Determining the Optimal Monetary Policy Instrument for Nigeria[1]

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It is considered inapt for central banks to adjust reserve money (quantity of money) and interest rate (price of money) at the same time. Thus, necessitates the need for a choice instrument. Enough evidence abounds in microeconomic theory on the undesirability of manipulating both price and quantity simultaneously in a free market structure. The market, in line with the consensus among economists, either controls the price and allows quantity to be determined by market forces, or influence quantity, leaving prices in the hands of the forces of demand and supply. This paper is, therefore, an attempt to examine the optimal monetary policy instrument for Nigeria between 1981Q1 to 2013Q2 using a bounds testing approach to cointegration. The result indicates the superiority of monetary instrument, followed by combined instrument and then interest rate instrument. The study therefore suggests that the CBN should lay more emphasis on monetary instrument particularly if output growth or stability is the primary goal of monetary policy.

Keywords: Optimal monetary policy, ARDL, interest rate, monetary aggregate, cointegration

JEL Classification Numbers: C53, E43, E47, E52

1.0 Introduction

Microeconomic theory has provided enough evidence on the undesirability of manipulating both price and quantity simultaneously in a free market structure. The market, in line with the consensus among economists, has the option of either controlling the price and allow quantity to be determined by market forces or influence quantity, leaving prices in the hands of demand and supply. Hence, it is inapt for central banks to adjust reserve money (quantity of money) and interest rate (price of money) at the same time. This consensus in economic literature on the inappropriateness of the simultaneous application of both reserve money and interest rate as monetary policy instruments necessitates the need for a choice instrument.

Economic Literature is, however, divided on the efficacy, as well as the superiority of the instruments. While some analysts opined that interest rate is inferior considering its inherent inability to determine equilibrium. They also

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posit that indeterminacy of price or rate of inflation has posed a significant practical problem particularly in term of zero bounds interest rate environment citing virtually two to three decades experience of Japan[4]. Market regulators, on other hand, apparently favoured interest rate, on the ground that changes in the reserve requirement is usually too infinitesimal to make a noticeable impact. They are of the opinion that the implementation of reserve requirement imposes an unbearable cost on the monetary authorities.

Market Players and participants, however argued in favour of interchanging both, negating the microeconomic principles and contending that the efficacy of the instruments depend largely on the prevailing economic situation. They are of the view that a weighted mixture of the two instruments can be adopted as is the case with monetary conditions index. A view highly challenged by Micro-economists on the ground that a combination of the two instruments will be tantamount to a deterministic relationship between money stock and interest rate. They also contend that it will lead to sub-optimal outcomes of monetary policy goals.

Despite the unending debate, however, the Central Bank of Nigeria (CBN) still uses both instruments, in her monetary policy implementation framework. This study is, therefore, an attempt to determine the most suitable of the instruments for the Nigerian economy and/or the appropriateness of the combined use of the instruments, so as to aid the CBN in making a decisive policy choice.

To achieve this, the paper is divided into five sections. After this brief introduction is section two which examines both the underlying principles and related empirical literature. Section three explains the data, methodology and estimation procedure, while section four analyses the results and the last section concludes.

2.0 Conceptual Framework and Literature Review

2.1 Conceptual Framework

If the assumption of the existence of two markets (i.e. goods and money markets) is recognised in line with the submission of Poole (1970) and following the Hicksian version of the *IS-LM* model, we have:

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[4] See Cargill and Guerrero (2006) for more detail.

$$y_t = \delta_0 + \delta_1 r_t \quad (1)$$

$$m_t = \vartheta_0 + \vartheta_1 y_t + \vartheta_2 r_t \quad (2)$$

Equation (1) represents a goods market – an IS function, while equation (2) is money market – a LM function. *Y* is aggregate demand, *r* represents interest rate and *m* is the money supply.

Equation (1) is a combination of consumption and investment equations reflecting the equilibrium represented as $Y = C + I$. The left hand side of equation (2) is money stock, while the right hand side represents the demand for money. Aggregate demand is assumed to be a function of interest rate in the goods market, which aids interest rate to influence movements in the money market. With only three variables (*y*, *r* and *m*) two of which are endogenous and one is exogenous, the central bank is expected to manipulate either the *m* or the *r* at any particular point in time. The parameters are not necessarily constant over time due to the influence of fiscal policy decisions of the government.

