INFLATION AND EXCHANGE RATE VOLATILITY PASS-THROUGH IN NIGERIA

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Abstracts

The paper investigates the impact of exchange rate volatility pass-through on price inflation in Nigeria. Annualised time-series data ranging from 1981 to 2015 was used and due to adjustment and generation of data for other variables from the sourced data, the paper used 30 years annualised data for its estimation. Vector Error Correction Model (VECM) was used to estimate the relationship that exists between the stated key variables. VECM estimation shows that all the variables specified in the model are relevant in Granger causing inflation in the long-run. ECM at long-run indicates a correction of deviation in one period and this is statistically significant at the 1 per cent significance level. We found no short-run relationship between inflation and exchange rate volatility, likewise with government expenditure, import, foreign direct investment and trade openness. However, money supply exhibited a positive relationship with inflation in the short-run. Variance decomposition makes it evident that other salient variables/factor included in the model contribute to change in inflation more than exchange rate volatility. We recommend that federal government agencies in Nigeria especially the Central Bank of Nigeria (CBN) and the Federal Ministry of Finance (FMF) should continue to take inflation targeting in the long-term as part of its monetary policy regime. The CBN should start given attention to the trade openness and foreign direct investment in managing the inflation. This paper discredits the public opinion that exchange rate volatility warranted inflation in the short-run. The paper investigates the impact of exchange rate volatility on inflation in Nigeria.

Keywords: *Time Series Inflation, Exchange Rate Volatility, Money Supply, Public Expenditure, Trade Openness, GARCH and VECM.*

JEL Code: C22, E31, E44, E5, H5, F41.

1. Introduction

A general rise in the price level of goods and services is a concern to the general populace in an economy, especially the indigent population because it implies a reduction in the real value of money. In Nigeria, the indigent population which account for over 72 per cent of the country's population tend to be more sensitive to Naira depreciation (Central Bank of Nigeria, 2014). In June 2014 the exchange rate was 155 Naira per 1 USD, but depreciated to about 500 Naira per 1 USD in the parallel market by the month of February 2017, amidst the perennial problem of high-interest rate (Nweze, 2017). Controlling inflation is an important task for the government and for this, both fiscal and monetary policies are utilised to meet this goal. Inflation notably has a negative effect on demand and positive effect on the supply side of goods and services in the economy. Speculations of high inflation rate took centre stage in the Nigerian media since international oil price began to fall in September 2014. This lead to shortages of foreign reserve needed to sustain the fixed exchange rate regime in Nigeria. There was general postulation that shortage of the US dollar coupled with the reluctance in floating the exchange rate will push up the inflation rate in the country. The Central bank of Nigeria floated the exchange rate in February 2018, but the inflation rate double to about 18.6 percent, a level that was last experienced in 11 years ago (Doya, 2016; The Economist, 2016; BBC News, 2016).

The Nigerian economy relies extensively on importation to sustain its teeming population along with high oil export for revenue and relatively low non-oil export. However, the country had a negative trade balance in the year 2015 in contrast to the previous years (Central Bank of Nigeria, 2015). As such, the shortage of foreign reserve currency in US Dollars to facilitate import demand implies price rises especially when there is no or insufficient locally produced substitute for the imported commodity. On this background, this study set out to investigate the effect of exchange rate volatility on inflation in Nigeria. This study aims to verifying whether exchange rate volatility has a direct effect on the inflation or not in Nigeria. The investigation is necessary in order to determine which policy action will be most appropriate for the Nigerian economy. Is it better to control exchange rate fluctuation or some other macroeconomic variables? The rest of the paper is classified into four sections Vis-a-Vis; review of relevant literature, methodology adopted, analysis and estimation of results, conclusion and policy recommendations.

2. Literature Review

2.1. Theoretical Review

There are various theories proposed by scholars as determinants of inflation but this study considers basically three of those theories. These are the Monetarist's view, the Keynesian theory and the structuralist theory of inflation.

Monetarist View: To the Monetarists, inflation is always a monetary phenomenon. They emphasise the role of money as the principal cause of demand-pull inflation. This classical theory of inflation employs the Fisher' Equation of Exchange:

$$MV=PQ$$

(where M=money supply; V=velocity of money; P=price level; Q=Real output) assumes that V and Q are constant, and P varies proportionately with M. Hence inflation proceeds at the same rate at which the money supply expands. Theoretically, when the money supply increases it creates more demand for goods but due to full employment, the supply of goods cannot be increased. This leads to a rise in prices. It is a continuous and prolonged rise in the money supply that will lead to true inflation (Jhingan, 2010). Currency depreciation implies more money supply (M) to maintain the same level of nominal expenditure (PQ) prior depreciation and vice versa.

Keynesian Theory: The Keynesian view emphasises the increase in aggregate demand as the source of demand-pull inflation. When the value of aggregate demand exceeds the value of aggregate supply at the full employment level, an inflationary gap arises. The larger the gap between aggregate demand and aggregate supply, the more rapid the inflation. This short run analysis assumes that prices are fixed and are determined by non-monetary forces (Jhingan, 2010). According to the Keynesian view, inflation can be caused by an increase in demand and or increase in cost. Demand-pull inflation is caused by excess demand which can originate from high exports, strong investment, and the rise in money supply or government financing its spending by borrowing. Keynesian theory of cost-push inflation attributes the cause of inflation basically to supply-side factor. This means that rising production costs will lead to inflation (Adeniji, 2013).

Structuralist Theory: According to Jhingan (2010), the structuralist stress structural rigidities as the principal cause of inflation in developing countries such as Brazil, Argentina and Chile and others. To the structuralists, inflation is necessary for growth. As the economy develops, rigidities arise which lead to structural inflation. In the initial phase, there are increases in non-agricultural incomes accompanied by the high growth rate of the population that tend to increase the demand for goods. According to Adeniji (2013), this theory is believed to evolve from the less developed countries, South America specifically shortly after the Second World War. Here, a host of non-monetary supply oriented factors influencing the price levels in the economy is considered.

