be reluctant in reducing the price so as not to reduce his profit margin.

The general believe that when Naira depreciates, it results into a rise in the prices of goods in the domestic economy, and when it appreciates, it is expected to lead to a fall in the prices of goods in domestic economy. But in reality, the producers or entrepreneurs hardly reduce the price of items in Nigeria, especially when the appreciation of Naira is small. The authorities need to take some measures that will safeguard the consumers against the reluctance of entrepreneurs in reducing the prices of goods when the cost of production has fallen due to appreciation of local currency in foreign exchange market. But for them to create any measure against the attitude of the entrepreneurs, they need to be guided by scientific studies that will give them insight on the nature of positive and negative change in exchange rate. So, the study intend to find out if positive and negative changes in exchange rate of Naira to US Dollars affect inflation rate, and specifically to find out if there is exchange rate pass-through in the cases of both positive and negative changes in the exchange rate.

The research questions is: does exchange rate has both positive and negative impact on inflation? The general objective is to examine the impact of exchange rate on inflation rate while the specific objectives are to analyze the disaggregated effect of exchange rate on inflation rate in Nigeria. The hypothesis in the study is $H_0$: exchange rate has no disaggregated impact on inflation rate in Nigeria. The justification of the study lies in the fact that if it is found that exchange rate has positive and negative impact on prices of goods in domestic market, authorities are expected to put in place measures that will facilitate the safeguard of consumers from being exploited by the entrepreneurs when Naira appreciate in value in the foreign exchange market by reducing the prices of goods locally. Choosing Nigeria as a case study, is to have an in-depth analysis of the disaggregated impact of exchange rate on inflation rate. This serves as geographical scope of the study. The study does not employ all the variables that affect inflation for the avoidance of multicollinearity in the estimated model; and this is the variable scope of the study. The data employed in the study is time series data which covers the period of January, 1996 to December, 2020. The choice of the period is based on data availability. Limitation of the study lies in the non-availability of data beyond December, 2020.

### 2.1 Literature Review

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This section covers discussion on theoretical review, which is found in Sub-section 2.2; empirical review, which is in Sub-Section 2.3 and research gap , which is found in Sub-section 2.4.

## 2.2 Theoretical Review

This sub-section is divided into four paragraphs, each paragraph discusses each theory in the section. Phillips Curve is discussed in paragraph one, while Monetary Theory of Inflation is discussed in paragraph two. Keynesian Theory of Inflation and New Keynesian Phillips Curve are discussed in paragraph three and four respectively.

**Phillip's Curve:** It a form of theory on inflation rate that explain the relationship between unemployment inflation. Phillips (1958) showed the existence of relationship between unemployment and wage rate, using the statistical data from United Kingdom that span between 1862 – 1957. It is established through the empirical investigation that inverse relationship exists between unemployment and wage rate of labour. This implies that when unemployment is high, the rate of increase in money wage rate (inflation) is low, and vice versa. This is based on the assumption that wages and prices move in the same direction.

**Monetary Theory of Inflation:** The monetarists believe that inflation is a monetary phenomenon. They emphasised that inflation rate is determined by increase in cash balances of the people as a result of increase in nominal income. Its earliest explanation is to be found in the simple quantity theory of money. The monetarists employed the notable identity of Fisher's Equation of Exchange:

$$MV = PQ \quad \ldots\ldots 2.1$$

Where M is the money supply, V is the velocity of circulation, P is the price level and Q is the level of real output (Jhingan, 2002). Assuming V and Q are constant, the price level (P) varies proportionately with the supply of money (M). With flexible wages, the economy is believed to operate at full employment level. The labour force, the capital stock and technology also changed only slowly over time. Consequently, the amount of money spent in the economy did not have effect on the real output level. So, if money supply is doubled, it will result into doubling of price level. Therefore, according to the monetarists, inflation rate is mainly determined by money supply.

**Keynesian Theory of Inflation:** To Keynes and his followers, they emphasised the increase in aggregate demand as the source of inflation. Aggregate demand comprises consumption, investment and government expenditures. If aggregate demand exceeds aggregate supply at the full employment level, the inflationary gap arises. The larger the gap between aggregate supply and demand, the more rapid the inflation. According to Keynesians, given a constant average propensity to save, rising money incomes at the full employment level would lead to excess of aggregate demand over aggregate supply and consequently to inflationary gap. The theory is based on the

short-run analysis in which prices are assumed to be fixed. Keynesians views on causation chain between nominal money income and inflation or prices is an indirect one through the rate of interest. The increase in nominal money income (money supply) leads to fall in interest rate, which will lead to increase in investment and in turn leads to aggregate demand increase. The increase in aggregate demand cannot lead to increase in output, if the economy is at full employment level, but will lead to increase in the price level (inflation)

**New Keynesian Phillip's Curve:** According to the proponents of NKPC model, inflation is determined by inflation expectation and real marginal costs, which is the expenses firms must make in the process of production for extra unit of their goods or services. It implies that inflation is determined by expected inflation rate ($\pi_{t+1}$) and marginal cost of production. Of course, the expectation of inflation by firms is based on rational expectation, which make use of the adaptive expectation and the future information about changes in wage rate.

### 2.3 Empirical Review

In a study on inflation, exchange rate depreciation and budget deficit in Nigeria, Egwaikhide, Chete and Falokun (1994) analysed the impact of exchange rate depreciation on inflation, using Error Correction Mechanism (ECM), with data that range from 1973 - 1989. The study measures inflation as CPI and exchange rate depreciation as lagged value of exchange rate. The control variables in the model specified in the study include money supply, real GDP, government revenue and expenditure, external debt, Then, it found that the exchange rate coefficient is positive and highly significant, which implies that depreciation of exchange rate exert positive influence on inflation rate.

In another study, Restrepo (2003) examined the price inflation and exchange rate pass-through in Chile, using data that span between 1986:1 to 2001:1, employing linear quadratic adjustment cost (LQAC) models. The study use the price level (excluding the price of items such as food perishable items, fuels, gas and regulated services), labour productivity, private wage, public wage, general wages, exchange rate and difference between actual output and Hodrick-Prescott's output (output gap). It found that exchange rate depreciation has upsurge impact on inflation rate in Chile, while such increase is neutralized by increase in output.

