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A Small-Size Macroeconometric Model for Nigerian Economy

Emeka Nkoro[1] and Aham Kelvin Uko[2]

Abstract

This paper attempts to develop a small size macro-econometric model of Nigeria's economy to examine the effects of monetary policy and crude oil price shock on selected macroeconomic variables through forecasting and simulations. The model comprises of 19 equations, out of which 12 are behavioral equations, four identities and three definitional equations. Ordinary Least Square technique is used to estimate the behavioral equations for the period 1981-2012. The estimated model parameters are used to perform simulation experiments to determine the model's ability to track historical data and to assess the behavior of the selected macroeconomic variables in response to the changes (shocks) in selected exogenous variables. The results give insight in the future path of the main economic variables.

JEL classification numbers: C20, C51, C52, C53, C63, E27, E37

Key Words: Macroeconometric Model, Nigerian Economy, Forecasting.

1 Introduction

Price and exchange rate stability, and inclusive growth have been the main objectives of the policymakers in Nigeria. To achieve these, various policies have been implemented with the

[1] University of Port Harcourt, Port Harcourt, Nigeria
[2] Abia State Ministry of Environment, Umuahia, Abia State, Nigeria

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aim of moderating the growth of absorption and the rate of inflation. For instance, Interest rate policies were aimed at achieving real interest rates that are low and positive, fiscal restraint policies were aimed at reducing the fiscal deficit to a sustainable level, hence restraining aggregate demand pressures, exchange rate policies which aimed at safe guarding the naira and create incentives for foreign investment, and external financing policy that aimed at reducing the stock of external debt that is perceived to be unsustainable and as well limit foreign borrowing were pursued. In addition, structural reforms policies aimed at liberalization of trade and financial sector activities were also pursued. These policies and reforms are still ongoing. It will be difficult to trace the effects of such policy changes on the basis of subjective judgments formed based on the available information. However, changes in structural relationship amongst economic variables can be tracked through macroeconometric model as it takes into account policy changes as well as shocks. Macroeconometric model is an important tool for analyzing the functioning of the economy and policy evaluation. It is useful, as it depicts the structure as well as temporal behaviour of the macroeconomy.

Therefore, there is need to develop a dynamic macroeconomic model that traces the cause and effect relationship between policy and target variables such as growth and price stability in Nigeria.

In trying to track the implications of policy changes as well as unexpected shocks in Nigerian economy several attempts have been made at building macroeconometric models for the Nigerian economy by individuals and institutions. These include Ojo(1972), Adamson (1974), Olofin (1977), Uwujaren (1977), Gosh and Kazi (1978), Soludo(1995), Iyoha(1996) and Iyoha (2003). Institutional based efforts include UNCTAD (1973), the Word Bank (1974), NISER (1987), the CEAR-FMNP-MODEL-MAC-III (Olofin and Ekeoku, 1984), the CEAR-MODEL-MAC-IV(Olofin and Poloamina, 1984), CBN (2010) etc. These studies examined effects of various discretionary policies on various target variables, and forecasting capacity of the models was x-rayed based on standard measures of predictive accuracy. Despite the already developed macroeconomic models for Nigerian economy, there is still the need to contribute to the existing literature to deepen our understanding of how the economy is working. It is against this

backdrop, that this study attempts to develop a small size macroeconometric model to evaluate the effects of policy options through forecasting and simulations on macroeconomic variables.

The rest of the work is structured as follows; Section two focuses on the specification of, and estimation of model; Section three explains the data and methodology; Section four focuses on the empirical results and discussion, and section five presents the evaluation of the performance of the model, section six anchors on policy simulation experiments while seven deals with summary and conclusion.

2 Specification and Estimation of Model

Features of the Model

Most policy measures aimed at stimulating growth are stabilization measures and expenditure-influencing instruments are contained in monetary and fiscal policies.

To capture the effects of these policy measures most researchers evolved macroeconomic frameworks that incorporates demand-oriented model (Keynesian-type models) and supply-side of the economy. However, this paper focuses on the demand side of the economy. In Nigeria most policy measures are geared towards stimulating effective demand and price stabilization. These policy measures deal with the problems of short-run instability of aggregate demand. Insufficiency of aggregate demand has far reaching consequences on employment and output (Bhattarai, 2005). In this work, a Keynesian aggregate demand framework is adopted to examine the impacts of monetary policies and crude oil price shock on the Nigerian economy.

