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Modeling the Dynamics of Money Income in Nigeria: a Co-Integration Approach

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Abstract *This study examined the relationship between real output, monetary aggregates, price, interest rate and exchange rate using Nigerian data. Analysis of the time series properties of the data revealed that the series are cointegrated which indicated that there is a long- run relationship among the variables. We specified an error correction model to analyze the nature of relationship among the variables. The data for the analysis were sourced mainly from the publications of the Central Bank of Nigeria. The result of the parsimonious model revealed that the error correction term of the broad money model came out with the right sign and significant, implying that a shock is rapidly (39%) accounted for in subsequent periods. A one period lag of real exchange rate and price has a negative relationship with output and significant while M2 and interest rate are positively related to real output and also significant. The result of the variance decomposition analysis revealed that the Nigerian data supports the Monetarists' explanations of business cycles and recommends however that a combination of both monetary and fiscal policies be explored by the relevant authorities.*

Keywords: *Monetary aggregates, cointegration, Nigeria, exchange rate Interest rate VDC*

1. Introduction

The relationship between the trend growth in money stock and business cycle fluctuations has for long been a subject of intense controversy. Hasan (2010) neatly classified the related literature into two broad groups namely: equilibrium theories comprising of the classical school, monetarists, new classical and the real business cycles theories. The other group - disequilibrium theories comprised of the Keynesians and the new Keynesian schools.

The 'equilibrium' theories opined that output and employment in the economy always tend to hover around the equilibrium level. According to them, a movement away from equilibrium levels is caused by monetary or real shocks. Freidman (1968), for example argued that changes in the growth rate of the money stock causes a movement of output from its equilibrium level. The new Classicalist however, contended that only unexpected movements in aggregate demand or money stock account for business cycles. The monetarist again recognized that in the short run, change in the trend growth of the money stock exerts a significant impact on output (Ajayi and Ojo 2006). On the other hand, the "real business cycle" (RBC) school contended that money supply is endogenous and a function of output which is determined by such exogenous factors as technology or real 'stochastic shocks' (Hasan 2010). The 'equilibrium' theories however reached a common conclusion on the long-run neutrality of money stock in affecting output and employment.

The 'disequilibrium' theories of business cycle as represented by the Keynesian and the new Keynesian economists contended that 'aggregate demand' shocks are the main causes of cyclical movements in output from its trend. The new Keynesians argued that actual demand policies determine real output and employment due to price and wage inertia (Gordon 1982), and hence concluded that stabilization policies "matter". Although several papers have investigated the money- output nexus in Nigeria (see Ajayi and Ojo, 2006); Akinlo (2007); several of the issues are largely unresolved. For example

Chuku (2009) using a SVAR model found that price – based nominal anchors do not have a significant influence on real economic activity whereas the quantity based nominal anchors (M2) affect economic activities modestly. Other studies (Chimobi and Uche (2010), Odusola and Akinlo (2001), Egwaikhide, Chete and Falokun (1994), which investigated various aspects of output, inflation and money, reported mixed results. This provided the first justification for this study. Also, given the lack of consensus on the empirical literature on Nigeria money – output inter relationships, this study seeks to investigate the characteristics of the target- goal relationship among monetary aggregates and output, prices, interest rates and exchange in terms of an intermediate target and informational variable using Nigerian data set. This approach will enable us access the information content of monetary aggregates so as to see whether monetary aggregates are informative about future movements in the variables of interest. Out findings will reveal which of the business cycle theories explain the Nigerian situation. The remainder of the paper is organized in sections. Following this introduction, section 2 presents a brief review of the related literature. Section 3 describes the methodology. Section 4 discusses the empirical results while section 5 concludes.

2. Review of Related Studies / Theoretical Anchorage

Understanding the sources of business cycles is an issue that has elicited much theoretical and empirical research. As noted earlier, between the Keynesians, monetarists and real business cycle schools was the controversy over the relative effectiveness of monetary and fiscal policies. Thereafter, several studies investigated the relationship between money and income. In presenting this review we shall organize it in two parts. First, we shall review studies based on developed and developing countries and second, we shall review those that are based on Nigeria.