Study by Nogueira (2007) analysed the exchange rate pass-through for a set of emerging and developed economies before and after the adoption of inflation targeting. Both short-run and long-run ARDL were employed to estimate the impact of exchange rate depreciation on producer and consumer prices. Monthly data on consumer and producer prices were sourced and used as dependent variables. The explanatory variables include changes in exchange rate, monthly output growth using industrial production index and changes in the unit of value of foreign prices of imports. The study

found that exchange rate pass-through declined after inflation targeting for consumer and producer price indices. It is concluded in the study that the reduction does not imply that the exchange rate pass-through is no longer in existence, especially over the long-run.

In another study, Charles and Chilaka (2019) analysed the effects of exchange rate on inflation in Nigeria for the period of 1981 – 2015. The study employed inflation rate, which is expressed as CPI, and which serves as the dependent variable in the study. The explanatory variables are exchange rate which is expressed as the rate at which a US dollar is exchanged for a Naira, non-oil export foreign exchange earnings and money supply. It employed Vector Error Correction Mechanism (VECM) and found that the exchange rate has impact on inflation in Nigeria. Then, the study concluded that efforts should be intensified by the government to increase the foreign exchange earnings emanating from non-oil exports in order to increase the foreign reserves of the country and forestall incessant depreciation of Naira.

In addition, the study by Ude and Anochie (2014) on monetary policy and price stability, using quarterly data from 1986:1 to 2012:4, found incomplete exchange rate pass-through with price stability. This is almost the same with findings of Hunegnaw (2012), Berga (2012), Ecevit and Kayham (2011) etc.

In a study on the impact of exchange rate depreciation on inflation in Nigeria from 1986 - 2008, Imimole and Enoma (2011) employed Auto Regressive Distributed Lag (ARDL) co-integration procedure to analyse the study. The dependent variable in the study is inflation rate while the explanatory variables are one-year lag-value of Nigeria inflation rate, nominal exchange rate of Naira to US Dollars, nominal money supply, government expenditure and real GDP, all expressed in natural log form. The study found that exchange rate depreciation, money supply and real gross domestic product are the main determinants of inflation in Nigeria and the impact of Naira depreciation is positive in the long-run. The study concluded that although Naira depreciation is a policy that is efficacious for promotion of exportable goods but should not be relied upon as a viable measure for controlling inflation in Nigeria.

The study by Audu and Amaegberi (2013) on exchange rate fluctuations and inflation targeting in Nigeria used inflation rate as the dependent variable, while exchange rate and interest rate are employed as explanatory variables. The data were analysed using Error Correction Mechanism (ECM), and it is found that interest rate positively influence inflation rate while exchange rate has negative influence on it. However, the model of the study might have omission of important variables as only exchange rate and interest rate are considered as the factors that determine inflation rate. Such omitted variables include money supply, GDP, average rainfall etc.

In an investigation on the impact of exchange on inflation in Nigeria, Abubakar, Apeh and Nweze (2021) employed inflation rate as the

dependent variable in the study while one year lag of inflation rate, exchange rate (in terms of Naira to US Dollar), GDP per capita, broad money supply and government expenditure are the explanatory variables. The study employed ARDL as an estimation technique and subsequently found that the lags of all the explanatory variables in the model have impact on the rate of inflation. It also found that long run relationship exist between inflation rate and the explanatory variables employed in the study. However, the study did not include, in its analysis, the impact of variables such as rainfall and interest rate, which some studies (e.g. Audu and Amaegberi, 2013) have found to have impact on inflation rate.

The study by Osabuohien, Obiekwe, Urhie and Osabohien (2018) on the exchange rate fluctuations and inflation in Nigeria found that parallel market exchange rate has pass-through effect on inflation in the short-run as official exchange rate has pass-through effect on inflation in the long-run. The estimation technique used by the study is Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and Vector Autoregressive (VAR) model, employing monthly time series data that span between January, 2006 and December, 2015. The dependent variable used in the study is inflation rate while the explanatory variables include exchange rate volatility, broad money supply, interest rate, oil price, official exchange rate and parallel exchange rate.

Also, Nwaru and Eke (2017) analysed the impact of exchange rate on inflation in Nigeria, employing annual data for the period of 1970 – 2014. The study employed inflation rate as the dependent variable while employing lagged value of inflation, exchange rate, money supply and import prices as explanatory variables. It found that all the regressors have impact on inflation rate.

In addition, Emerenini, and Eke (2014) examined the determinants of inflation in Nigeria, using OLS estimation technique for monthly data from January, 2007 to August, 2014. Expected inflation, money supply and exchange rate were employed as explanatory variables while inflation rate was employed as dependent variable. The study found that exchange rate, expected inflation and money supply influence inflation rate.

In a separate study on inflation rate and exchange rate in Nigeria, Inyiama and Ekwe (2014) assessed the impact of exchange rate on inflation rate in Nigeria between 1979 and 2010, using Ordinary Least Square (OLS) estimation technique. The study employed inflation rate as the dependent variables while employing exchange rate, gross domestic product, interest rate and inflation rate as explanatory variables. It found that exchange rate has positive impact on inflation in Nigeria. However, the study missed up the procedural processes as the study applied OLS for non-stationary series, even with different order of integration. It excluded some important determinants of inflation rate including expected inflation rate and money supply.

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### 2.4 Gap in Literature

A number of studies have reviewed the impact of exchange rate on inflation in Nigeria and other countries, using different econometrics techniques such as OLS, ARDL, ECM, ARCH and GARCH etc. but there is no extant study, as far as the researcher know, especially from Nigeria, that has employed non-linear autoregressive distributed lag (NLARDL). The method is applied to analyse the disaggregated impact of exchange rate on inflation in Nigeria (that is, positive and negative impact of exchange rate). Also, this study will be the first, as far as the researcher know, apart from Sani, Ismaila, Danlami and Sani (2020), that employed average rainfalls as one of the factors that determine inflation rate.

## Methodology

This section discusses the methodology of the study including theoretical framework, model specification, estimation techniques, diagnostic tests and nature, measurement and coverage of variables.