The model is based on the small open economy framework taking into account the relevant macro linkages as it relates to the demand side of the economy. Also it seeks to provide an operational framework that can be used for policy analysis and as well for tracking the impacts of various policy scenarios on the economy.

Structure of the Model

The model covers the demand side of Nigeria economy. The model has 19 equations of which 12 are behavioural, 4 are identities and 3 are definitions. The model consists of four key blocks of the economy such as the domestic absorption block, fiscal block, external block and

monetary block. Economic theory and empirical literature are taken into consideration in the specification of this macroeconomic model. The model specifications in this work follow that of Soludo (1995), Iyoha (2003) and Khan and Din (2011) but with some modifications.

Domestic Absorption Block

This block starts with domestic absorption identity:

$$GDP = PCE + GC + PI + GI + (EXPO-IMPO) \quad (1)$$

Where GDP is domestic absorption, PCE is private consumption expenditure, GC is government consumption expenditure, PI is private investment, GI is government expenditure, EXPO is expenditure on export of goods and service and IMPO is expenditure on import of goods and service.

GDP is domestic absorption which consist of household consumption expenditure (*C*), domestic investment expenditure (*I*) and government expenditures (*G*) net export (export (*EXPO)* – import (I*MPO)).*

Private Consumption Expenditure Function

This function is based on permanent income and life-cycle hypothesis formulation. Hence, consumption depends on disposable income (YD), real interest rate (RINT) and real money balances (RMB=M2) which capture wealth effect (Rankaduwa, *et al*. 1995). C_{-1} captures the adaptive expectations or ratchet effect. Thus,

$$PCE=f(YD,RINT,RBM,C_{-1});f_1>0,f_2<0,f_3,>0,f_4>0 \quad (2)$$

Following Iyoha (2003), disposable income is defined by subtracting depreciation and taxes from Gross National Product (GNP).

$$YD = (GNP – 0.2K_{-1}) – (TR*GDP)/NGDP \quad (3)$$

Where $0.2K_{-1}$ is the measure of depreciation, total government tax receipt (TR) and nominal Gross Domestic Product (NGDP).

Hence, personal saving identity is presented: personal saving equals disposable income less consumption expenditure.

$$SP = YD - C \quad (4)$$

The GNP identity indicates that GNP equals GDP plus net income abroad. Thus:

Government Consumption Expenditure

Government consumption expenditure is current expenditure on goods and services and is taken as endogenous variables. Government consumption expenditure depends on government investment (GI), output (GDP), government revenue (GR) and fiscal deficit (FD).

$$GC = f(GI, GDP, GR, FD) \quad (5)$$

Private Investment Expenditure

This function is based on neo-classical approach (Jorgenson: 1963). This is because it incorporates all cost minimizing and profit maximizing decision making processes by firms (Khan and Din, 2011). This is the most appropriate approach in estimating the investment function in Nigeria: Thus private investment is a function of income (GDP), User cost of capital(UCC), government capital(investment) expenditure(GI), the level of political instability captured by a dummy(DM) and lagged of investment(I_{-1}). Thus:

$$PI = f(GDP, PI_{-1,} UCC, GI, DM,), f_{1,} f_2 > 0, f_{3,} f_4, f_{5,} < 0 \quad (6)$$

UCC is derived as one plus interest rate multiplied by nominal exchange. That is, user cost of capital is derived through an exchange rate adjusted interest (lending) rate. Since most of the

investments in Nigeria are from abroad and an exchange rate is seen as a country's risk by the investors. Thus:

$$UCC = (1+INT)*EXR$$

Government Investment Expenditure

Government investment is assumed to be exogenously determined. It is measured through capital expenditure.

$$GI = \overline{GI} \quad (7)$$

Fiscal Block

Government Total Revenue (GTR)

Government revenue is related to the main elements of the tax bases. It depends on the aggregate economic activity (GDP):

$$GTR = f(GDP),\ f_1 > 0 \quad (8)$$

Next is an identity of the fiscal deficit (FD), which is given by the expression. Fiscal deficit results when government expenditures exceed government revenues.

$$FD = GEXP - GTR \quad (9)$$

Where
FD = Fiscal Deficit, GEXP = Government Expenditures, GTR = Government Total Revenues.

