Exchange Rate Volatility and Inflation Upturn in Nigeria: Testing for Vector Error Correction Model

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Abstract

This paper empirically examines the impact of exchange rate volatility on inflation in Nigeria using annual time series data from 1986 – 2012. The methodology employed includes: ADF, PP and KPSS test of unit root, Johansen Julius cointegration test, VECM, granger causality test, impulse response function and variance decomposition. The unit root test result shows that all variables are stationary at first difference, while Maxi-eigen value shows a long run relationship between the variables. VECM result established positive and significant relationship between inflation, exchange rate volatility, money supply and fiscal deficit, while gross domestic product show negative relationship. Granger causality outcome shows a bi-directional relationship between all the variables. Subsequently, exchange rate volatility is deduced to influence inflation in Nigeria. Therefore, it becomes imperative for the government to understand and control the various channels through which exchange rate transmits to affect inflation in Nigeria, check the growth of money supply, increase the level of productivity in the country and lastly cut down public sector expenditure and possibly make a shift from excessive consumption expenditure to capital expenditure believing this will reduce the burden of fiscal deficit and the rate of inflation.

KEYWORD: Exchange rate volatility, inflation upturn, VECM, granger causality, impulse response and variance decomposition,

I. INTRODUCTION

Exchange rate is a very important price which links the domestic price with international prices (Obadan, 2006). It is simply the price of one currency in terms of another. In general, trade between nations can occur only if it is possible to exchange the currency of one nation for that of another. People buy and sell foreign exchange as a result of international transactions. These transactions are broadly divided into income-related and capital-related transactions. The former transaction is concerned with the purchase and sale of internationally traded goods and

services, plus international movement of income such as interest and dividends that is earned on investments. They are recorded in the current account. The latter arises from movement of capital itself which are recorded in the capital account.

As one of the most important prices in the economy, exchange rate affects the domestic prices of traded goods as well as exports and imports (Obadan, 2006). Given that the exchange rate is defined as the number of domestic currency needed to buy one unit of foreign currency; the appreciation of the domestic currency or depreciation of the exchange rate has crucial implication on the economy. Considering a small open economy, which is an economy that can exert no influence on the world prices of traded goods, an appreciation of the value of domestic currency, lowers the domestic prices of traded goods whereas the depreciation of the value of domestic currency raises the domestic price of traded goods (Begg 2003). As regards the effect of changes in exchange rate on exports and imports, an appreciation of the value of domestic currency lowers the price of traded goods thereby reducing the quantity supplied and increasing the quantity demanded domestically. Therefore, the quantity of exports falls and quantity of imports rises. On the other hand, a depreciation of the domestic currency raises the prices of traded goods thereby increasing the quantity supplied and reducing the quantity demanded domestically. This implies that the quantity of exports increases, while the quantity of imports falls.

In the light of the above, it can be inferred that variations in exchange rate affect a country's balance of payment position. As such, the major objective of exchange rate policy is to equilibrate the balance of payments position. The exchange rate policy tries to accomplish this by influencing the relative price structure in the domestic currency terms between traded goods and non-traded goods as well as overall level of domestic prices. Essentially, the exchange rate influences four key relative prices in the economy, viz: the price of traded goods relative to non-traded goods; the price of exports relative to the price of exports of competitor countries(in foreign currency); and the price of exports or imports-substitutes relative to the cost of producing these goods. By influencing these relative prices, the exchange rate can affect the allocation of resources in the economy, including the volume of international trade.

Before the introduction of the structural adjustment programme (SAP) in 1986, the systems of exchange rate in use in the Nigerian economy were both the exchange control system and the IMF adjustable peg system. Under this system, the exchange rate, like other prices such as interest rate was administratively controlled by the Central Bank of Nigeria. This system of exchange rate management, however, engendered several distortions in the economy and led to the introduction of a Second-Tier-Foreign–Exchange Market (SFEM)-which is a variant of flexible exchange rate regime in 1986 (Egwaikhide, Chete and Falokun, 1994)

Under this new exchange rate policy, market forces of demand for and supply of foreign exchange become the hallmark of naira exchange rate determination (Egwaikhide, Chete and Falokun, 1994). Against the background of structural imbalances, key aspects of which were excessive dependence of the domestic production structure on imports and extreme concentration of the export-based capacity to import on a single commodity with a volatile market, the new

exchange rate policy was expected to play a key role in the structural transformation of the economy. However, since the introduction of market-determined exchange rate system in Nigeria, the naira exchange rate has exhibited the features of continuous depreciation and instability. The exchange rate volatility, following Obadan (2006) has had significant impact on the economy. Therefore, this paper work seeks to examine the trend and pattern of exchange rate and inflation, examine whether a causal relation exist between exchange rate volatility and inflation and investigate the relative effect of exchange rate volatility on inflation in Nigeria from 1986 – 2012. The choice of this period is based on the introduction of second tier Foreign Exchange Market (SFEM) in September1986. Under SFEM, the determination of the Naira exchange rate and allocation of foreign exchange were based on market forces.

The rest of the section is arranged as follows. Section II deals with literature review, while the third section assesses the theoretical framework. Section IV presented the model specification and estimation techniques. Thus, section V involves the empirical analysis and discussion of result, and the last section (section VI) concludes the paper.

