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Effects of Some Monetary Policy Targets on Inflation and Inflation Volatility: Evidence from Nigeria

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ABSTRACT

The persistent inflationary pressure despite monetary policy targets has become a phenomenon of interest among researchers. The study investigates the effects of monetary policy targets on inflation and its volatility in Nigeria using data spanning from 1985 to 2019. The ADF unit root test used confirmed that all the variables under study are integrated order zero in their level series. A Comparison of inflation volatility models (ARCH and GARCH models) with appropriate error distribution using AIC indicated that ARCH (1) is most appropriate. The results of least squares (LS) and maximum likelihood (ML) ARCH methods of estimation for the model specifications showed that measures of monetary policy targets such as narrow money supply (M1), broad money supply (M2), net domestic credit(NDC), net credit to government(NCG) and credit to private sector(CPS) have no significant effect on inflation and inflation volatility respectively except M2. However, M2 effect spurs inflation rather than curbing it. Hence, it becomes imperative for the government to make proactive policies targeted to reduce inflationary pressures so as to attain price stability in Nigeria's economic space.

Keywords: monetary policy targets, inflation, Volatility models

1. INTRODUCTION

The rising inflationary pressure which has necessitated consistent increase in the prices of goods and services in Nigeria has become a phenomenon of concern to doubt if monetary policies targeted at inflation by the Monetary Policy Committee (MPC) are actually curbing inflationary pressure. In order to deal with the causal factors of inflation in Nigeria, there is the urgent need to have empirical evidence relating the rising inflation to either monetary or nonmonetary factors. The recent economic recession couple with rising inflation (observable from rising domestic prices) in Nigeria spurred the need for the present study, as this will help the monetary policy makers to take necessary actions the will combat the inflationary pressure and restore price stability within Nigeria's economic space.

There is this general conformity among economists that inflation rate is essentially dependent on the growth rate of money supply in the long-run. And, in the short and medium term inflation tends to be affected by supply and demand pressures in the economy, and influenced by the relative elasticity of wages, prices and interest. In many economists view, prices and wages adjust at different rates, and these differences have enough effects on real output to be "large period" in the view of person in an economy.

Some earlier studies have shown that inflation uncertainty have positive relationship with interest rate. Many researchers like [13]; [18]; [12] and [9] have provided empirical evidence for the positive relationship between expected inflation variation and the t-bill rates under different specifications such as asset pricing models. [14] have confirmed a relationship between

interest rate and inflation rate in the long-run.

The dynamic relationship between short term interest rates and inflation was investigated for the US, the UK, France, Germany, and Switzerland for the period 1974-1980. The result strongly suggests the variation of the nominal interest rate and inflation help to predict the ex ante real interest rate [17]. The effect of inflation and uncertainty on interest rates in the UK with quarterly data from 1958:4 to 1994:4 was studied and the result showed that both expected inflation and conditional variability of inflation positively affect the UK three-month treasury- bill rate [6].

[20]incorporated inflation, output gap and nominal interest rate regarding monetary policy according to Taylor's rule and suggested a realistic model of output gap that may be quite different from theoretical measures which should be based on interest rate. [5] applied VAR model and found the optimization problem regarding adjusting policy rates at central banks by the policymakers and also suggested that Taylor rule must be incorporated with the macroeconomic models to forecast the economy.

The interaction between nominal interest rates and inflation was examined for for Turkey over the period of 1984-2003 and the result supports the idea that there is a long-run relationship between interest rates and inflation for Turkish markets, and causality exists in only one direction from nominal interest rates to inflation [15]. [16] employed a VEC model to examine the relationship between inflation and interest rates for 114 economies over a 45 year period using monthly data. Interest rates and inflation are found to exhibit a long-run equilibrium relationship for numerous economic states. However, in states with large positive changes of inflation, high inflation risk or high interest rates, a long-run equilibrium relationship may not exist.

