Exchange Rate Pass-Through, Exchange Rate Volatility and Inflation Rate in Nigeria

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Abstract—**Recently, the Nigerian economy has been experiencing significant exchange rate fluctuations, particularly depreciations in the foreign exchange market which has been accompanied with inflation. Given this background, This paper investigates the degree of pass-through of the official and parallel exchange rates to inflation as well as the relationship between exchange rate volatility and inflation in Nigeria based on monthly time series data (January 2006 to December 2015). It employs, among others, The Generalized Auto Regressive Conditional Heteroskedasticity (GARCH), technique in achieving its objectives. The results suggest that the parallel exchange rate passes through to inflation in the short run while the official exchange rate passes through to inflation in the long run exclusively. It also found out that exchange rate volatility has a positive and significant effect on inflation in the long run.**

Index Terms— Exchange rate, Pass-through, Volatility, Inflation, GARCH models

I. INTRODUCTION

Macroeconomic performance is determined by the unemployment rate, inflation rate, and the growth rate of output of an economy [1]. It is no wonder then that the issue of price stability, in addition to being the main aim of fiscal and monetary policy in both developed and developing countries, has also gained a huge amount of attention from economists and policy makers around the world.

Inflation can be defined as the persistent rise in the prices of goods and services. It has positive as well as negative implications. Inflation might be emphatically correspond with growth at some low levels, but at higher levels inflation is is liable to be unfavorable for growth [6]. The Central Bank of Nigeria (CBN) targets about 2 percent rate of inflation which shows that inflation can be a serious advantage to the economy especially during periods of economic stagnation. Inflation helps in debt settlement, creates employment and boost growth. On the other hand, the negative effects of high inflation cannot be overemphasized. Examining countries such as Germany in the early 1920s, Hungary in mid 1940s and Zimbabwe in late 2000s, further strengthens this fact [3]. Rising level of Inflation reduces the value of a currency which further erodes the purchasing power of money. It is usually associated with higher interest rates which results in low savings and discourages investment and long term growth. It also erodes export competitiveness and leads to balance of payment deficits.

Since 1980, inflation in the developing countries has doubled that of developed countries [4]. Average inflation rates in more advanced countries have taken various patterns in recent years, trending downwards after 2012 in developed countries, while remaining constant or expanding further in developing countries [5]. The trend of inflation in Nigeria have been characteristically positive ranging from creeping to running inflation. [2], discovered that inflation is inimical to growth when it approaches 10.5 to 12 per cent in Nigeria. According to Central Bank Statistical Bulletin (2005) high inflation was recorded in the early 1970's from 13.8 percent in 1971 to 16.0 percent in 1972 which could be explained by the oil boom period and the economic controls and measures that were introduced after the Biafra (civil war) of 1967 to 1970.

The oil glut of the early 1980's which led to high prices of oil in the domestic market marked another period of inflation in Nigeria which recorded 23.2 percent in 1983 and 39.6 in 1984. This led to the Structural Adjustment Programme (SAP) in 1986 which presented another inflation period in the late 1980's. According to [6], one major problem in the post SAP era was exchange rate instability which led to high output volatility, higher cost of foodstuffs, lower wages and salaries and high unemployment thereby creating burden on the poor. The early 1990's (1992-96) also recorded high inflation at an average of 57 percent and in 1995 inflation was seen to be as high as 72.8 percent. Inflation rate in Nigeria from 1996 to 2015 is averaged at 12.2 percent and in January 1996 inflation rate was as high as 47.56 percent. Inflation at 8.70 percent in September 2015. Nigeria has recorded high volatility in inflation rates and these fluctuations should therefore be a concern and should be checked by the monetary authorities.

The increasing over dependence of the Nigerian

economy on imports necessitates the need to continually check the extent to which exchange rate fluctuations transmits to consumer prices [7]. Exchange rate is a standout amongst the most imperative macroeconomic variables in the developing and emerging nations as it influences inflation, exports, imports and monetary action [8]. Exchange rate is the rate at which one currency is traded for one another currency. The modelling of exchange rate volatility has noteworthy ramifications for some monetary and budgetary matters. Exchange rate volatility alludes to swings or vacillations in exchange rates over a timeframe (Mordi, 1993). It is seen as the risk connected with sudden and unpredictable movements in the exchange rate [6].

