An Application of Autoregrssive Distributed Lag (ARDL) Bound Testing To Modeling Inflation Rates in Nigeria (2006 – 2018)

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Abstract
This study used Autoregressive distribution log (ARDL) Bound Testing procedure to assess the impact of crude oil prices and exchange rates on inflation rates. Monthly time – series data for the period January 2006 to December 2018, obtained from the electronic database of the Central bank of Nigeria CBN and the National Bureau of Statistics were used. The study obtained statistically significant results suggesting that both crude oil prices and the exchange rates have a positive impact on inflation rates in Nigeria..The result of the long run ARDL indicate that crude oil prices have a positive effect on the exchange rate; while of inflation rate indicated that 15.38% increase in inflation causes a down fall in the exchange rate up to 0.40%. The Relationship between oil prices and exchange rate on inflation shows a significant positive relationship.

Key words: *Inflation, Exchange rate, Oil Price, Auto regression model.*

1.0 Introduction

Nigeria is a country which has experienced high and chronic inflation period and fluctuating Exchange rates during the past decades. After the Nigerian civil war and world oil crisis, high inflation has been one of Nigeria's most important problems. Especially during past years by cotts against trade caused unstable exchange rates and high inflations in Nigeria. The aim of this study is to analyze the relationship between inflation rates, exchange rates and oil export prices, based on time series data using the Autoregressive Distributed Lag Modeling. (ARDL).To this end, we use monthly data for the period January 2006 to December 2018.

The inflation and Exchange rate relationship has always been one of the fascinating topics for research (Svensson 1987). The exchange rate, inflation relationship has a vital importance, especially in emerging economy. In these economics, exchange rate fluctuation can significantly affect the general level of the prices (Dornbuch, 1976). According to Dombach when the exchange rate defined as the rate of exchange between two national currencies, increase will exist in the overall level of prices. Then whenthe exchange rate fall, that is when the domestic currency appreciates, prices are expected to fall in the general level. A change in exchange rate will affect oil price export as well as exchange rate. For this reason, it is possible to say that there is a very relationship between the exchange rate, oil price and inflation.

Over the past decreased, most governments have been realizing the increasing importance of inflation expectations through their self-fulfilling effect on actual inflation and hyperinflation where the expectations are left uncontrolled (Ueda, 2011).Previous studies revealed that well anchored inflation expectations enable the monetary authorities to achieve other monetary policy objectives such as economic growth and price stability (Mboweni 2003 and Ueda, 2011). Given the importance of inflation rates in influencing the monetary police of nations, governments in both developed countries (for example United States of America) and developing countries (for example Nigeria) adopted the inflation targeting monetary policy framework. According to Mboweni (2003), inflation targeting provides an anchor for inflation rates. Some empirical literature support the implementation of inflation targetingas a monetary policy tools that anchorsinflation rates by households,(Mohanty 2012),inflation forecasting (Bernanke,2007)as well as the public attitude to inflation and interest rates (Driver and Windran,2007). The success of a nation's monetary policy framework depends on how the inflation rates were formed, that is, it is imperative to consider the antecedents of inflation rates in a country, as they play major role in the formation of inflation rates.

EmpirTical studies revealed the common determinants of inflation rate tobe change in oil price and exchange rate (Nkomo, 2006 and Wakeford, 2006).

I.6 Definitions of the Macroeconomic variables Rates

Inflation is the unremitting and unrepressed increasing in price level of goods and services that subsequently decrease the purchasing power of currency and economic growth of any economy.

Namjour et al (2014) categorized inflation rate into three types:

(i) Creeping inflation which increases within the range of 1 to 6 percent or 4 to 8 in one year.

(ii) Severe inflation, where the price level increases rapidly as compared to creeping inflation. It ranges within 15 to 25 percent per year.

(iii) Hyperinflation where the prices of goods and services increase up to 50 percent every six months.

1.6.2 Exchange Rate

The exchange rate is the current market price for which one currency can be exchange foranother. For example if the Naira exchange rate for the United State Dollar stands at N155, this means that m155 can be exchanged for $1.