[19] examined the *rel*ationship between inflationary expectations and the variations in interest rate in Nigeria using the Generalized Method of Moment (GMM) estimator and their result indicated that the effect of interest rate variation on expected inflation in Nigeria is negative and significant. [2] investigated the effects of inflation and its risk on interest rate in Nigeria. ARCH(1) and GARCH(1, 1) were used to measure inflation risk and the result indicated that GARCH(1, 1) measured inflation risk better than ARCH(1) model based on Schwarz Information Criterion (SIC), and adopting multiple regression method, the result reveals that inflation and inflation risk exact negative and positive impacts on interest rate respectively, but none is significant. This result implies that the direction of monetary policy rate (MPR) is not proactive enough to curb the rising inflationary pressure in Nigeria. [3] also examines whether long-run equilibrium relationship exist between interest rate and inflation in Nigeria, using frame work of Johansen cointegration test vector error correction model (VECM) of granger causality test and his results show evidence of long-run equilibrium relationship between the two variables with strong evidence of unidirectional granger causality flow from interest rate to inflation at the long-run.

The effect of monetary policy on inflation in Nigeria was studied with a data sets covering the period of 2006M1 to 2017M4. The results of the generalized linear models (GLM) specified showed that three months deposit rate(IIIMDR) exacts right directional (negative) effect on inflation, significant at 10% level while), twelve months deposit rate(XIIMDR) and prime lending rate(PLR) have positive (unexpected directional effect) on inflation, significant at 1% and 5% respectively. Treasury bill rate(TBR) at lag 2 exacts right directional (negative) effect on current inflation significant at 1% level. It is observed that among all the predictors considered in this study, three months' deposit rate has direct effect in controlling inflation towards the right direction while treasury bill rate influences inflation toward

the right direction in shot-run [4]. [1] studied the relationship between interest rates and inflation in Ghana and their impact on economic growth for the period 2006-2019. The result showed that interest rates and inflation rates in Ghana were positively correlated and they had strong impact on the economic growth of Ghana within the period under review. The researcher, however, observed that the coefficient of correlation between interest rates and inflation rates from 2006-2015 was stronger than from 2016-2019.

Previous studies have concentrated on the effects of monetary policy rates on inflation. The essence of the study is to examine how proactive some monetary policy targets curb inflation and its volatility in Nigeria. The study also investigates the effects of previous inflation together with some monetary targets on current inflation and its volatility.

The rest part of the paper is organized as follows; section 2 presents the material and methods, section 3 deals with the data analysis and results, and section 4 presents the conclusion.

2. MATERIALS AND METHODS

This research is descriptive in nature and the data is quantitative in nature. Only the secondary data were used. Time sample data were collected from the world development indicators report, internal database and websites from 1972-2016.

This section provides information on source of data collection, variable measurement and definition, Volatility model specification, method of estimation, method of unit root tests, and diagnostic test

2.1 Source of Data Collection

The data sets on narrow money supply (M1), broad money supply(M2), net domestic credit(NDC), Net credit to government(NCG), credit to private sector(CPS) and inflation (INF) were obtained from published Central Bank of Nigeria [8] statistical bulletin as compiled by Debt Management Office and Central bank of Nigeria. The yearly time series data sets cover the period of 1985 to 2019.

2.2 Variable Measurement and Definition

This paper uses narrow money supply (M1), broad money supply (M2), net domestic credit (NDC), net credit to government (NCG), credit to private sector (CPS) are measures of monetary policy target.

2.3 Conditional Heteroskedasticity Model

Moreover, since inflation risk is not directly observable, the better describing Conditional Heteroskedasticity model between Autoregressive Conditional Heteroskedasticity (ARCH (1)) Model and Generalized ARCH (1, 1) model were adopted to measure inflation risk. In other words, inflation risk is measured using inflation volatility (conditional variance).

According to [11] given the mean equation of inflation as $\inf_t = \mu + \varepsilon_t$, the ARCH(p) is of the form;

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \varepsilon_{t-i}^2 \qquad (1)$$

were the nonnegativeness and stationarity of σ_t^2 are guaranteed for $\alpha_0 > 0$ and $0 \le \alpha_i < 1$. Hence, σ_t^2 becomes a function of the previous squared shock, large shocks of either sign tend to be preceded by large shock and vice versa. Though the ARCH (1) model can capture the stylized facts of volatility clustering and excess kurtosis, its short coming is that, it is unlikely that the model accommodates for the features related to the autocorrelation function of squared disturbances ε_t^2. And according [7] GARCH(1, 1) is of the form;

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \alpha_{2j} \sigma_{t-j}^2 \quad (2)$$

where $\varepsilon_t \to t(o, \sigma^2, v)$, the tail parameter $v > 2$ and t-distribution approaches normal distribution if $v \to \infty$. According to the property of GARCH model, $0 \le \alpha_{1i}, \alpha_{2j} \le 1$

and $(\alpha_{1i} + \alpha_{2j}) < 1$ show that the model is covariance stationary. For instant, a large ε_{t-1}^2 or σ_{t-1}^2 gives rise to a large σ_t^2. This means that a large ε_{t-1}^2 tends to be followed by another large ε_t^2, generating again, the well-known behavior of volatility clustering in financial time series. Note that ε_{t-1}^2 (ARCH term) represents news concerning volatility from the previous period, which is measured as the lag of the squared residual from the mean equation and σ_{t-1}^2 (GARCH term) represents the last period's forecast variance.