There are a number of reasons why we need to study the relationship between exchange rate volatility and inflation. First and foremost, both exchange rate and inflation are important for the macroeconomic goal of price stabilization. Secondly, when exchange rate changes, particularly a depreciation, passes through to consumer prices resulting in inflation, our exports no longer become competitive due to high prices [9]. This is due to the fact that the high inflation cancels out the export competitiveness that would have resulted from exchange rate depreciation, therefore exchange rate becomes an ineffective in correcting balance of payment deficits and relieving debt burden. [7] gave four main reasons why we should study exchange rate volatility in Nigeria: Firstly, Nigeria's economy is driven by her external sector, secondly, there is the need for a stable and strong currency, thirdly, the inflation in Nigeria has become endemic and so there is need to check the extent to which exchange rate volatility contributes to it, and lastly but not least is the need to make the external sector competitive.

Prior to 1986, Nigeria Nigeria had embraced the fixed exchange rate regime which was upheld by trade control regulations that incited disequilibrium in the economy preceding the presentation of Structural Adjustment Program (SAP) [6]. The exchange rate had been relatively stable during this period. The SAP programme then introduced a second tier foreign exchange market that allowed for the determination of exchange rate by forces of demand and supply thereby introducing a flexible exchange rate regime which also created uncertainty in the foreign exchange market. Since then, Nigeria has been experiencing significant exchange rate depreciations till date. However from 1993 to 1998 exchange rate was fixed at 21.886 while inflation rose from 13.8 in 1991 to 72.8 9 (its highest) in 1995. In 1999 exchange rate was allowed to float and so it depreciated to 92.7, more than 3 times its value in 1998. Inflation however fell to 6.6 but continued increasing as the exchange rate continued depreciating. On 19th February 2015, the exchange rate was devalued from 168 to 199 Naira per dollar while the Naira exchange rate reached 213.2 from 196.13 Naira per dollar in the parallel market. Since March the CBN rate has remained almost fixed at about 197 Naira per dollar while creating a huge gap and severe exchange rate volatility in the parallel market due to dollar scarcity. Inflation during this period however increased gradually from 8.1 in February to 9.01 in December (Source: CBN website). These significant exchange rate depreciations coupled with speculations about 2015 general elections alongside dwindling oil prices and fuel scarcity adversely affected the economy, businesses and investments and led to an endemic inflation in the economy.

Thus, this study differs from other studies by separating the pass-through effects of the official and parallel exchange rates and establishing the effects of their volatility on inflation based on monthly time series data. The study is divided into five sections. Section one is the introduction, while section two provides some insights from the relevant literature. In section three, the empirical model used in the study is presented. Section four encapsulates the presentation of results from the estimation techniques and discussion while the last section concludes with some recommendations for policy and further research.

II. Some Insights From Extant Literature

The need for adjustments to structural disequilibria in developed countries resulting after the Great Depression led to development of vast researches on exchange rate pass-through in order to determine a nominal anchor for inflation [10]. However, although many authors highlight the relation between exchange rate volatility and exchange rate pass-through, the literature on the impact of exchange rate volatility is not as comprehensive as the one available on exchange rate pass-through [11].

Some authors have found out that pass-through rates have been declining over time. [12], investigated the reason why the prices of non-tradable goods and services responded by so little after large devaluations motivated by the devaluations in the U.K. (1992), Korea (1997) and Uruguay (2002). The author found that in Korea, inflation stayed stable after the devaluation. On the other hand, inflation climbed considerably in Uruguay after the devaluation. The devaluation in UK was generally little and was trailed by a gentle expansion and stable inflation. The model attributed this result to two situations: First, is sticky non tradable goods prices and second, is the effect of real shocks connected with large devaluations which prompted a decrease in the price of non-tradable goods relative to traded goods. [13] investigated declining pass-through rates over-time in twenty industrial countries and found out that exchange rate pass-through to consumer prices has been declining since the 1980s and asserted the monetary policy may be the reason for the declining rate of exchange rate pass-through.

[14] investigated slow pass-through in 76 countries using VAR analysis and found out that low pass-through rates were no longer unique to advanced countries as conventionally perceived as developing countries have recently been experiencing rapid downward trends in the degree of short-run pass-through, and in the speed of adjustment. [15] also discovered that levels of pass-through are largely uncorrelated with country size, among others based on 25 OECD countries. They also found that across the OECD countries, exchange rate pass-through is incomplete in the short-run, however over the long run, pass-through is common for many types of imported goods.