1.6.3 Crude Oil Price

This is the price for which a barrel of oil is sold at the international market. For example one barrel at $56 implies that I barrel of rude oil sells for 56 dollars.

2.1 LITERATURE REVIEW

Empirical Literature exist on the impact of both oil prices and exchange rates on inflation. Most of these were done on developed countries and include the works of Ueda (2010) as well as Sequal (2011). Studies have also been conducted in ongoing economics such as Turkey (Celik and Akgul, 2011). In Nigeria contest, available literature does not examine a combination of the variables explored in this study (Nkomo 2006, Chisada, et al, 2013 as well as Niyimbanira, 2013).

This section provides a review of literature related to the relationship between oil prices, exchange rates and inflation rates.

Ueda (2010) employed the Vector Auto Regression (VAR) model to examine the determinant of inflation rates in Japan and the United State of America.

The study used survey data on household inflation rates for Japan and the US and found that inflation expectations adjust more quickly than actual inflation rates to the changes in exogenous prices and to monetary policy shocks. It was also revealed in the study that when compared with Japan the effect of the exogenous prices on inflation were large and long termed in the UnitedState of America.

Segal (2011) followed a literature analysis methodology to investigate the impact of oil price shock on the macro economy. The paper sought to explain why the rise in oil price up to 2008 has little impact on the world economy. The study revealed that high oil prices have never been as important as they are popularly thought to be.

In addition, the finding of this study showed that high oil prices have not reduced growth in recent years because they no longer pass through to the core inflation. As a result there was no evidence of monetary tightening previously seen in response to high oil prices. The study also revealed that oil prices have little impact on the global recession of 2008-2009.

Celik and Akgul(2001) examined the relationship between the consumer price index (CPI) and the fuel oil price index in Turkey, using the Vector Error Correction Model (VECM). The study used the time internal monthly data of theperiod 2005-2010.The findings of the study revealed that a 1% increase in fuel oil price caused the CPI to rise by 1.26% with an approximate one yearlag.Moreso, the changes in fuel oil prices were found to be the one way Granger Cause for exchanges in the CPI.

In South Africa,Chisadza, et al (2013) investigated the impact of oil supply and demand shocks on the South African economy, using a sign restriction based Structural Vector Auto Regressive (VAR) model. Their findings revealed that an oil supply shock has a short lived significant impact only on the inflation rates, while the impact on other variables was statistically insignificant. More so, their study reported a negative reaction to oil specific demand shocks of inflation rate and real exchange rate. The study also revealed that unanticipated changes in oil prices resulting from speculations have a positive impact in output.

Nkomo (2006) conducted a study on crude oil movements and their impact on South Africa, using a history and literature analysis method. The study concluded that South Africa has been shielded from much of the negative impacts of Crude Oil price increase because of its strong US Dollar/Rand exchange rate, though vulnerable to external sources of oil supply and to increases in international oil prices. The study also concluded that the immediate impact of high crude oil prices is on economic growth and development of the oil consuming country.

3.0Methodology

The data used in this study employs monthly time series data covering the period January 2006 to December 2018.

Data for all the variables were obtained from the electronic database of Nigeria Central bank at www.cbn.ng.gov and the Nigeria Bureau of statistics at www.nbs.ng.gov.

3.2 Model Specification

To examine the impact of oil prices and exchange rates on inflation rates in Nigeria, this study uses the Autoregressive Distributed Lag (ARDL) model to investigate the relationship. This modified model to examine the impact of oil prices and exchange rate on inflation expectations, we used the transformation into the logarithm of the form:

LOG (INFR) =βo +β1LOG (OILP) +β2LOG (EXCR) + μ_t(3.1)

Where: LOG (INFR): Inflation expectations.