### 3.1 Theoretical Framework

The study is premised on the Keynesian Theory of inflation, Monetary Theory of inflation and New Keynesian Phillips Curve Model.Keynesian theory emphasised that inflation is determined by the increase in aggregate demand over and above aggregate supply. The monetary theory stressed the role of money supply or increase in cash balances without proportionate increase in output as a determinant of inflation. The **NKPC** describes a simple relationship between inflation, the expectation that firms hold about future inflation, and real marginal costs, that is, the real (adjusted for inflation) resources that firms must spend to produce an extra (marginal) unit of their good or service. It states that **inflation** is a function of two factors: Next period's expected **inflation** rate, ($\pi_{t+1}$) and MC.

The models of the study include the four variables in those theories mentioned above, which include the aggregate demand and supply, which is proxied as GDP, money supply, marginal cost of producing goods, which is proxied as interest rate (i.e. cost of capital) and expected inflation, which is proxied as lag of inflation rate. Also, Average rainfall is included in the models as one of the variables that determines inflation rate. The models are in three categories based on the three different measures of inflation viz: core inflation, headline inflation and food inflation. Therefore, three models are specified for the study and are as below.

### 3.2 Model Specification

$$CINF_t = \beta_{01} + \beta_{11}EXRt + \beta_{21}GDPt + \beta_{31}M_2t + \beta_{41}INTt + \beta_{51}ARFt + \beta_{61}CINFt_{-1} + \mu_{t1....} \quad \ldots\ldots 3.1$$

$FINF_t = \beta_{02} + \beta_{12}EXRt + \beta_{22}GDPt + \beta_{32}M_2t + \beta_{42}INTt + \beta_{52}ARFt + \beta_{62}FINFt_{-1} + \mu_{t2}$ …..……3.2

$HLINF_t = \beta_{03} + \beta_{13}EXRt + \beta_{23}GDPt + \beta_{33}M_2t + \beta_{43}INTt + \beta_{53}ARFt + \beta_{63}HLINFt_{-1} + \mu_{t3}$ …..…3.3

Apriori expectation: $\beta_1$, $\beta_3$, $\beta_4$ and $\beta_6 > 0$and $\beta_2$ and $\beta_5 < 0$

The dependent variables are three, including $CINF_t$, $FINF_t$ and $HLINF_t$, which are different measures of inflation rate. $CINF_t$ is the core inflation, which is expressed as the inflation rate of all baskets of goods except food and energy. $FINF_t$ is food inflation, which is expressed as inflation rate for only food items while $HLINF_t$ is headline inflation, which is expressed as inflation rate for all baskets of goods without exception.

The explanatory variables are $EXR_t$, $GDP_t$, $M_{2t}$, $INT_t$, $ARF_t$ $CINF_{t-1}$, $FINF_{t-1}$ and $HLINF_{t-1}$. Exchange rate is represented by $EXR_t$, Gross Domestic Product is denoted as $GDP_t$, $M_{2t}$, represents money supply; $INT_t$ represents interest rate while $ARF_t$ represents average rainfall; $CINF_{t-1}$, $FINF_{t-1}$ and $HLINF_{t-1}$ represent expected inflation in core, food and headline inflation.

The justification for inclusion of exchange rate ($EXR_t$), Gross Domestic Product ($GDP_t$) and money supply ($M_{2t}$) is based on the thrust of Monetary Theory of Inflation, Keynesian Theory of Inflation and New Keynesian Phillips Curve (NKPC) while the inclusion of average rainfall ($ARF_t$) rainfall is born out of the fact that, in reality, food and agricultural items production depends on the volume of rainfall in the year.

With reference to the adopted estimation technique, because the study is interested in looking at the disaggregated effect of exchange rate on inflation rate in Nigeria (i.e. negative and positive effect of exchange rate on inflation, which is known as asymmetries), Non-Linear ARDL which is put forth by Shin, Yu and Greenwood-Nimmo (2014) will be employed. Shin et al. (2014) presented a non-linear ARDL approach (NARDL) as an extension to the notable ARDL model developed by Pesaran, Shin and Smith (2001) to capture asymmetries in modelling.

To capture the asymmetric impact of exchange rate on inflation, we specify a non-linear model by decomposing the variable ($EXCR_t$) into positive and negative shocks as follows:

$$EXR_t = EXR_t^+ + EXR_t^- \quad \text{……3.4}$$

$$EXR_t^+ = \sum_{j=i}^{t} \Delta EXR^+ = \sum_{j=i}^{t} \max \Delta EXR_{j,}0 \quad \text{……..3.5}$$

$$EXR_t^- = \sum_{j=i}^{t} \Delta EXR^- = \sum_{j=i}^{t} \min \Delta EXR_{j,}0 \quad \text{……....3.6}$$

Putting equation 3.4 into 3.1 – 3.3, we derive the equation below

$CINF_t = \beta_{07} + \beta^{+}_{17}EXR_t^{+} + \beta^{-}_{17}EXR_t^{-} + \beta_{27}GDP_t + \beta_{37}M_{2t} + \beta_{47}INT_t + \beta_{57}ARF_t + \beta_{67}CINFt_{-1} + \mu_{t1}$……..3.7

$FINF_t = \beta_{08} + \beta^{+}_{18}EXR_t^{+} + \beta^{-}_{18}EXR_t^{-} + \beta_{28}GDP_t + \beta_{38}M_{2t} + \beta_{48}INT_t + \beta_{58}ARF_t + \beta_{68}FINF_{t-1} + \mu_{t2}$……..3.8

$HLINF_t = \beta_{03}\ \beta^{+}_{19}EXR_t^{+} + \beta^{-}_{19}EXR_t^{-} + \beta_{29}GDP_t + \beta_{39}M_{2t} + \beta_{49}INT_t + \beta_{59}ARF_t + \beta_{69}HLINF_{t-1} + \mu_{t3}$ ……3.9

In a bid to express more useful dynamics in the model, the study expresses equations (3.7) - (3.9) in autoregressive distributed lag (ARDL) model as shown in equations (3.10) - (3.12). Equations (3.10) - (3.12) are ARDL as put forth by Pesaran et al., (2001) while Equations 3.13 – 3.15 are usually described as a non-linear (asymmetric) ARDL model due to the disaggregated exchange rate (see Shin et al., 2014).