External Sector Block

The external sector captures the balance of payment position of the economy. It comprises of the current account and capital account balances. The current account consists of exports of goods and services, imports of goods and services and the nominal exchange rate.

Exports Function

Exports of goods and services depend positively on oil prices per barrel, world income growth rate (U.S) and negatively on relative prices of goods and services (the ratio of domestic prices to U.S prices).

$$Expo = f(OILP, GWI, RPM),\ f_1, f_2 > 0,\ f_3 < 0 \quad (10)$$

Imports Function

Imports of goods and services positively depend on the level of domestic income (GDP), foreign exchange reserve, and negatively depend on relative prices of goods and services/import price deflator.

$$IMPO = f(GDP, EXRESEV, RPM),\ f_1, f_2 > 0,\ f_3 < 0 \quad (11)$$

Next is an identity of the trade balance (*TB*) which is defined as:

$$TB = EXPO - IMP0 \quad (12)$$

Exchange Rate Function

Following the specification of Dornbusch (1976,1980) and the Frankel (1979) on the determinants of nominal exchange rate. Exchange rate equation is thus specified with modification. Exchange rate negatively depends on the level of domestic income, positively on import price deflator, foreign reserve, relative money supply (the ratio of domestic money supply to U.S money supply) and speculation (EXR_{+1}).

$$EXR = f(GDP/GNP, IMPD, FRESV, RMS, EXR_{+1}),\ f_1, f_4 < 0,\ f_2, f_3 > 0 \quad (13)$$

Monetary and Price Block

The monetary block presents explanation on the behavior of money demand, short-term interest rate and the domestic price level.

Money Demand Function

The main objective of the monetary policy is to provide sustainable economic growth and maintenance of price stability. The achievement of this objective depends on the stability of money demand function. Real money balances are assumed to passively depend on real income, negatively depend on short-term interest rate and inflation: Thus:

$$RBM^d = f(RGDP, INT, INF),\ f_1 > 0,\ f_2 < 0 \quad (14)$$

Money supply is assumed to be exogenously determined in the system.

Interest Rate Function

Interest rate is also a monetary policy instrument being used by the Central Bank.

The short-term interest rate is assumed to negatively depend on money supply and positively depend on domestic price level and policy discount rate. Monetary Policy rate captures the pass-through effect of monetary policy changes on the market rate of interest.

$$INT = f(RBM^s, CPI, MPR),\ f_1<0,\ f_2,\ f_3,>0 \qquad (15)$$

Prices Equation

Domestic price is assumed to positively depend on money supply, disposable income, short term interest rate, imported price (import index*exchange rate), exchange rate and labour cost (measured by wage compensation), total government expenditure and lagged inflation(measured inflationary sickness).

$$CPI = f(RBM^s, DY, INT, IMPP.EXR, W, GEXP, CPI_{-1}),\ f_1, f_2, f_3, f_4, f_5, f_6 >0 \qquad (16)$$

GDP Deflator

GDP (Output) deflator is assumed to be influenced by domestic price. However, in an open economy, domestic price is not only the determinant of output deflator but include exchange rate, interest rate (factor cost) and import index.

$$GDPDFL = f(CPI, EXR, INT, IMPD, CPI_{-1}),\ f_1, f_2, f_3, f_4, f_5, f_6 >0 \qquad (17)$$

GNP deflator is defined (GDPDF) as: money GNP divided by real GNP

$$GDPDFL = (MGDP/RGDP)*100 \qquad (18)$$

Unemployment Block

Unemployment

The level of employment is assumed to negatively depend on the capacity utilization and the real wage (real compensation of employees).

$$UNMP = f(CAU, RW),\ f_1, f_2 < 0 \qquad (19)$$

Working of the Model

The model consists of 19 equations of which 12 are behavioural equations, four are identities and three definitions. The model works in the following ways:

- User cost capital affects private investment which influences output level through the channel of capital stock.
- Government investment influences private investment, which in turn affects output level.
- Foreign price affects domestic price level, which in turn affect the prices of raw material.
- Domestic price level is also affected by real and monetary variables.
- Oil price determines the volume of exports, which in turn affects output level.
- Private investment affects real output, which effect government revenues and expenditure hence, budget deficits.
- Disposable income also affects the domestic price level.