Note that the appropriate lag of the conditional variance will be selected on the basis of Akaike information criterion

2.4 Unit Root Test

The unit root test here, is based on Augmented Dickey Fuller (ADF) test and it is of the form

$$\nabla y_t = \alpha + \alpha_1 t + \beta y_{t-1} + \sum_{i=1}^{k} \xi_i \nabla y_{t-i} + a_t \quad (3)$$

where k is the number of lag variables. In (3) there is intercept term, the drift term and the deterministic trend. ADF unit root test null hypothesis $H_0 : \beta = 0$ and alternative $H_a : \beta < 0$. According to [10], if the ADF test statistic is greater than 1%, 5% and 10% critical values, the null hypothesis of a unit root test is accepted.

2.5 Regression Model Specification

The multiple regression specification is necessary to examine the effects of the monetary policy targets (m1, m2, ndc, ncg, and cps) on inflation.

$$inf_t = \beta_0 + \beta_1 inf_{t-1} + \beta_2 m1_t + \beta_3 m2_t + \beta_4 ndc_t + \beta_5 ncg_t + \beta_6 cps_t + e_{t1} \quad (4)$$

where $\beta_i (i = 0,1,2,3,4,5 \text{ and } 6)$ are regression coefficients. The error term e_{t1} is expected to be normally distributed with mean zero (0) and variance σ^2. The β_1 becomes the coefficient of Inflation at time *t-1* (previous year inflation).

The model specification for the effects of monetary policy targets (m1, m2, ndc, ncg, and cps) on Inflation volatility is given as follows

$$\sigma_{inf,t}^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \beta_3 m1_t + \beta_4 m2_t + \beta_5 ndc_t + \beta_6 ncg_t + \beta_7 cps_t \quad (5)$$

where $\sigma_{\text{inf},t}^2$ is the conditional variance of inflation and $\beta_i = (1 = 0,1,\cdots,7)$ are the parameter coefficients.

2.6 Method of Estimation

The coefficients of the ARCH/GARCH models are estimated by the method of maximum likelihood under the assumption that the model errors are conditionally normally distributed.

3. DATA ANALYSIS AND RESULTS

This chapter presents the pictorial representation, unit root test, conditional volatility model comparison and estimation, regression analysis and some diagnostic tests. The specified regression model is estimated using generalized least square method.

3.1 Graphical Representation of the Variables

In this section, the time series plot of inflation(INF), narrow money supply (M1), broad money supply(M2), net domestic credit(NDC), Net credit to government(NCG), credit to private sector(CPS) are presented below