The General Equilibrium Theory of Exchange Rate states that the exchange rate of a country depends upon the demand and supply of foreign exchange. If the demand for foreign exchange is higher than its supply, the price of the foreign currency will go up. Similarly, if the demand of foreign exchange is lesser than its supply, the price of foreign exchange will decline at the expanse of the local currency (Kanamori & Zhao, 2006).

2.2. Conceptual Review

Inflation refers to a persistent average increase in the general level of prices of goods and services. According to Ukemenam (2016), inflation simply refers to change in the consumer price index (CPI). Arinde (2002) asserted that inflation is a situation of rising prices and costs in an economy. Therefore, inflation is the erosion of the purchasing power or real value of money in an economy. Inflation can be classified into four based on its magnitude: creeping inflation, walking inflation, running inflation and hyperinflation (Madesha, Chidoko & Zivanomoyo, 2013).

2.2.1. Need to Fight Inflation

The Central Bank of Nigeria like any other apex bank in the world implements monetary policies in an attempt to control inflation because of its dire consequences which include:

discouragement of long-term planning; reduction of savings, capital accumulation and investment; misallocation of resources and creation of uncertainty and distortion in the economy among others. The apex bank in the world ensures that price stability - good management of inflation is always one of the core objectives of the macroeconomic policy targets. Inflation (instability in price) has a trickled down effect to individuals in the following ways: it makes the creditors be worse off, decreases the living standard of the salary and wage earners, recipients of transfer payment also worse off. Meanwhile, equity holders and investors, businessmen and agriculturalists stand to gain during price instability because the value of their inventory rises and prices of consumer goods rises rapidly.

2.2.3. Exchange Rate Volatility

The exchange rate is relevant in the achievement of the Central Bank's macroeconomic goals because the exchange rate is one of the monetary aggregates through which monetary policy is channelled in order to achieve set policy targets such as ideal unemployment rate, inflation rate and economic growth among others. The exchange rate is an intermediate policy variable through which monetary policy is transmitted to the larger economy through its impact on the value of the domestic currency, domestic inflation (which is the pass-through effect), the external sector, macroeconomic credibility, capital flows, and financial stability (Monetary Policy Department, CBN, 2006).

The term foreign exchange rate has been defined as the price of the unit of one country's currency expressed in terms of another country's currency. It is the relative price that measures the worth of a domestic currency in relation to a foreign currency (Ezike, 2009; Pandey, 2008; Unuafe, 2005). The foreign exchange rate is the medium by which one currency is converted into another (Esezobor, 2009). In general, the exchange rate of currency A in terms of currency B is the number of units of B needed to buy one unit of A. For instance, the exchange rate between the UK and USA is the price of dollars in terms of pounds (Copeland, 2005).

Exchange rate policy has been defined as the framework, rules and other measures designed to determine and influence the level of the exchange rate at a given point in time (Ezike, 2009). Basically, there are two types of exchange rate regimes: fixed exchange rate system and floating exchange rate system. According to Unuafe (2005), under the fixed exchange rate system, the government pegs the rate of exchange of its currency with respect to goods or to other convertible currencies while under the floating exchange rate system, the rate of exchange of a country's currency with respect to other currencies is depended solely on the forces of demand and supply.

Volatility is the measure of the amount of randomness in an asset return at any particular time. There is volatility when the values of a given series change rapidly from period to period in an unpredictable manner (Greene, 2003). Therefore, exchange rate volatility refers to a swing or fluctuation over a period of time in the exchange rate (Bala & Asemota, 2013). Olusola and Opeyemi (2013) also explained that exchange rate volatility has to do with the unusual movements of the exchange rate.

2.2.4. Exchange Rate Volatility on Inflation Rate

Exchange rate volatility does have a pass-through effect on price inflation, especially in the developing countries of the world. Mostly, the developing countries serve as a feeder to the developed countries and rely on the developed countries for the supply of capital items and some consumer items inclusive. A depreciation in the local currency usually makes the imported commodity becomes dearer because more of local currency would now be needed to buy the same item which had been valued at a lesser amount initially. It passes through importation of both consumer and capital goods. On capital goods, when producers spend more to buy their intermediate inputs, they reflect it on the price of their items. Also, 'import-competing firms might increase prices in response to an increase in foreign competitor price in order to improve profit margins' (Mulwa, 2013). In summary, the extent of a country's importation determines the extent of a pass-through effect it will experience.

On the other hand, the pass-through effect of exchange rate volatility had been found to be slow in some economies. Even though there were empirical investigations to what could account for that, but it is worthy of note that most time the developing countries used to adjust their economies to fit into global structure patterned out by the developed economies. While the developed economies carried out devaluation mostly to take care of attendant economic expansion and inflationary control. Golberg and Knetter (1997) note that a very low exchange-rate pass-through has been observed in New Zealand, Brazil and Australia, where substantial depreciation has taken place after 1997 without having a proportional effect on inflation. The pass-through effect of exchange rate volatility is not limited to inflation but equally has an effect on investment and trade.

Furthermore, Gidigbi and Akanegbu (2017) assert that due to a shortage of hard currencies that is exchange rate volatility, it becomes difficult for most third world countries to maintain a promising monetary policy or balance of payments. In Nigeria, exchange rate volatility led to banning of forty items from the list of items that are benefitting from the official forex, and among the banned items is Eurobond/purchasing of shares. The situation may degenerate to a point whereby the government of the country may not allow individuals to hold a claim on foreigners, or some kind of claims or claims dominated in foreign currencies. Being a mixed economy system, the government simply put it to the public that for certain transactions, the official forex window is not available but an individual can source anywhere else.

2.3. Empirical Review

Okoli, Mbah and Agu (2016) examined the relationship between exchange rate volatility and inflation in Nigeria. The Granger-causality test shows that there is a unidirectional causality running from inflation to real exchange rate volatility. This implies that depreciation of the Naira exchange rate will not trigger more inflationary tendencies within the economy.