3 Method of Estimation

Ordinary least squares (OLS) method is used in estimating the stochastic equations. The reason for its adoption is based on its best linear unbiased estimator (BLUE) assumption. This technique has been used by other authors for estimating behavioural equations, such authors include Kwack et al (1989) and Iyoha(2003). Further, according to Krishnamurthy (2002), the innumerable macroeconometric models that have been estimated for India, OLS technique has been used.

Data Sources

The data for the model estimation span between1981-2012. The choice of this period is based on the availability of data. The major sources of data used are; Central Bank of Nigeria statistical bulletin, World Bank socio-economic time series, UN-International Trade Statistics, International Monetary Fund-International Financial Statistics.

4 Estimation Results of Individual Equations

Private Consumption Function

$Pce = 96.08 + 8.73E\text{-}11Dy + 1.20Rintr - 0.01Rbm + 0.56Pce_{t-1}$
(2.87) (2.73)** (2.50)** (-1.56)*** (3.63)*
$R^2 = 0.89$ DW-Stat = 2.04 F-Stat = 49.11(0.00)

Government Consumption Function

$Gc = -0.39 + 0.05Gi + 0.01Gdp - 0.04GTR - 0.04Fd$
(-0.70) (1.21) (3.27)* (-1.25) (-1.03)
$R^2 = 0.95$ DW-Stat = 0.82 F-Stat = 110.66(0.00)

Private Investment Function

$Pi = 18.17 + 0.002Gdp - 0.004Ucc - 1.14Dm + 0.46Pi_{t-1}$
(1.84) (2.21)** (-0.47) (-0.08) (2.30)**
$R^2 = 0.86$ DW-Stat = 1.53 F-Stat =37.64(0.00)

Government Total Revenue Function

$Gtr = 128.44 + 0.26Gdp$
(0.76) (23.5)*
$R^2 = 0.95$ DW-Stat = 1.66 F-Stat= 559.12(0.00)

Export Function

$Expo = 91.18 - 1.20Oilp + 1,25Gwi + 203.28Rp$
(0.12) (-0.05) (0.28) (8.91)*
$R^2 = 0.80$ DW-Stat=0.95. F-Stat = 33.98(0.00)

Import Function

$Impo = 42.18 + 0.01Gdp + 0.0009Exresev + 0.31Rpm$
(3.60) (6.20)* (1.06) (1.38)
$R^2 = 0.88$. DW-Stat = 1.99. F-Stat = 66.68(0.00)

Exchange Rate Function

$Exr = 2.57 - 2.1E\text{-}11Gnp + 0.01Impd -).0006Exresev + 0.0008Rbm + 0.89Exr_{t-1}$
(0.65) (-1.76)*** (2.24)** (-203)** (0.22) (5.80)*
$R^2 = 0.96$. DW-Stat = 2.00. F-Stat = 45.67(0.00)

Real Broad Money Function

Rbm = -4973-19 + 42.78Rgdp + 5.63Rintr + 8.75Inf
(-5.17) (11.01)* (0.28) (0.48)
R^2 = 0.84. DW-Stat = 0.37. F- Stat = 45.67(0.00)

Interest Rate Function

Int = 6.66 + 0.0001Rbm + 0.02Cpi + 0.81Mpr
(2.27) (0.19) (0.32) (4.15)*
R^2 = 0.42. DW-Stat = 2.10. F- Stat = 6.24(0.00)

Consumer Price Index (Price) Function

Cpi = -0.27 + 0.0003Rbm + 3.28E-12Dy + 0.07Int- 0.02Exr -0.001W + 0.002Gexp + 1.03Cpi_{t-1}
(-0-20) (0.49) (2.55)** (1.02) (-0.78) (-2.06)** (0.62) (14.86)*
R^2 = 0.99. DW-Stat = 1.52. F-Stat = 1987.75(0.00)

Gross Domestic Deflator Function

Gdpdfl = -4.71 + 1.13Cpi – 0.18Exr + 0.13Int
(-0.72) (10.89)* (-2.83)** (0.39)
R^2 = 0.94. DW-Stat = 1.06. F-Stat = 146.42(0.00)

Unemployment Function
Unem = -7.33 + 0.33Cau + 0.05Rw
(-1.73)*** (3.06)* (2.63)**
R^2 = 0.63. DW-Stat = 0.78. F- Stat = 22.92(0.00)

