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Fiscal response to oil price volatility in Nigeria

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Abstract

Objective: This study aims to conduct investigation on fiscal response to oil price volatility in Nigeria, and simultaneously comparing two hybrid methods of econometric analysis.
Methods: The theoretical model was derived from the consumption theory, and two hybrid methods (OLS-ARMA and 2SLS-GMM) of estimation were adopted to form the methodologies of the study. OLS and ARMA were combined in order to control for autocorrelation and heteroskedasticity in the model. While 2SLS and GMM were combined in order to accurately account for endogenous regressors.
Findings: The findings from model estimation shows that government responds insignificantly to oil price shocks. Consequently, the study recommends that Nigeria should increase her productive capacity, especially on crude oil in order to generate more revenue, in turn influencing government expenditure. It was observed from the computation conducted on data series of government expenditure, which was obtained from organization of petroleum exporting countries (OPEC) statistical bulletin, such that Government expenditure has been on a decline over the years. This raises some questions on the capacity of its determinants which are responsible for influencing the trending pattern. In other words, productivities for exportation and other sources of government revenue are insufficient to ignite government expenditure desirably. Evaluation on methodologies adopted shows that 2SLS-GMM is superior and more efficient than OLS-ARMA based on the econometric criteria used in the diagnostic tests
Application: Evidences from literature reviewed show that government revenue is the major determinant of government expenditure. Therefore, it adds to knowledge to investigate the effect of oil price volatility on government expenditure.
Keywords: Fiscal response, Volatility, OLS-ARMA, 2SLS-GMM, Oil price

1. Introduction

Nigeria discovered oil in 1956 and began to export it in 1958. In 1971, Nigeria joined Organization of Petroleum Exporting Countries (OPEC) and realized $390 billion as oil revenue over the period 1971 – 2005. The oil windfall apparently presented net wealth in the economy. Oil also accounts for about 90 percent of total exports and its revenue generates approximately four-fifth of total government expenditure. Evidence shows that Nigeria is one of the world's top oil exporters [1]. Evidences from OPEC reveals that Nigeria 2016 budget proposal is anchored on an oil price of $38pb and production of 2.2 million bpd and the N6.06 trillion out-lay is expected to be substantially funded by oil proceeds. Also that the 36 states and 774 local government areas similarly depend on monthly payouts from federally collected revenue (mostly oil receipts) for their survival; yet, price has often been below $36pb since January. Nigeria's economy has been in doldrums for several months now, has experienced a sudden surge following the current development in the oil and gas industry market, but how far the surge would last remains the decision of the market which became over supplied thereby creating a glut. The market raised the hope of Nigerians whose economy has remained mono-cultural due to its dependence on oil and gas as its main export earner. Nigeria with an output of about 2.1 million barrels of crude oil per day would be earning over $100 million per day. The current development in the market sees the price of Brent crude, against which Nigeria's oil priced, rise to $42.29 dollars, $4.29 higher than the country's proposed benchmark of $38 for the 2016 budget [2]. Crude oil is one of the most actively traded commodities in the world. Petroleum still remains the primary energy source for transportation and manufacturing industries. For this reason, oil price movements may impose significant influence on economic situation in different countries.

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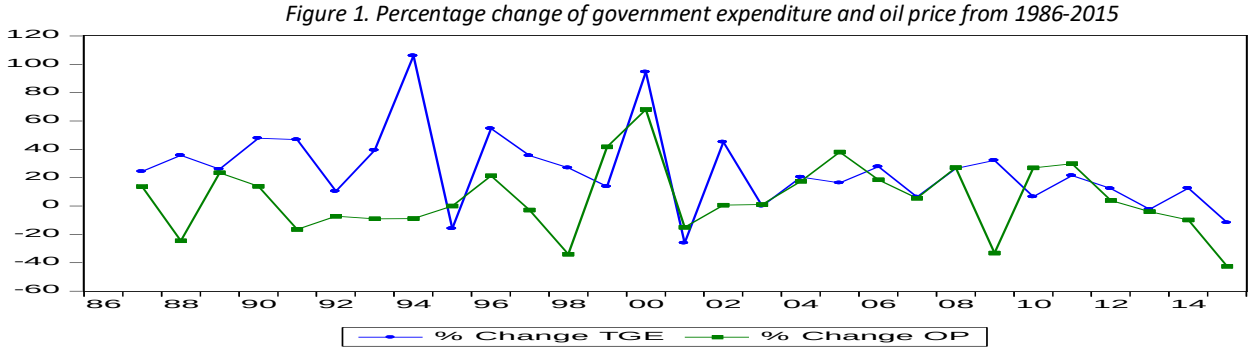
Oil prices are changing due to the interaction between supply and demand forces on the international commodity markets [3]. Oil price amplifies asymmetrical responses to economic activities. Theoretically, oil price increases when demand outweighs supply, and decreases when supply outweighs demand. Furthermore, the effect of oil price on economic activities can as well be categorized into supply and demand sides respectively. The supply side is on the overall production cost while the demand side is on individual choice of consumption and investment. Oil price volatility affects both importing and exporting countries. Combating against it can help enhance economic development in the long-run. Crude oil still remains the key driver of the Nigerian economy and changes in the price of oil can generate asymmetric effects on government expenditure, and thus economic growth. The asymmetry in the impact of oil price shocks on economic growth implies that the routes of effect go beyond the simple mechanism that was originally envisioned [4]. In other words, oil price volatility may possess positive or negative shocks.