In their study, Obiekwe and Osubuohien (2016) investigated the degree of pass-through of the official and parallel exchange rate to inflation as well as the relationship between exchange rate volatility and inflation in Nigeria employing monthly time series data 2006:01 to 2015:12. The Generalised Autoregressive Conditional Heteroscedasticity (GARCH) and VECM results indicate that there is a negative and significant relationship between exchange rate volatility and inflation in the short run while the co-integration result shows a positive significant relationship between the variables in the long run. The study also reveals 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.

Exchange rate volatility and inflation in Nigeria was also empirically studied by Inam (2015) using annual data spanning 1970 to 2011. The Ordinary Least Squares (OLS) regression result indicates that the exchange rate has an insignificant, negative effect on the inflation rate. This implies that when exchange rate depreciates, inflation rate decreases and vice versa. There was no causality between the two variables in Nigeria as indicated by the result of the Granger-causality test.

Using annual time series data from 1986 to 2012, Adeniji (2013) investigated exchange rate volatility and inflation upturn in Nigeria via the Vector Error Correction Model (VECM) and Granger-causality. The results of VECM show that exchange rate volatility, money supply and fiscal deficit are positively and significantly related to inflation while real Gross Domestic

Product (GDP) has a negative and insignificant relationship with inflation. Also, the Granger –causality outcome shows a bi-directional relationship between the variables.

Bobai, Ubangida and Umar (2013) also carried out an assessment of exchange rate volatility and inflation in Nigeria based on annual time series data from 1986 to 2010. The result of VECM shows that there is a negative shock between exchange rate and inflation which means that an increase in inflation rate leads to a decrease in the exchange rate.

According to Madesha, Chidoko and Zivanomoyo (2013), there is a long run relationship between exchange rate and inflation and both variables were found to Granger-cause each other. This is based on Granger –causality test carried out to test the relationship between exchange rate and inflation in Zimbabwe using annual time series data spanning 1980 to 2007.

Erol and Wijnbergen (1997) empirically analysed the relationship between real exchange rate targeting and inflation in Turkey using quarterly data from 1980:1 to 1993:4. The outcome of the simulation experiments with a macro-model of exchange rate policy for Turkey indicates a moderate inflationary consequence of real exchange rate policy based on the relative purchasing power parity (PPP). The real exchange rate appreciation is found to be contractionary.

3. Methods and Model Specifications

This paper is a cause and effect experimentation. In order to successfully execute this, data for variables of interest were extracted from the Central Bank of Nigeria Statistical Bulletin for the year 2015, covering the period of 1981 to 2015. However, the estimation only involved data from 1986 to 2015 due to the generation of the variable that is not directly provided in the statistical bulletin. Most of the variables are measured in Billion Naira (₦) with the exception of the inflation rate, which is measured in percentage and the exchange rate volatility is measured as standard deviation of the exchange rate for the five periods covering the last four previous and current periods. Also, government expenditure over gross domestic input is measured as the ratio of the government expenditure to gross domestic output. The conventional definition of trade openness is adapted. This paper adopts the Vector Error Correction Model (VECM) as the method of model estimation and specified in equation 3.1. The VECM specification only indicates inflation model again, others were generated but not reported (see appendix), and so, the only model of interest was specified.

3.2. Model Specification:

$$INF_t = \beta_0 + \beta_1 LINF_{t-1} + \beta_2 \sum_{j=1}^{n=8} X_{1,t-1} + +\upsilon_t^{LINF} \ldots\ldots\ldots\ldots\ldots (3.1)$$

$$\sum_{j=1}^{n=8} X_{1,t-1} = \beta_1 LIMP_{t-1} + \beta_2 LM2_{t-1} + \beta_3 LINTR_{t-1} + \beta_4 LGTEXP\_GDP_{t-1}$$
$$+ \beta_5 LGTEXP_{t-1} + \beta_6 LFDI_{t-1} + \beta_7 EXCRV5_{t-1} + \beta_8 LTOP_{t-1} \ldots\ldots (3.1.1)$$

Table 3.1: Variable Definition

LINF	Log of the Inflation rate
LIMP	Log of Import Value
LM2	Log of Money Supply
LINTR	Log of Interest Rate
LGTEXP_GDP	Log of Government Expenditure over Outputs
LGTEXP	Log of Government Expenditure
LFDI	Log of Foreign Direct Investment
LEXCRV5	Log of Exchange Rate Volatility (5 periods SD)
LTOP	Log of Trade Openness

3.2.1. Econometrics Diagnostic

The following diagnostic test was carried:

3.2.1.1. Unit Root Tests

Econometric methodologies assume stationary time series data to estimate ordinary least squares, even though stationarity may not exist in the data in the real sense. Time series data to be used are expected to be stationary that is constant variance over time and the covariance value between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed (Gujarati & Porter, 2009).

It becomes imperative to test for stationarity of the variables of concern, in order to rule out the presence of serial autocorrelation from the study analyses, which may result in spurious statistical outputs. This paper uses the Augmented Dickey-Fuller (ADF) unit root test because the data of interest are time-series in nature. Philips-Perron (PP) is also used to test for the unit-root test in an instance where induced stationarity could not be achieved at first difference under the ADF test. X in the model implies any variable of interest to be tested.

Augmented Dickey-Fuller unit root test specification:

$$\Delta \boldsymbol{x_t} = \boldsymbol{\rho_t} + \boldsymbol{\rho x_{x-1}} + \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \boldsymbol{\delta_i} \Delta \boldsymbol{x_{t-1}} \dots\dots\dots\dots\dots\dots (3.2)$$

The expectation about the variables to be used prior to the estimation as stated in the model 3.1 is that it should be -1≤ ρ ≤ 1, achieved through equation 3.2

3.2.1.2. Cointegration Test

Economically speaking, variables in the specified model for this paper should have a long run or equilibrium relationship. Thereby, they are subjected to Johansen and Juselius cointegration test to verify the existence of their long-run relationship. If the variables involve are not stationary at the level, then the variables involve will be differenced so that their linear combination will cancel out the stochastic trends in them. Cointegration model according to Johansen (1991) specified in equations 3.3.1 to 3.3.3:

$$\Delta Log(Y)_t = \prod Log(Y)_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Log(Y)_{t-1} + aLog(X)_t + \epsilon_t \quad \dots\dots (3.3.1)$$

$$\Delta Log(Y)_t = \prod Log(Y)_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Log(Y)_{t-1} + aLog(W)_t + \epsilon_t \quad \dots\dots (3.3.2)$$

$$\Delta Log(W)_t = \prod Log(W)_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Log(W)_{t-1} + aLog(X)_t + \epsilon_t \quad \dots\dots (3.3.3)$$

The pattern continues until all the included variables are covered.