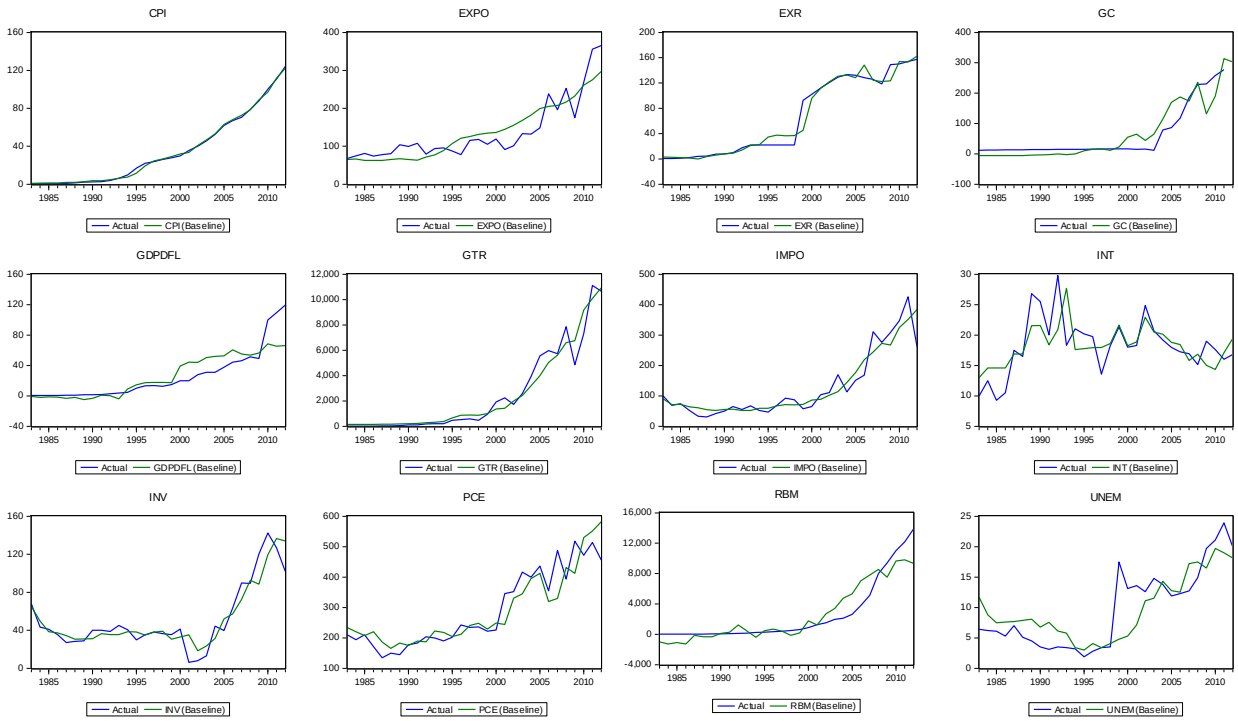
Note: *one percent significant, **five percent significant, and **10 percent significant

5 Model Appraisal and Simulation

Within-sample simulations were conducted to test the reliability of the model in predicting the movement of the endogenous variables. The assessment of the statistical properties in individual equations did not necessarily imply a good performance of the model. Rather, the tracking performance of the model and its forecasting accuracy were also examined. In doing this, the actual and simulated values of endogenous variables were compared to evaluate the accuracy of the models over the period 1983-2012. A cursory examination of the graphs in

figure 1 revealed that the model tracked the time paths and turning points of the endogenous variables reasonably well. This was an indication of good performance of the model.

Figure Figure 1: Actual and Simulated Values of the Endogenous Variables, 1983 -2012
(In-sample Forecast of the Model, 1983-2012)



6 Policy Simulation Experiments and Impact Analysis

Based on the level of satisfactory performance observed in many of the variables in the *Ex-Post* Simulations, we present simulations on possible impact of changes in selected exogenous variables (policy variables) on the current values of endogenous variables. The process was to introduce shocks in selected policy variables and trace their impacts on the current values of some selected endogenous variables, given the relationships in the model. The objective was to examine the effect of a change in a particular policy instrument on selected macroeconomic variables. In doing this, we adopted the ex-post simulation. The impacts of oil price shocks and monetary policy shocks are considered. The examinations are set such that sustained changes are made from 2013 to 2017 for each of the shock variables. However, experiments from 2016

and 2017 are presented in Table 1 and 2. The reason for this is because 2016 and 2017 are recent years. The impacts of changes in policy variables-known as instruments on a few selected endogenous variables-known as targets are presented in the form of percentage change.