LOG (OILP): Crude Oil prices in US$ per barrel (nominal/ real values).
LOG (EXCR): Exchange rate: this is nominal exchange rate of Nigeria naira per US dollar foreign exchange rate.
β_1-β_2: coefficients
μ_t: Error term
t : Time variant
The basic ARDL to model the data (economic variables) in a single equation time series set up: The basic ARDL model specification for the Bounds Testing methodology order (p,q,r) takes the form:
$Y_t = \beta_0 + \sum_{i=1}^{p} \beta_I Y_{t-1} + \sum_{i=1}^{q} \alpha_i X_{t-1} + \sum_{i=1}^{r} \rho_{iW_{t-1}} + \mu_t$ (3.2)
Where Y_t= Inflation rate (Dependent variable)
Xt = Exchange rate (Independent variable)
Wt = Crude oil price (independent variable)
The model 3.2 is similarly defined for higher order, for example (p, q, r, s …) to involve four or more summations in the right hand side.

2. 2Unit Root Test

Before estimating the model in (3.2) we checked the Time series properties of the data using the Augumented Dickey Fuller (ADF), in order to ensure that the series (variables) to be integreted0f order 1(0) or 1(1)

2.3 Co- integration Test

For a co-integrated data set, a standard ECM test takes the form:
$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_I \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \rho_i \Delta W_{t-1} + \varphi Z_{t-1} + \mu_t$ (3.3)*We* further formulated the conditional ECM (Pesaram et al 2001) of the form:
$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_I \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \rho_i \Delta W_{t-1} + \theta_0 Y_{t-1} + \theta_1 X_{t-1} + \theta_2 W_{t-1} + Y_t$ (3.4)

3.4 Bound Test

We used the unconstrained ECM format(3.4) to perform the bounds testing
$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_I \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \rho_i \Delta W_{t-1} + \theta_0 Y_{t-1} + \theta_1 X_{t-1} + \theta_2 W_{t-1} + k_t$ (3.5)
The econometric models used to estimate the impact of oil prices and exchange rates on inflations rates in this study proceeds in two steps. Firstly the cointegration of inflation rates , oil prices and exchange rates are examined by testing for stationarity in these series. If the series are integrated of the same order, it suggests that a cointegrating Vector can be found and the variables are stationary. Secondly, the cointegration residuals is used as an Error Correction Term ,leading to the estimation of both the short run effect and the speed of adjustment. Subsequent to the two steps are diagnostic checks which will perform to test for Heteroskedasticity, Autocorrelation and Normality. The Augmented Dickey-Fuller (ADF) and Unit root tests were used to examine the Statistical and Time Series properties of the data. Testing for stationarity is essential because, if non-stationary variables are employed in a regression, then the standard assumption for asymptotic analysis will not be valid. This implies that the casual t-ratio will not follow a t-distribution and the F- statistic will not follow an F- distribution. Therefore, Unit root test should be done on all the time series used before estimating the parameters and testing for cointegration so as to avoid spurious and or nonsense regression. The adopted ADF is given by the equation.
The ADF (Dickey and Fuller, 1981) equation given in 3.3 allows for AR process that may include a non-zero overall mean for the series and trend variable.

The test statistic of the Augmented Dickey –Fuller would be invalidated if the residual of the reduced form equation were Autocorrelated. In order to test the null hypothesis of non stationarity, the t-statistic of the estimate is used

To make this choice the adjusted R-squared and the Schwartz (1978) criterion is used. The ADF Fisher Unit Root Test is a more robust unit root test that may be applied together with DF-style. This is because DF-style tests are commonly criticized for having low power (Gujarati 2003), and tend to accept the null hypothesis of unit root more frequently than is warranted (Baun, 2001).

The Breusch-Godfrey Serial correlation LM test corrects for high order serial correlation by adding lagged difference terms on the right hand side. It makes a correction to the t-statistic of the coefficient from the regression to account for serial correlation in the error term.