II LITERATURE REVIEW

2.1 Conceptual Issues

2.1.1 Inflation

Inflation is a phenomenon which affects everybody in one way or the other. Following Blanchard (2002) "inflation is a sustained rise in the general level of prices in the economy. It is the persistent tendency for the general price level to rise." Macroeconomists typically look at two measures of the price level. These measures are the GDP deflator and the consumer price index.

As a measure of the general price level, the GDP deflator is defined as:

$$P_t = \frac{Nominal\ \ GDP_t}{Real\ \ GDP_t} \qquad 2.1$$

The GDP deflator gives the average price of final goods produced in the economy. Since consumers care about the average price of goods they consume, macroeconomists look at another index, the consumer price index (CPI). Using this index, the rate of inflation is defined as the percentage increase in the consumer price index over a period of one year (Khan, 1989).

Persistence or sustain increase in the general price level can either be anticipated or unanticipated. If it is fully anticipated, then all groups and individuals in the economy expect it and are able to gain full compensation for it. In this case, the inflation will have no appreciable effect on the distribution of income and wealth in the economy. Inflation, however, may be unanticipated for three possible reasons: (a) if there is a general failure on the part of the economy as a whole to predict the inflation correctly so that the actual rate of inflation exceeds the expected rate; (b) if certain group or individual in the economy fail to predict inflation correctly so that they seek lower money wages increases than are actually necessary to maintain real wages. (c) if certain groups or individuals, even though they may correctly predict the inflation, are unable to gain full compensation for it (for example, if they have weak unions or if they earn contractually fixed incomes).

Where the inflation is unanticipated either by the economy as a whole or by groups or individuals within it, there will be a redistribution effect: that is, some people will be made better off while some people will be made worse off. The following are some of the possible redistribution effects of unanticipated inflation. Inflation redistributes income from fixed-income earners and weakly unionized workers to strongly unionized workers. During inflation, lenders lose and borrowers gain because when debts are repaid, their real value will be less than that prevailing when the loans were made. Inflation redistributes income from taxpayers to the government. This is so because as money incomes rise, earners with some real income move into higher tax banks and so pay a bigger proportion of their income in tax.

In this section, a standard approach to analyzing the causes of inflation is to examine the link between the money supply (M) and the general price level (P) using an accounting identity called the "equation of exchange":

$$MV = PY \qquad 2.2$$

Where V denotes the income-velocity of money (the number of times per year the average naira turns over in transactions for final goods and services), and Y denotes the economy's real income (as measured by real GDP). V is *defined* as PY/M, the ratio of nominal income to money balances. The quantity theory of money maintained that a higher or lower level of M does not cause any permanent change in Y or desired V—or, in other words, does not permanently affect the real demand to hold money. It follows that, in the long run, a larger M means a proportionally higher P.

The equation of exchange can be employed to show how the inflation rate depends on the growth rates of M, V, and y. The relationship among all four growth rates is given by the "dynamic," or growth-rate, version of the equation, $gM + gV = gP + gv$, which says: the rate of growth of the quantity of money, plus the rate of growth of the velocity of money, equals the rate of inflation plus the rate of growth of real income. The equation holds exactly for continuously compounded growth rates. For year-over-year rates it is an approximation.

The dynamic equation of exchange indicates that, as a matter of accounting, inflation depends not only on the rate of monetary expansion, but also on the rate of velocity growth and (negatively) on the rate of real income growth. The basic question at this point is that which of these three factors contributes the most to inflation in practice? Friedman (1992) argued that "Inflation is always and everywhere a monetary phenomenon." This implies that sustained inflation has historically always been due to sustained money supply growth, not to sustained velocity growth or sustained negative growth in real income.

The implication for controlling inflation is straightforward. Achieving zero inflation merely requires the central bank, which controls the money supply, to refrain from expanding the money supply too rapidly (more specifically, adjusting for velocity growth, expanding the money supply at a rate faster than the economy's real output of goods and services is expanding). The Central Bank could maintain zero inflation ($gP = 0$), on average, by controlling growth in the stock of money (gM) appropriately.

Some economists call the above analysis a "demand-pull" explanation (monetary expansion fuels spending that pulls prices up), while proposing a "cost-push" alternative. For particular episodes of inflation, they have variously blamed monopolies, labour unions, and oil cartel like OPEC for pushing up prices. The equation of exchange warns us that for a "supply shock" to account for a large rise in the *general* price level (not just a *relative* rise in some prices, such as the price of oil), the economy's output must shrink by a large percentage. In practice, "supply shock" cases are seldom large enough to account for much inflation and are typically short-lived.

2.1.2 Exchange Rate

Exchange rate is the rate at which one currency can be exchanged for another. It is the price of one country's expressed in another country's currency of foreign currency. For example, the exchange rate between the British pound and the U.S. dollar is usually stated in dollars per pound sterling ($/£); an *increase* in this exchange rate from, say, $1.80 to say, $1.83, is a *depreciation* of the dollar. The exchange rate between the Japanese yen and the U.S. dollar is usually stated in yen per dollar (¥/$); an increase in this exchange rate from, say, ¥108 to ¥110 is an *appreciation* of the dollar. Some countries "float" their exchange rate, which means that the central bank (the country's monetary authority) does not buy or sell foreign exchange, and the price is instead determined by supply and demand.