$$\Delta CINF_t = \beta_{010} + \sum_{i=0}^{t}\beta_{110}\Delta EXR_{t-i} + \sum_{i=0}^{t}\beta_{210}\Delta GDP_{t-i} + \sum_{i=0}^{t}\beta_{310}\Delta M_{2t-i} + \sum_{i=0}^{t}\beta_{410}\Delta INT_{t-i} + \sum_{i=0}^{t}\beta_{510}\Delta ARF_{t-i} + \sum_{i=1}^{t}\beta_{610}\Delta CINF_{t-i} \dots\dots\dots\dots 3.10$$

$$\Delta FINF_t = \beta_{011} + \sum_{i=0}^{t}\beta_{111}\Delta EXR_{t-i} + \sum_{i=0}^{t}\beta_{211}\Delta GDP_{t-i} + \sum_{i=0}^{t}\beta_{311}\Delta M_{2t-i} + \sum_{i=0}^{t}\beta_{411}\Delta INT_{t-i} + \sum_{i=0}^{t}\beta_{511}\Delta ARF_{t-i} + \sum_{i=1}^{t}\beta_{611}\Delta CINF_{t-i} \dots\dots\dots\dots 3.11$$

$$\Delta HLINF_t = \beta_{012} + \sum_{i=0}^{t}\beta_{112}\Delta EXR_{t-i} + \sum_{i=0}^{t}\beta_{212}\Delta GDP_{t-i} + \sum_{i=0}^{t}\beta_{312}\Delta M_{2t-i} + \sum_{i=0}^{t}\beta_{412}\Delta INT_{t-i} + \sum_{i=0}^{t}\beta_{512}\Delta ARF_{t-i} + \sum_{i=1}^{t}\beta_{612}\Delta CINF_{t-i} \dots\dots\dots\dots 3.12$$

$$\Delta CINF_t = \beta_{013} + \sum_{i=0}^{t}\beta^{+}_{113}\Delta EXR^{+}_{t-i} + \sum_{i=0}^{t}\beta^{-}_{113}\Delta EXR^{-}_{t-i} + \sum_{i=0}^{t}\beta_{213}\Delta GDP_{t-i} + \sum_{i=0}^{t}\beta_{313}\Delta M_{2t-i} + \sum_{i=0}^{t}\beta_{413}\Delta INT_{t-i} + \sum_{i=0}^{t}\beta_{513}\Delta ARF_{t-i} + \sum_{i=1}^{t}\beta_{613}\Delta CINF_{t-i} \dots\dots\dots\dots 3.13$$

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$$\Delta FINF_t = \beta_{014} + \sum_{i=0}^{t} \beta_{114}^{+} \Delta EXR_{t-i}^{+} + \sum_{i=0}^{t} \beta_{114}^{-} \Delta EXR_{t-i}^{-} + \sum_{i=0}^{t} \beta_{214} \Delta GDP_{t-i} + \sum_{i=0}^{t} \beta_{314} \Delta M_{2t-i} + \sum_{i=0}^{t} \beta_{414} \Delta INT_{t-i} + \sum_{i=0}^{t} \beta_{514} \Delta ARF_{t-i} + \sum_{i=1}^{t} \beta_{614} \Delta FINF_{t-i} \dots \dots \dots \dots 3.14$$

$$\Delta HLINF_t = \beta_{015} + \sum_{i=0}^{t} \beta_{115}^{+} \Delta EXR_{t-i}^{+} + \sum_{i=0}^{t} \beta_{115}^{-} \Delta EXR_{t-i}^{-} + \sum_{i=0}^{t} \beta_{215} \Delta GDP_{t-i} + \sum_{i=0}^{t} \beta_{315} \Delta M_{2t-i} + \sum_{i=0}^{t} \beta_{415} \Delta INT_{t-i} + \sum_{i=0}^{t} \beta_{515} \Delta ARF_{t-i} + \sum_{i=1}^{t} \beta_{615} \Delta HLINF_{t-i} \dots \dots \dots \dots 3.15$$

### 3.3 Estimation Technique

In order to know the nature of the data employed in the study, it carries out the descriptive statistics and trend analysis of the variables employed in the study. The descriptive and trend analysis are presented in Section Four of the study. In line with the objective of the study, which is analysing the disaggregated impact of exchange rate on inflation in Nigeria, econometrics techniques employed to estimate the models in the study is Non-linear Autoregressive Distributed Lag (NLARDL). The diagnostic tests employed to test the robustness of the estimates in the study are Breusch-Pagan-Godfrey test of heteroscedasticity, Breusch-Godfrey test of serial correlation, Jarque-Bera test of normality of residuals, Multicollinearity test, Ramsey Reset test of model misspecification test.

### 3.4 Sources and Measurement of Data

a) Inflation Rate: It is divided into three areas of measurements viz: food inflation, core inflation and headline inflation. Core inflation rate is represented as inflation rate for all baskets of goods with exception of food and energy. Food inflation Rate represents the inflation rate of food items alone, while headline inflation rate is expressed inflation rate as for all the basket of goods in the economy, without exception. The data are monthly time series, which are sourced from the CBN online data bank.

b) Exchange Rate: The average rate at which naira is exchanged for a US dollar in a particular month, which is measured as the change in the nominal exchange rate that is sourced from the CBN online data bank.

c) Interest Rate: Interest rate is measured as lending rate of banks, using average lending rate in each month, which is sourced from the CBN online data bank.

d) GDP: The Gross Domestic Product is measured as the monetary value of goods and services produced in a country. The data is monthly one, which is sourced from the CBN online data bank.

e) Average Rainfall: This is measured as the average rainfall in the country per month. The data is monthly one, which is sourced from the CBN online data bank.

f) Money Supply: This deals with the volume of money in circulation which include currency in circulation, demand and fixed deposits in banks. The data are monthly data that are sourced from the CBN online data bank. All the data are monthly time series data, which span from January, 2006 to December, 2020.

**Presentation and Analysis of Results**

This section covers discussion on descriptive statistics and trend analysis. It also discusses the unit root and co-integration tests, which is followed by presentation of estimates from the regression equations.