The Nigeria oil and gas sector accounts for about 35 per cent of gross domestic product, and petroleum exports revenue represents over 90 per cent of total exports revenue. Nigeria depends heavily on crude oil as the major source of government revenue. Oil prices are characterized by high volatility which often translates into volatilities in the crude oil revenue and consequently public expenditure in the country. In other words, how does government responds to oil price volatility? Fiscal response is the reactions of government to changes in the prices of crude oil and oil revenue. Fiscal response could be in form of changes in public expenditures at levels as well as composition, revenue generations-efforts, reforms and diversification; borrowing and debt accumulation. Government could also put up other strategies in response to the increase or decrease in the flows of oil related revenue to the government.

Figure 1 (*Percentage change of government expenditure and oil price from 1986-2015*) depicts the percentage change of total government expenditure (TGE) and oil price (OP) over the years. It shows that government expenditure and oil price have been moving in nearly the same proportion over the years. Since it is no news that one of Nigeria characteristics is crude oil exportation, and as a result, oil revenue contributes a giant share to its government revenue, consequently determining its expenditure. This justifies the trending pattern of government expenditure and oil price in Figure 1. Later in the Section 3 of this study, assessment of volatility in the oil price series shall be discussed, as one of the prerequisites for the model specification.

Figure 1. Percentage change of government expenditure and oil price from 1986-2015



Source: Computed using data obtained from OPEC (2016)

2. Empirical review

Analysis on the behavioral responses of macroeconomic agents to oil price volatility indicates that there is a high degree of oil price volatility and has characterized the market for the past four decades, since it represents a fundamental barrier to economic growth, due to its damaging and destabilizing effects on the macroeconomic [5]. Research on the effect of stabilization funds on the volatility of government expenditure in resource-rich countries shows that the existence of stabilization funds contributes to smoothing government expenditure. Also, political institutions and fiscal rules were found to be significant in reducing the expenditure volatility, while highlighting the roles of the size of economy, diversified exports, real sector management, and financial markets [6]. *Analysis on* volatility spillovers in the United States from crude oil using futures prices provides insights into the extent of volatility linkages among energy and agricultural markets in a period characterized by