[11] in order to establish the relationship between exchange rate volatility and inflation in Brazil from 1999 found out that the relationship between exchange rate volatility and inflation is semi concave. Using bivariate GARCH model his results revealed that when volatility is very high, inflation response is low and the impacts are little, and therefore assumed that firms adopted a "wait and see" strategy when volatility is high in the short run. This also aligns with the findings of [16] and [17] in Nigeria. On the contrary, [18] investigated this relationship and found positive and significant relationship between exchange rate volatility and inflation in Nigeria from 1986 – 2012 using the Vector Error Correction Mechanism (VECM).

Another line of reasoning stems from the fact that in order to achieve a stable output, low inflation and exchange rate stability would be traded off. This is consistent with the findings of [4] conducted tests on a sample of eighty developing countries from 1980 to 1989 found out that there is a trade-off in the choice of exchange-rate regime between inflation or exchange rate volatility and output volatility and that inflation tends to be 10 percent higher in a country that adopts floating exchange rate regime than a country that adopts fixed exchange rate regime. However, [19] used a two-sector dependent-economy model to compare the properties of a series of different monetary rules and argued that the trade-off differs according to regime and that a flexible exchange rate policy that stabilizes output can do so without high inflation and exchange rate volatility.

III. THEORETICAL FRAMEWORK AND EMPIRICAL MODEL

A. Theoretical Framework

The theoretical backing establishing the relationship between exchange rate and inflation is the Purchasing Power Parity (PPP) doctrine. According to [20], PPP asserts that the exchange rate change between two currencies over any period of time is determined by the change in the relative price level the two countries. He also stated that the theory has also been referred to as the "Inflation Theory of Exchange Rates" as the theory asserts that the price level between two countries mainly determines exchange rate movements. It is now an established wisdom that the exchange rate parity does not hold across countries at every instant [21]. This is due to the fact that pass-through tends to be incomplete and prices sticky in the domestic country. [19] also found out that local currency pricing induces exchange rate volatility which in turn leads to deviations from purchasing power parity. Although according to [22], the relationship between exchange rate pass-through and law of one price is unclear and maintained that partial exchange rate pass-through is not necessarily an evidence against market integration, that is, law of one price.

However, [23] tested PPP in 31 developing countries and found out relative PPP holds almost exactly in the long-run. The result is also consistent with [24] interpretation of the consensus view of the PPP debate; that in the short-run PPP due to incomplete pass-through, does not hold while in the long-run PPP may hold due to the reversion of the real exchange rate to its mean. The Purchasing Power Parity theory would be adopted in this study. [25] analysed the consistency, persistency and severity of volatile exchange rate in Nigeria from 1986 to 2008 using the Purchasing Power Parity (PPP) model to analyse consistency and ARCH and GARCH models to analyse the severity of exchange rate volatility. The result indicated the existence of extreme volatility shocks and that both the real and nominal exchange rate are not consistent with the traditional long run PPP model in Nigeria.

B. Empirical Model and Sources of Data

The model adopted in this study are in two strands namely; The Generalised Auto Regressive Conditional Heteroscedasitic (GARCH 1, 1) Model and the Vector Auto Regressive (VAR) Model.

The GARCH model is used for the estimation of exchange rate The GARCH model is preferred over the standard deviation because it is sensitive to outliers and volatility clusters. It consists of a mean equation and a variance equation. The mean equation is specified as follows:

$$INFL_t=\pi_0+\pi_1 EXOF_{t-1}+\pi_2 EXPARL_{t-1}+\mu t \quad (1)$$

Where: $INFL_{t-1}$, $EXOF_{t-1}$ and $EXPARL_{t-1}$ are the current inflation rate, previous session of the official and parallel exchange rate respectively. π_1 is the coefficient of exchange rate while μt is the stochastic term of the model. The a priori expectation sign is $\pi_1 > 0$ and $\pi_2 > 0$.

The GARCH model allows the conditional variance to depend on its pervious lags, therefore the conditional variance in this case is:

$$\delta^2_t = \alpha_1 + \alpha_2\mu^2_{t-1} + \lambda_1\delta^2_{t-1} \quad (2)$$

Where: α_1 is the log run average variance which is constant, μ^2_{t-1} is the information about volatility observed in the previous period (ARCH term), δ^2_{t-1} is the lagged variance of exchange rate (GARCH term), $\delta^2 t$ is known as the conditional variance (i.e the variance of the error term derived from equation 3). It is one–period ahead forecast variance based on past information and is also known as the exchange rate volatility which would be plugged into VAR model.