4. Analysis and Estimation of Results

4.1. Descriptive Statistics

The data in percentage, ratio and standard deviation were revealed by their means; and the ones with the same unit of measurements such as IMP, M2, GTEXP and FDI maintained the same pattern of mean. Following the Central Limit Theorem (CLT), it is assumed that each of the time series variables is normally distributed irrespective of its Jarque-Bera's probability value since the observation is up to 30. Less attention was given to the maximum and minimum values towards data cleaning since the data are for the emerging economy.

Table 4.1: Descriptive Statistics

	INF	IMP	M2	INTR	GTEXP_GDP	GTEXP	FDI	EXCRV5	TOP
Mean	20.77081	3111.511	4568.331	12.34383	3.612948	1656.520	3.15E+09	10.80743	0.229197
Median	12.07481	1171.601	1175.974	12.88042	3.691129	982.8578	1.87E+09	5.601520	0.165006
Maximum	76.75887	11076.07	18893.71	23.24167	8.202188	5185.318	8.84E+09	44.53879	0.647326
Minimum	0.223606	5.983600	27.38980	5.699167	0.106469	16.22370	1.93E+08	1.78E-15	0.001371
Std. Dev.	19.77085	3832.676	6237.623	3.908137	2.868037	1807.011	2.76E+09	12.54245	0.205229
Skewness	1.538864	1.104587	1.177780	0.667441	0.240903	0.837195	0.776167	1.613698	0.521313
Kurtosis	4.091752	2.673957	2.844966	3.597058	1.614456	2.150666	2.131120	4.518641	1.916843
Jarque-Bera	13.33042	6.233445	6.965873	2.672983	2.689838	4.406190	3.955864	15.90295	2.825376
Probability	0.001274	0.044302	0.030717	0.262766	0.260561	0.110461	0.138355	0.000352	0.243488
Observations	30	30	30	30	30	30	30	30	30

Source: *Authors' computation using Eviews 8*

4.2. Unit-Root Tests

The unit root tests result summarised in Table 4.2 shows that all the variables of interest are of induced stationarity at the integration of order one that is I(1) with the exception of interest rate (INTR) and exchange rate volatility (EXCRV5) which are stationary at level. All the variables are statistically significant at 1 per cent significance level with the exception of interest rate (INTR), which is statistically relevant at the 5 per cent significance level. In carrying out the test, the PP test was used for M2 and GTEXP as earlier stated and ADF test was used for all other variables.

Table 4.2: Unit Root Tests

Variable	Test statistics	t-statistics	Prob.	Significance Level	Order of integration
INF	ADF	-4.635852	0.0045	1 percent	I(1)
IMP	ADF	-5.272354	0.0009	1 percent	I(1)
M2	PP	-4.453786	0.0069	1 percent	I(1)
GTEXP_GDP	ADF	-8.409116	0.0000	1 percent	I(1)
GTEXP	PP	-6.752230	0.0000	1 percent	I(1)
FDI	ADF	-7.057841	0.0000	1 percent	I(1)
EXCRV5	ADF	-3.628391	0.0.447	5 percent	I(1)
TOP	ADF	-5.520775	0.0005	1 percent	I(1)

Source: *Authors' computation using Eviews 8*

Table 4.3 shows the result of the volatility test on the variable- exchange rate. The statistical significant coefficient of RESID(-1)^2 (this can equally be referred to as the ARCH test) under the variance equation implies the presence of volatility in the exchange rate variable.

Furthermore, adding the ARCH and GARCH's coefficients at lag one still gives a result of one, which buttresses the presence of volatility in the variable.

Table 4.3: Volatility Test on Exchange Rate

Dependent Variable: Exchange Rate				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.993791	1.313924	0.756354	0.4494
		Variance Equation		
C	2.034055	2.552224	0.796974	0.4255
RESID(-1)^2	1.798579	0.649241	2.770278	0.0056
GARCH(-1)	-0.040719	0.227951	-0.178631	0.8582

Source: *Authors' computation using Eviews 8*

4.3. Cointegration Estimation

The unit root tests show that all the variables of concern are not stationary until the first difference; testing for cointegration becomes imperative to ascertain whether the variables in the model share long-run relationship. The cointegration test results are reported in table 4.4. Both the Trace and Maximum Eigenvalue test results are based on Rank Test, thereby, any of the results is valid. Maximum-Eigenvalue test is used for the further analysis. The test output that indicates 4 cointegrating equations at the 5 per cent significance level was used since the data generation procedure for some choice variables caused our data to be reduced to 30 periods after the adjustment and it seems not reasonable to further reduce our data period. Cointegration test result that may permit sufficient data for further analysis was preferred to others which may require more data for lagging or lead to insufficient data.

Table 4.4: Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Max-Eigen Statistic	0.05 Critical Value
None	0.981028	360.0706**	114.9789**	159.5297
At most 1	0.964921	245.0917**	97.15478**	125.6154
At most 2	0.832752	147.9369**	51.86000**	95.75366
At most 3	0.690465	96.07694**	34.00786**	69.81889
At most 4	0.599143	62.06908**	26.51036	47.85613
At most 5	0.559501	35.55873**	23.77555**	29.79707
At most 6	0.320638	11.78318	11.21145	15.49471
At most 7	0.019522	0.571735	0.571735	3.841466

Trace test indicates 6 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level (sic)
** denotes rejection of the hypothesis at the 0.05 level
Source: *Authors' computation using Eviews 8*

4.4. Vector Error Correction (VECM) Estimation

Vector Error Correction Model (VECM) was used to estimate the relationship between the inflation, exchange rate volatility and other control variables due to the fact that the variables are of induced stationarity at first difference and there exist some cointegrating equations among them. As earlier noted, Max-Eigen Statistic that indicates four (4) cointegrating equation was applied in VECM specification with a lag of 1, 1. Only the inflation (INF) equation specification is reported in Table 4.5 and other equations are reflected in the VECM estimation table in Appendix.