Adding error term to both equations (1) and (2), they become:

$$y_t = \delta_0 + \delta_1 r_t + \varepsilon_t \quad (3)$$

$$m_t = \vartheta_0 + \vartheta_1 y_t + \vartheta_2 r_t + \mu_t \quad (4)$$

$$E(\varepsilon) = 0, E(\mu) = 0, E(\varepsilon^2) = \sigma_\varepsilon^2, E(\mu^2) = \sigma_\mu^2, E\ (\varepsilon\mu) = \sigma_{\varepsilon\mu} = \rho_{\varepsilon\mu}, \sigma_\varepsilon \sigma_\mu$$

Following Poole (1970) the optimal instrument is determined by ability of the instrument to minimise the expected loss function in term of the variations between the actual and targeted income.

If we denote the desired level of output by the central bank as *y** and assume a quadratic loss function, then the difference between actual and the targeted level of income expected to achieve full employment can be given as:

$$l = E[(y - y^*)^2] \quad (5)$$

The central bank would strive to achieve *r* in the good market and *m* in the money market that minimises the loss function.

Following Gichuki *et al*. (2012), the starting point is to derive the reduced forms of equations (3) and (4) such that the endogenous variables become functions of the exogenous ones.

With preference for interest rate, for instance, Poole (1970) was of the view that the minimum expected loss function is achieved when $r = r^*$, hence if we substitute equation (3) into equation (5), we have:

$$\underset{r}{Min}\, E\left\{(\delta_0 + \delta_1 r^* + \varepsilon) - y^{*2}\right\} \quad (6)$$

If we equate the derivative to zero, we have:

$$E\left[2\delta_1\left((\delta_0 + \delta_1 r^* + \varepsilon) - y^*\right)\right] = 0 \quad (7)$$

If we divide through by $2\delta_1$ and as well consider the expectations, the equation becomes:

$$r^* = \delta_1^{-1}(y^* - \delta_0) \quad (8)$$

Equation (8) has attained the optimal value for r (i.e. r*). However, to equate the expected minimum loss function for interest rate to the variance of the *IS* curve, there is the need to substitute equation (8) into equation (3) since it is the reduced form of interest rate equation. Thus we have:

$$y = \delta_0 + \delta_1\delta_1^{-1}(y^* - \delta_0) + \varepsilon$$
$$\Rightarrow y = \delta_0 + y^* - \delta_0 + \varepsilon$$
$$\Rightarrow y = y^* + \varepsilon \quad (9)$$

Substituting equation (9) into equation (5) – the loss function, yields:

$$l_r = E\left[\left((y^* + \varepsilon) - y^*\right)^2\right]$$
$$l_r = E[y^* - y^* + \varepsilon^2] = E[\varepsilon^2] = \sigma_\varepsilon^2$$
$$l_r = \sigma_\varepsilon^2 \quad (10)$$

Equation (10) equated the expected minimum loss to the variance of the good market.

In case of preference for reserve money as a major instrument of monetary policy, the reduced form becomes:

$$y = (\delta_1\vartheta_1 + \vartheta_2)^{-1}[\delta_0\mu_2 + \delta_1(m - \vartheta_0) + \vartheta_2\varepsilon - \delta_1\mu] \quad (11)$$

Equation (11) makes *y* as contained in equation (4) a function of interest rate (*r*) and reserve money (*m*). Now, to eliminate *y* in the loss function, substitute equations (3) and (4) into the loss function such that the central bank now has to strive to attain a minimisation as given below:

$$\underset{m}{Min}\, E\left\{\left[\left(\frac{\delta_0\vartheta_2 + \vartheta_2\varepsilon - \delta_1\mu + \delta_1(m - \vartheta_0)}{\delta_1\vartheta_1 + \vartheta_2} - y^*\right)\right]^2\right\} \quad (12)$$

If we take the derivatives and set the equation to zero, we have:

$$E\left[\frac{2\delta_1}{\delta_1\vartheta_1 + \vartheta_2}\left(\frac{\delta_0\vartheta_2 + \vartheta_2\varepsilon - \delta_1\mu + \delta_1(m - \vartheta_0)}{\delta_1\vartheta_1 + \vartheta_2}\right) - y^*\right] = 0 \quad (13)$$

If we consider expectations and solve for *m*, the equation becomes:

$$m^* = \frac{y^*(\delta_1\vartheta_1 + \vartheta_2) - \delta_1\vartheta_2 + \delta_1\vartheta_0}{\delta_1} \quad (14)$$

Equation (14) has attained the optimal value for *m* (i.e. *m**).