Until the 1970s, exports and imports of merchandise were the most important sources of supply and demand for foreign exchange. Today, financial transactions overwhelmingly dominate. When the exchange rate rises, it is generally because market participants decided to buy assets denominated in that currency in the hope of further appreciation. Economists believe that macroeconomic fundamentals determine exchange rates in the long run. The value of a country's currency is thought to react positively, for example, to such fundamentals as an increase in the growth rate of the economy, an increase in its trade balance, a fall in its inflation rate, or an increase in its real - that is, inflation-adjusted - interest rate(Taylor, 1995).

One simple model for determining the long-run equilibrium exchange rate is based on the quantity theory of money. The domestic version of the quantity theory says that a one-time increase in the money supply is soon reflected as a proportionate increase in the domestic price level. The international version says that the increase in the money supply is also reflected as a proportionate increase in the exchange rate. The exchange rate, as the relative price of money (domestic per foreign), can be viewed as determined by the demand for money (domestic relative to foreign), which is in turn influenced positively by the rate of growth of the real economy and negatively by the inflation rate (Frankel and Rose, 1996).

A. Exchange Rate System/ Regime

Exchange rate system includes set of rules, arrangement and institutions under which nations effect payments among themselves. It represents the way prices of a currency can be determined against another. The system can be fixed exchange rate or floating exchange rate.

Fixed Exchange Rates

Fixed or pegged exchange rate is a rate the government (central bank) sets and maintains as the official exchange rate. A set price will be determined against a major world currency (usually the U.S. dollar, but also other major currencies such as the euro, the yen or a basket of currencies). In order to maintain the local exchange rate, the central bank buys and sells its own currency on the foreign exchange market in return for the currency to which it is pegged. If, for example, it is determined that the value of a single unit of local currency is equal to US$3, the central bank will have to ensure that it can supply the market with those dollars. In order to maintain the rate, the central bank must keep a high level of foreign reserves. This is a reserved amount of foreign currency held by the central bank that it can use to release (or absorb) extra funds into (or out of) the market. This ensures an appropriate money supply, appropriate fluctuations in the market (inflation/deflation), and ultimately, the exchange rate. The central bank can also adjust the official exchange rate when necessary.

Floating Exchange Rates

Unlike the fixed rate, a floating exchange rate is determined by the private market through supply and demand. A floating rate is often termed "self-correcting", as any differences in supply and demand will automatically be corrected in the market. Take a look at this simplified model: if demand for a currency is low, its value will decrease, thus making imported goods more expensive and stimulating demand for local goods and services. This in turn will generate more jobs, causing an auto-correction in the market. A floating exchange rate is constantly changing.

In reality, no currency is wholly fixed or floating. In a fixed regime, market pressures can also influence changes in the exchange rate. Sometimes, when a local currency does reflect its true value against its pegged currency, a "black market", which is more reflective of actual supply and demand, may develop. A central bank will often then be forced to revalue or devalue the official rate so that the rate is in line with the unofficial one, thereby halting the activity of the black market. In a floating regime, the central bank may also intervene when it is necessary to ensure stability and to avoid inflation; however, it is less often that the central bank of a floating regime will interfere.

2.2 Empirical Review

Several empirical studies that have undertaken to identify the possible determinants of inflation in Nigeria and elsewhere have identified exchange rate as an inflation determining variable. Montiel (1989) applied a five-variable VAR model (money, wages, exchange rate, income and prices) to examine sources of inflationary shocks in Argentina, Brazil and Israel. The findings indicate that exchange rate movements among other factors significantly explained inflation in the three countries. Elbadawi (1990) also noted that precipitous depreciation of the parallel exchange rate exerted a significant effect on inflation in Uganda. Odedokun (1996), Canetti and Greene (1991), Egwaikhide, Chete, and Falokun (1994) reached similar conclusions for some selected African countries.

Studies have also examined these effects in both short-run and long-run. Lu and Zhang (2003) study of China observed that in the short-run, changes in the devaluation rate are positively

correlated with the increase in the inflation rate. The findings shed some light on China's exchange rate policy reform, which was aimed at transforming its overvalued currency into a meaningful economic lever. Odusola and Akinlo (2005) also examine the link between exchange rate depreciation, inflation and output in Nigeria. These authors conclude that exchange rate depreciation exerts expansionary effect on output in the medium and long-run but has contractionary impact in the short-run.

On the other hand, Omotor (2008) examines the impact of exchange rate reform on inflationary trend in Nigeria. The author concludes that exchange rate reform policy and money supply are the main determinant of inflation in Nigeria. Yoon, (2009) shows that the real exchange rate demonstrates different patterns of behavior depending on the exchange rate regime in place. His findings show evidence that real exchange rate series behave as stationary processes during the fixed exchange rate regime. But he acknowledged the fact that, more stationary episodes are found in the gold standard and the Bretton-Woods periods.

Kamin and Khan (2003) empirically investigated the multi-country comparison of the linkages between inflation and exchange rate competitiveness found that a relationship exists between inflation rate and the RER in most Asian and Latin American countries. Their study further revealed that the influence of exchange rate changes on inflation rate is higher in Latin American countries than those in Asia and industrialized countries. Aydin (2010) employed panel data examine the impact of exchange rate volatility in 182 countries from 1973-2008 and discovered different dynamics in the impact of macroeconomics fundamentals on the equilibrium real exchange rate of Sub-Saharan economies in the less advance economies.

Therefore, it can be deduced from the conclusions of authors stated above that there is no clear cut conclusion on the existence of significant relationship between exchange rate volatility and inflation in Nigeria. Hence this study wants to fill the gap by empirically analyze the significant relationship between exchange rate volatility and inflation as well as investigate other macroeconomic variables that significantly related to inflation.