The long-run estimation from the equation shows that all the variables exhibit a long-run relationship with the inflation (INF) and that any deviation in the variable will be restored within a period time; there is convergence within one period. This Error Correction Mechanism (ECM) coefficient is statistically significant at the 1 per cent significance level. Referring to the observed relationship, this finding is in consonance with Obiekwe and Osubuohien (2016), Madesha, Chidoko and Zivanomoyo (2013) and contrary to that of Inam (2015) and Adeniji (2013); though, Adeniji (2013) used the same method as ours.

Table 4.5: Vector Error Correction Model (VECM) Estimation

Variable	Coefficient	t-statistics	Prob.	0.05 Significance Level
ECM	-1.025334	-4.397226	0.0004	Significant
D(LOG(INF(-1)))	-0.204649	-1.546695	0.1415	Not significant
D(LOG(IMP(-1)))	0.395569	0.340540	0.7379	Not Significant
D(LOG(M2(-1)))	3.815726	4.179709	0.0007	Significant
D(LOG(GTEXP_GDP(-1)))	7.056561	1.725104	0.1038	Not Significant
D(LOG(GTEXP(-1)))	-7.230557	-1.686199	0.1112	Not Significant
D(LOG(FDI(-1)))	0.261908	0.923263	0.3696	Not Significant
D(LOG(EXCRV5(-1)))	-0.038737	-1.115961	0.2809	Not Significant
D(LOG(TOP(-1)))	-0.284345	-0.24279	0.8113	Not Significant
C	-0.518623	-1.48285	0.1575	Not Significant
R-squared	0.915538			
Adj. R-squared	0.852192			
F-stat	14.45292			

Source: *Authors' computation using Eviews 8*

In the short-run, it is only Money Supply (M2) that shows a positive and statistically significant relationship with the inflation. Most of the other variables exhibited a negative relationship, but not statistically significant. Meanwhile, Obiekwe and Osubuohien (2016) observed significant negative coefficient between exchange rate volatility and inflation but ours is not statistically significant. The Coefficient of Determination (R2) shows that the model accounts for 91.55 per cent of the total variation in the Inflation (INF), which is very robust and the Adjusted R^2 for the goodness of fit is 85.21 per cent, which implies that the model is still robust. Other statistics are used to verify the VECM concerning stability.

4.4.1 Serial Correlation LM and Stability Tests

It is imperative to carry out other tests such as these because the conventional estimation output would not give us a clue about this unless the model is re-estimated using conventional Ordinary Least Squares (OLS). Table 4.6 below shows the output from the Breusch-Godfrey Serial Correlation LM test. The test result with a probability value of F-statistic greater than 5 per cent implies non-rejection of the null hypothesis of no of serial correlation. It means the past error does not affect the present one in our data. More so, the CUSUM Test in Figure 4.1 shows that the model is dynamically stable as the blue trend line is within the 5 per cent significance level boundaries.

Table 4.6: Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.860787	Prob. F(2,14)	0.4440
Obs*R-squared	3.175615	Prob. Chi-Square(2)	0.2044

Source: *Authors' computation using Eviews 8*

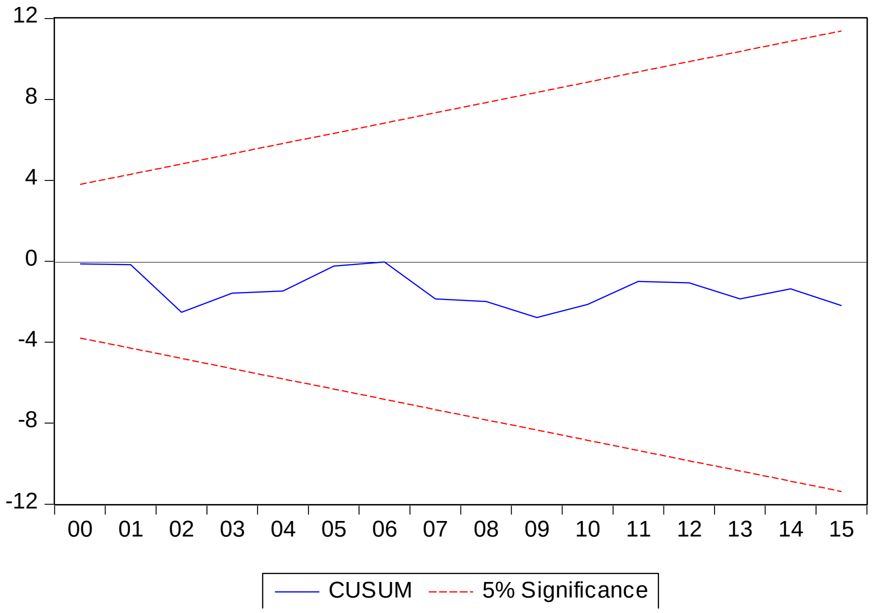

Figure 4.1: Stability Test

Source: *Authors' computation using Eviews 8*

4.5 Impulse Response Output

The impulse response outputs shown in Table 4.7 indicate the accumulated response of inflation to one standard deviation shock of each of the variable in the table. It is vivid from the table that the accumulated response of inflation (INF) to exchange rate volatility (EXCRV5) is the only positive response in all the periods. Shock to EXCRV5 at period 9, imparts inflation by 13 per cent. Frankly, we cannot rule out the fact of exchange rate volatility contributing positively to inflation but in long-run.