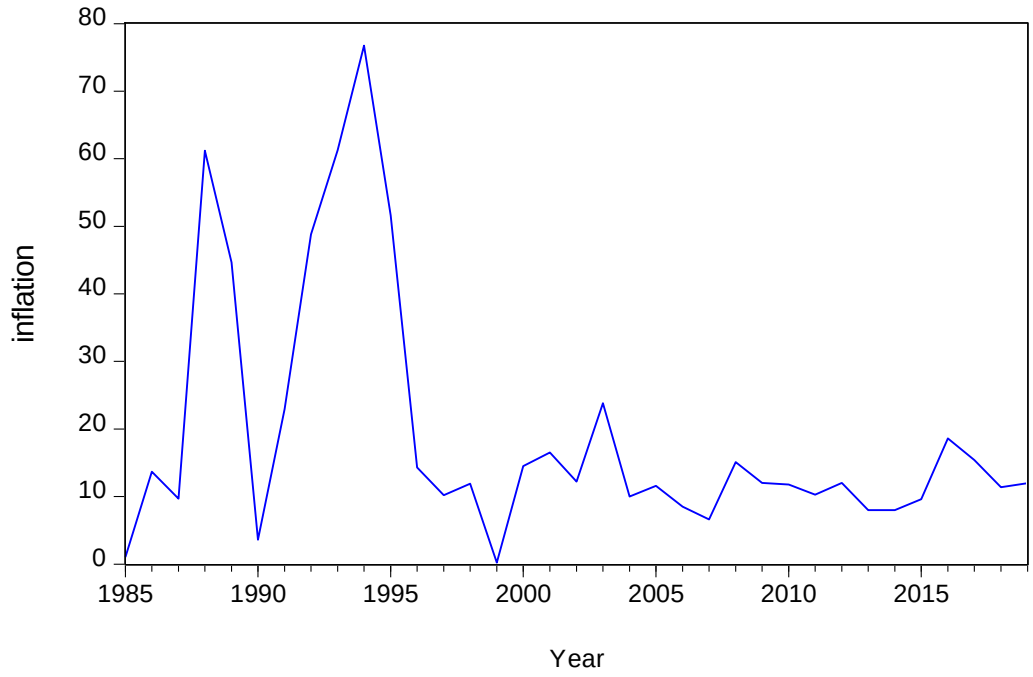

Figure1. Time series plot of actual inflation (1985 – 2019)

The plot in Figure1 exhibits more variation in the first half of the series than in the second half of the series. The lowest inflation value occurred in 1999 and highest peak in 1995 for the period under study.

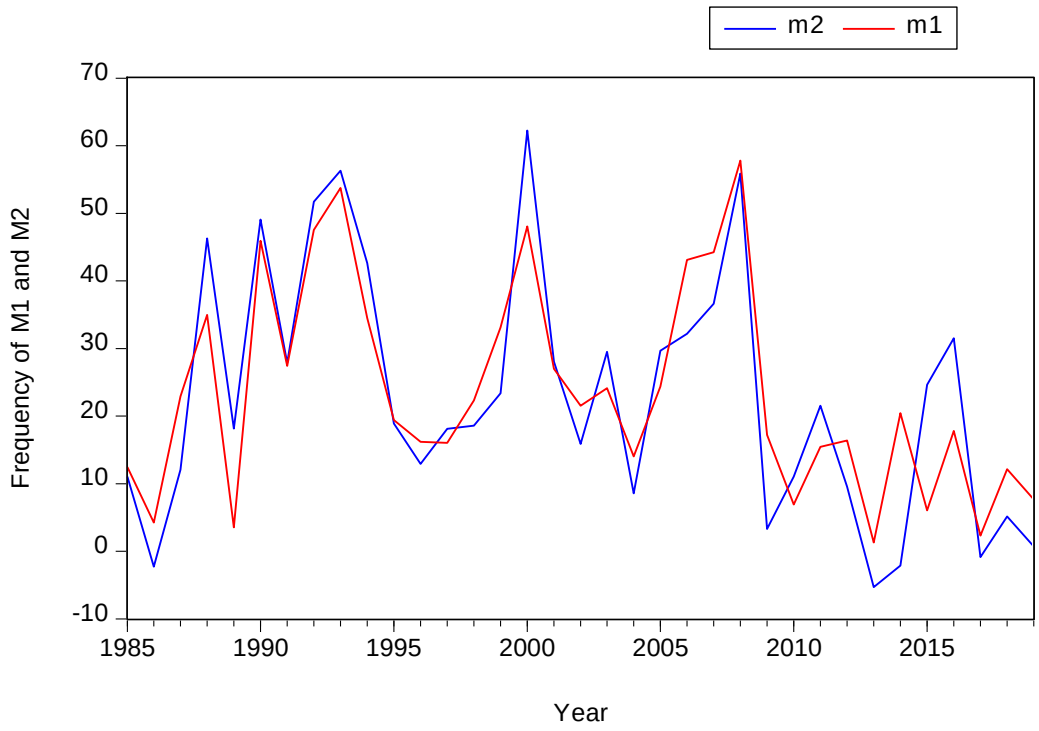

Figure2. Time series plot of M1 and M2 (1981 – 2019)

Narrow money supply (M1) and broad money supply (M2) in Figure 2 are very close in their distribution and tend to slowly trend downwards.