However, to equate the expected minimum loss function for reserve money to the variance of the *LM* curve, there is the need to substitute equation (14) into equations (3) and (4) since it is the reduced form of reserve money equation and thereafter substitute the result into equation (5) – the loss function. Thus, we have:

$$l_m = [(y_r - y^*)^2] = E\left[\left(\frac{\vartheta_2\varepsilon - \delta_1\mu}{\delta_1\vartheta_1 + \vartheta_2}\right)^2\right]$$

$$= (\delta_1\vartheta_1 + \vartheta_2)^{-2}E[\vartheta_2^2\varepsilon^2 + \delta_1^2\mu^2 - 2\delta_1\vartheta_2\varepsilon\mu]$$

$$= (\delta_1\vartheta_1 + \vartheta_2)^{-2}\left[\vartheta_2^2\sigma_\varepsilon^2 + \delta_1^2\sigma_\mu^2 - 2\delta_1\vartheta_2\sigma_{\varepsilon\mu}\right] \quad (15)$$

Equation (15) has attained the minimum loss for the money market.

However, if the central bank is interested in both instruments as is the case in Nigeria, then monetary base becomes a function of the prevailing market interest rate, such that at zero interest rate, for instance, we have a case of strict monetary base targeting and when interest rate approaches infinity, then it can be taken for strict interest rate targeting.

If money supply equation as presented by Poole (1970) is taken, then $m = c_1' + c_2' r$. The combination of both interest rate and reserve money instruments can be defined by setting the values for c_1 and c_2 in the above money equation. Considering the difficulty of determining c_1' and c_2', money supply function can be re-expressed as:

$$c_0 m_i = c_1 + c_2 r_i \qquad (16)$$

Equation (16) equated c_0 to the common denominator of the optimal c_1' and c_2'.

If equations (3) and (4) are enlarged with equation (16), the values of c_1 and c_2 would represent the two policy instruments and the optimal policy would thus become:

$$c_0 m = c_1^* + c_2 r^*$$

Where, $c_0 = \vartheta_1 \sigma_\varepsilon^2 + \sigma_{\varepsilon\mu}$

$$c_1^* = c_0(\vartheta_0 + \vartheta_1 y^*) + (y^* - \delta_0)\left(\sigma_\mu^2 + \vartheta_1 \sigma_{\varepsilon\mu}\right)$$

$$c_2^* = c_0 \vartheta_2 - \delta_1\left(\sigma_\mu^2 + \vartheta_1 \sigma_{\varepsilon\mu}\right) \qquad (17)$$

The minimum expected loss function l_c is given as:

$$l_c = \frac{\sigma_\varepsilon^2 \sigma_\mu^2 \left(1 - {\rho_{\varepsilon\mu}}^2\right)}{\sigma_\mu + 2\rho_{\epsilon\mu} \vartheta_1 \sigma_\varepsilon \sigma_\mu + \vartheta_1^2 \sigma_\varepsilon^2} \qquad (18)$$

Equation (18) is the combined use of the two instruments.

2.2 Decision Rule

To be able to take decision on the superiority of one policy instrument over the other, there is the need to compare the loss arising from each of the two instruments as presented in equation (10) for interest rate instrument, equation (15) in case of reserve money instrument and equation (18) for both. The ratio of loss in the money market to loss in the goods market provides the basis for final decision.

The following formula consequently ensued:

$$\frac{l_m}{l_r} = (\delta_1\vartheta_1 + \vartheta_2)^2 \left[\vartheta_2^2 + \delta_1^2 \frac{\sigma_\mu^2}{\sigma_\varepsilon^2} - 2\delta_1\vartheta_2 \frac{\sigma_{\varepsilon\mu}}{\sigma_\varepsilon^2}\right] \qquad (19a)$$

Such that if:

$$\frac{l_m}{l_r} > 1, \quad Interest\ rate\ instrument\ is\ superior \qquad (19b)$$

$$\frac{l_m}{l_r} < 1, \quad Reserve\ money\ instrument\ is\ superior\ (19c)$$

$$l_c < l_r, \quad Combination\ of\ the\ two\ instruments\ is\ superior\ to\ interest\ rate\ (19d)$$

$$l_c < l_m, \quad Combination\ of\ the\ two\ instruments\ is\ superior\ to\ reserve\ money\ (19e)$$

2.3 Related Literature

The debate on the suitability of either interest rate or money supply as an appropriate instrument of monetary policy was ignited with the introduction of *k*-percent rule by Friedman in 1960. Friedman contends that central banks should grow money supply by a predetermined amount (the k-variable) each year to contend inflationary spiral, regardless of the cyclical state of the economy. Specifically, Friedman proposed the growth rate of money supply to equal the growth rate of gross domestic product (GDP) each year. Poole (1970) proved that money stock is more relevant than interest rate to stabilise the economy in case of distortion in equilibrium output arising from shift in IS curve.