Following this model, the econometric model for this study follows insights from [26] but with slight modifications. The model consists of two equations in order to analyse the effects of the official and parallel exchange rates separately which is specified as:

$$INFL = f(ERV, MSP, INT, OILP, EXOF, EXPARL) \quad (3)$$

The explicit form of equation 3 is represented as follows:

$$INFL_t=\beta_0+\beta_1 ERV+\beta_2 MSP+\beta_3 INT+\beta_4 OILP+\beta_5 EXOF+U_t \quad (4)$$

$$INFL_t=\beta_0+\beta_1 ERV+\beta_2 MSP+\beta_3 INT+\beta_4 OILP+\beta_5 EXPARL+U_t \quad (5)$$

From equation 4 and 5, the VAR model can be expressed as:

$$INFL_t=\beta_0+\beta_1ERV_{t-1}+\beta_2MSP_{t-1}+\beta_3INT_{t-1}+\beta_4OILP_{t-i}+\beta_5EXOF_{t-i}+U_t. \quad (6)$$

$$INFL_t=\beta_0+\beta_1ERV_{t-1}+\beta_2MSP_{t-1}+\beta_3INT_{t-1}+\beta_4OILP_{t-i}+\beta_5EXPARL_{t-i}+U_t. \quad (7)$$

Where *INFLt* = Inflation Rate at time t, *ERVt* = Exchange Rate Volatility at time t, *MSP*t = Broad money supply at time t *INTt* = Interest rate at time t, *OILPt* = Oil price at time t, *EXOFt* = Official exchange rate at time t, *EXPARLt* = Parallel exchange rate at time t and Ut = error term. The apriori expectation is such that $\beta_0 > 0$, $\beta_1 > < 0$, $\beta_2 > 0$, $\beta_3 < 0$, $\beta_4 > 0$, $\beta_5 > 0$.

The dependent variable, Inflation (*INFL*), is measured by the percentage change in the Consumer Price Index (*CPI*)**.** *INFL* is brought about by the other variables specified in the model while the error term (U_t) that covers the variables not included in the equation that might affect inflation.

The key explanatory variables in the study are brought in based on the various theories of inflation. The quantity theory of money and demand pull inflation recognises the role of money supply and interest rates in determining inflation, cost push inflation recognises the role of oil price and PPP recognises the role of exchange rates in determining inflation.

Exchange rate:- is domestic price of a foreign currency. The official (*EXOF)* exchange rate is controlled by the government while the parallel (*EXPARL*) is not controlled by the government and reflects the true value of a currency. Exchange rate volatility (*ERV*) is estimated from the GARCH model using monthly exchange rate data. It is the risk associated with fluctuations in exchange rate.

Money supply:- Broad money supply (M2) consists of currency notes in circulation and check deposits as well as quasi money which includes savings and time deposits and money market mutual funds.

Interest rate:- Deposit interest rate is the amount paid to individuals who have deposit accounts in financial institutions.

Oil price:- Crude oil price measures the spot price of barrels of oil in the world market which is usually determined by the Organisation of Petroleum Exporting Countries (OPEC).

To test the empirical evidence, the Johansen Co-integration technique would be used to determine the long run relationships among the variables. Co-integration ensures that the linear combination of variables are stationary while regression analysis using ordinary least squares (OLS) based on time series data discretely assumes all values to be stationary which may not always be the case. The regression of a non-stationary time series data will lead to spurious (nonsense) regression thereby leading to misleading results. The restricted VAR (also VECM) would also be used to determine the short run relationships among the variables. However, the coefficients from VAR are often difficult to interpret and so further interpreted with estimates from impulse response function (IRF) [27]. Therefore, the Impulse Response Function and Variance Decomposition Analysis would be used to further specify interrelationships among the variables for this study. As similar approach was done by [28].

The econometric software which would be used for this study is E-views 7. Monthly data spanning from January 2006 to December 2012 in Nigeria would be analysed for the purpose of this study. The data used in the estimation process are sourced from the Central Bank of Nigeria.