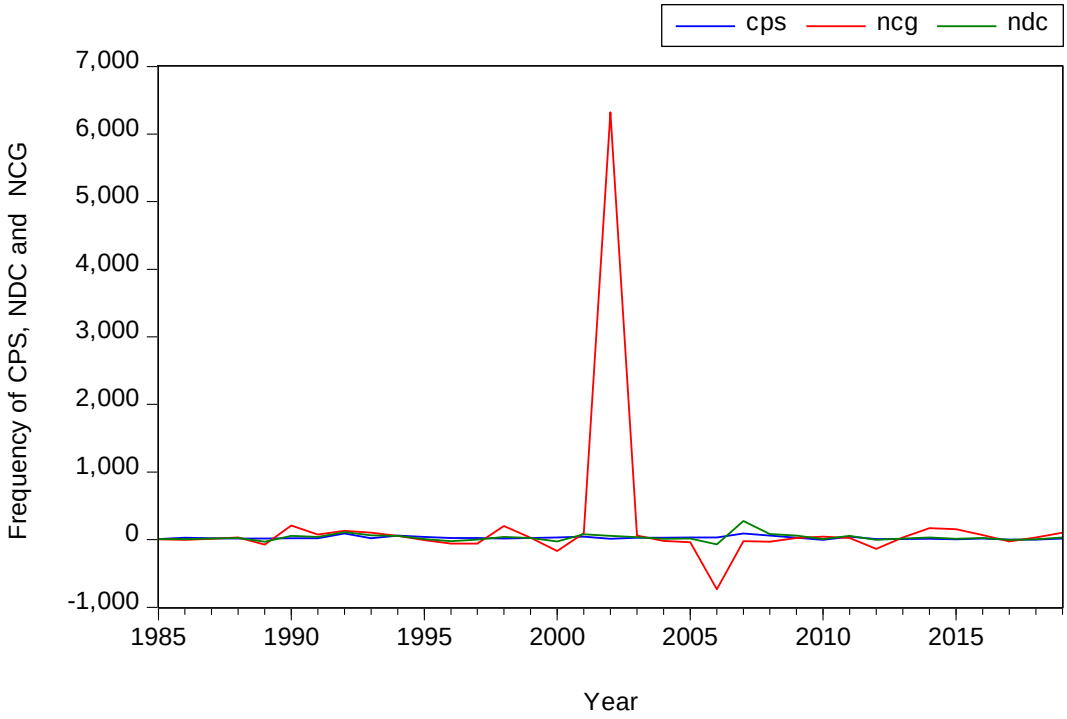

Figure3. Time series plot of CPS, NDC and NCG (1981 – 2019)

Apart from 2003 where NCG showed a peak outside zero, the net domestic credit (NDC), net credit to government(NCG) and credit to private sector(CPS) in Figure 3 exhibit fluctuation around zero

3.2 Result of ADF Unit Root Test

The result of ADF unit root test of the variables under investigation is summarized below;

Table 1 Analysis of unit root test

Test	*Series*	*Deter-ministic Term(DT)*	*Lags/ Band-width*	*Test Value*	*1% level 5%level 10%level*	*Prob.*	*Remark*
ADF	*inf*	C,T	6	-3.2621	-4.3240 -3.5806 -3.2253	0.0934	Stationary at 10% level
	cps	C,T	0	-4.8343	-4.2529 -3.5484 -3.2071	0.0023	Stationary under 5% level
	m1	C,T	0	-3.9858	-4.2529 -3.5484 -3.2071	0.0189	Stationary at 5% level
	m2	C,T	0	-4.3538	-4.2529 -3.5484 -3.2071	0.0078	Stationary under 5% level
	ncg	C,T	0	-5.5995	-4.2529 -3.5484 -3.2071	0.0003	Stationary under 5% level
	ndc	C,T	0	-5.7676	-4.2529 -3.5484 -3.2071	0.0002	Stationary under 5% level

The unit root test in Table1 indicates that the variables under investigation are all stationary under their level series and all are significant under 5% level, except inflation that is significant under 10% level.