James and VanHoose (2000) adopts an extended version of Cukierman's (1992) model of monetary policy discretion, private information and credibility to an endogenous quantity of money, where central banks have to choose between bank reserves or interest rate as a monetary policy instrument. With the hindsight of exploring the determinants of credibility for the alternative policy instruments, as well as weigh the level of political influence on the choice of policy instrument by the monetary authority. The results reveal that Poole criterion on the choice of monetary policy instrument is just one out of many problems faced by central banks when there is political pressure. The results also show that even if interest rate instrument yields a relatively higher precision vis-à-vis reserve-oriented policy, a natural bias towards the preference for interest rate policy will still emerged especially if the credibility gain arising from the use of interest rate is high.

Widjaja and Mardanugraha (2009) apply a combination of mathematical and econometric models to determine the optimal monetary policy instrument for Indonesian economy. The study covered the period 1993Q1-2006Q4. The results indicate that, although the setting of the nominal interest rate policy was not in line with inflationary trend during the studied period, the varying concerns of the Indonesian Central Bank with regard to inflation stability or output growth do not largely explain the direction of the nominal interest rate policy. Hence, they suggested that the Bank of Indonesia should concentrate on enhancing output growth, considering its insignificant influence on the changes in nominal interest rate.

Pongsaparn (2001) employ an eclectic approach ranging from basic tests and single equation to VAR as well as rolling regression and vector error correction model to determine the optimal monetary policy instrument for Thailand between 1986 and 2001.The result shows positive relationships between the level of financial development, monopoly power (uniqueness) in exports, strength of the country's institutions and the efficiency of interest rate as a monetary policy instrument. They submitted that interest rate was the most effective monetary policy instrument for Thailand during the studied period. The unsuitability of exchange rate regime and monetary targeting was attributed to the economic structure of the country.

Giannoni (2002) develop a model based on a property of zero-sum two-player games to determine a robust optimal monetary policy rules particularly in a situation of uncertainties about the parameters of the structural model. He then applied it to an optimal Taylor rules in a simple forward-looking macroeconomic model. The results, contrary to the common belief that monetary policy should be less responsive in case of parameter uncertainty, show stronger reaction of nominal interest rate to fluctuations in the rate of inflation and output gaps as against the period of certainty.

Giannoni and Woodford (2003) estimate an optimal monetary policy rules for different variants of a simple optimizing model of the monetary transmission mechanism with sticky prices and wages. The results show interest rate feed-back rules is a good representative of robust optimal rules but not in the form proposed by Taylor (1993). They submitted that a robust optimal rule is in most cases an implicit rule which requires the use of structural model to project the growth rate of the economy under a given policy prescription.

Giannoni (2007) exemplifies a robust optimal policy rule in a forward-looking model, under conditions of policy maker's uncertainty about model parameters and shock processes. The result indicates that an optimal policy rule requires a robust reaction of the interest rate to movements in both inflation and output gaps as compared to the case when policy makers are certain about model parameters and shock processes. They, therefore, conclude that although the parameter uncertainty is not necessary for a trivial response of monetary policy to distress but it is capable of enlarging the degree of apathy required by optimal monetary policy.

Svensson and Williams (2008) use a Markov Jump Linear-Quadratic (MJLQ) approach to design an optimal monetary policy instruments under uncertainty. Various discrete models were used to estimate different types of uncertainties that policy makers contend with. With Markov chain and mode-dependent linear-quadratic approximations of the underlying model, the authors apply algorithms to analyze effects of uncertainties as well as potential gains in a New Keynesian Phillips curve model. The results show that new initiatives by central banks significantly affect losses.

Orphanides and Williams (2008) under rational expectations hypothesis asses the robustness characteristics of optimal control policies. They assumed that agents do not only have insufficient knowledge about the structure of the economy but also form expectations based on forecasting models that are formulated and updated based on the available data. The results show that the optimal control policy based on rational expectations performs poorly when expectations do not coincide with rational expectations. They proved that the efficiency of the optimal control policy can be enhanced simply by detaching the importance attach to stabilization of real economic activity and interest rates vis-à-vis the inaction in the central bank loss function.

Bhattacharya and Rajesh (2008) used a micro-founded model of money under an overlapping generation's economy in which information asymmetry and stochastic relocation creates an endogenous transactions role for fiat money. The results show that welfare is higher under monetary growth targeting, in term of real shocks than during nominal shocks. The result further suggests the optimality of an expansionary policy under inflation targeting than as against money growth targeting.

Dotsey and Hornstein (2011) in their study find that the non-uniqueness of Markov-perfect equilibria as claimed in the literature is sensitive to the instrument in use. A unique Markov-perfect steady state and point-in-time equilibria exists, if the central bank, for instance, uses nominal interest rate rather than nominal money balances. This according to them makes monetary policy solely implementable when interest rate is in use as against money stock instrument.