Table 4.7: Impulse Response of LOG(INF)

Period	LOG(INF)	LOG(IMP)	LOG(M2)	LOG(GTEXP_GDP)	LOG(GTEXP)	LOG(FDI)	LOG(EXCRV5)	LOG(TOP)
1	0.522129	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	-0.376133	0.864819	0.187266	-0.362780	0.089215	0.140462	0.481404	-0.174549
3	-0.253440	0.520787	0.331908	0.066221	-0.079574	0.033815	0.144557	-0.216344
4	-0.203583	0.450004	-0.076960	0.056363	0.032064	-0.070480	0.182397	-0.386826
5	-0.319830	0.145991	-0.266468	0.064732	-0.084975	-0.153398	0.098035	-0.450986
6	-0.308170	0.142435	-0.270270	0.202844	-0.006727	-0.102988	0.153338	-0.490326
7	-0.316264	0.000494	-0.318778	0.042483	0.107749	-0.127923	0.114629	-0.361268
8	-0.295318	0.056373	-0.390944	0.033220	0.131452	-0.105636	0.143172	-0.411555
9	-0.343442	-0.043938	-0.391136	0.000335	0.151740	-0.132639	0.136286	-0.356193
10	-0.327523	0.027799	-0.366318	-0.007278	0.180716	-0.084066	0.161036	-0.337758

Source: *Authors' computation using Eviews 8*

Figure 4.2 shows the response of inflation to one standard deviation innovations to other variables. It is evident from the figure that all the variables exhibited a relationship with inflation, especially starting from the second period. The much glaring relationship among all is an import (IMP), exchange rate volatility (EXCRV5), foreign direct investment (FDI) and government expenditure (GEXP).

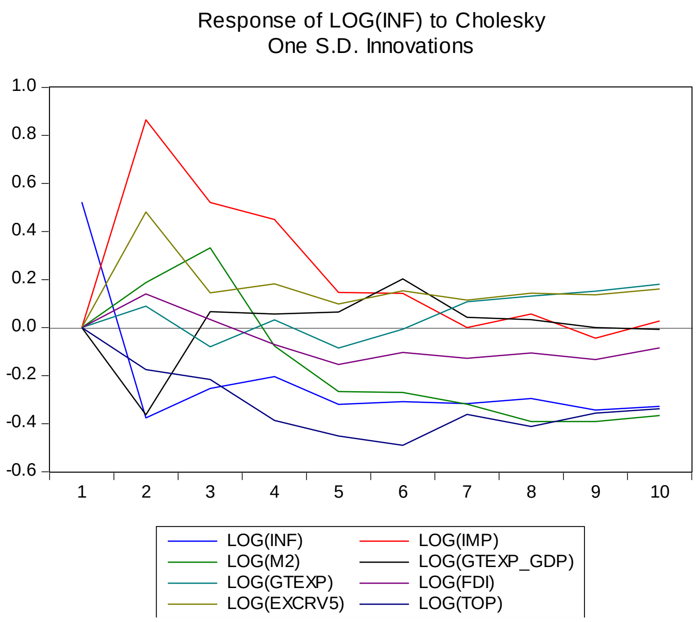

Figure 4.2: Impulse Response Graph
Source: *Authors' computation using Eviews 8*

4.6 Variance Decomposition Output

Variance decomposition shows the relative contribution of the variables of choice to change in inflation. Variance decomposition of inflation is reported in Table 4.8. It is evident that none of the variables contributed to inflation in period one. A general view of the variance decomposition outputs shows that over the period, some variables contribution to change in inflation decline, while some others gained momentum. Over the period, the contribution of import (IMP) to change in inflation declined considerably, but still high. Likewise, that of exchange rate volatility is at a slow rate, but substantial, all through, it has positive innovate on inflation and only variable with that feature. However, trade openness (TOP), foreign direct investment (FDI), government expenditure (GTEXP) and money supply (M2) have been gaining momentum steadily and slowly. Trade openness and money supply contributed much to the change in inflation among the variables that are having an increasing change to inflation.

Table 4.8: Variance Decomposition of LOG(INF):

Period	S.E.	LOG(INF)	LOG(IMP)	LOG(M2)	LOG(GTEXP_GDP)	LOG(GTEXP)	LOG(FDI)	LOG(EXCRV5)	LOG(TOP)
1	0.522129	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.272239	25.58365	46.20758	2.166621	8.131118	0.491742	1.218932	14.31801	1.882349
3	1.464161	22.31243	47.53926	6.774604	6.343728	0.666642	0.973660	11.78518	3.604497
4	1.608016	20.10170	47.24553	5.845758	5.382323	0.592462	0.999354	11.05750	8.775368
5	1.740191	20.54192	41.04490	7.336200	4.734123	0.744328	1.630348	9.758932	14.20925
6	1.879441	20.29932	35.76245	8.357320	5.223439	0.639399	1.697980	9.032054	18.98803
7	1.976708	20.91061	32.32956	10.15579	4.768223	0.875151	1.953793	8.501331	20.50555
8	2.090459	20.69255	28.97961	12.57801	4.288674	1.177914	2.002303	8.070373	22.21057
9	2.197488	21.16857	26.26541	14.55075	3.881088	1.542777	2.176330	7.688013	22.72706
10	2.291502	21.51012	24.16916	15.93680	3.570171	2.040733	2.136005	7.563987	23.07303

Source: *Authors' computation using Eviews 8*

5. Conclusion and Policy Recommendations

The paper investigated the impact of price inflation and exchange rate volatility by using annual time series data within a vector error correction model. The results with the exception of money supply show that exchange rate volatility along with other model variables does not Granger cause inflation in the short-run during a twelve-months calendar period. However, in the long-run all the variables contribute to change in inflation and deviation from equilibrium is corrected with a speed of adjustment of about 103 per cent. Therefore, the findings indicate that exchange rate volatility does not have a short-run effect on inflation in Nigeria, but rather other factors such as trade openness, foreign direct investment, government expenditure and money supply contribute to change in inflation more significantly than exchange rate volatility.

Consequently, government monetary agencies in Nigeria should utilise other economic metrics such as foreign direct investment, trade openness along with exchange rate in its monetary policy framework towards the control of inflation in the long run. Monetary control measures through the use of government expenditure and interest rates in the banking sector should be used more in the short-run towards the control of inflation. The Nigerian government's decision to float the domestic currency and restrict import since the year 2016 has yielded mixed results.