**4.1 Descriptive and Trend Analysis**

The descriptive statistics in Table 4.1 is employed to describe the characteristics of the data. All the series are monthly data that span between January, 2006 and December, 2020. The summary statistics include mean, median, maximum, minimum, standard deviation (std. dev.), coefficient of variation (CoV) and number of observation (Obs), which are respectively reported in Columns two, three, four, five, six, seven and of the table. The first column is for the list of the variables in the study. The descriptive statistics of the variables are discussed, following the presentation.

**4.1 Descriptive Statistics of Variables Employed**

| Variables | Mean | Median | Maximum | Minimum | Std. Dev. | CoV. | Obs. |
|---|---|---|---|---|---|---|---|
| HLINF | 11.2842 | 11.3400 | 18.7200 | 3.0000 | 3.2935 | 0.2919 | 180 |
| RMSTGDP | 3.8541 | 3.6150 | 9.4000 | 0.7000 | 1.8230 | 0.4730 | 180 |
| INT | 16.5098 | 16.6950 | 19.6600 | 11.3100 | 1.5353 | 0.0930 | 180 |
| ARF | 5098.2960 | 5096.1650 | 5454.9650 | 4509.0140 | 154.3880 | 0.0303 | 180 |
| CINF | 10.0334 | 10.9800 | 14.0000 | 0.6000 | 2.9472 | 0.2937 | 180 |
| FINF | 12.1969 | 12.7950 | 20.9000 | -3.7000 | 4.8082 | 0.3942 | 180 |
| GDP | 4129746.0 | 4087323.0 | 4938290.0 | 3197595.0 | 430817.7 | 0.1043 | 180 |
| CEXCHR | 0.6460 | 0.0000 | 27.1013 | -3.3263 | 3.0366 | 4.7005 | 180 |

*Explanatory notes: Std. dev.= standard deviation; CoV. = coefficient of Variation with observation (t) = 180 for all the variables in the table which begins from January, 2006 to December, 2020. The exchange rate is expressed as change in nominal exchange rate.* ***Source:Author's computation (2022).***

As shown in Table 4.1, the mean and median of headline inflation (HLINF) are 11.2842 and 11.3400 respectively, while the maximum and minimum values are 18.7200 and 3.0000 respectively, which are found in January, 2017 and January 2006 with standard deviation of 3.2935. In the case of ratio of money supply to GDP, the mean and median are 3.8541 and 3.6150 respectively, while the maximum and minimum values of

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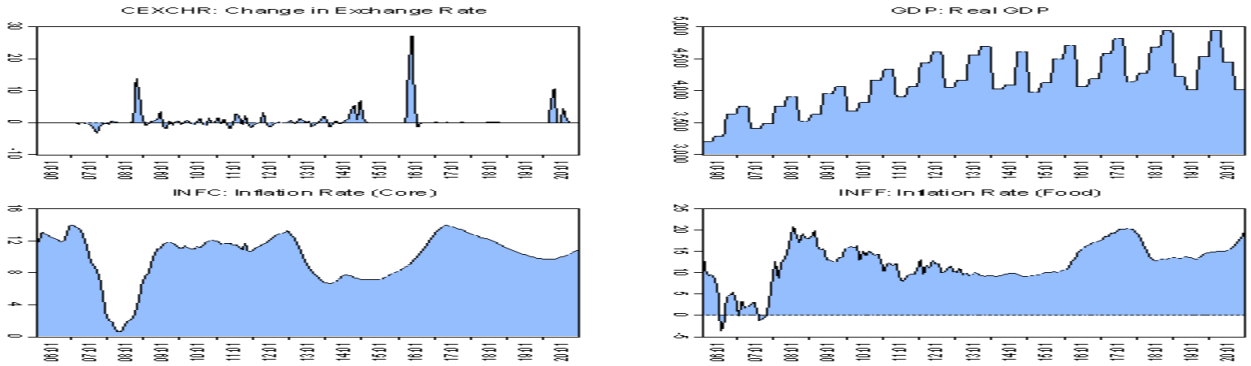
9.4000 and 0.7000 respectively, which are found in December, 2020 and February, 2006 with standard deviation of 1.8230. Considering, interest rate (INT), the mean is 16.5098 with median of 16.6950. The maximum value is 19.6600 with minimum value of 11.3100, which can be found in November, 2009 and October, 2020 with standard deviation of 1.5353. Also, the mean and median of average rainfall (ARF) are 5098.2690 and 5096.1650 respectively, while the maximum and minimum values are 5454.9650 and 4509.0140 respectively, which can be found in December, 2020 and January 2006, with standard deviation of 154.3880. Also, the mean and median of core inflation (CINF) are 10.0334 and 10.9800 respectively, while the maximum and minimum values are 14.0000 and 0.6000 respectively, which are found in January, 2007 and April, 2008 with standard deviation of 2.9472. In the case of food inflation, the mean and median are 12.1969 and 12.7950 respectively, with the maximum and minimum values of 20.900 and -3.7000 respectively, which are found in July, 2008 and July, 2006 with standard deviation of 4.8082. Considering, Gross Domestic Product (GDP), the mean is 4129746.0 with median of 4087323.0. The maximum value is 4938290.0 with minimum value of 3197595.0, which can be found in February, 2020 and January, 2006 with standard deviation of 430817.7. In addition, the mean and median of change in exchange rate (CEXCHR) are 0.6460 and 0.0000 respectively, while the maximum and minimum values are 27.1013 and -3.3263 respectively, which are found in May, 2016 and September, 2007 with standard deviation of 3.0366.