Gichuki *et al*. (2012) apply an error correction model (ECM) on Kenyan data from period 1994 to 2010. The results show that interest rates is more effective than reserve money as it yielded the least minimum loss in output when compared with reserve money instrument. However, a combination of both instruments minimizes losses from equilibrium output far better than the other two instruments consider separately. They, therefore, concluded that, Central Bank of Kenya (CBK) should rely more on interest rate, if it desires to use only one instrument at a time, but in case the CBK wishes to utilize both instrument, it should construct a monetary conditions index to determine the degree of adjustment of each of the variable that would yield the desired monetary policy outcome. This according to them will help the Bank on the implementation of a combined instrument policy.

Naoyuki *et al.* (2012) develop a dynamic stochastic general equilibrium model for small open economies of Singapore and Thailand covering the period 1997Q3–2006Q2. The model was used to derive a simple basket weight rule. Although, the result was said to be sub-optimal but comparison among cumulative losses associated with the policy instrument rules, show that the use of a basket weight rule is superior to other instrument rules particularly in a free floating regime.

Vargas and Cardozo (2012) use three distinct models to determine the conditions for the efficacy of reserve requirements as an optimal monetary policy framework especially in an inflation targeting regime for Colombia. The central bank is expected to minimize an objective function that depends on deviations of the objective function from its target. (i.e. inflation from its target, output gap from its target and/or deviations of reserve requirements from its optimal long term level). The results show that, optimal monetary policy, in a closed economy model for instance, entails setting reserve requirements at their long term level, while fine-tuning the interest rate in accordance with the prevailing macroeconomic environments.

3.0 Empirical Implementation, Data Issues and Sample Period

3.1 Empirical Implementation

The study adopts autoregressive distributed lag (ARDL) approach developed by Pesaran *et al.* (2001) to estimate equations (3) and (4). The choice of the ARDL is based on several considerations. First, the model does not require stationarity of the data. In other words, the model can be applied irrespective of whether the underlying regressors are stationary at I(0) or I(1) or a mixture of both. Second, it has a small sample property. Third, it provide unbiased estimate of the long-run model as well as valid t-statistics even when some of the regressors are endogenous (Harris and Sollis, 2003).

Following Pesaran *et al.* (2001) the ARDL formats of equations (3) and (4) are:

$$\Delta ly_t = \delta_0 + \delta_1 ly_{t-1} + \delta_2 r_{t-1} + \sum_{i=0}^{m} \varphi_1 \Delta ly_{t-i} + \sum_{i=0}^{n} \varphi_2 \Delta r_{t-i} + \mu_t \quad (20)$$

$$\Delta lm_t = \beta_0 + \beta_1 lm_{t-1} + \beta_2 ly_{t-1} + \beta_3 r_{t-1} + \sum_{i=0}^{m} \gamma_1 \Delta lm_{t-i} + \sum_{i=0}^{n} \gamma_2 \Delta ly_{t-i} + \sum_{i=0}^{o} \gamma_3 \Delta r_{t-i} + \mu_t \quad (21)$$

Where *y* is the real gross domestic product, *r* represents real interest rate, *m* is real money supply (M_2), *l* is natural logarithm, Δ is the first difference, μ is an error term while β_0 *to* β_3, φ_1 to φ_2, δ_0 to δ_2 as well as γ_1 to $\gamma_3$are coefficient of the respective variables. Note also that δ_0 and δ_2 in equation (20) is the same as δ_0 and δ_1 as presented in equation (3), while β_0, $\beta_2$and β_3 in equation (21) are the equivalents *of* φ_0, φ_1 and φ_2 in equation (4). Note that optimal lag length is determined automatically using Bayesian information Criterion in Microfit 4.1.

Following the Granger representation theorem, when variables are co-integrated, there is an error correction model (ECM) that describes adjustment of the co-integrated variables towards equilibrium values. Hence, the general error correction representation of equations (20) and (21) are formulated as:

$$\Delta ly_t = \varphi_0 + \sum_{i=0}^{m} \varphi_1 \Delta ly_{t-i} + \sum_{i=0}^{n} \varphi_2 \Delta r_{t-i} + \Omega EC_{t-1} \quad (22)$$

$$\Delta lm_t = \gamma_0 + \sum_{i=0}^{m} \gamma_1 \Delta lm_{t-i} + \sum_{i=0}^{n} \gamma_2 \Delta ly_{t-i} + \sum_{i=0}^{o} \gamma_3 \Delta r_{t-i} + \zeta EC_{t-1} \quad (23)$$

Where EC = error correction term from equations (20) and (21), respectively.