Therefore, Policymakers should aim at setting policies that will promote the export segment of the economy through diversification into non-oil exports and development of internal mechanisms that will promote capital investment. This should help to reduce pressure on the federal reserve through the foreign exchange market and uphold the strength of the domestic currency in the long term.

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Appendix

Date: 04/11/18 Time: 10:53
Sample (adjusted): 1987 2015
Included observations: 29 after adjustments
Trend assumption: Linear deterministic trend
Series: INF IMP M2 GTEXP_GDP GTEXP FDI EXCRV5 TOP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.981028	360.0706	159.5297	0.0000
At most 1 *	0.964921	245.0917	125.6154	0.0000
At most 2 *	0.832752	147.9369	95.75366	0.0000
At most 3 *	0.690465	96.07694	69.81889	0.0001
At most 4 *	0.599143	62.06908	47.85613	0.0014
At most 5 *	0.559501	35.55873	29.79707	0.0097
At most 6	0.320638	11.78318	15.49471	0.1676
At most 7	0.019522	0.571735	3.841466	0.4496

Trace test indicates 6 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.981028	114.9789	52.36261	0.0000
At most 1 *	0.964921	97.15478	46.23142	0.0000
At most 2 *	0.832752	51.86000	40.07757	0.0015
At most 3 *	0.690465	34.00786	33.87687	0.0483
At most 4	0.599143	26.51036	27.58434	0.0681
At most 5 *	0.559501	23.77555	21.13162	0.0207
At most 6	0.320638	11.21145	14.26460	0.1439
At most 7	0.019522	0.571735	3.841466	0.4496

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Vector Error Correction Estimates
Date: 04/11/18 Time: 17:59
Sample (adjusted): 1987 2015
Included observations: 29 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4
LOG(INF(-1))	1.000000	0.000000	0.000000	0.000000
LOG(IMP(-1))	0.000000	1.000000	0.000000	0.000000
LOG(M2(-1))	0.000000	0.000000	1.000000	0.000000
LOG(GTEXP_GDP(-1))	0.000000	0.000000	0.000000	1.000000
LOG(GTEXP(-1))	-0.731696	-0.575572	-1.353792	-0.640314
	(0.34121)	(0.05609)	(0.10489)	(0.05378)
	[-2.14440]	[-10.2620]	[-12.9072]	[-11.9068]
LOG(FDI(-1))	0.600501	-0.056230	-0.453131	0.279190
	(0.21909)	(0.03601)	(0.06735)	(0.03453)
	[2.74088]	[-1.56134]	[-6.72828]	[8.08540]
LOG(EXCRV5(-1))	-0.180083	-0.026844	-0.014582	0.014482
	(0.02107)	(0.00346)	(0.00648)	(0.00332)
	[-8.54794]	[-7.75173]	[-2.25171]	[4.36168]
LOG(TOP(-1))	0.575089	-0.581956	0.429962	-0.333613
	(0.28103)	(0.04619)	(0.08639)	(0.04429)
	[2.04639]	[-12.5980]	[4.97723]	[-7.53220]
C	-9.420091	-3.151864	12.42859	-3.371386

Error Correction:	D(LOG(INF))	D(LOG(IMP))	D(LOG(M2))	D(LOG(GTEXP_GDP))	D(LOG(GTEXP))	D(LOG(FDI))	D(LOG(EXCRV5))	D(LOG(TOP))
CointEq1	-1.025334	0.016676	-0.047018	0.104173	0.124557	0.317047	-1.407139	0.095254
	(0.23318)	(0.09458)	(0.05389)	(0.07252)	(0.06991)	(0.12583)	(4.00172)	(0.11153)
	[-4.39723]	[0.17632]	[-0.87240]	[1.43649]	[1.78177]	[2.51967]	[-0.35163]	[0.85405]
CointEq2	1.744970	-0.475693	0.034057	0.064083	-0.073293	-2.523122	37.92580	-0.142608
	(1.52139)	(0.61707)	(0.35164)	(0.47316)	(0.45611)	(0.82098)	(26.1096)	(0.72770)
	[1.14696]	[-0.77089]	[0.09685]	[0.13544]	[-0.16069]	[-3.07330]	[1.45256]	[-0.19597]
CointEq3	0.763412	0.447384	-0.125329	0.480142	0.522492	1.670526	5.795737	0.443681
	(0.77270)	(0.31341)	(0.17860)	(0.24032)	(0.23165)	(0.41697)	(13.2609)	(0.36959)
	[0.98798]	[1.42750]	[-0.70174]	[1.99797]	[2.25547]	[4.00634]	[0.43706]	[1.20046]
CointEq4	2.076391	1.821325	0.005570	0.411391	0.285326	-2.297792	16.31432	1.965144
	(1.40901)	(0.57149)	(0.32567)	(0.43821)	(0.42242)	(0.76034)	(24.1809)	(0.67395)
	[1.47366]	[3.18699]	[0.01710]	[0.93880]	[0.67546]	[-3.02207]	[0.67468]	[2.91588]
D(LOG(INF(-1)))	-0.204649	-0.116167	0.003276	-0.023942	-0.025954	0.019317	0.725670	-0.090613
	(0.13231)	(0.05367)	(0.03058)	(0.04115)	(0.03967)	(0.07140)	(2.27073)	(0.06329)
	[-1.54669]	[-2.16462]	[0.10712]	[-0.58181]	[-0.65430]	[0.27054]	[0.31957]	[-1.43177]
D(LOG(IMP(-1)))	0.395569	-0.075643	0.019480	-0.364340	-0.247986	1.073739	-34.14910	-0.187629
	(1.16159)	(0.47114)	(0.26848)	(0.36126)	(0.34824)	(0.62683)	(19.9349)	(0.55561)
	[0.34054]	[-0.16055]	[0.07256]	[-1.00852]	[-0.71210]	[1.71297]	[-1.71303]	[-0.33770]