3.3 Comparison of Conditional Heteroskedasticity Model

In this section, the AIC model selection criterion will be used to select the best describing ARCH/GARCH model for

measuring the volatility of inflation and the result is presented in Table 2 below;

Table 2. Comparing ARCH/GARCH Models with Apposite Error Distribution using AIC

Error Distribution	Model	AIC	SIC	Remark
Normal	ARCH(1)	8.3720	8.5053	No heteroskedasticity in the model residuals up to lag 3
	GARCH(1,1)	7.9879*	8.1656	No heteroskedasticity in the model residuals up to lag 4
	GARCH(2,1)	8.1514	8.3735	No heteroskedasticity in the model residuals up to lag 4
	GARCH(1,2)	8.0230	8.2452	No heteroskedasticity in the model residuals up to lag 4
Student's t	ARCH(1)	7.5937	7.7715	No heteroskedasticity in the model residuals up to lag 3
	GARCH(1,1)	7.7098	7.9320	No heteroskedasticity in the model residuals up to lag 3
	GARCH(2,1)	Singular co-variance coefficients		
	GARCH(1,2)	7.7208	7.9874	No heteroskedasticity in the model residuals up to lag 3
GED	ARCH(1)	7.4072	7.5849	No heteroskedasticity in the model residuals up to lag 3
	GARCH(1,1)	7.4557	7.6779	No heteroskedasticity in the model residuals up to lag 15
	GARCH(2,1)	7.5086	7.7752	No heteroskedasticity in the model residuals up to lag 15
	GARCH(1,2)	7.4976	7.7642	No heteroskedasticity in the model residuals up to lag 15

The symbol (*) indicates the smallest value of AIC

The analysis in Table 2 above indicates that comparing ARCH/GARCH models with appropriate error distribution, AIC chose the generalize error distribution (GED) and ARCH(1) has the smallest value of AIC, hence, it is selected as the best conditional heteroskedasticity measure of inflation volatility. For the mean equation $\inf_t = 12.0 + e_t$, the ARCH(1) model is of the form;

$$\sigma_t^2 = 124.0055 + 4.7918\varepsilon_{t-i}^2 \qquad (6)$$
$$p-val.\ (0.4171)\ (0.5712)$$

The volatility model in (6) indicates that ε_{t-1}^2 (news about volatility from the previous period) has no significant effect on current volatility.

3.3 Result of Regression Model

The result of the regression model on the effect of monetary policy target on inflation is presented in Table 4 below;

Table 4. Regression Estimates of Equation (4)

Dependent Variable: INF				
Method: Least Squares				
Sample (adjusted): 1986 2019				
Included observations: 34 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.103598	5.305692	0.584956	0.5634
inf(-1)	0.521053	0.137345	3.793744	0.0008
cps	0.096892	0.185783	0.521534	0.6062
ndc	-0.003304	0.065089	-0.050766	0.9599
m1	-0.457889	0.354435	-1.291885	0.2073
m2	0.647187	0.282114	2.294063	0.0298
ncg	3.63E-05	0.002399	0.015116	0.9881
R-squared	0.526400	Mean dependent var		19.96417
Adjusted R-squared	0.421156	S.D. dependent var		18.69839
S.E. of regression	14.22607	Akaike info criterion		8.329271
Sum squared resid	5464.292	Schwarz criterion		8.643522
Log likelihood	-134.5976	Hannan-Quinn criter.		8.436440
F-statistic	5.001690	Durbin-Watson stat		1.646420
Prob(F-statistic)	0.001462			

The regression result in Table 4 shows that the monetary policy target variables (narrow money supply (M1), broad money supply(M2), net domestic credit (NDC), net credit to government(NCG) and credit to private sector (CPS)) have no significant effect on inflation except that of M2 and it is significant at 5% level. The result also showed that the previous year inflation has positive impact on present inflation and it is significant at 1% level. The R^2 indicates that 52.6% variation in inflation is accounted by Nigeria's NDC, CPS, M1, M2 and NCG and previous year actual inflation. The F-statistic is significant under 1% level, showing the existence of linear relationship between the explanatory variables and

inflation in Nigeria. But Durbin-Watson statistic is getting closer to 2, however, indicating presence of serial correlation in the residual and a further test of serial correlation will be done using Breusch-Godfrey Serial Correlation LM Test and the result is presented in Table 5 below.

Table 5. Serial Correlation Test for the Estimated Regression model

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.630344	Prob. F(2,25)	0.2160
Obs*R-squared	3.922884	Prob. Chi-Square(2)	0.1407

Breusch-Godfrey Serial Correlation LM Test in Table5 indicates absence of serial correlation in the residuals of the regression model up to lag 2.

Table 6. Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	2.453045	Prob. F(6,27)	0.0505
Obs*R-squared	11.99525	Prob. Chi-Square(6)	0.0621

The result in Table6, shows there is no heteroskedasticity in the model residuals as the p-values are not significant under 5% level.