III Theoretical Framework

3.1 Theories of inflation

In respect to the determinants of inflation, there are various theories proposed by various economists to explain the occurrence of inflationary situations. In this study, the various theories of inflation are grouped basically into two broad theories, the excess demand theories under the umbrella of expectations-augmented Phillips curve (which comprises the monetarist and the Keynesians theories of inflation) and the cost-push theories which are currently termed structuralists/institutional theories of inflation.

A. The Classical theory of Inflation

One way of defeating inflation, according to the early classical economists, is to reduce the money supply. The prescription arises from their belief that the economy always operates in equilibrium. The result of this belief is that when the money supply increases, this will simply result in more money chasing the same amount of goods. The excess demand will then increase

the price level back to equilibrium (fast or immediately) and nothing in the "real" sector of the economy has changed. The only difference is an increase in the price level. Clearly there are some problems with this model. The main problem is that it ignores the possible rigidities in the economy. For example the adjustment processes might work at different speeds. Another problem is that it does not account for the real affects of changes in the monetary sector to the goods sector.

B. Keynesian theory

According to Keynesian, inflation can be caused by increase in demand and or increase in cost. In response to the deficiencies of the Classical theory, Keynes developed a new theory of inflation. This theory stressed rigidities in the economy, most importantly in the labour market. This source of rigidities was that workers were reluctant to reduce their nominal wages. Rigidity was that firms did not always change their prices as a response to changes in demand, often increasing output instead. Putting these rigidities (and others) together one gets what is called a fixed-price model. In this model there are several ways of defeating inflation. The basic cause of inflation is excess aggregate demand and hence the most obvious cure is to reduce aggregate demand. The policy instruments available to do this could be tax increases or cuts in public spending. Another possibility in this model is to reduce the rigidities. Demand-pull inflation is a situation where aggregate demand persistently exceeds aggregate supply when the economy is near or at full employment. Aggregate demand could rise because of several reasons. A cut in personal income tax would increase disposable income and contribute to a rise in consumer expenditure. A reduction in the interest rate might encourage an increase in investment as well as lead to greater consumer spending on consumer durables. A rise in foreigners' income may lead to an increase in exports of a country. An expansion of government spending financed by borrowing from the banking system under conditions of full employment is another cause of inflation.

An increase in demand can be met initially by utilizing unemployed resources if these are available. Supply rises and the increase in demand will have little or no effect on the general price level at this point. If the total demand for goods and services continue to escalate, a full employment situation will eventually be reached and no further increases in output are possible. This leads to inflationary pressures in the economy.

Demand-pull inflation is caused by excess demand, which can originate from high exports, strong investment, rise in money supply or government financing its spending by borrowing. If firms are doing well, they will increase their demand for factors of production. If the factor market is already facing full employment, input prices will rise. Firms may have to bid up wages to tempt workers away from their existing jobs.

It is most likely that during full employment conditions, the rise in wages will exceed any increase in productivity leading to higher costs. Firms will pass the higher costs to consumers in the form of higher prices. Workers will demand for higher wages and this will add fuel to aggregate demand, which increases once again. The process continues as prices in the product market and factor market are being pulled upwards.

Keynesian theory of cost-push inflation attributes the basic cause of inflation to supply side factors. This means that according to Keynesian, rising production costs will lead to inflation. Cost-push inflation is usually regarded as being primarily a wage inflation process because wages usually constitute the greater part of total costs. Powerful and militant trade unions that negotiate wage increases in excess of productivity are more likely to succeed in their wage claims the closer the economy is to full employment and the greater the problem of skill shortages.

C. Structural Theory

This theory is believed to have originated from the less developed countries (LCD.s) South America to be specific shortly after the Second World War. Chilean economist Osvaldo Sunkel (1962) has written extensively on inflation and economic development and Geoff Riley (2006) also has an over view that, instead of focusing on monetary phenomena as a root of the problem, inflation in developing nations such as Latin America and some Africa countries are related to non monetary imbalance.

The cost-push theory of inflation is a generic term for Marxists, Structural theory and Keynesians theories of inflation that are not based on excess-demand influences on the economy. In this group of theories of inflation, a host of non-monetary supply oriented factors influencing the price levels in the economy are considered. Thus cost-push causes of inflation result when cost in production increases independently on aggregate demand. The Keynesians argued that wage mark-up via trade unions lead to increases in the cost of living.

IV Model Specification and Estimation Techniques

4.1 Model Specification

To investigate the impact of exchange rate volatility on inflation in Nigeria, this study builds on the literature review and theoretical framework in the previous sections.

Taking into cognizance the above theories of inflation, the model of inflation can be expressed as:

$$INF = f(M, Y, FD, ERV) \qquad 4.1$$

Where INF = inflation rate, M = money supply, Y = level of output, FD = fiscal deficit, and ERV = exchange rate volatility.

The Equation (4.1) above expresses inflation as a function of several variables. Since this equation is only in an implicit form, the explicit form of the model could be expressed as:

$$\inf = \alpha_0 + \alpha_1(m) + \alpha_2(y) + \alpha_3(fd) + \alpha_4(erv) + u_i \qquad 4.2$$

The a priori expectations are: $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 > 0$ and $\alpha_4 > 0$.