The study also tests for stability in the model using VAR stability condition check. To trace the responsiveness of expected inflation to shocks in oil prices as well as the exchange rates; and to measure the proportion of forecast error variance in expected inflation that is explained by innovations in itself and the other variables, this study respectively performed an perform an Inverse Roots of AR characteristics polynomials (First Differenced Data)

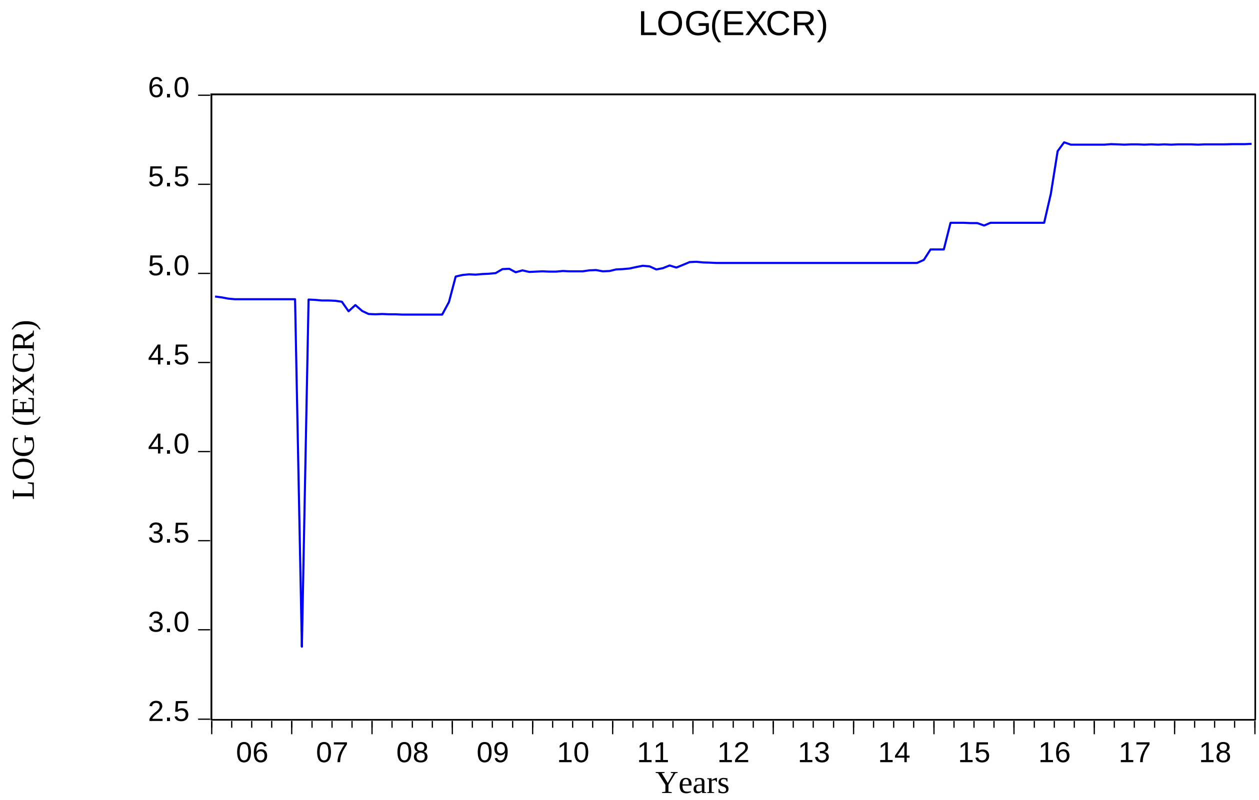

Figure 4.1. Time plot of Exchange Rate between Naira and US Dollar

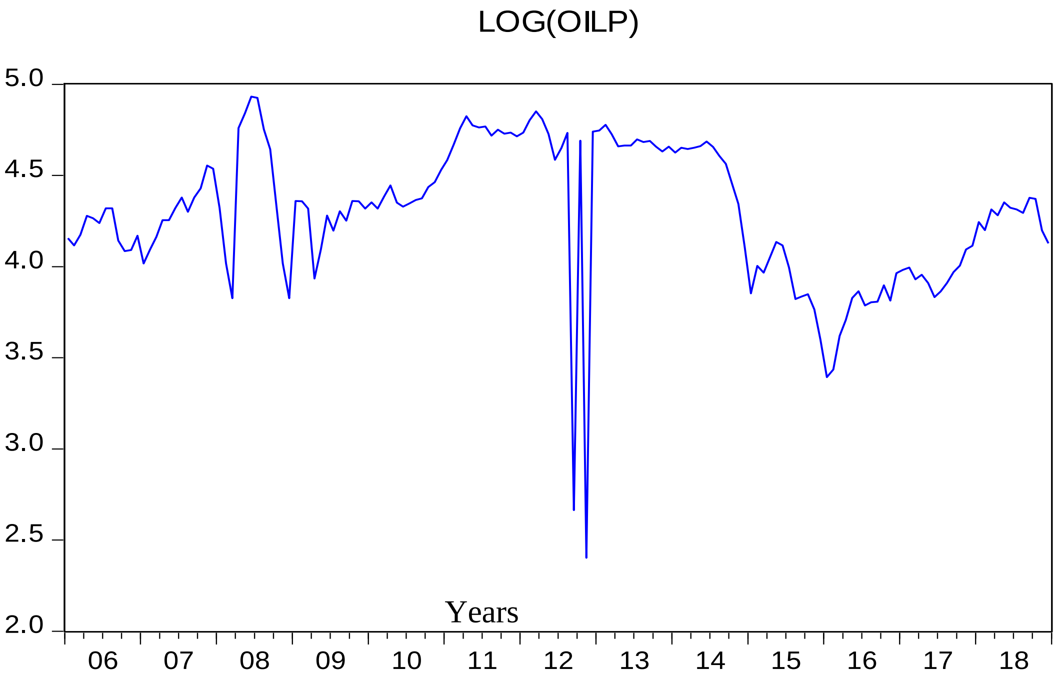

Figure: 4.2: Monthly price of crude oil

Figure 4.3: Nigeria monthly inflation Rate (naira) inflation from January 2005 to December 2018.

Figure 4.3 below is the graphical representation of monthly Nigeria inflation rate from January 2006 to December 2018.

Inflation rate) is on the vertical axis while the year is one the horizontal axis.