According to Pesaran, *et al.* (2001), two stages are involved in estimating equations (20) and (21). First, the null hypothesis of the non-existence of the long run relationship among the variables is defined by H_o: $\delta_1 = \delta_2 = 0$ for equation (20) and $\beta_1=\beta_2= \beta_3 = 0$ for equation (21). H_o is tested against the alternative of H_1: not H_o. rejecting the null hypothesis implies that there exists a long run relationship among the variables irrespective of the integration properties of the variables. Two sets of critical values are tabulated with one set assuming all variables are I(1) and the other I(0). This provides a band covering all possible classifications of the variables into I(1) and I(0). If the calculated F-statistics lies above the upper level of the band, the null hypothesis is rejected, implying that there is co-integration, if it lies below the lower level of the band; the null cannot be rejected, indicating lack of co-integration. If the F-statistics falls within the band, the result is inconclusive.

3.2 Data Issues and Sample Period

To estimate the equation, quarterly data spanning the period 1981Q1 to 2013Q2 is employed. The data set is obtained from the publications of the Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS).

4.0 Empirical Results

4.1 Time Series Properties of the Data

The study deployed various techniques to test the presence of unit root in the series. Among which are Augmented Dickey Fuller (ADF) based on Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Criterion (HQC), as well as Phillips-Perron (PP). Table 1 shows that all the series are I(1) variables and significant at 1.0 per cent. This reveals that the data does not contain I(2) series, hence provides support for the use of ARDL model.

Table 1: Unit-Root Test (Augmented Dickey-Fuller and Phillips-Perron)

Variable	Augmented Dickey Fuller						P-P test statistics	
	AIC		SBC		HQ			
	Level	First Diff.	Level	First Diff.	Level	First Diff.	Level	First Diff.
m	2.519087	-4.552947*	2.179513	-11.75693*	2.179513	-11.75693*	2.592992	-11.80885*
y	0.960944	-5.242515*	1.849953	-15.95531*	1.849953	-5.242515*	1.050033	-12.71563*
r	-0.313438	-6.584713*	-0.451111	-10.35853*	-0.238211	-10.35853*	-0.447289	-11.46957*

*Note: * significant at 1%.*

From Table 2, the calculated F-statistics (i.e. 56.3 for equation 20 and 14.2 for equation 21) indicate that the null of no co-integration can be rejected at 0.05 per cent level for both equations since they are higher than the upper bound critical value of 4.85 and 4.35 at 0.05 per cent for *IS* and *LM* equations, respectively as tabulated in Pesaran *et al.* (2001). This implies that a long-run relationship exist among the examined variables.

Table 2: Estimated Long-Run Coefficients ARDL (4, 0)
Selected Based on Schwarz Bayesian Criterion

Dependent Variable: **LY - (IS Equation 20)**			
Variables	**Coefficient**	**t-Statistic**	**Prob-Values**
δ_0	-4.0573	-0.8120	0.4180
δ_2	10.7025	2.1202	0.0360
R^2 = 0.99	*F-Stat = (5, 120) =56.351 [0.000]*		*DW = 1.66*
Adjusted - R^2 = 0.99	*AIC = 177.1320, SBC = 168.6232*		

Estimated Long-Run Coefficients ARDL (2, 0, 0)
Selected Based on Schwarz Bayesian Criterion

Dependent Variable: **LM - (LM Equation 21)**			
β_0	-0.4437	-0.7437	0.4590
β_2	1.1395	15.5278	0.000
β_3	-0.0746	-0.1369	0.8910
R^2 = 0.99	*F-Stat = (4, 121) =14.2356 [0.000]*		*DW = 2.0561*
Adjusted - R^2 = 0.99	*AIC = 208.5662, SBC = 201.4754*		

The relevant critical values for unrestricted intercept and no trend under 2 variables for 0.05 is 3.79 - 4.85 and 3.25 - 4.35 for 3 variables. They are obtained from Pesaran et al. (2001) CI(iii) Case III.

Table 2 indicates that both models are well fitted as the independent variables exert about 99.0 per cent ($\bar{R}^2$) influence on the dependent variables in both equations. The results of the error correction models (ECM), presented in Table 3 yield statistically significant negative coefficients.