In the model represented by equation (4.2) above, the alphas are the parameters to be estimated and u is the error term that captures other variables not explicitly included in the model. Moreover, "INF" denotes the log of consumer price index while "M" is the log of money supply. "Y" also stands for the log of real GDP while "FD" is the log of government expenditure minus

the log of government revenue and "ERV" denotes the log of exchange rate volatility. It is expected that α_1 will be positive. This means that an increase in the money stock will lead to proportional increase in the general price level.

4.2 Estimation Techniques

This study employs the ADF, Philips-Perron (PP) and KPSS unit root test, Johansen cointegration test, VECM modeling, impulse response function, variance decomposition and granger causality. They are all adopted in order to arrive at a conclusion that will be free from every iota of doubt and lead to unequivocal recommendations as no other study has gone to such extent to estimate the relationship between exchange rate volatility and inflation in Nigeria.

A. Unit Root Test

Three standard procedures of unit root test namely the Augmented Dickey Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski-Phillips- Schmidt-Shin (KPSS) tests will be employed as a prior diagnostic test before the estimation of the model to examine the stochastic time series process properties of exchange rate volatility and inflation in Nigeria. This enables us to avoid the problems of spurious result that are associated with non-stationary time series models.

B. Co-integration Estimate

This is employed to determine the number of co-integrating vectors using Johansen's methodology with two different test statistics namely the trace test statistic and the maximum Eigen-value test statistic. The trace statistic tests the null hypothesis that the number of divergent co-integrating relationships is less than or equal to '*r*' against the alternative hypothesis of more than '*r*' co-integrating relationships, and is defined as:

$$\theta_{trace}(r) = -T \sum_{j=r+1}^{P} 1n\left(1-\hat{\theta}_j\right) \qquad 4.3$$

The maximum likelihood ratio or the maximum eigen-value statistic, for testing the null hypothesis of at most 'r' co-integrating vectors against the alternative hypothesis of 'r+l 'co-integrating vectors, is given by:

$$\theta_{\max}(r,r,+1) = -T\,1n\,(1-\hat{\theta}_{r+1}) \qquad 4.4$$

Where $\hat{\theta}_j$ = the eigen values, T = total number of observations. Johansen argues that, trace and statistics have nonstandard distributions under the null hypothesis, and provides approximate critical values for the statistic, generated by Monte Carlo methods.

In a situation where Trace and Maximum Eigenvalue statistics yield different results, the results of trace test should be preferred.

C. Vector Error Correction Model (VECM)

VECM model comes to play when it has been established that, there exist a long run relationship between the variables under consideration. This enables us to evaluate the cointegrated series. In

a situation where there is no cointegration, VECM is no longer required and we can precede to Granger causality tests directly to establish casual relationship between the variables.

VECM regression equation is given below as thus:

$$\Delta Y_t = \alpha_1 + P_1 e_1 + \sum_{i=0}^{n} \beta_i Y_{t-i} + \sum_{i=0}^{n} \emptyset_i \Delta X_{t-i} + \sum_{i=0}^{n} Y_i Z_{t-i} \quad 4.5$$

$$\Delta X_t = \alpha_2 + P_2 e_{i-1} + \sum_{i=0}^{n} \beta_i Y_{t-i} + \sum_{i=0}^{n} \emptyset_i \Delta X_{t-i} + \sum_{i=0}^{n} Y_i Z_{t-i} \quad 4.6$$

In VECM, the cointegration rank shows the number of cointegrating vectors. For example a rank of two indicates that two linearly independent combinations of the non-stationary variables will be stationary. A negative and significant coefficient of the ECM (i.e. e_{t-1} in the above equations) indicates that any short-term fluctuations between the independent variables and the dependent variable will give rise to a stable long run relationship between the variables.

D. Granger Causality Test

A general specification of the Granger causality test in a bivariate (X, Y) context can be expressed as:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + ... + \alpha_i Y_{t-i} + \beta_1 X_{t-1} + ... + \beta_i X_{t-i} + \mu \quad 4.7$$

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + ... + \alpha_i X_{t-i} + \beta_1 Y_{t-1} + ... + \beta_i Y_{t-i} + \mu \quad 4.8$$

In the model, the subscripts denote time periods and μ is a white noise error. The constant parameter "0 represents the constant growth rate of *Y* in the equation 7 and *X* in the equation 8 and thus the trend in these variables can be interpreted as general movements of cointegration between *X* and *Y* that follows the unit root process. Hence, in testing for Granger causality, two variables are usually analyzed together, while testing for their interaction. All the possible results of the analyses are four:

(i) Unidirectional Granger causality from variable Y_t to variable X_t.

(ii) Unidirectional Granger causality from variable X_t to Y_t

(iii) Bi-directional causality and

(iv) No causality

V Estimation and Analysis of Results

5.1 Stationarity Test

Table 5.1 summarizes the results obtained for each variable from the various techniques used to test the hypothesis of unit root or no unit root as the case may be.