6.1 Policy Instrument Alteration: Simulation Scenarios.

The effects of monetary policy rate and crude oil price shocks are simulated as follows:

- ✓ Scenario 1:- an increase in monetary policy rate (MPR) by 500 basis points.
- ✓ Scenario 2:-a decrease in monetary policy rate (MPR) by 500 basis points.
- ✓ Scenario 1:- an increase in the crude oil price by 5 per cent.
- ✓ Scenario 2:- a decrease in the crude oil price by 5 per cent.

In the analysis, the simulated variables value percentage change is compared with the baseline values.

Table 1: Performance of Some Selected Macroeconomic Variables under Monetary Shocks

Macroeconomic Variables	Baseline		Policy Variables Projection*			
			Monetary Stimulus 500 basis point increase in MPR		Monetary Stimulus 500 basis point decrease in MPR	
	2016	2017	2016	2017	2016	2017
Consumer Price Index(Inflation)	7.96	7.49	7.73	7.27	7.96	7.47
Lending Interest Rate	3.85	1.54	-2.17	-0.28	-1.00	-0.91
Exchange rate	1.74	1.73	1.74	1.73	1.74	1.73
Private Investment	-19.45	-11.49	-19.52	-11.56	-19.45	-11.50
Export of goods and Services	0.73	-0.15	0.73	-0.15	0.73	-0.15
Import of goods and Services	1.30	1.28	1.27	1.26	1.29	1.27
Gross Domestic Product(GDP)	1.79	0.75	1.56	0.57	1.71	0.66
Real Broad Money Supply(M2)	-0.62	-1.10	-0.62	-1.10	-0.62	--1.10
Unemployment	-1.13	-0.60	-1.13	-0.60	-1.13	-0.60
Fiscal Deficit	0.63	-1.81	0.65	-1.78	0.63	-1.80
Trade Balance	0.45	-0.86	0.47	-0.85	0.46	-0.86
Government Total Revenue	1.37	0.57	1.19	0.44	1.31	0.51

Note: *The projections for oil price stimulus show only percentage change in the selected macroeconomic variables

Negative (–) values indicate decrease and positive values indicate increase.

6.1.1 Simulation of Monetary Policy Rate (MPR).

An increase in MPR by 500 basis points resulted in 1.68 percent and 1.26 percent fall in the nominal maximum lending rate, and also led to 0.06 and 0.22 percent fall impact on price level in 2016 and 2017 respectively. Lower investment led to lower economic activities. Also, this brought about no impact on exchange rate in 2016 and 2017. Similarly, a 500 basis point reduction in MPR decreased maximum lending rate by 2.85 and 0.63 percent in 2016 and 2017 respectively. This also brought about no change in price in 2016, and 0.2 percent fall in price in 2017. Furthermore, this brought about no impact on exchange rate. The decreasing growth rate of private investment retards growth rate of GDP as depicted in Table 1. Unemployment level remains the same with the baseline values. This result showed that monetary policy stance is ineffective in reviving the economy. However, this could be attributed to large infrastructural decay and lack of confidence in business environment in the country.

Table 2: Performance of Some Selected Macroeconomic Variables under Oil Price Shocks

Macroeconomic Variables	Baseline		Policy Variables Projection*			
			Oil Price Stimulus. 5% increase in Oil Price		Oil Price Stimulus. 5% decrease in Oil Price	
	2016	2017	2016	2017	2016	2017
Consumer Price Index(Inflation)	7.96	7.49	7.96	7.49	7.96	7.49
Nominal Interest Rate	3.85	1.54	3.85	1.54	3.85	1.54
Exchange rate	1.74	1.73	1.74	1.73	1.74	1.73
Private Investment	-19.45	-11.49	-19.33	-11.39	-19.45	-11.49
Export of goods and Services	0.73	-0.15	1.38	0.22	0.73	-0.15
Import of goods and Services	1.30	1.28	1.32	1.29	1.30	1.28
Gross Domestic Product(GDP)	1.79	0.75	1.89	0.80	1.79	0.75
Real Broad Money Supply(M2)	-0.62	-1.10	-0.62	-1.10	-0.62	-1.10
Unemployment	-1.13	-0.60	-1.13	-0.60	-1.13	-0.60
Fiscal Deficit	0.63	-1.81	0.61	-1.82	0.63	-1.81
Trade Balance	0.45	-0.86	1.40	-0.24	0.45	-0.86
Government Total Revenue	1.37	0.57	1.45	0.62	1.37	0.57

Note: *The projections for oil price stimulus show only percentage change in the selected macroeconomic variables

Negative (–) values indicate decrease and positive values indicate increase.