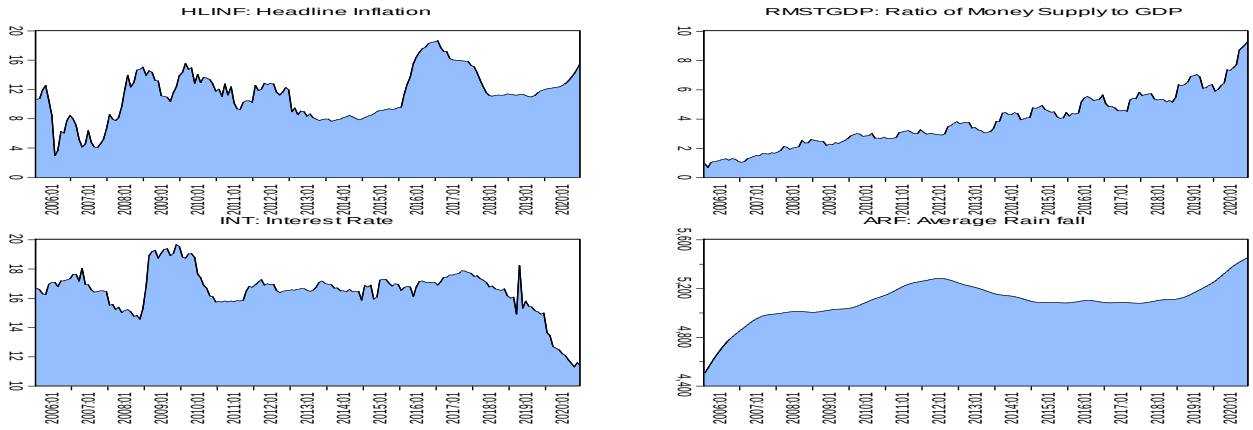
**Figure 4.1 Trend of Change in Exchange Rate (CEXCHR), GDP, Core Inflation (CINF) and Food Inflation (FINF)**




**Explanatory Note:** the horizontal axis measures the months the changes in the variables occur. Change in exchange rate rate (CEXCHR), Gross Domestic Product (GDP), core inflation (INFC) and food inflation (INFF) are measured along the vertical axis.

From Figure 4.1 above, the trend of change in nominal exchange rate exhibits oscillation between negative and positive axis, showing a zigzag shape while GDP exhibits a zigzag shape as well. The shape of core inflation shows that it fluctuates right from 2006 till the end of 2020, with a relatively stable shape towards the end of 2020. Also, it is revealed in the figure that food inflation rate oscillates throughout its entire live. It was negative in late 2006 and 2007.

**Figure 4.2: Trend of Headline Inflation, (HLINF), Ratio of Money Supply to GDP (RMSTGDP), Interest Rate (INT) and Average Rainfall (ARF)**




*Explanatory Note: the horizontal axis measures the periods the changes in the variables occur. Headline inflation rate (HLINF), ratio of money supply to GDP (RMSTGDP), interest rate (INT) and average rain fall (ARF) are measured along the vertical axis.*

From Figure 4.2, it is revealed that headline inflation (HLINF) moves upward and downward throughout the entire periods, while ratio of money supply to GDP (RMSTGDP) slope positively right with some levels of fluctuations from January, 2006, which is the beginning period, till December, 2020, which is the end period. Also, the figure shows that interest rate (INT) maintain a zigzag movement from the starting point till the end, while the figure reveals that average rainfall's movement is positive and look like mountain, with little fluctuations.

### 4.1.1 Unit Root Test

In order to find out the time series property of the variables employed and to avoid spurious results from the regression estimates, the study carried out stationary test to. This is done to know whether the series are stationary at levels, order 1 and order 2. A series will be adjudged to be stationary at level (I(0)) or at first difference (I(1)) if the probability value is less than 0.05 significance level. The results of Dickey-Fuller test for the variables employed in the study are presented as below.

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| Var./Prob. Values | P-Value at | P-Value at 1st | Order of |
|---|---|---|---|
| CINF (Core inflation rate) | 0.3464 | 0.0334 | I(1) |
| HLINF (Headline Inflation rate) | 0.2822 | 0.0000 | I(1) |
| FINF (Food Inflation rate) | 0.7111 | 0.0200 | I(1) |
| CEXCHR (change in nominal | 0.0000 | - | I(0) |
| INT (interest rate) | 0.4282 | 0.0000 | I(1) |
| ARF (Average rainfall) | 0.7819 | 0.0901 | I(1) |
| GDP (Real Gross Domestic | 0.3919 | 0.0000 | I(1) |
| RMSTGDP (Ratio of money supply to GDP) | 0.2822 | 0.0000 | I(1) |

**Table4.2: Results of Dickey-Fuller Unit Root Test for the Variables Employed in the Study**

*The following are the meaning of acronyms for the variables in Table 4.2:CINF is the core inflation, HLINF is the headline inflation, FINF is denoted as food inflation, while CEXCHR is denoted as changes in exchange rate. INT represents interest rate, while ARF means average rain fall, GDP implies real GDP and RMSTGDP implies ratio of money supply to GDP. All the series span from 2006M01 – 2020M012, I(0) and I(1)mean stationary at order 0 and 1 respectively.The probability valueof order of integration is in the second and third columns. A variable is considered stationary when the probability value is statistically significant at 5%.*

***Source:Author's computation (2022).***

It is shown in Table 4.2 above that the p-value for all the series, except CEXCHR, at levels are not statistically significant, which means that they are not all stationary at levels, except change in exchange rate (CEXCHR). Also, it is revealed that the p-value of all the series are statistically significant at first difference, which implies that all the series are stationary at first difference or integrated of order 1.

### 4.1.2 Co-integration Test

In order to test whether long run relationship exist among the series in each of the three models, co-integration test is carried out, using ARDL Bound Test. The choice of ARDL Bound Test is born out of its suitability for the series that are stationary at different orders. The ARDL Bound Tests results are as presented below in Table 4.3.

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**Table 4.3: Results of ARDL-Bound Test for FINF, CINF and HLINF Models**

| MODELS | F-statistics | 5% Sig | Remarks |
|---|---|---|---|
| **FINF: Food Inflation** | 1.7913 | $I_0$ = 2.22 $I_1$ =3.39 | Not Co-integrated |
| **CINF: Core Inflation** | 1.5446 | $I_0$ = 2.22 $I_1$ =3.39 | Not Co-integrated |
| **HLINF: Headline Inflation** | 1.6335 | $I_0$ = 2.22 $I_1$ =3.39 | Not Co-integrated |

*The following are the meaning of acronyms for the variabls in Table 4.3: FINF is denoted as food inflation, CINF is the core inflation while HLINF is the headline inflation. All the series span from 2006M01 – 2020M012, $I_0$ and $I_1$mean lower bound and upper bound critical value respectively. A model is adjudged to be co-integrated, if F-statistics is greater than the upper bound critical value at 5% significance level and not co-integrated, if F-statistics is less than upper bound critical value.*

***Source:Author's computation (2022).***

As shown in Table 4.3 above, the F-statistics of FINF, CINF and HLINF models are 1.7913, 1.5446 and 1.6335, which are less than upper bound critical value at 5% significance level. This implies that all the models, based on decision rule, are not co-integrated. Therefore, the suitable estimation technique is short-run non-linear-ARDL.