Table 5.1: Stationarity Test Result

VARIABLES	ADF TEST *HO: VARIABLE IS NON-STATIONARY*	PPT TEST *HO: VARIABLE IS NON-STATIONARY*	KPSS TEST *HO: VARIABLE IS NON-STATIONARY*	ORDER OF INTEGRATION
INF	-2.565094*	-2.534216*	0.810919***	
D(INF)	-3.878171***	-5.744646***	0.242385***	I(1)

LM	-0.824865	-0.791660	0.762451	
D(LM)	-7.534741***	-12.41183***	-0.278820***	I(1)
LY	0.386998	1.084085	0.757192	
D(LY)	-3.318423*	-3.421221*	0.281184*	I(1)
LFD	-0.819527	-0.435516	0.680995	
D(LFD)	-7.163938***	-7.166293***	0.135493***	I(1)
ERV	-2.201204	-2.202348	1.096513	
D(ERV)	-5.201204***	-5.202348***	0.096513***	I(1)
ASYMPTOTIC CRITICAL VALUES				
1%	-3.788030	-3.724070	0.739000	
5%	-3.012363	-2.986225	0.463000	
10%	-2.646119	-2.632604	0.347000	

**** implies significant at 1% level, ** implies significant at 5% level and * implies significant at 10% level. Δ represents first difference*

Source: Author's computation, 2013.

From the table above, it can be deduced the variables are not stationary at level meaning that the null hypothesis of unit root cannot be rejected since the asymptotic critical values is less than the calculated value for ADF and PP and greater calculated value for KPSS. After all the variables are transformed to their first difference, the null hypothesis is rejected and became stationary. Therefore, they are said to maintain stationarity at an integration of order one, I(1).

5.2 Lag Length Selection Test

The Schwarz Information Criterion (SC) is used to select the optimal lag length considering the smaller value of smaller information criterion. This is presented below:

Table 5.2: VAR lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-14.04013	NA	5.11e-06	2.004225	2.252761	2.046287
1	68.74740	113.2882	1.30e-08	-4.078673	-2.587454	-3.826300
2	125.4717	47.76782*	9.37e-10*	-7.418071*	-4.684169*	-6.955386*

Note: LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, and HQ: Hannan-Quinn information criterion.

Source: Author's computation, 2013.

5.3 Cointegration Test

Having established that the variables are integrated of the same order, we proceed to testing for cointegration. The Johansen-Juselius maximum likelihood procedure was applied in determining the cointegrating rank of the system and the number of common stochastic trends driving the entire system. We reported the trace and maximum eigen-value statistics and its critical values at both one per cent (1%) and five per cent (5%) in the table below. The result of multivariate cointegration test based on Johansen and Juselius cointegration technique reveal that there are three cointegrating equations at 5% and three cointegration equation at 1% level of significant as indicated by the trace statistic while the max-Eigen statistic only indicated four cointegrating equation at 5% significant level and three cointegrating equation at 1% significant

level. These results suggest that the appropriate model to use is the VECM specification with more than one cointegrating vector in the model.

Table 5.3: Cointegration result

TRACE STATISTIC Unrestricted Cointegration Rank Test (Trace)						
Hypothesized No. of CE(S)	***Eigenvalue (5%)***	***Trace Statistic (5%)***	***0.05 Critical Value***	***Eigenvalue (1%)***	***Trace Statistic(1%)***	***0.01 Critical Value***
None **	0.992420	189.3501	69.81889	0.992420	189.3501	77.81884
At most 1 **	0.941563	96.58684	47.85613	0.941563	96.58684	54.68150
At most 2 **	0.771787	42.63043	29.79707	0.771787	42.63043	35.45817
At most 3	0.528394	14.55841	15.49471	0.528394	14.55841	19.93711
At most 4	0.014514	0.277784	3.841466	0.014514	0.277784	6.634897

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
Trace test indicates 3 cointegrating eqn(s) at the 0.01 level

MAX-EIGEN STATISTIC						
Hypothesized No. of CE(s)	***Eigenvalue (5%)***	***Maxi-Eigen Statistic (5%)***	***0.05 Critical Value***	***Eigenvalue (1%)***	***MaxiEigen Statistic (1%)***	***0.01 Critical Value***
None **	0.992420	92.76327	33.87687	0.992420	189.3501	77.81884
At most 1 **	0.941563	53.95641	27.58434	0.941563	96.58684	54.68150
At most 2 **	0.771787	28.07201	21.13162	0.771787	42.63043	35.45817
At most 3 *	0.528394	14.28063	14.26460	0.528394	14.55841	19.93711
At most 4	0.014514	0.277784	3.841466	0.014514	0.277784	6.634897

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.01 level

Source: Author's Computation, 2013.

5.4 Vector Error Correction Model

The presence of cointegration between variables suggests a long term relationship among the variables under consideration. Then, the VEC model was applied and the long run relationship between inflation rate, money supply, real gross domestic product, fiscal deficit and exchange volatility in Nigeria is presented below:

Table 5.4: Vector Error Correction Model Result

Error Correction	D(INF)	D(LY)	D(LM)	D(ERV)	D(LFD)
CointEq1	-1.081119	1.80E-06	-0.000850	-0.000204	0.011673
	[-6.71470]	[0.00638]	[-0.09282]	[-1.96581]	[1.86206]
D(INF(-1))	0.520480	0.000510	-0.001035	8.79E-05	-0.002872
	[3.83259]	[2.14418]	[-0.13399]	[1.00560]	[-0.54307]
D(LY(-1))	-65.37331	0.206974	-0.870522	-0.217267	-2.540624
	[-0.60703]	[1.09647]	[-0.14214]	[-3.13524]	[-0.60590]
D(LM(-1))	1.164064	0.000806	-0.496611	-0.002726	0.213234
	[2.21400]	[0.08449]	[-1.60543]	[-0.77882]	[1.00681]
D(ERV(-1))	86.54353	0.016759	-0.773126	0.040433	0.295543
	[2.06999]	[0.22870]	[-0.32518]	[1.50293]	[0.18156]
D(LFD(-1))	11.74263	-0.006691	-0.069472	0.000203	0.045519
	[3.16574]	[-1.02910]	[-0.32935]	[0.08496]	[0.31518]
C	0.848417	0.022275	0.187313	0.007442	0.098196
	[0.22791]	[3.41375]	[0.88482]	[3.10663]	[0.67747]
R-squared	0.852169	0.747596	0.213153	0.847952	0.871302
Adj. R-squared	0.733904	0.545672	-0.416324	0.726313	0.768343
F-statistic	7.205608	3.702368	0.338619	6.971068	8.462641

Source: Author's Computation, 2013.