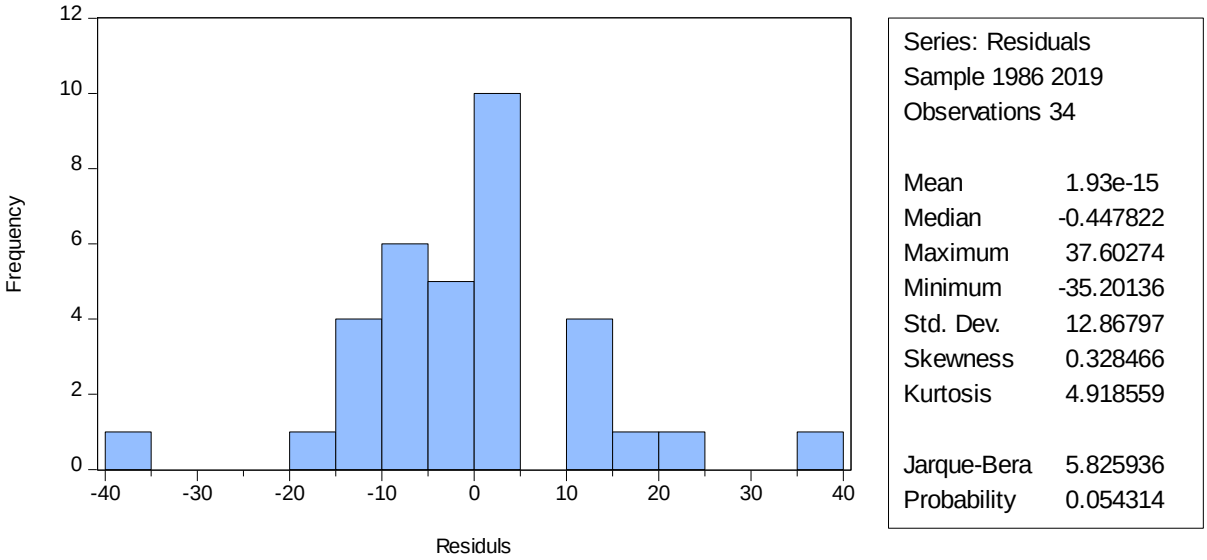

Figure4. Histogram of Residuals Normality Test

The result of the test of normality in Figure 4 indicates that we accept the hypothesis of normal distribution of the model error term at the 10% level. Hence, we conclude that the regression model specification in Equation (4) is adequate.

Table 7. Regression Estimates of Equation (5)

Dependent Variable: INF Volatility				
Method: ML ARCH - Generalized error distribution (GED) (BFGS / Marquardt steps)				
Sample: 1985 2019				
Included observations: 35				
Coefficient covariance computed using outer product of gradients				
Presample variance: backcast (parameter = 0.7)				
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*CPS + C(5)*M1 + C(6)*M2 + C(7) *NCG + C(8)*NDC				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	11.99998	0.046838	256.2013	0.0000
	Variance Equation			
C	38.20624	41.97437	0.910228	0.3627
ε_{t-1}^2	2.391478	2.867654	0.833949	0.4043
CPS	-2.873133	2.938685	-0.977693	0.3282
M1	0.184975	4.240435	0.043622	0.9652
M2	3.566392	4.947609	0.720831	0.4710
NCG	-0.020308	0.015805	-1.284955	0.1988
NDC	0.271139	0.896773	0.302349	0.7624
GED PARAMETER	0.509676	0.184778	2.758318	0.0058
R-squared	-0.162263	Mean dependent var		19.42322
Adjusted R-squared	-0.162263	S.D. dependent var		18.69728
S.E. of regression	20.15722	Akaike info criterion		7.464767
Sum squared resid	13814.66	Schwarz criterion		7.864713
Log likelihood	-121.6334	Hannan-Quinn criter.		7.602828
Durbin-Watson stat	0.664936			

The result in Table 7 shows that the monetary policy targets (narrow money supply (M1), broad money supply (M2), net domestic credit(NDC), net credit to government(NCG) and credit to private sector(CPS)) have no significant effect on inflation volatility.