6.1.2 Simulation of Crude oil Price

An increase in nominal oil price by five percent is simulated in the model. Table 2 shows that a five percent increase in oil price resulted in no percentage change in price (inflation) as the projected and baseline scenarios are the same in 2016 and 2017 respectively. The increase in the crude oil price slightly raised the government revenue by 0.08 and 0.05 percent in 2016 and 2017 respectively. Nominal lending rate and exchange rate remain unchanged. Also, GDP slightly increased by 0.10 and 0.05 percent in 2016 and 2017 respectively with a constant inflation.

Similarly, a decrease in oil price by five percent brought about no percentage change in GDP, inflation, exchange, unemployment and government revenue in 2016 and 2017 respectively.

7 Summary and Conclusion

This study examined the structure of a small-scale dynamic macroeconometric framework of the Nigeria's economy. The primary objectives of this study was to; construct a small-scale dynamic macroeconometric model for Nigeria that captures the effects of monetary and external(oil price) shocks on the key macroeconomic variables such as output, investment, price, revenue, exchange rate, interest rate etc. Since macroeconometric modeling is a very complex exercise and the working of Nigeria's economy is very complicated, hence, it cannot be claimed that our model framework gives detailed picture of the Nigeria's economy. However, our model studied the behaviour of some key macroeconomic variables towards internal and external shocks and provides some useful insights for the policymakers. The model is solved as a coherent system within-sample and out-of-sample. In the within-sample analysis, the performance of the model is evaluated by inspection of the plots of the actual series against the series generated by the solutions of the model. In the out-of-sample analysis, the impacts of policies options are evaluated in terms of percentage deviations of the simulation paths from the baseline paths of the key macroeconomic variables. Overall, four policy simulation experiments are evaluated. Two policy options are with regard to monetary policy. These involve 500 basis points increase/decrease in monetary policy rate. The other two are with regards to external shock policy options, and it involves five percent increase/decrease in crude oil price. The

model is estimated using time series data for the period 1982- 2012 and the estimated parameter are used to determine the effects of changes in some selected exogenous variables on the key macroeconomic variables. The main findings are summarized below:

- ✓ The simulation results as revealed by the graphical representations of the model show that the tracking performance of the model within-sample was relatively satisfactory in general terms, indicating a good fit. Both the static and dynamic solution values tend to track the actual time paths of the variables closely.

- ✓ A rise (500 basis points) in the monetary policy rate revealed that inflation, nominal interest rate, private investment and gross domestic product in 2016(2017) would fall by 0.23(0.22), 1.68(1.26), 0.07(0.07) and 0.23(0.18) while unemployment would be stable respectively. On the other hand, A fall (500 basis points) in the monetary policy rate showed that inflation, nominal interest rate and gross domestic product in 2016(2017) would fall by 0(0.002), 2.85(0.63) and 0.08(0.09) respectively while private investment and unemployment would be stable.

- ✓ An increase in nominal oil price by five percent showed that inflation(price), nominal lending rate and exchange rate would be stable in 2016 and 2017 while GDP and government revenue would slightly increase by 0.10 (0.05) and 0.06 (0.05) percent in 2016 (2017) respectively. Similarly, a five percent decrease in oil price revealed that GDP, inflation (price), exchange rate; unemployment and government revenue would be stable in 2016 and 2017 respectively.

Conclusively, the policy simulations reveal that gross domestic product is responsive to internal and external shocks while domestic price is only responsive to internal shocks.