**4.2 Regression Estimates**

This sub-section discusses the parameter estimates of the three models, which include CINF, FINF and HLINF models. The estimation technique employed is short-run non-linear ARDL. Nonlinear ARDL is employed to determine the asymetrics impact or effect of exchange rate on inflation. The short-run regression equation estimates for Core inflation, Food inflation and Headline inflation are presents as below,

### 4.4: Regression Equations Estimates for Core, Food and Headline Inflation

| | **CINF** | | | **FINF** | | | **HLINF** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **Coeff** | **t-Stat** | **P-value** | **Coeff** | **t-Stat** | **P-value** | **Coeff** | **t-Stat** | **P-value** | **VIF** |
| D(CINF(-1)) | 0.6939 | 13.3211 | 0.0000 | - | - | - | - | - | - | - |
| D(INFHL(-1)) | - | - | - | - | - | - | 0.1232 | 1.5817 | 0.1156 | |
| D(CEXCHR_POS) | 0.0147 | 1.0992 | 0.2733 | 0.0144 | 3.5122 | 0.0009 | 0.0408 | 2.6441 | 0.0020 | 9.0000 |
| D(CEXCHR_POS(-1)) | -0.0734 | -2.2801 | 0.0239 | - | - | - | - | - | - | - |
| D(CEXCHR_NEG) | 0.0447 | 1.4541 | 0.1478 | 0.0338 | 0.8196 | 0.4136 | 0.0493 | 1.9841 | 0.0489 | - |
| D(INT) | 0.0444 | 1.4329 | 0.1538 | -0.0842 | -0.6735 | 0.5016 | -0.0410 | -0.5366 | 0.5922 | 4.8000 |
| D(ARF) | 0.0080 | 1.5892 | 0.1139 | -0.0389 | -2.3726 | 0.0188 | -0.0142 | -1.4171 | 0.1583 | 9.0000 |
| D(GDP) | 0.0000 | -0.9903 | 0.3235 | 0.0000 | 0.7088 | 0.4794 | 0.0000 | 0.2149 | 0.8301 | 2.0000 |
| D(RMSTGDP) | -0.0960 | -1.0118 | 0.3131 | 0.4689 | 1.2457 | 0.2146 | 0.2157 | 0.9253 | 0.3561 | 1.9000 |
| ect(-1) | -0.0447 | -3.1019 | 0.0023 | -0.0883 | -3.0172 | 0.0029 | -0.0524 | -1.9291 | 0.0554 | - |
| S/Corr. | 5.4611 | - | 0.1213 | 0.7920 | - | 0.4546 | 1.1704 | - | 0.1852 | - |
| Hetero. | 3.5455 | - | 0.3001 | 3.6580 | - | 0.2002 | 3.4521 | - | 0.1004 | - |
| J/Bera | 6.6511 | - | 0.2001 | 5.2561 | - | 0.1211 | 2.9140 | - | 0.2132 | - |
| Ramsey/R | 1.6954 | | 0.1950 | 3.4438 | | 0.0652 | 1.6200 | | 0.2049 | |

*Explanatory Note: CINF is core inflation, FINF is food inflation, HLINF is headline inflation, CEXCHR is change in exchange rate, INT is interest rate, ARF is average rainfall, GDP is gross domestic product, RMSTGDP is ratio of money supply to GDP, ect is error correction term, S/Corr. is serial correlation test Hetero. Is heteroscedasticity test, J/Bera is Jaque Bere statistics and Ramsey/R is Remsey Reset Statistics.* The p-values attached to each coefficient is in the column next to t-statistics, which is denoted as t-stat. A coefficient is adjudged to be statistically significant in the study if its p-value is not more than 0.05 significance level.

**Source: Author's computation (2022).**

#### 4.2.1 Diagnostic Tests

**a) Serial Correlation:** It is shown from the table that F-statistics in CINF, FINF and HLINF models are 5.4611, 0.7920 and 1.1704 respectively with p-values of 0.1213, 0.4546 and 0.1852. Since the p-values are more than 0.05 significance level, the null hypothesis of no serial correlation cannot be rejected in the three models. Therefore, the models are not suffering from the problem of serial correlation.

**b) Heteroscedasticity:** It is shown from Table 4.4 that F-statistics in CINF, FINF and HLINF models are 3.5455, 3.6580 and 3.4521 respectively with p-values of 0.3001, 0.2002 and 0.1004. Since the p-values are more than 0.05 significance level, the null hypothesis of no heteroscedasticity cannot be rejected in the three models. Therefore, the models are not suffering from the problem of heteroscedasticity or unequal variance

**c) Normality in the Distribution of Residuals:** As shown in Table 4.4, the Jaque-Bera value of CINF, FINF and HLINF are 6.6511, 5.2561 and 2.9140 respectively with p-values of 0.2001, 0.1211 and 0.2132. Since the p-values are greater than 0.05 significance level, the null hypothesis of

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normality in the distribution of residuals cannot be rejected. Therefore, the models are not suffering from the problem non-normality of residuals.

**d) Multicollinearity:** It is reveled from Table 4.4 that Variance Inflation Factor (VIF) for CEXCHR, INT, ARF, GDP and RMSTGDP are 9.00, 4.80, 9.00, 2.00 and 1.90 respectively. Since no explanatory variable has VIF that is equal or greater than ten, the models do not have the problem of multicollinearity among their explanatory variables.

**e) Model Misspecification:** It is shown in Table 4.4, the Ramsey F-statistics for CINF, FINF and HLINF are 16954, 3.4438 and 1.6200 respectively with p-values of 0.1950, 0.0652 and 0.2049. Since the p-values are greater than 0.05 significance level, the null hypothesis of no misspecification error cannot be rejected. So, the models are not suffering from model misspecification errors.