The VECM result presented above shows that all the explanatory variables' relationship are in line with the aprior expectation and satisfy the stability condition, that is, the vector error correction term in each of the models should have the required negative sign and lie within the accepted region of less than unity. The vector error correction term in column two has the expected negative sign and is statistically significant and it shows a low speed adjustment towards equilibrium. The results of the estimation show that the explanatory variables account for about 85 percent variation in inflation rate in Nigeria and 15 percent can be due to other factors not captured in the model. Taking into consideration the degree of freedom, the adjusted R-squared shows that 73 percent of the dependent variable is explained by the explanatory variables.

The estimation also shows a positive and significant relationship between inflation rate and exchange rate volatility in Nigeria. It shows 1% increase in exchange rate volatility will lead to 86.5% increase in inflation. In the same vein, money supply and fiscal deficit also show a positive and significant relationship with inflation in Nigeria given 1.16% and 11.7% response of inflation rate to 1% increase in money supply and fiscal deficit respectively. The negative relationship between inflation and real gross domestic product show a negative but insignificant relationship with inflation and indicates that 1% increase in real gross domestic product will cause 65.3% decrease in inflation in Nigeria.

5.5 Granger Causality

Cointegration between two variables does not specify the direction of a causal relation, if any, between the variables. Economic theory guarantees that there is always Granger Causality in at least one direction Order, D. and L. Fisher, (1993). Hence, this aspect of the work seek to verify the direction of Granger Causality between ERV, LM, LY LFD and INF. Estimation results for granger causality between the very variables are presented below:

Table 5.5: Granger Causality Test Result

Null Hypothesis	F-Statistics	Decision	Probability	Type of Causality
LY does not Granger Cause INF	4.40413	Reject H_0	0.0260	Bi-directional causality
INF does not Granger Cause LY	1.09963	DNR H_0	0.3523	No causality
LM does not Granger Cause INF	4.10766	Reject H_0	0.0468	Bi-directional causality
INF does not Granger Cause LM	0.12795	DNR H_0	0.8806	No causality
ERV does not Granger Cause INF	4.12793	Reject H_0	0.0406	Uni-directional causality
INF does not Granger Cause ERV	5.64871	Reject H_0	0.0334	Uni-directional causality
LFD does not Granger Cause INF	11.5128	Reject H_0	0.0011	Bi-directional causality
INF does not Granger Cause LFD	0.33285	DNR H_0	0.7224	No causality
LM does not Granger Cause LY	0.91897	DNR H_0	0.4151	No causality
LY does not Granger Cause LM	1.60836	DNR H_0	0.2251	No causality
ERV does not Granger Cause LY	0.33119	DNR H_0	0.7219	No causality
LY does not Granger Cause ERV	0.38942	DNR H_0	0.6825	No causality
LFD does not Granger Cause LY	3.36960	DNR H_0	0.0639	No causality
LY does not Granger Cause LFD	1.73547	DNR H_0	0.2122	No causality
ERV does not Granger Cause LM	0.02991	DNR H_0	0.9706	No causality
LM does not Granger Cause ERV	0.05023	DNR H_0	0.9511	No causality
LFD does not Granger Cause LM	0.99387	DNR H_0	0.3948	No causality
LM does not Granger Cause LFD	1.94424	DNR H_0	0.1798	No causality
LFD does not Granger Cause ERV	0.16342	DNR H_0	0.8508	No causality
ERV does not Granger Cause LFD	14.2406	Reject H_0	0.0004	Bi-directional causality

Source: Author's computation, 2013.
Note: DNR means do not reject.

From the table above, it was found that, exchange rate volatility, money supply, real gross domestic product and fiscal deficit granger cause inflation in Nigeria. Meanwhile, in terms of the ability of inflation to predict the explanatory variables, it was revealed that inflation Granger cause volatility in exchange rate.