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APPENDIX A

Table 3: VARIABLES DESCRIPTION

NOTATION	DESCRIPTION	TYPE
PCE	PRIVATE CONSUMPTION	ENDOGENOUS
GC	GOVERNMENT CONSUMPTION	ENDOGENOUS
PI	PRIVATE INVESTMENT(gross fixed capital formation)	ENDOGENOUS
GI	GOVERNMENT INVESTMENT	ENDOGENOUS
GRT	GOVERNMENT TOTAL REVENUE(calculated as sum of oil revenues and non-oil revenues)	ENDOGENOUS
EXPO	EXPORT	ENDOGENOUS
IMPO	IMPORT	ENDOGENOUS
EXR	EXCHANGE RATE	ENDOGENOUS
RBM	REAL BROAD MONEY SUPPLY	ENDOGENOUS
INT	INTEREST RATE	ENDOGENOUS
CPI	CONSUMER PRICE INDEX	ENDOGENOUS
GDPDF	GROSS DOMESTIC PRODUCT DEFLATOR	ENDOGENOUS
UNEM	UNEMPLOYMENT	ENDOGENOUS
DY	DISPOSABLE INCOME	ENDOGENOUS
RINTR	REAL INTEREST RATE	EXOGENOUS
GDP	GROSS DOMESTIC PRODUCT	ENDOGENOUS
UCC	USER COST OF CAPITAL	ENDOGENOUS
DM	DUMMY FOR POLITICAL INSTABILITY	EXOGENOUS
FD	FISCAL DEFICIT (calculated as the difference between government total expenditures and government total revenues)	ENDOGENOUS
OILP	OIL PRICE	EXOGENOUS
GWI	GROWTH RATE OF WORLD INCOME (US INCOME)	EXOGENOUS
RP	RELATIVE PRICE	EXOGENOUS
EXRESEV	EXTERNAL RESERVE	EXOGENOUS
GNP	GROSS NATIONAL PRODUCT	EXOGENOUS
IMPD	IMPORT PRICE DEFLATOR	EXOGENOUS
INF	INFLATION	EXOGENOUS
MPR	MONETARY POLICY RATE	EXOGENOUS
W	WAGE RATE	EXOGENOUS
K	DEPRECIATION	EXOGENOUS
TGEXP	Total GOVERNMENT TOTAL EXPENDITURE	EXOGENOUS
CAU	CAPACITY UTILIZATION	EXOGENOUS
RW	REAL WAGE	EXOGENOUS
TB	TRADE BALANCE	ENDOGENOUS
SP	PERSONAL SAVINGS	ENDOGENOUS
Source: World Bank Data, 2016 and CBN Statistical Bulletin Various Issues		

APPENDIX B

Mathematical Representation of the Model
Stochastic Equations

1. $PCE = \alpha_0 + DY + RINTR + RBM + PCE(-1) + \varepsilon_{1t}$
2. $GC = \beta_0 + GI + GDP + GTR + FD + \varepsilon_{2t}$
3. $PI = \sigma_0 + GDP + UCC + DM + PI(-1) + \varepsilon_{3t}$
4. $GTR = \theta_0 + GDP + \varepsilon_{4t}$
5. $EXPO = \gamma_0 + OILP + GWI + RPM + \varepsilon_{5t}$
6. $IMPO = \phi_0 + GDP + EXRESEV + RPM + \varepsilon_{6t}$
7. $EXR = \partial_0 + GNP + IMPD + EXRESEV + RBM + EXR(+1) + \varepsilon_{7t}$
8. $RBM = w_0 + RGDP + RINTR + INF + \varepsilon_{8t}$
9. $INT = \Omega_0 + RBM + CPI + MPR + \varepsilon_{9t}$
10. $CPI = \upsilon_0 + RBM + DY + INT + EXR + W + GEXP + CPI(-1) + \varepsilon_{10t}$
11. $GNPDF = \varkappa_0 + CPI + EXR + INT + \varepsilon_{11t}$
12. $UNEM = \mu_0 + CAU + RW + \varepsilon_{12t}$

Identities and Definitional Equations

13. $DY = (GNP - 0.2K_{-1}) - (TV*GDP)/GDPV$ (disposable income definition)
14. SP = YD- C (personal saving identity)
15. UCC = (1+INT)*EXR (user cost of capital definition)
16. GNP = GDP + NFY (gross national income identity)
17. FD = GEXP – GTR (fiscal deficit identity)
18. TB = EXPO – IMPO (Trade Balance identity)
19. GDP = (PCE +GC) + (PI + GI) + (XMP-IMP) (domestic absorption block identity)