IV. Empirical Results And Discussions

A. Results from Econometric Estimation

a. The Estimation of GARCH Model

The GARCH model was used in testing for the effect of exchange rate volatility on Inflation from 2006M1 to 2015M12 and the results as reported in Table 2 shows that both the volatility of the official and parallel exchange rates have negative effects on inflation in the short run. However the relationship between the parallel exchange rate volatility and inflation is significant at 5% level while the official exchange rate volatility is not significant in determining inflation judging by the probability value of 0.9309. This implies that a 1% increase in the parallel exchange rate volatility or official exchange rate volatility would lead to a less proportionate decrease in inflation by about 0.003 %.

TABLE 1. Garch Result

Mean Equation				
Variable	Coefficient	Std. Error	z-Stat	Prob.
DLEXPARL	0.114	0.065	1.751	0.080
DLEXOF	-0.046	0.048	-0.970	0.332
C	-0.003	0.002	-1.196	0.232
Variance Equation				
C	0.000	0.000	1.556	0.120
RESID(-1)^2	0.735	0.221	3.325	0.001
GARCH(-1)	0.067	0.256	0.261	0.794
DLEXPARL	-0.003	0.0014	-2.444	0.0145
DLEXOF	-0.003	0.0036	-0.087	0.9309
R-squared	0.2279	Mean var		-0.006
Adjusted R2	0.0059	S.D. var		0.0412

Note: Dependent Variable: DLINFL\GARCH=C(4)+C(5)*RESID(-1)^2+C(6)*GARCH(-1)+C(7)*DLEXPARL +C(8)*DLEXOFF
Source: *Computed by researcher using E-views7*

The mean equation shows a positive significant relationship between the parallel exchange rate and inflation in Nigeria at the 10% level however the co-efficient shows that pass- through is low and inelastic in the short run. It also reveals a negative but not significant relationship between official exchange rate and inflation which means the official exchange rate does not pass through to inflation that in the short run. The summation of the ARCH and GARCH components (0.73 and 0.067) is less than one; therefore we can conclude that volatility is not persistent.

B. Johansen Maximum Likelihood Co-integration

Based on unit root test, all variables were found to be integrated of order one I (1), therefore we can then proceed to co-integration. Johansen maximum likelihood co-integration is used to determine the co-integrating rank and number of common stochastic trends in the system. The variables are presented in their log-linear form because they reduce the problem of heteroscedasticity and are useful in showing rates of changes [29].The co-integration test would be carried out to determine the nature of the long run relationship between exchange rate volatility based on the objective of the study.

Table 2. Unrestricted Co-Integrating Test

Trace Statistic				
No. of CE(s)	**Eigenvalue**	Trace **Stat**	**C. V.**	**Prob.****
None *	0.389	119.219	95.75	0.0005
At most 1	0.199	61.5144	69.82	0.1918
At most 2	0.153	35.5317	47.86	0.4203
At most 3	0.085	16.0826	29.8	0.7064
At most 4	0.043	5.657	15.49	0.7356
At most 5	0.004	0.509	3.842	0.4756
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level				
Maximum Eigenvalue				
No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**C.V**	**Prob.****
None *	0.389	57.7047	40.08	0.0002
At most 1	0.199	25.9828	33.88	0.3218
At most 2	0.153	19.449	27.58	0.3806
At most 3	0.085	10.4256	21.13	0.704
At most 4	0.043	5.148	14.26	0.723
At most 5	0.004	0.509	3.842	0.4756
Max-eigen test indicates 1 cointegrating eqn(s) at 0.05 level				

Source: Authors' *Computation using E-views 7*

The result of the co-integration rank test presented below reveal that there is one co-integration equation for both the Trace and the Max-Eigen statistic at the 5% level. These results suggest that the VECM is appropriate model to use for this specification.

The results from the Johansen co-integration test are displayed below in Table 4. The T-statistics is used to show the significance of the independent variable in the long run. If the T-statistics is approximately equal to 2 or greater than 2, the variable is statistically significant but however, if the T-statistics is less than 2, the variable is not statistically significant.

Based on the result above, it can be concluded that there is a positive and significant relationship between exchange rate volatility and inflation rate in the long run. A 1% increase in exchange rate volatility leads to a more than proportionate increase in inflation by about 2%. This means that a stable exchange rate is necessary to curb inflation in Nigeria.