Friedman and Schwartz (1963) contended that there is a strong correlation between monetary aggregates and output and submitted that innovations in monetary variables have the potential for remedying cyclical fluctuations. However Bernanke and Mihov (1998) argued that the effectiveness of monetary policy will depend on the type of instrument used because the growth rate of monetary aggregates could be exogenously determined.

Employing time series data and standard co-integration methodology, Abbas and Husain (2006) investigated the relationship between money and prices in Pakistan and concluded that a long-run relationship existed among money income and prices. The study also reported a bi-directional relationship between money and inflation. Hossain (2005) using Indonesian data also found similar results as the study reported that given economic growth, there existed a long-run causal relationship between money supply and the level of inflation.

Agenor (1991), Morley (1992), pooling data from several countries investigated the effects of devaluation on output growth. Using regression methods, both studies reported that depreciation of the level of the real exchange rate exerted a contraction effect on output growth.

Rodriguez and Diaz (1995) fitted a VAR model to Peruvian data in efforts to determine the nature of cycles in that country. The study reported that output growth was explained by its own shocks. A similar result was reported by Ndung'u (1997) for Kenya. Ndung'u also reported that there is a bi-directional causality between inflation and exchange rates.

Hasan (2010) investigated the characteristics of target- goal relationship and output, prices, interest rates and exchange rates in terms of a good intermediate target. He employed a five- variable VAR analysis using India data and found that M1 and M2 may not serve as good intermediate targets. The result also showed that the interest rate is subject to a feedback from the non-policy variable such as price.

Odusola and Akinlo (2001) examined the link among naira depreciation, inflation and output in Nigeria. The study revealed the existence of mixed results on the impacts of exchange rate depreciation on output. The study also found that the impacts of the lending rate and inflation on the output were negative and that output and parallel exchange rate are the major determinants of inflation dynamics in Nigeria. The study however did not investigate the role of monetary aggregates on output.

Chimobi and Uche (2010) investigate the relationship between money, inflation and output in Nigeria and found that M2 appears to have a strong causal effect on real output and prices. The study found no long- run relationship between money supply, inflation and output in Nigeria. This result is rather surprising.

Chuku (2009) examined the effects of monetary policy shocks on output and prices using a structural vector auto regression approach on Nigerian data series. The study found that monetary policy

innovations have both real and nominal effects on economic parameters depending on the policy variable selected. The study also concluded that price-based nominal anchors (for example minimum rediscount rate and the real exchange rate) do not have a significant influence on real economic activity. The study failed to analyze the long-run equilibrium relationship.

3. Materials and Methods

3.1 Data

The data used for this study are annual series covering the period 1970 – 2009 on five variables as described below:

RGDP	=	real output
M_1	=	narrow money
M_2	=	broad money
CPI	=	Price Index
IR	=	Interest rate
REER	=	real exchange rate

All the variables except RGDP and REER are in nominal. Before proceeding with the estimation, the time series properties of the data must be carefully evaluated so as to avoid spurious regression (Engel and Granger (1987). In this regard the Augmented Dickey Fuller (ADF) test was considered good given the fairly large size of the data sets (Enders). The results of the ADF unit Root test is reported in table 1 below

Table 1. *ADF Unit Root Test*

Variable	ADF Test Statistic at Levels	ADF Test Statistic at 1st difference	Order of Integration
M_2	-0.0803	-3.7844	1(1)
M_1	-0.4190	-7.0566	1(0)
IR	-1.4577	-5.0069	1(1)
RGDP	-2.7615	-8.7277	1(1)
REE R	-0.2128	-3.6480	1(1)
CPI	-2.9180	-0.6313	1(0)

Source*: Authors computations.*

From the results of the ADF unit root tests, M_1 and CPI are found to be stationary at levels while the other variables are 1(1). In specifying our models, the variables would be used at the levels at which they are stationary. The ADF test was also applied to the residual of the regression of a static model using the variables at levels. The result shows that it is stationary at levels

Having confirmed the order of integration of the variables, we then test whether there is a long-run relationship between the dependent and the explanatory variables. The Johansen co-integration test was conducted. Table 2 below presents the Johansen co- integration test.