Table 8. Heteroskedasticity Test: ARCH

F-statistic	0.091048	Prob. F(16,2)	0.9990
Obs*R-squared	8.007051	Prob. Chi-Square(16)	0.9487

The result in Table 8, shows there is no heteroskedasticity in the model residuals as the p-values are not significant under 5% level. Hence, there is no ARCH effect.

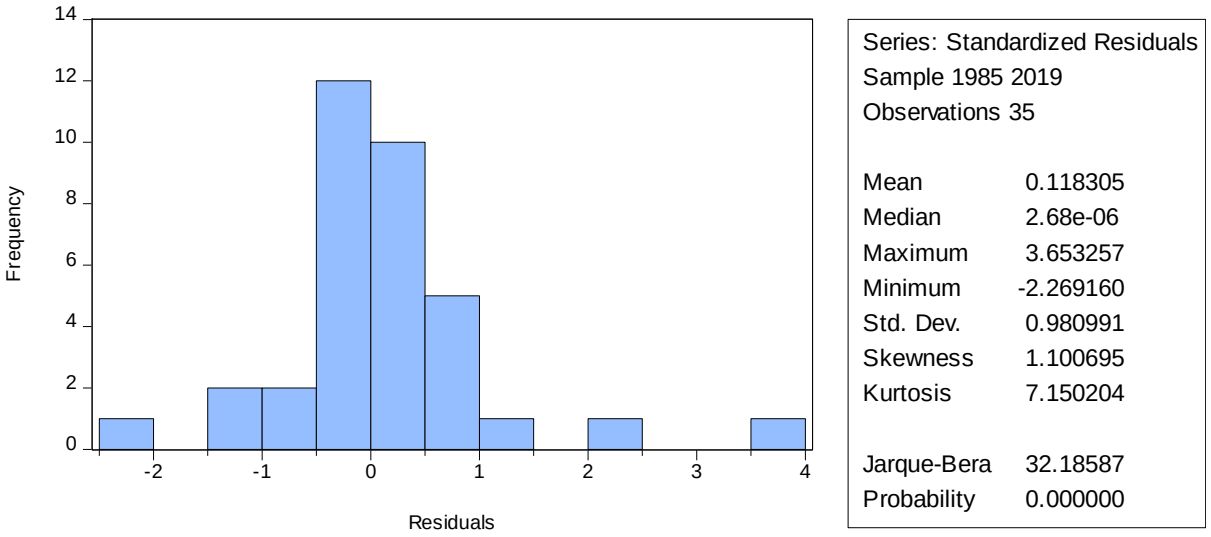

Figure5. Histogram of Residuals for Normality Test

The result of the test of normality in Figure 5 indicates that the p-value of the Jarque-Bera test is significant under 5% level hence, we accept the hypothesis of normal distribution of the model error term. Consequently, the regression model specification in Equation (5) is adequate.

3.4 DISCUSSION OF RESULTS

The result in Table 4 showed that the monetary policy target variables (narrow money supply (M1), broad money supply(M2), net domestic credit(NDC), net credit to government(NCG) and credit to private sector(CPS)) have no significant effect on inflation except that of M2 and it is significant at 5% level. This implies that amongst all the monetary policy targets, only M2 is sensitive to inflation and this sensitivity spurs inflation instead of curbing it. How? The empirical outcome of the analysis in Table 4 showed that a unit rise in M2 will result to about 3.57 units rise in inflation. If M2 is targeted to control inflation, the effect should be negative. And if M2 is targeted to control deflation, its effect should be positive.

The result in Table 5 revealed that the monetary policy targets under study have no significant effect on the volatility of inflation. The finding is related to that of [4] who opined that monetary policy rate (MPR) such as one month deposit rate is not proactive enough to curb the rising inflationary pressure in Nigeria.

However, the findings of the study could not be related to previous study due to the fact that there is little or no past study that focused on the exogenous variables used in the present study.

4. CONCLUSION

There is no doubt that the narrow money supply (M1), broad money supply(M2), net domestic credit(NDC), net credit to government(NCG) and credit to private sector(CPS) are targeted to curb inflationary pressure so as to attain price stability in Nigeria's economic space. However, the findings showed that monetary policy targets are neither sensitive

to inflation nor inflation volatility except M2 that significantly enhanced inflation instead of decreasing it.

Hence, it becomes imperative for the government, especially the CBN Monetary policy Committee (MPC) to make proactive policies targeted to reduce inflationary pressures so as to attain price stability in Nigeria.

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