Table 3. Co-Integration Result

Normalized co-integrating coefficients T- statistic [ ]					
LINFL	**LERV**	**LINTR**	**LMSP**	**LOILP**	**LEXOF**
1	-1.9852	0.0634	-3.1374	0.6036	-3.8314
	[-7.4208]	[0.0990]	[-2.76]	[0.5776]	[-0.9513]
LINFL	**LERV**	**LINTR**	**LMSP**	**LOILP**	**LEXPARL**
1	-2.2124	0.6020	-8.0564	5.1675	8.597
	-[6.3079]	[0.7282]	[-6.46]	[3.8243]	[2.2644]

Source: Authors' *Computation using E-views 7*

The result shows that there is a negative relationship between interest rate and inflation. A 1% increase in interest rate would lead to about 0.06% and 0.6% less proportionate decrease in inflation for model 1 and 2 respectively and vice versa. This is theoretically expected as increased interest rates increases savings rate and decreases current consumption. However, this relationship is insignificant judging by the t-stat of 0.0990 and 0.7282, respectively.
There is also a positive and significant relationship between money supply and inflation in the long run based on the result. This is expected based on the quantity theory of money. A 1% increase in money supply will lead to a more than proportionate increase in inflation by about 3% for the official exchange rate equation and 6% for the parallel exchange rate equation and vice versa.

The result however reveals a negative relationship between oil price and inflation. A 1% decrease in oil price would increase inflation less proportionately by about 0.6% and more than proportionately by 5% for model 1 and 2 respectively and vice versa. This is not theoretically expected but could be attributed to the structure of the Nigerian economy during this period. Since, the Nigerian economy depends mostly on oil for her exports, a decrease in oil price worsens the terms of trade balance and depreciates the exchange rate, thereby making imports more expensive and making consumer prices rise. This relationship however is insignificant for the official exchange rate equation but significant for the parallel exchange rate equation.

Also, in the long run, a 1% increase in the parallel exchange rate would lead to a more than proportionate decrease in inflation by about 9% which is significant while a 1% increase in the official exchange rate would lead to more than proportionate increase in inflation by about 4% but is insignificant. This shows that in the long run, the official exchange rate passes through to inflation while the parallel exchange rate does not.

C. Vector Error Correction Model

The presence of co-integration relationship between the variables means that the restricted VAR (VECM) should be used for the estimation. The VECM restricts the log run behavior of endogenous variables to incorporate short run disequilibria. The short run deviations are corrected through series of adjustments. To satisfy the stability condition the VECM should have a negative sign, lie between 0 and 1 and be statistically significant.

The co-efficient of the error term has a negative sign and is statistically significant for both models. This shows that there a long run convergence between inflation and the independent variables. The co-efficient shows that for model 1 and 2 about 0.46% and 0.3% of errors in the current period will be corrected in the subsequent period respectively which implies a slow speed of adjustment. This slow speed could be attributed to sticky prices i.e. prices take time to adjust downwards and so when there is short disequilibrium, it takes a long time before it converges to its long run equilibrium.

Table 4. Vector Error Correction Results

Model 1		Model 2	
Dependent	D(LINFL)	Dependent	D(LINFL
ECM	-0.0046	ECM	-0.003
	[-3.9814]		[-3.5014]
D(LINFL(-1))	0.8621	D(LINFL(-1))	0.825
	[20.5290]		[18.1068]
D(LERV(-1))	-0.0064	D(LERV(-1))	-0.0048
	[-2.5331]		[-1.9846]
D(LINTR(-1))	-0.02786	D(LINTR(-1))	-0.0216
	[-1.4436]		[-1.1072]
D(LMSP(-1))	-0.00486	D(LMSP(-1))	-0.0158
	[-0.1188]		[-0.3857]
D(LOILP(-1))	0.0329	D(LOILP(-1))	0.0393
	[1.6813]		[1.8678]
D(LEXOF(-1))	-0.03628	D(LEXPARL(-1))	0.0067
	[-0.4574]		[0.1112]
C	-0.00018	C	-0.0003
	[-0.10044]		[-0.1815]
R-squared	0.8273	R-squared	0.823
Adj.Rsquared	0.8162	Adj. R-squared	0.8116
F-statistic	74.581	F-statistic	72.386

Source: Authors' *Computation using E-views 7*

The result of the estimation for the official exchange rate equation shows that the explanatory variables account for about 83% of the variations in inflation and 82% for the parallel exchange rate equation. The results of the estimation give the short run relationships among the variables. The result reveals that exchange rate volatility is the only significant variable and has a negative relationship with inflation in the short run. The results of the estimation of the remaining variables follow a priori expectations apart from money supply. The negative relationship between money supply and inflation could be due to the fact that broad money supply includes time and savings deposits which are not yet in circulation and do not contribute to inflation in the short run.