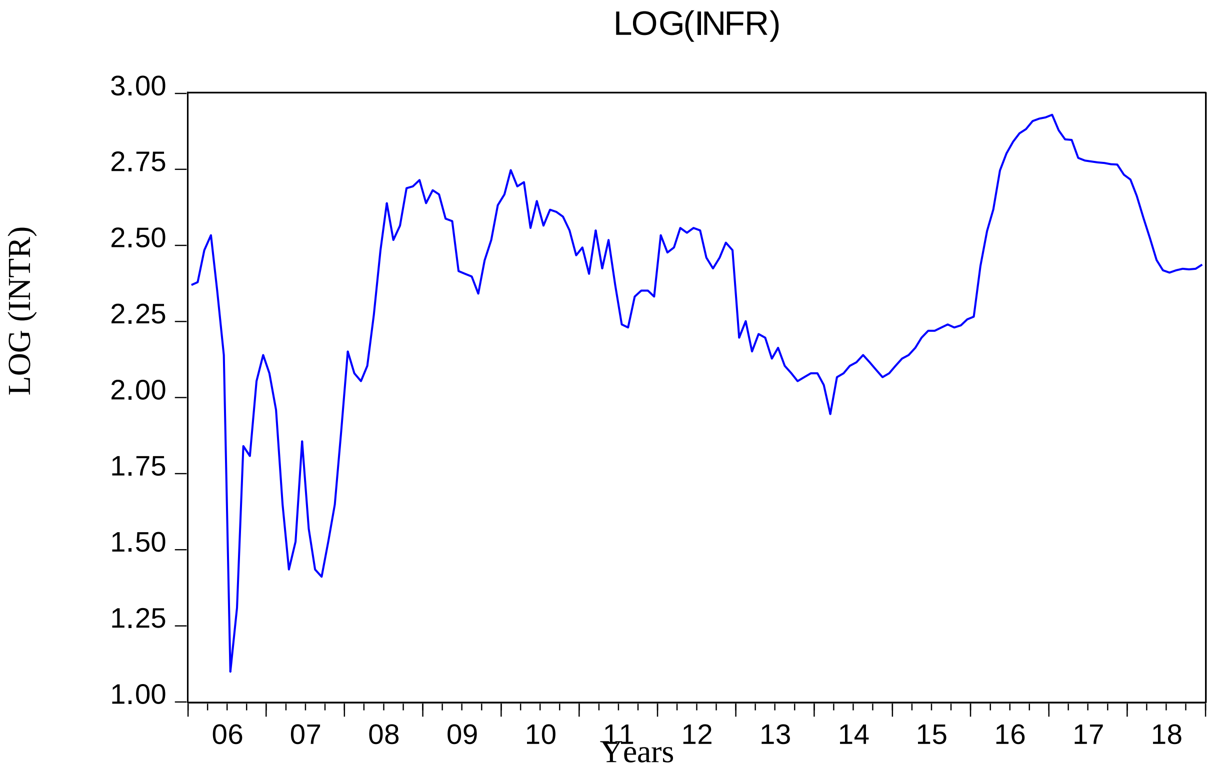

Figure: 4.3: Monthly Interest Rate

Table 4.1 Heteroskasticity Test
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.861364	Prob. F(10,141)	0.0555
Obs*R-squared	17.72576	Prob. Chi-Square(10)	0.0598
Scaled explained SS	208.4554	Prob. Chi-Square(10)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/02/19 Time: 14:17
Sample: 2006M05 2018M12
Included observations: 152

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.563235	0.250347	-2.249814	0.0260
LOG(INFR(-1))	-0.058043	0.047674	-1.217502	0.2254
LOG(INFR(-2))	0.046977	0.047269	0.993835	0.3220
LOG(EXCR)	0.027775	0.035027	0.792966	0.4291
LOG(EXCR(-1))	0.025587	0.035309	0.724663	0.4699
LOG(EXCR(-2))	0.030270	0.035624	0.849699	0.3969
LOG(EXCR(-3))	0.029110	0.035396	0.822402	0.4122
LOG(EXCR(-4))	0.023125	0.035174	0.657433	0.5120
LOG(OILP)	0.004882	0.016704	0.292272	0.7705
DUM2012	0.051143	0.029809	1.715653	0.0884
@TREND	-0.001749	0.000518	-3.378273	0.0009

R-squared	0.116617	Mean dependent var	0.014701
Adjusted R-squared	0.053966	S.D. dependent var	0.077110
S.E. of regression	0.075000	Akaike info criterion	-2.273029
Sum squared resid	0.793135	Schwarz criterion	-2.054195
Log likelihood	183.7502	Hannan-Quinn criter.	-2.184131
F-statistic	1.861364	Durbin-Watson stat	2.227089
Prob(F-statistic)	0.055456		

Source: Researche's computation using Eview Software Version ten.

4.2 To ascertain the stationary level of the series under consideration, unit root test was carried out using ADF