Table 2. *Johansen Cointegration Test Result*

Date: 05/21/11 Time: 14: 21
Sample (adjusted): 1973 2009
Included observations: 37 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: LRGDP LM1 LM2 CPI LREER LIR
Lags interval (in first differences): 1 to 2

Unrestricted Co integration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None*	0.784964	146.9114	94.15	103.18
At most 1**	0.712729	90.04431	68.52	76.07
At most 2**	0.445353	43.89319	47.21	54.46
At most 3	0.330614	22.08451	29.68	35.65
At most 4	0.177321	7.232938	15.41	20.04
At most 5	0.000296	0.010953	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at both 5% and 1% levels

Source: *Author's computations*

From table 2, Trace test indicates 2 co integrating equations at both 5% and 1% levels. Since there is growing evidence in favour of the trace statistics compared to the maximum eigenvalue statistics (Kasa, 1992), we accept the trace test results. This result shows that there is a long-run relationship between output, price and monetary variables which the monetary authorities may exploit in the formulation of monetary policies. Also the evidence of a cointegrating relationship rules out the possibility of spurious correlation and Granger non-causality among the real output, money stock, interest rates, prices and exchange rates.. This permits us to specify a dynamic long-run equation between output and its determinants in the following form:

$$RGDP = a_0 + a_1m_1 + a_2CPI + a_3IR + a_4REER + e_1 \quad - \quad - \quad (1)$$

$$RGDP = b_0 + b_1m_1 + b_2CPI + a_3IR + a_4REER + e_2 \quad - \quad - \quad (2)$$

Where $a_1 > 0$; $a_2, a_3, a_4 < 0$

$b_1 > 0$, b_2 $b_3, b_4 < 0$

and e_1 and e_2 are the error terms.

Since the cointegration tests showed the existence of a long-run relation among the variables, we test for unit root of the residuals from the static regression of the variables at levels in (1) and (2) above. If they are found to be stationary, we then incorporate them into a dynamic long-run error correction specification of equations (1) and (2). The ADF unit root test on the residuals of (1) and (2) above shows that the residuals are stationary at levels, which is a further evidence of cointegration among the variables. The residual series generated in (1) and (2) above are then incorporated into (1) and (2) as the error correction term (ECM-1) and (ECM-2) respectively thus:

Thus:

$$\Delta RGDP = h_0 + h_1 \Delta RGDP(-1) + h_2\Delta M_1 + h_3\Delta CPI + h_4\Delta IR + h_5 \Delta REER + ECM(-1) + U_1 \quad - \quad - \quad - \quad - \quad (1^1)$$

$$\Delta RGDP = go + g_1 \Delta RGDP(-1) - g_2\Delta M_2 + g_3 \Delta CPI + g_4 \Delta IR + g5 \Delta REER + ECM(-2) + U_1 \quad - \quad - \quad - \quad (2^1)$$

Where, Δ indicates first difference and

$ECM_1(-1)$ and $ECM_2(-1)$ are the lagged error correction terms and the U_1, U_2 and the error terms.

The coefficient the of error correction term (ECM) depicts the speed of convergence to equilibrium in the event of a shock. In estimating equations (1^1) and (2^1) we adopted the general- to – specific

framework by specifying an over-parametised error correction model given the need to identify the main dynamic patterns in the model and to ensure that the dynamics of the models have not been restricted by a too short lag length (Komolafe (1995). For (1^1) and (2^1) we estimate the over-parametised versions using a lag length of 4 using the OLS methods. The over-parametised equation is then simplified until theory consistent and data coherent parsimonious result is achieved.

In the (1^1) model the results turned out to be weak and m_1 was not significant. We decided not to report the results. The result in the (2^1) equation turns out better and together with the VDC results reported latter in this study would enable us to analyse the dynamic relationships between output, price and monetary variables. Table 3 below presents the results of model (2^1).