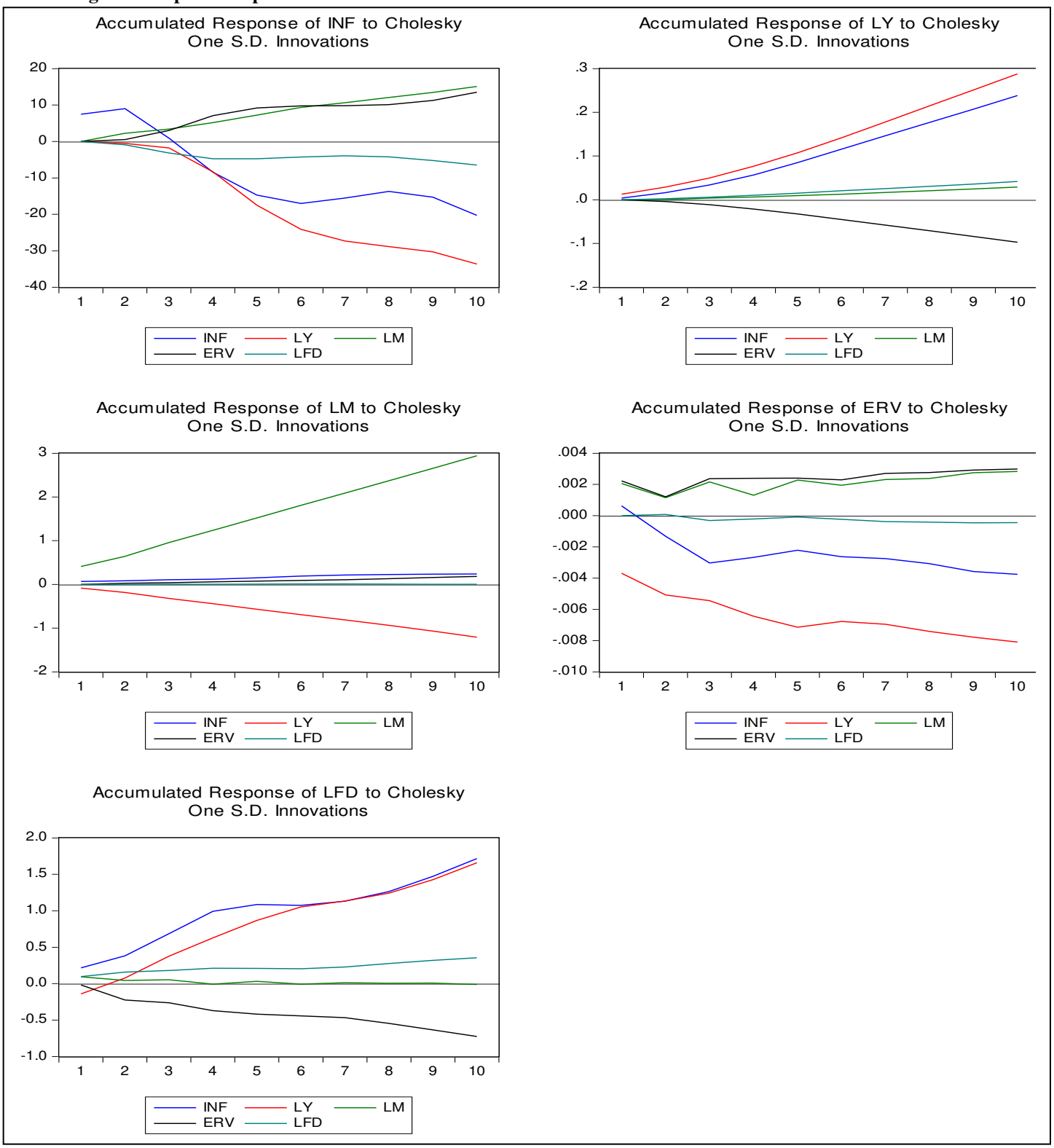
5.6 Impulse Response Function (IRF)

Impulse response function depicts the reaction of a dynamic system to a brief input signal or some external change, called an impulse. It describes the reaction of the system as a function of time (or possibly as a function of some other independent variable that parameterizes the dynamic behavior of the system). It investigates the effect of cholesky one S.D innovation on the behavior of the time series. Therefore, we present the analysis of accumulated impulse responses of economic variables as thus:

From the below *figure I*, the first figure is the impulse of inflation, exchange rate volatility and money supply response is positive, while fiscal deficit and real gross domestic product produce a

negative response. When the impulse is exchange rate volatility, money supply response is positive, fiscal deficit fluctuate around the line zero, while inflation and real gross domestic product produce negative response.

Figure I: Impulse Response Functions



VI Conclusion

This paper empirically analyzes the impact of exchange rate volatility on inflation a vector error correction model and granger causality approach in Nigeria over a period of 1986 to 2012. Exchange rate volatility was not considered alone but efforts were made to investigate the impact of other variables such as money supply, real gross domestic product and fiscal deficit. The result from the vector error correction model shows that exchange rate volatility, money supply and fiscal deficit positively and significantly related to inflation, while real gross domestic product gives a negative and insignificant relationship. The granger causality result is akin to the above result given a uni-directional and bi-directional relationship among the variables. Hence, the result of this empirical analysis strongly supports various economic theories. Therefore, the following recommendations are necessary for policy making on inflation in Nigeria.

Firstly, there is the need to understand the various channels through which exchange rate transmits to affect inflation in Nigeria. The present situation is that most people are not well informed about the detrimental effect of exchange rate volatility. A proper study of the causes of exchange rate variability will help in minimizing its impact on macroeconomic variables.

Secondly, there is the need for the central bank of Nigeria to check the growth of money supply. This is necessary as a positive relationship exists between the level of money supply and inflation.

Thirdly, every effort should be channeled it expenditure to the key productive sectors of the economy such as agriculture and manufacturing this will go a long way in increasing the production of goods and services which is capable of stabilizing prices and reduce inflation given their negative relationship.

Lastly, the size of the public sector expenditure needs to be reduced and possibly make a shift from excessive consumption expenditure to capital expenditure. Doing this will reduce the burden of fiscal deficit and the rate of inflation

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