D. Impulse Response Analysis

The impulse response function shows the accumulated response of inflation to one standard deviation shock to each of the variables.

Table 5. Accumulated Response of Inflation

Period	LINFL	LERV	LEXOF	LEXPARL	LINTR	LMSP	LOILP
1	0.02	0.000	0.0000	0.0000	0.0000	0.000	0.000
2	0.05	0.001	-0.0006	-0.0001	-0.002	0.000	0.002
3	0.10	0.010	-0.0013	-0.0008	-0.006	-0.0007	0.007
4	0.15	0.020	-0.0015	-0.0023	-0.012	-0.0024	0.014
5	0.21	0.040	-0.0008	-0.0047	-0.018	-0.005	0.021
6	0.28	0.070	0.001	-0.008	-0.026	-0.0087	0.029
7	0.36	0.100	0.0039	-0.0122	-0.034	-0.0133	0.038
8	0.44	0.140	0.0079	-0.0173	-0.042	-0.0189	0.046
9	0.52	0.190	0.0129	-0.0231	-0.051	-0.0254	0.054
10	0.61	0.250	0.0188	-0.0296	-0.06	-0.0326	0.062

Source: Authors' *Computation using E-views 7*

From the plot below there is clear evidence of the effect of exchange rate volatility on inflation over the 10 period interval. According to the table the immediate effect of a shock to LERV at say period 9 is about 24% increase in inflation. The full effect of this shock would be realized as the period increases.

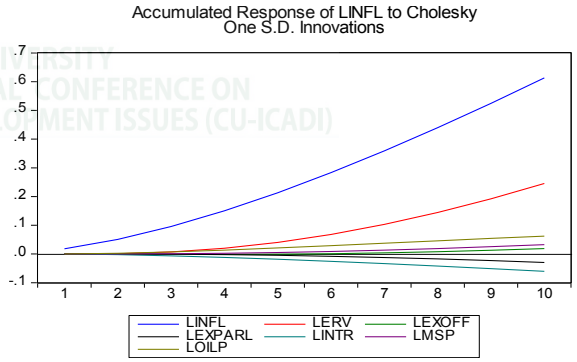

Fig 1. Accumulated Response of Inflation
Source: Authors' *Computation using E-views 7*

The diagram above shows no relatioship between inflation and shocks to the variables throughout the 1st period. However from the 2nd to the 10th period inflation showed a postive reponse to shocks from exchange rate volatility and oil price throughout, while the postive response started from the 3rd period for money supply shocks and 6th period for the official exchange rate. The accumlated response of inflation to the parallel exchange rate and interest rate is negative throughout the period.

E. Variance Decomposition Analysis

Variance decomposition analysis shows the relative contributions of shocks in the independent variables to inflation variance (i.e changes in inflation).

The variance decomposition of inflation has shown that in the first period none of the independent variables could

explain changes in inflation. While exchange rate volatility caused significantly large changes in inflation, other variables caused relatively smaller changes in inflation. For instance, in the 7th period, exchange rate volatility, interest rate, money supply and oil price account for about 10uints, 0.87unit, 0.19unit. and 1unit changes in inflation respectively.

Table 6. Variance Decomposition

Period	LINFL	LERV	LEXOF	LEXPARL	LINT	LMSP	LOILP
1	100.0	0.000	0.0000	0.0000	0.0000	0.000	0.000
2	99.10	0.060	0.0269	0.0003	0.3761	0.000	0.425
3	97.40	1.100	0.0256	0.0134	0.6273	0.016	0.790
4	95.10	3.050	0.0137	0.0413	0.7628	0.049	1.017
5	92.40	5.520	0.0130	0.0769	0.8322	0.091	1.112
6	89.60	8.180	0.0276	0.1154	0.8627	0.139	1.120
7	86.80	10.80	0.0541	0.1543	0.8706	0.187	1.079
8	84.30	13.30	0.0883	0.1919	0.8657	0.234	1.016
9	82.00	15.60	0.1264	0.2274	0.8541	0.279	0.944
10	79.90	17.70	0.1656	0.2601	0.8392	0.320	0.874