D(LOG(M2(-1)))	3.815726	-0.356742	0.332551	0.246796	0.187422	0.121640	21.31467	-0.609018
	(0.91292)	(0.37028)	(0.21100)	(0.28392)	(0.27369)	(0.49263)	(15.6672)	(0.43666)
	[4.17971]	[-0.96345]	[1.57604]	[0.86924]	[0.68479]	[0.24692]	[1.36046]	[-1.39472]
D(LOG(GTEXP_GDP(-1)))	7.056561	2.493588	1.149235	-0.416280	-0.927659	-2.089345	-61.30702	1.307171
	(4.09051)	(1.65910)	(0.94545)	(1.27217)	(1.22633)	(2.20735)	(70.2001)	(1.95654)
	[1.72510]	[1.50298]	[1.21554]	[-0.32722]	[-0.75645]	[-0.94654]	[-0.87332]	[0.66810]
D(LOG(GTEXP(-1)))	-7.230557	-3.484016	-1.009470	0.152271	0.668540	3.502020	71.81238	-2.188273
	(4.28808)	(1.73923)	(0.99111)	(1.33362)	(1.28556)	(2.31396)	(73.5908)	(2.05104)
	[-1.68620]	[-2.00319]	[-1.01852]	[0.11418]	[0.52004]	[1.51343]	[0.97583]	[-1.06691]
D(LOG(FDI(-1)))	0.261908	-0.272739	0.062875	-0.001415	0.037538	-0.086118	1.833804	-0.334659
	(0.28368)	(0.11506)	(0.06557)	(0.08823)	(0.08505)	(0.15308)	(4.86838)	(0.13569)
	[0.92326]	[-2.37044]	[0.95895]	[-0.01604]	[0.44139]	[-0.56257]	[0.37668]	[-2.46641]
D(LOG(EXCRV5(-1)))	-0.038737	-0.014372	-0.009032	0.005439	0.008981	0.049111	-0.158333	0.004595
	(0.03471)	(0.01408)	(0.00802)	(0.01080)	(0.01041)	(0.01873)	(0.59572)	(0.01660)
	[-1.11596]	[-1.02083]	[-1.12577]	[0.50383]	[0.86297]	[2.62185]	[-0.26579]	[0.27677]
D(LOG(TOP(-1)))	-0.284345	-0.132136	0.012337	0.355847	0.243067	-1.510179	25.57902	0.007885
	(1.17115)	(0.47501)	(0.27069)	(0.36423)	(0.35111)	(0.63198)	(20.0989)	(0.56018)
	[-0.24279]	[-0.27817]	[0.04558]	[0.97697]	[0.69228]	[-2.38959]	[1.27266]	[0.01408]
C	-0.518623	0.747082	0.169934	0.144904	0.172106	-0.279776	-6.580289	0.662617
	(0.34975)	(0.14186)	(0.08084)	(0.10877)	(0.10485)	(0.18873)	(6.00224)	(0.16729)
	[-1.48285]	[5.26649]	[2.10217]	[1.33216]	[1.64140]	[-1.48240]	[-1.09631]	[3.96093]
R-squared	0.915538	0.805495	0.435613	0.714535	0.712634	0.838084	0.465546	0.741437
Adj. R-squared	0.852192	0.659616	0.012323	0.500437	0.497110	0.716647	0.064706	0.547515
Sum sq. resids	4.361893	0.717568	0.233021	0.421903	0.392044	1.270169	1284.682	0.997928
S.E. equation	0.522129	0.211774	0.120681	0.162385	0.156533	0.281754	8.960615	0.249741
F-statistic	14.45292	5.521669	1.029111	3.337415	3.306516	6.901398	1.161426	3.823378
Log likelihood	-13.68057	12.48893	28.79764	20.18977	21.25411	4.208897	-96.11829	7.706649
Akaike AIC	1.840039	0.035246	-1.089493	-0.495846	-0.569249	0.606283	7.525399	0.365059
Schwarz SC	2.452965	0.648172	-0.476567	0.117080	0.043677	1.219209	8.138325	0.977984
Mean dependent	-0.012376	0.259432	0.225394	0.145442	0.197534	0.116149	0.114575	0.199718
S.D. dependent	1.358090	0.362984	0.121431	0.229748	0.220735	0.529306	9.265392	0.371268

Determinant resid covariance (dof adj.)	1.19E-12
Determinant resid covariance	1.02E-14
Log likelihood	137.8835
Akaike information criterion	-0.129898
Schwarz criterion	6.282248

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.860787	Prob. F(2,14)	0.4440
Obs*R-squared	3.175615	Prob. Chi-Square(2)	0.2044

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 04/12/18 Time: 14:36
Sample: 1987 2015
Included observations: 29
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.102723	0.264269	0.388706	0.7033
C(2)	-0.061740	1.537397	-0.040159	0.9685
C(3)	-0.369582	0.837327	-0.441383	0.6657
C(4)	-0.120709	1.491053	-0.080956	0.9366
C(5)	-0.017307	0.151934	-0.113913	0.9109
C(6)	-0.361125	1.250597	-0.288762	0.7770
C(7)	-0.220371	0.956011	-0.230511	0.8210
C(8)	1.811739	4.366358	0.414931	0.6845
C(9)	-1.950011	4.594637	-0.424410	0.6777
C(10)	-0.129908	0.307033	-0.423106	0.6786
C(11)	0.006931	0.039319	0.176287	0.8626
C(12)	0.375894	1.256592	0.299138	0.7692
C(13)	0.205464	0.386616	0.531442	0.6034
RESID(-1)	-0.359500	0.400700	-0.897180	0.3848
RESID(-2)	-0.379899	0.377081	-1.007474	0.3308

R-squared	0.109504	Mean dependent var	9.57E-17
Adjusted R-squared	-0.780992	S.D. dependent var	0.394692
S.E. of regression	0.526732	Akaike info criterion	1.861993
Sum squared resid	3.884248	Schwarz criterion	2.569215
Log likelihood	-11.99891	Hannan-Quinn criter.	2.083487
Durbin-Watson stat	2.028329		