4. Presentation and Analysis of Results

Table 3. *Results of the parsimonious model*

Dependent Variable: DLRGDP Method: Least Squares Date: 05/21/11 Time: 14: 21 Sample (adjusted): 1973 2009 Included observations: 37 after adjusting endpoints				
variable	**Coefficient**	**Std. Error**	**t- Statistic**	**Prob.**
DLREER(-1)	-0.698798	0.146390	-4.773544	0.0000
DLREER(-2)	-0.049846	0.155323	-0.320916	0.7506
CPI(-1)	-0.407148	9.198256	-2.053643	0.0483
DLM2	2.833005	0.586330	4.831761	0.0000
DLM2(-1)	0.656294	0.465237	1.410665	0.1690
DLIR(-1)	1.798383	0.409333	-4.393451	0.0001
ECM(-2)	-0.398301	0.118932	-3.348988	0.0023
C	0.170068	0.191139	0.889761	0.3809
R-squared	0.582358	Mean dependent var		0.072560
Adjusted R-squared	0.481548	S.D dependent var		0.524013
S.E. of regression	0.377308	Akaike info criterion		1.077301
Sum squared resid	4.128482	Schwarz criterion		1.425608
Log likelihood	-11.93008	f- statistic		5.776776
Durbin-Watson stat	1.728412	prob (F-statistic)		0.000295

Source*: Author's Computations*

From table 3, the error correction term (ECM_2 (-1)) came out with the expected negative sign and is significant at the 1% level. The ECM_2 also indicates that the speed of convergence to equilibrium is 39.8%. That is, if there is a shock in RGDP, 39.8% of it will be eliminated in the next period.

From table 3 above, M_2 turns out to be positively related to RGDP and significant at the 1% level. This indicates that the monetary authorities could significantly affect economic activities and output by varying the level of broad money stock. The price level (CPI) has a negative relationship with real output suggesting that the level of inflation diminishes real output after a one period lag. Also from table 3, a period lag of the real exchange rate has a negative sign and significant at the 1% level. The observed negative sign indicates that with a lag length of 1, an inverse relationship exists between real output and real exchange rate. This tends to suggest that devaluing the naira will depress real output after a period lag. This is not surprising because the effects of devaluation in a mono-commodity driven economy on output would be negative. This result is similar to Agenor (1991) which found that depreciation of the real exchange rate exerted a contractionary effect on output. Edwards (1989), Agenor (1989) also found that at least in the short- run devaluation tended to reduce real output. The interest rate variable turns out to carry the unexpected positive sign andsignificant at the 1% level. This result however may be a reflection of the structural rigidities within the financial system in Nigeria. Overall the model results indicate that monetary aggregates, inflation and the real exchange rates have significant impact on the level of real output in Nigeria for the period under study. Although table 3 above indicated the nature of the relationship that existed among the dependent and explanatory variables, the causal links are not revealed. In order to analyze the dynamic characteristics of the major macroeconomic variables, variance decompositions (Sims 1980b) were computed and reported in table 4 below:

Table 4. *Variance Decomposition*

Variance Decomposition of LRGDP:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.336546	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.590500	39.20524	0.169322	5.913950	46.45722	4.830905	3.423364
3	0.784811	24.70639	1.706264	5.343421	61.46154	4.004690	2.777692
4	1.006993	15.13572	3.062250	6,402075	70.47262	3.237365	1.689965
5	1.333859	8.673460	6.746661	6.515638	74.38396	2.627742	1.0525536
6	1.685055	5.434906	10.12044	6.262935	75.14410	2.344136	0.693474
7	2.011620	3.847005	12.75786	5.309599	74.95247	2.504584	0.628476
8	2.338682	2.908494	15.52422	4.376942	73.81451	2.632014	0.743814
9	2.663098	2.297491	18.64065	3.730396	71.75638	2.641623	0.933468
10	2.979236	1.878455	21.41777	3.228665	69.62740	2.691454	1.156259
Variance Decomposition of LM 1:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.546010	0.020714	99.97929	0.000000	0.00000	0.000000	0.000000
2	0.680863	0.268088	77.60380	0.018763	18.06926	2.695788	1.344302
3	0.866591	1.007894	52.37105	8.744889	35.36399	1.664802	0.847376
4	1.033077	2.034993	43.29075	9.778459	43.03706	1.226424	0.632314
5	1.210964	2.696082	34.07987	8.323807	52.53939	1.626414	0.734440
6	1.395703	3.491707	26.33891	7.863753	60.12845	1.534910	0.642266
7	1.541157	4.170110	21.89451	7.714341	63.90419	1.471120	0.845727
8	1.698173	4.546542	18.11708	7.297221	67.30829	1.567505	1.163358
9	1.854138	4.697253	15.20846	6.843693	70.32722	1.634818	1.288559
10	1.991615	4.934956	13.22675	6.443445	72.15197	1.747125	1.495758
Variance Decomposition of LM 2:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.151546	2.254606	18.49341	79.25198	0.000000	0.000000	0.000000
2	0.233603	3.186814	22.05874	73.06050	1.125122	0.044392	0.524436
3	0.294073	3.516937	26.24487	67.68628	0.945688	0.076488	1.529738
4	0.355693	2.707474	34.09681	59.64694	0.849422	0.059696	2.639659
5	0.413746	2.269411	40.14559	53.49631	0.629680	0.142922	3.316096
6	0.474837	1.938249	43.66294	50.07129	0.494187	0.295102	3.538234
7	0.538025	1.724195	46.06115	47.55946	0.387080	0.419172	3.848942
8	0.599394	1.569002	48.05503	45.26599	0.318266	0.489836	4.301876
9	0.659138	1.400243	49.99580	43.17221	0.266619	0.526599	4.638535
10	0.717170	1.255444	51.55410	41.51058	0.229356	0.581991	4.868522
Variance Decomposition of LCPI:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.320049	4.795746	0.376482	13.88918	80.93859	0.000000	0.000000
2	0.686271	4.100792	2.113304	15.59152	77.87915	0.129370	0.185861
3	1.079932	4.670002	3.725919	14.68525	76.72493	0.092411	0.101491
4	1.535291	5.025826	5.282651	12.02237	77.34721	0.200870	0.121067
5	1.985173	5.247806	7.918805	9.998535	76.34498	0.279000	0.210877
6	2.427241	5.487559	10.40039	8.543192	74.71297	0.405976	0.449913
7	2.870806	5.491849	12.93235	7.264634	73.08680	0.526364	0.698007
8	3.302137	5.404326	15.64614	6.245704	71.11082	0.640308	0.952702
9	3.718096	5.315871	18.10565	5.408655	69.17771	0.764417	1.227700
10	4.119531	5.189860	20.44460	4.696366	67.29885	0.876289	1.494037
Variance Decomposition of LREER:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.391321	22.304331	2.662038	1.149860	9.064654	64.81914	0.000000
2	0.813563	19.59768	2.783426	4.418570	43.30481	29.14997	0.745539
3	1.379903	14.07459	1.274405	7.370960	63.47817	12.58757	1.214311
4	1.954663	13.24347	0.657479	7.929660	69.70292	7.363516	1.102957
5	2.509430	13.39319	0.508072	7.718865	72.67730	5.000472	0.702096
6	3.102138	12.92985	0.963123	7.494894	74.60927	3.543407	0.459453
7	3.685652	12.42608	1.884498	7.125137	75.60153	2.633872	0.328882
8	4.239139	12.16827	2.924263	6.534222	76.06954	2.025007	0.278695
9	4.771479	11.952662	4.161570	5.891938	76.09470	1.608823	0.290352
10	5.279592	11.72515	5.604418	5.361338	75.64067	1.318516	0.349902

Variance Decomposition of LIR:							
Period	S.E	LRGDP	LM1	LM2	LCPI	LREER	LIR
1	0.193450	10.93594	0.734898	0.207290	2.545665	32.22953	53.34667
2	0.303596	11.23369	7.382017	1.768889	31.03861	19.77943	28.79737
3	0.365765	10.34328	18.34470	7.484536	21.38906	16.37328	26.06515
4	0.436883	10.13968	15.72133	13.06714	15.49086	17.29498	28.28602
5	0.498096	8.358040	17.16041	19.27034	12.35799	15.96339	26.88982
6	0.562697	6.752513	18.07932	20.93781	14.42218	14.10324	25.70494
7	0.618443	5.723617	16.32974	23.02032	16.17518	13.43632	25.31482
8	0.672567	4.842538	15.15558	25.52202	18.06980	12.54058	23.86947
9	0.726487	4.156210	13.71807	26.40494	21.43386	11.67323	22.61370
10	0.775048	3.653151	12.22751	27.24697	24.24829	10.98946	21.63461
Cholesky Ordering: LRGDP LMI LM2 LCPI LREER LIR							