Table 3: Error Correction Estimates of the ARDL Models

Regressors	*Coefficient*	*t-Stats*	*Prob. Values*
Dependent Variable: ΔLY - Equation 22 - The IS Market			
θ_0	-0.053	-1.030	0.305
$\theta_1(-1)$	-0.532	-6.559	0.000
$\theta_1(-2)$	-0.240	0.914	0.010
θ_2	0.139	3.279	0.001
$\theta_2(-3)$	-0.396	-5.018	0.000
Ω	-0.013	-2.008	0.047
R^2 = 0.43		DW = 1.66	
Adjusted - R^2 = 0.40	*F-Stat = (5, 120) =17.6957 [0.000]*		
Dependent Variable: ΔLM - Equation 23 - The LM Market			
γ_0	-0.031	0.768	0.444
$\gamma_1(-1)$	-0.257	-3.028	0.003
γ_2	0.079	2.342	0.021
γ_3	0.005	0.133	0.894
ζ	-0.069	-2.361	0.020
R^2 = 0.14		DW = 2.0561	
Adjusted - R^2 = 0.10	*F-Stat = (4, 121) =4.8506 [0.000]*		

The stability of the estimated parameters are tested for both the *IS* and *LM* equations using cumulative sum (CUSUM) of recursive residual and cumulative sum of squares (CUSMSQ) of recursive residual tests.

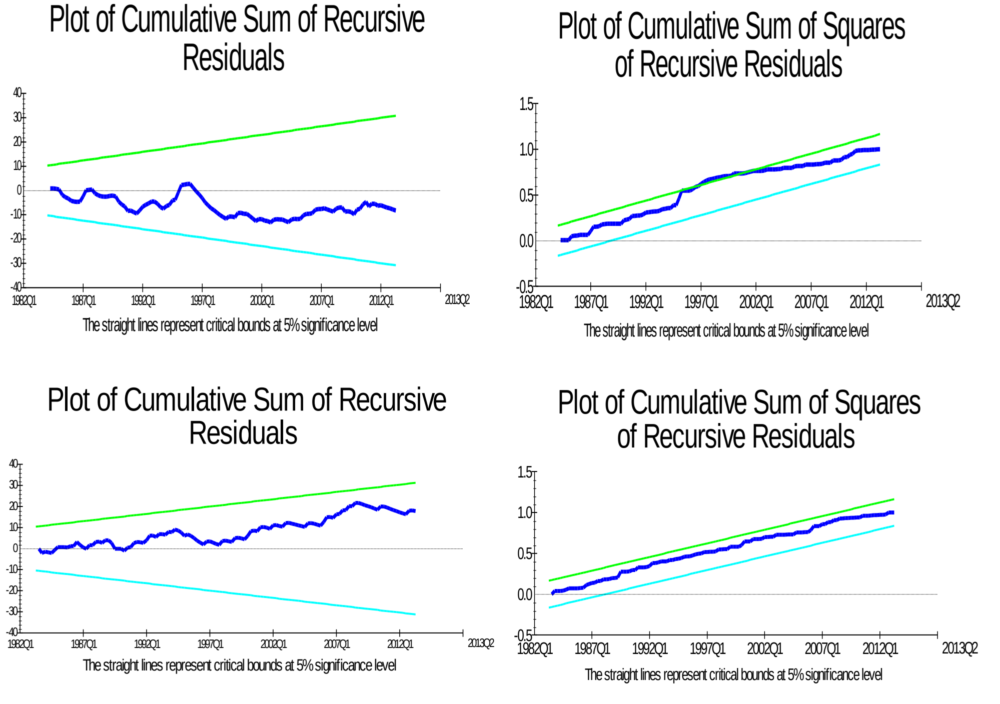

Figure 1: Cumulative Sum of Recursive Residuals

All the CUSUM and CUSUMSQ show that the estimated parameters of the analysed equations are stable, given that the recursive errors lie within the critical lines of 0.05 per cent.

4.2 Determining an Optimal Instrument for Nigeria

The residuals of equations (20) and (21) yield the following standard deviations and variances:

$$\sigma_\varepsilon = 0.056791, \sigma_\mu = 0.044604,\ \sigma_\varepsilon^2 = 0.0032252,$$
$$\sigma_\mu^2 = 0.0019895 \text{ and } \sigma_{\varepsilon\mu} = 0.050961$$

Note that from Table 2, δ_0 = -4.0573, δ_1= 10.7025, φ_0 =-0.44369, φ_1 = 1.1395 and φ_2 =-0.074615. Note also that from equation (4), $E(\varepsilon\mu) = \sigma_{\varepsilon\mu} = \rho_{\varepsilon\mu}, \sigma_\varepsilon\sigma_\mu$.