Source: Authors' *Computation using E-views 7*

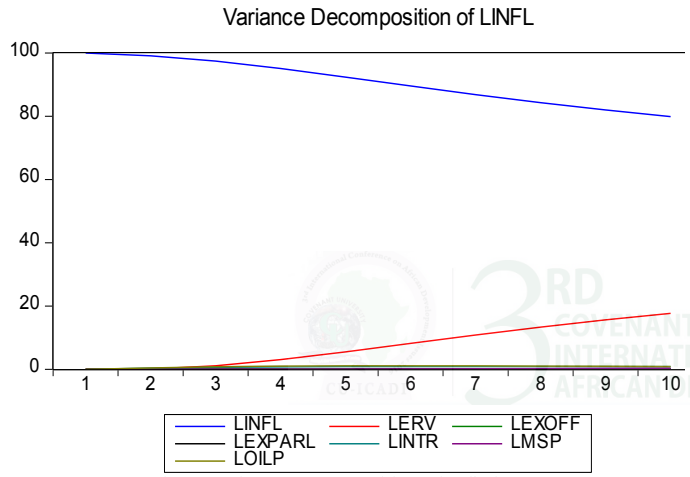

Fig 2. Variance Decomposition of Inflation
Source: Authors' *Computation using E-views 7*

V. Summary of Results and Conclusion

A. Summary of Main Findings

This study examines the degree of pass-through of the official and parallel exchange rates to inflation as well as the relationship between exchange rate volatility and inflation in Nigeria based on monthly time series data from January 2006 to December 2015). The Generalized Auto Regressive Conditional Heteroscedasticity (GARCH), Cointegration, Vector Auto Regression (VAR) analysis, Impulse Response Function and Variance Decomposition techniques were used in examining the relationship. Inflation is modeled as a function of exchange rate volatility, official and parallel exchange rate, interest rate, money supply and oil price.

The GARCH and VECM results reveal the there is a negative and significant relationship between exchange rate volatility and inflation in the short run while the co-integration result reveal a positive significant relationship in the long run. The short run result supports the work of [11], which showed that when volatility is high, inflation response is reduced as firms adopt a "wait and see" strategy. The impulse response and variance decomposition functions also reveal that exchange rate volatility very significant in determining inflation response and variance. The results also reveal that the parallel exchange rate only passes through to inflation in the short run while official exchange rate only passes through to inflation in the long run. This means that the higher official exchange exchange rate would generate a poor inflation response in the short run and its effects would only be revealed in the long run. Also, the results in this present study suggest that exchange rate pass through is low in the short-run. This corroborate previous studies such as [14], [15], and [30] where it has been established that the notion of sticky prices is expected.

B. Recommendations

Furthermore, it was found that interest rate is negative but not significant in determining inflation both in the long and short run. Broad money supply has a negative insignificant relationship with inflation in the short run due to time deposits but positive and significant in the long run as theoretically expected. Oil price has a positive insignificant relationship with inflation in the short run but negative in the long run due to unfavorable terms of trade balance. Finally, the coefficient of error correction term indicate a rather a slow but significant speed of adjustment from the short-run distortion to long-run equilibrium due to sticky prices in the short-run.

Finally, from the results of the empirical study, the following recommendations are proposed to ensure price stability in Nigeria. Firstly, the the Central Bank should strengthen the managed float system, such that the parallel exchange rates are left to freely operate through the workings of demand and supply, while the official exchange rate is strictly managed by the central bank so that it is not devalued to reflect the value of the currency operating in the parallel market. This is due the fact that, the increases in the parallel exchange rate would affect inflation or may cause economic hardships only in the short run but not in the long run. However, a depreciation or devaluation of the official exchange rate would ultimately increase inflation over the long run. Secondly, the government should set up proper approaches and procedures that will guarantee the support of an exceptionally stable exchange rate as this is an important determinant of inflation. Thirdly, there is need to provide foreign exchange in order to reduce dollar scarcity and close the gap between the parallel and official exchange rate. Therefore, the government should direct its spending to the yielding sectors of the economy such as agriculture and manufacturing as this will go far in expanding the production of goods and services thereby stabilizing the exchange rate.

This current study is confronted with some limitations as it relies on the dollar exchange rate for the model therefore the relationship may not be the same if other major currencies were added in the model. The scope (i.e. January 2006 to December 2015) was also limited by available data. Thus, complementing what has been done in this study, it is recommended future scholars should focus on using other alternate currencies such as the Euro to model the relationship between exchange rate and inflation. It may also be interesting to do a panel data study across countries in order to further strengthen the research.

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