Source: *Authors computations using Eviews*

The variance decomposition shows the proportion of forecast error variance for each variable that is attributable to its' own' innovation and to innovations in the other endogenous variables. The variance decomposition also can be interpreted as the causality flows from one variable to the other. In this sense the variance decomposition convey a sense of dynamics of the system. Hasan (2010) opined that since variance decompositions account for the absolute size of an economically important variable regardless of its statistical significance, we caution therefore that the causal inferences embodied in our earlier models may be different from the causal inferences obtained in the variance decomposition analysis.

From table 4, RGDP 'own shocks' variation ranged from 1.9% to 100% over the ten year horizon. At the end of ten- period forecast horizon M_2 innovations explain 3.22% of the forecast error variance of real output (RGDP) while RGDP innovations only explain 1.25% of the variation in M_2. This demonstrates that the causality flowing from M_2 to real output is stronger than a reverse causality from output to M_2. Also, at the end of ten-period forecast horizon, M_1 innovations explain 21.4% of the forecast error variance of real out output while RGDP innovations only explain 4.9% of the variation in M_1. The causality from M_1 to RGDP is stronger than the reverse causality. IR innovations explain 1.49% of the forecast error variance in CPI at the tenth-period horizon which implies a weak price effect while CPI explains 24.2% of the forecast error variance in IR which means that a strong causality runs from CPI to IR. Price (CPI) innovations explains 72.2% and 22.9% of the forecast error variance in M_1 and M_2 respectively at the end of tenth-period forecast horizons which suggest a strong causality runs from CPI to money stock.

As for exchange rate, CPI innovations exert a significant and discernible effect (75.6%) on the movement of exchange rate whereas RGDP innovations exert a weak effect (11.72%, table 4) on the movements of exchange rates.

To sum up, although M_1 did not perform well in our error correction model, yet the variance decomposition results indicate that M_1 exerts a discernible impact on income (RGDP), suggesting that M_1 is a leading indicator in explaining output. This result may be due to the fact that Nigeria is largely a "cash" economy. From table 4, we observe that movements in M_1 and M_2 also result from movements in the goal variables such as prices (72.5% for M1) and real output. We attempt to conclude then that the use of M_1 and M_2 as intermediate targets for monetary policy may not be too effective. For price (CPI) variability, innovations in M_1, M_2 and RGDP explain the bulk of movements observed in price. This implies that M_1 and to a little extent M_2 may serve as an appropriate monetary aggregate to attain the goal of price stability. For IR variability, innovations in price (CPI), M_2 exchange rate and M_1 explains the substantial movement in interest rates (IR). Hence exchange rate, price and M_1 may serve as the appropriate price and monetary aggregates to control interest rates.

5. Conclusion

The identification of the empirical characteristics of monetary aggregates in terms of a good intermediate target and informational variable is less investigated in Nigeria. We adopted a cointegration approach in an attempt to fill this gap.

The study revealed that a long-run relationship exists between real output, monetary aggregates and price. The one period lag of real exchange rate, broad money and the one period lag of interest rate as

well as one period lag of price are significant in explaining movements in real output within the Nigerian economy. Innovations in the price level (CPI), broad money (M_2) and exchange rates explain substantially (see, table 4) movements in interest rates. These variables could serve as appropriate aggregates to control interest rates. Output growth was explained weakly by its "own shocks" (table 4)

Since movements in M_1 and M_2 also result from movements in the goal variables such as prices and output (see table 4), the use of M_1 and M_2 as intermediate targets for monetary policy may be effective. Overall, these results are supportive of the Monetarists explanation of business cycles. Given these results, which indicate the information content and forecasting value of monetary aggregates (M1, M2) and interest rates, monetary authorities in Nigeria should adopt a wider range of real and financial variables as well as fiscal actions that are mutually supportive in the management of the domestic economy.

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