ADF Fisher Unit Root Test on GROUP03

Null Hypothesis: Unit root (individual unit root process)
Series: LOG(INFR), LOG(EXCR), LOG(OILP)
Date: 11/02/19 Time: 13:54
Sample: 2006M01 2018M12
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Total number of observations: 458

Cross-sections included: 3

Method	Statistic	Prob.**
ADF - Fisher Chi-square	11.5556	0.0726
ADF - Choi Z-stat	-0.98109	0.1633

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Intermediate ADF test results GROUP03

Series	Prob.	Lag	Max Lag	Obs
LOG(INFR)	0.1465	0	13	155
LOG(EXCR)	0.9105	6	13	149
LOG(OILP)	0.0232	1	13	154

Source: Researcher's Computation using Eview Software version 10

Table 4.3. Result of Unit root test for D (LOG (INFR), D(LOG (EXCR)), D(LOG(LOG(OILP)

Null Hypothesis: Unit root (individual unit root process)
Series: D(LOG(INFR)), D(LOG(EXCR)), D(LOG(OILP))
Date: 11/02/19 Time: 13:59
Sample: 2006M01 2018M12
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0
Total (balanced) observations: 462
Cross-sections included: 3

Method	Statistic	Prob.**
ADF - Fisher Chi-square	199.227	0.0000
ADF - Choi Z-stat	-13.2285	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Intermediate ADF test results GROUP04

Series	Prob.	Lag	Max Lag	Obs
D(LOG(INFR))	0.0000	0	13	154
D(LOG(EXCR))	0.0000	0	13	154
D(LOG(OILP))	0.0000	0	13	154

Source: Researcher's computation Using Eview Software Version Ten.

Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.537962	0.135248	3.977589	0.0001
@TREND	0.001965	0.000633	3.106037	0.0023
DLOG(INFR(-1))	0.151288	0.078022	1.939052	0.0545
DLOG(EXCR)	0.013598	0.055435	0.245290	0.8066
DLOG(EXCR(-1))	0.155152	0.066434	2.335412	0.0209

DLOG(EXCR(-2))	0.224918	0.066619	3.376198	0.0009
DLOG(EXCR(-3))	0.164925	0.055921	2.949246	0.0037
DUM2012	-0.127783	0.048611	-2.628696	0.0095
CointEq(-1)*	-0.153822	0.037338	-4.119657	0.0001

R-squared	0.192838	Mean dependent var	-0.000635
Adjusted R-squared	0.147682	S.D. dependent var	0.135400
S.E. of regression	0.125003	Akaike info criterion	-1.263572
Sum squared resid	2.234484	Schwarz criterion	-1.084527
Log likelihood	105.0315	Hannan-Quinn criter.	-1.190838
F-statistic	4.270482	Durbin-Watson stat	1.912873
Prob(F-statistic)	0.000126		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.578070	10%	4.19	5.06
K	2	5%	4.87	5.85
		2.5%	5.79	6.59
		1%	6.34	7.52

t-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-4.119657	10%	-3.13	-3.63
		5%	-3.41	-3.95
		2.5%	-3.65	-4.2
		1%	-3.96	-4.53

SOURCE: Researcher's computation using Eview software version ten.

5.1 Discussion

The first commission in our econometric analysis was to test for stationarity (unit root) in the time series properties of our data. Unit root tests were performed using the Augmented Dickey-Fuller (ADF) – Fisher unit root test. Results obtained from the tests in levels and when the data where first differenced.

ADF Fisher Unit Root Test; LOG (INFR) = 0.1465, Log (EXER) = 0.9105; LOG (OILP) = 0.0323; while Unit Root Test- First Differences, ADF- Fisher ΔLog (INFR) = 0.0000; DLOG (EXCR) = 0.0000 and DLOG (OILP) 0.0000 As shown in table 4.1 and 4.2, unit root test result from ADF –Fisher indicates that the variables are mostly not stationary in level series and are all stationary when first differenced. This means that the variables are integrated of the first order 1(1), thereby satisfying the requirement for the Johnson and Julius (1990) cointegration test which can only be adopted if the observed variable are 1(1)

: Cointegration Test Results

Sample (adjusted): 2006 MO1 2018MI2

Included observation 152 after adjustment. Trend assumption: Liner deterministic trend, series:Linear deterministic trend Series:
Selected model ARDL (2,4,0).
LOG (INFR (-1))*, LOG (EXCR (-1)) LOG (OILP) ** *P value incompatible with t-Bounds distribution .** variables interpreted as lags interval (in first differences): 1 to 1. z =z (-1) +D(Z).

The study uses Error Correction Model (ECM) to disaggregate the short run and long run effects of crude oil prices LOG (OILP), exchange rates LOG (EXCR), on inflation rates LOG (INFR) in Nigeria . ECM results showing the long run relationship between LOG (INFR) and its selected determinants are presented in table 4.5.
Long-run conintegration equation of LOG (INFR), LOG (EXCR), LOG (OILP)
Coefficients 0.151288, 0.01359 8, 0.0155152. Standard Error (0.040419) (0.084909) (0.028038)
t-statistic (-3.80568), (0.0357263), (-0.980344)
ECM cointegration result can be substituted in Equation
3.1 to explain the relationship between inflation rates and its selected explanatory variables. The impact of the selected explanatory variables on inflation rates (LOG (INFR) yielded statistically significant results; showing a positive relationship between LOG (INFR) and Crude Oil Prices; LOG (OILP), that is unit increase in LOG (OILP) leads to 0.151 percent increase in inflation rates. This result is compatible with theory and the actual events in the actual events in the case of Nigeria.