It, therefore, follows that:

$$\sigma_{\varepsilon\mu} = \rho_{\varepsilon\mu}, \sigma_\varepsilon\sigma_\mu \qquad (24)$$

$$\therefore \rho_{\varepsilon\mu} = \frac{\sigma_{\varepsilon\mu}}{\sigma_\varepsilon\sigma_\mu} = \frac{0.050961}{0.00253} = 20.11777 \qquad (25)$$

$$\therefore \rho_{\varepsilon\mu} = 20.11777 \text{ and } {\rho_{\varepsilon\mu}}^2 = 404.724$$

From the loss in interest rate instrument as represented in equation (10), we have:

$$l_r = \sigma_\varepsilon^2$$

$$\therefore l_r = 0.0032252 \qquad (24)$$

Following equation (15) depicting the loss in monetary instrument:

$$l_m = (10.7025 * 1.1395 - 0.074615)^{-2}[-0.074615^2 * 0.0032252 + 10.7025^2 * 0.0019895 - 2(10.7025 * -0.074615 * 0.05091)]$$

$$l_m = 0.002105 \qquad (25)$$

In line with equations (19b) and (19c), thus:

$$\frac{l_m}{l_r} = \frac{0.002105}{0.0032252} = 0.652673$$

From the results presented above, one can conclude that monetary instrument is more effective than interest rate instrument, given that:

$$\frac{l_m}{l_r} < 1$$

For the combination policy as reported in equation (18), we have:

$$l_c = \frac{0.0032252 * 0.0019895(1 - 404.724)}{0.044604 + 2(0.5454041) + 1.1395^2 * 0.0032252}$$

$$l_c = -0.0023 \qquad (26)$$

$$l_c < l_m < l_r \qquad (27)$$

Equation (27) implies that, the combination policy is the most optimal, followed by monetary aggregate and then interest rate policy.

The result of the study is in line with that of Bhattacharya and Rajesh (2008) for the US, who contends that the target of monetary instruments in enhancing welfare is robust even during economic shocks. It also corroborates that of Vargas and Cardozo (2012) for Columbia who reported that setting reserve requirement at their long term level is optimal for monetary policy. The study, however, only partially agrees with that of Gichuki *et al.* (2012) and Naoyuki *et al.* (2012). For Gichuki *et al.*, while the combination instruments far more minimises the loss function, interest rate instrument yielded a minimum loss function comparatively to reserve instrument. Naoyuki *et al.* also submitted that a basket weight of the instruments is superior to the use of either instrument.

The result does not, however, conform to that of Pongsarpan (2001), Giannoni (2002), Giannoni and Woodford (2003), Giannoni (2007), Orphanides and Williams (2008) and Dotsey and Hornstein (2011) who all reported the superiority of interest rate over other instruments.

5.0 Conclusion and Policy Implication

The strong rebuff of the simultaneous manipulation of both price and quantity in a free market structure has ignited a search for the optimal monetary policy instrument to be adopted by the central banks in their monetary policy operations. The market, following the consensus among micro-economists should either control the price or quantity at any particular point in time but not the two together. Despite this exceptional submission, most central banks across the globe still, at least occasionally, resort to the twin instruments, especially in term of crisis. This paper examined the optimal monetary policy instrument for the Central Bank of Nigeria between 1981Q1 to 2013Q2 using a bounds testing approach to cointegration. The results provide a strong support for the optimality of monetary instrument over interest rate instrument but show that a combination of both instrument is superior to the two used separately.

This result tends to be in tandem with the notion that monetary policy actions of the central banks affect credit supply majorly through money supply. Monetary policy tightening by the CBN, particularly via reserve instruments[5], contracts money supply, hence squeezes credit supply by the Deposit Money Banks (DMBs) via increase in interest rate. This process occurs even in an exceptional money demand environment. In a nutshell, therefore, the interest rates elasticity of money demand, is in this case, rendered less effective, while ability of credit supply to vary interest rate is strengthened, thereby bringing to fore the laws of supply.

The result, by extension shows that, the influence of CBN on money supply is far more significant than her influence on credit supply, because, the monetary base is the most important determinant of total supply of credit which the CBN has less influence to vary. With insignificant influence on credit supply, it becomes difficult for the Bank to considerably affect the equilibrium level of interest rates. This is why the CBN, regardless of her effort, can hardly achieve the low lending rate being advocated for several years now. Therefore, the occasional achievement of fall in interest rate in Nigeria, to a large extent, is an after-effect of the impact of monetary policy actions on money supply and not credit supply.

Generally speaking, this type of development could have probably informed Friedman (1999) submission that the influence of Federal Reserve Bank on supply of credit in the US is negligibly too small to have remarkable effect on interest rate and hence concludes that the CBs influence on interest rate can only be attributed to her monopoly in the supply of reserves and not her influence on the supply of credit. If the CBs increase reserves, credit by the commercial banks to households and firms declined. The competitive pursue of the limited supply escalates interest rate.

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[5] The interest rate channel could also occur if via interest rate but with relatively less severity.

Following the above, the study, therefore, suggests that the CBN should continue the use of the combined instruments as it is more effective than the use of a single instrument. However, if the CBN has preference for the use of a single instrument, emphasis should be placed on monetary instrument, particularly when output growth or stability is the primary goal of monetary policy[6].

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