**Discussion of Results**

From Table 4.4, it is shown that the coefficient of lag1 of INF is 0.6939 with p-value of 0.0000, which implies that the coefficient is positive and statistically significant at 5% significance level. It means that expected inflation has positive impact on inflation, especially core inflation in Nigeria. Also, it is revealed from the table that the coefficient of lag1 of headline inflation is 0.1232 with p-value of 0.1156, which implies that the coefficient is positive and statistically insignificant.

It is shown in Table 4.4 that the coefficients of POS_CEXCHR in CINF, FINF and HLINF models are 0.0147, 0.0144 and 0.0408 respectively, with p-value of 0.2733, 0.0009 and 0.0020. This implies that the coefficient of POS_CEXCHR is positive and statistically significant in FINF and HLINF models. Based on preponderance of evidence, it can be inferred that positive change in exchange rate will bring about positive change in inflation rate, especially food inflation and headline inflation in the short-run. This is in line with theory and apriori expectation. The finding also follows the study such as Osabuohien et al. (2018).

Also, it is shown in the table that the coefficients of NEG_CEXCHR in CINF, FINF and HLINF models are 0.0447, 0.0338 and 0.0493 respectively, with p-value of 0.1478, 0.4136 and 0.0489. This implies that the coefficient of NEG_CEXCHR is positive and statistically significant in only HLINF model. It can be inferred that negative change in exchange rate will bring about negative change in inflation rate, especially headline inflation in the short-run. This is not in line with theory and apriori expectation as no theory has made proposition that explain how negative change in exchange rate brings about any change in inflation, whether negatively or positively.

It is also revealed in Table 4.4 that the coefficients of INT in CINF, FINF and HLINF models are 0.0444, -0.0842 and -0.0410 respectively with p-value of 0.1538, 0.5016 and 0.5922. This implies that the coefficients of INT are statistically insignificant. So, based on the want of evidence, it can be inferred that interest rate

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has no impact on inflation rate in the short-run.

It is also shown in the table that the coefficients of ARF in CINF, FINF and HLINF models are 0.0080, -0.0389 and -0.0142 respectively, with p-value of 0.1139, 0.0188 and 0.1583. This means that the coefficient of ARF is negative and statistically significant at 5% significance level in only FINF model, while its coefficient are not statistically significant in CINF and HLINF. Based on balance of evidence, it can be inferred that rainfall has negative impact on inflation, especially food inflation. This is in line with apriori expectation and it is in line with previous study such as Sani et al. (2020).

In addition, it is shown in the table that the coefficients of GDP, in the short-run, in CINF, FINF and HLINF models are 0.0000, 0.0000 and 0.0000 respectively, with p-value of 0.3235, 0.4794 and 0.8301 This implies that the coefficients of GDP, though small, is positive but not statistically significant in all the models. It can be inferred that GDP does not have impact on inflation rate in Nigeria in the short-run. This is in line with theory and apriori expectation.

Table 4.4 also shows that the coefficients of RMSTGDP in CINF, FINF and HLINF models are -0.0960, 0.4689 and 0.2146 respectively with p-value of 0.3131, 0.2146 and 0.3561. This implies that the coefficients of RMSTGDP is positive but not statistically significant. It can be inferred that RMSTGDP does not have impact on inflation rate in Nigeria in the short-run. This is in line with theory and apriori expectation.

## Summary, Conclusion and Recommendation

This section covers summary, which is discussed in Sub-section 5.1, conclusion, which is discussed in Section 5.2 and recommendation of the study which is discussed in Sub-section 5.3.

### 5.1 Summary

Exchange rate play a vital role in any economy, which include international trade and general economic performance. Exchange rate determines a number of macroeconomic variables such as inflation. It affects the entire aspects of the economy of any nation, ranging from household spending, investment of businesses, unemployment rate, tax policies, interest rate etc. Because of the nature of inflation in any economy, authority needs to put in place some policy measures to always control it in order to avoid distortions in the economy. Before the authority could put in place policies to curb inflation, they need to be well guided by studies that will give them insights on the various economic variables that could influence inflation rate. To this end, a number of studies have been carried out to bring to bear the impact of exchange rate on inflation rate in Nigeria. For this study to make contribution to the stock of knowledge in this area, it poised to examine the asymmetric and non-asymmetric impact of exchange rate on inflation.

In order to know the level of research efforts in this area and draw the research gap, the

study carry out literature review, which covers theoretical and empirical review. The theory reviewed include Phillips Curve, Keynesian Theory of Inflation, Monetary Theory of Inflation, New Keynesian Phillips Curve (NKPC). A number of empirical studies were reviewed such as Egwaikhide, Chete and Falokun (1994), Nogueira (2007), Abubakar, Apeh and Nweze (2021), Ude and Anochie (2014), Charles and Chilaka (2019), to mention but a few. After the empirical review of literature, research gap was drawn.

In order to choose a suitable methodology for the study, the theoretical framework was put in place, which serves as a precursor for model specification in the study. Various estimation techniques employed in the study were discussed including trend and descriptive analysis, unit root tests and co-integration test, non-linear ARDL and diagnostic tests.

In a bid to bring to bear the findings of the study, the results was presented and discussed. The descriptive statistics results was presented to show the summary statistics of the series in the study, along with the presentation of trend analysis of the series. The results of pre and post-estimation tests were discussed, with that of non-linear ARDL regression.

## 5.2 Conclusion

Based on the findings of the study, the following are the conclusion of the study.

Expected inflation or lag of inflation has positive impact on inflation in the short-run in Nigeria.

Exchange rate has symmetric impact on inflation rate in the short-run in Nigeria. It has positive impact on FINF and HLINF in the short-run.

The impact of rainfall on inflation rate is negative in the short-run in Nigeria.

## 5.3 Recommendation

The study recommends that authority should put in place exchange rate and price harmonization institution that will ensure that exchange rate pass-through occurs at the time when Naira appreciates and depreciates. This is to control the producers from charging excessive prices, especially when the cost of production has fallen due to appreciation of Naira.

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