ARDL Error Correction

Error Correction result of LOG (INFR), DLOG (EXCR), DLOG (OIP)

CointEq (-)*, (- 01.153822), (0.037338), (-4.119647), [0.0001].
*p-value incompatible with t-Bounds distribution shows a 0.0001 error correction term with a 4.119657 statistical significance suggesting that the explanatory variables LOG (OILP), LOG(EXCR) are both the short and long-term Granger cause for LOG (INFR).
Inflation rates bear a slight burden of disperse error correction of short tem balance to achieve long term balance as little term balance as little as 15.38 percent within a year.
This study also tested for Serial Correlation in the estimated equation. Serial correlation arises when a variable has relationship with itself in a manner that the value of such a variable in past periods will have an effect on its future values. The Breusch-Godfry Lagrange multiplier (LM) test was used to test for general, high-order ARMA errors. The null hypothesis of the test is that there is no serial correlation in the residuals up to the specified order. An LM test may be used to test higher order ARMA errors and its applicable whether there are lagged dependent variables or not and is recommend (in preference to the DW Statistics). Whenever there are concerns with the possibility that errors exhibit autocorrelation. VEC Residual Serial Correlation LM tests ,the Null hypothesis : no serial correlation at lag order 'h' included observations 152 lags LM-Stat prob. Log (INFR) 0.0902 LOG (EXCR) 0.9760, LOG (OILP) O.6768. LM Statistic of -0480970 at 1 lag with a probability of 0.0902; hence the null hypothesis of no serial correlation is not rejected, that is there is no serial correlation in the equation estimated in this study. Inferences from this study can therefore be relied on.
Subsequent to the autocorrelation test, the study tested for heteroskedasticity using the Breusch-Pagan-Godfrey with no Cross terms. This test is a test of the null hypothesis of no heteroskedasticity against heteroskadisticity unknown, general form. The presence of heteroskadisticity means the model has some misspecifications, hence conclusive results cannot be derived from such a model. The p-value of 0.0000 less than 0.5 suggests that the null hypothesis of no heteroskadisticity or no misspecification will thus be rejected.

Therefore, the model used in this study does not suffer from any misspecification hence significant and can be relied on.

6.2 Recommendations

The results of the analysis of this study and many other studies in the literature emphasize that inflation is monetary phenomenon in the Nigerian economy. Therefore, the Central Bank should control the money supply to a degree that does not cause economic depression, since the liquidity increases is the main reason for inflation. Since inflation is affected by exchange rates and inflationary expectations, the Central Bank must be transparent in the application of foreign exchange policy, thus avoiding the inflation stems from inflationary expectations and protecting the exchange rate from excessive fluctuations by means of a more managed exchange rate policy.

The negative impact of crude oil price volatility on naira's exchange rate calls for urgent shift inNigeria economy from crude oil export to non-oil export through the exploration of other solid minerals and even agricultural produce. This is because Nigeria does not have control over crude oil price in international market as controlled by OPEC.(Organization of Oil producing and Exporting Countries).Thus diversification away from oil for primary product export will go a long way in reducing frequent fluctuations in the value of the naira. The ARDL Model isrecommended forfurther studies in modeling inflation expectations with other macroeconomic variables, such as trade openness, interest rates etc.

6.3 Contributions of this study.

(i) This study has contributed to the empirical work in the relationship between inflation and exchange rates and between inflation and oil prices,where empirical works on the subject is already limited.

(ii) The data treatment unambiguously confirm the negative effect of inflation rates on exchange rates volatility proves to be useful measure and highly comparable to existing measures and is therefore useful for further research.

(iii)This dissertation modifies the specification of the ARDL by the transformation of the data series into the Logarithm form which gives a more suitable relationship in cointegration analysis compared with the other form of analysis.

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