strong price variability and significant production of corn-based ethanol. They pointed out that external crude oil shock generates spillovers to the corn and ethanol markets. GJR-GARCH model was applied to estimate the degree of the crude oil shocks spillover on corn and ethanol markets [7]. *R*eal exchange rate and oil price can generate changes on growth of real GDP, using vector error correction model (VECM) and Engle-Granger for statistical estimations. The findings shows that there is a long-run relationship between the growth of real GDP, international oil prices, and real exchange rate in the economy of Bahrain [8]. *A*nalysis on the effects in terms of size and volatility of government revenue and spending on growth in OECD and EU countries suggests that both variables are detrimental to growth. Particularly, looking more closely at the effect of each component of government revenue and spending, the results point out that i) indirect taxes (size and volatility); ii) social contributions (size and volatility); iii) government consumption (size and volatility); iv) subsidies (size); and v) government investment (volatility) have a sizeable, negative and statistically significant effect on growth [9]. *Empirical* evidence showing that smaller countries tend to have more volatile government spending for a sample of 160 countries from 1960 to 2000 evinces that country size is negatively related to the discretionary part of government spending and volatilities of most of the government items [10]. Investigation on the relationship between government expenditure and government revenue, and thereby to ascertain the empirical link between the two variables of the budgetary process using asymmetric error correction model, shows that revenue and expenditure have a long-run relationship and that they respond to the long-run requirements of the budgetary balance only when the budget is worsening [11]. *T*he main elements of public spending are treated as endogenous variables which rise in line with GDP (endogenously determined by GDP) over the medium term, and public borrowing is another direct determinant [12]. *E*xamining the factors determining public expenditure in sub-saharan africa, using a modelling framwork which draws on insights from the theory of the private consumer, which states that the particular interest is the extent to which countries of different kinds are limited in their ability to adjust borrowing and fiscal revenue [13] *Investigation was conducted on t*he causal relationship between government revenue and expenditure, and it was concluded that a unidirectional causal influence run from government revenue to total government expenditure which suggests that revenue control could be used as an integral component of a tax reform programme [14]. *Government* expenditure is seen as state expenditure, and state expenditure is influenced by institutional and political variables [15].

Following the evidences from literature reviewed, it is deduced that government revenue is a major determiant of government expenditure. It should be noted that economic determinants can be categorized into supply side and demand side. The supply side determinants serve as injections to the economy. While the demand side determinants serve as leakages from the economy. Much emphases have been placed on the demand side determinants of government expenditure. However, there are other economic variables on the supply side that affect government expenditure such as oil price, especially in Nigeria where oil revenue is the major source of government revenue, since government revenue in turn determines the amount of government expenditure. Consequently, this study aims to contribute to literature on how government responds to oil price shocks in Nigeria.

3. Model specification and estimation procedure

The theoretical framework for model specification is derived by exercising a deep modification on the consumption theory. It may be appropriate to proxy fiscal response with total government expenditure as the dependent variable in a model. The explanatory variables include oil price, total government revenue (as a major determinant of fiscal response, standing for financial capability) and Population (adopted as a measure of need to finance). It should be observed that oil price and government revenue may present the problem of multicollinearity in the prospective model. This is because changes in the price of oil will automatically affect oil revenue which contributes giant percentage to total government revenue in Nigeria. However, this can be ignored because multicollinearity is not a serious problem in time-series analysis. Note further that, it is redundant to specify a volatility model for this study, because the oil price series does not possess the clustering volatility elements (such as presence of ARCH effect (0.003) and occurrence of clustering volatility in the series). Nonetheless, since the study focus more on the influence of oil price volatility, and Figure 1 shows that oil price series have not been stable over the years, it is still appropriate to include oil price in the model, thus,

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investigating the effect of variation of oil price on government expenditure. As a result, non volatility models are adopted for estimation.

Hybrid methods of estimation are adopted to conduct investigation on "Fiscal response to oil price volatility in Nigeria". In this study, a combination of ARMA elements are specified with ordinary least square (OLS) regression model purposely to control for autocorrelation and heteroskedasticity. ARMA elements include the Autoregressive (AR) term and Moving Average (MA) term. The order of AR and MA terms are obtained by estimating their autocorrelation function (ACF) and partial autocorrelation function (PACF) respectively. Two-stage least square (2SLS) is adopted because it may be more efficient than OLS as it considers regressors that are endogenously determined in a model, as a result, controlling for heteroskedasticity. Generalized method of moment is adopted to analyze and estimate the Two-stage least square (2SLS) because of its desirable asymptotic properties. Additionally, the study conducts comparison test on OLS and 2SLS method along with their hybrid elements such as ARMA and GMM respectively. Furthermore, to estimate a model using 2SLS-GMM method, it requires some set of instrumental variables, and this may include GDP (linked with Government Revenue), Oil differential (difference between crude oil supply and demand), previous year Oil price, previous year total government expenditure (current TGE may be affected by its lagged value) and Total investment (as a core determinant of TGR, GDP). Total government expenditure model using OLS-ARMA and 2SLS-GMM methods are depicted by Equation 1 and 2 respectively.

$$TGE_t = \phi_0 + \phi_1 TGR_t + \phi_2 POP_t + \phi_3 OP_t + AR(p) + MA(q) \quad \{1\}$$

$$TGE_t = \lambda_0 + \lambda_1 TGR_t + \lambda_2 POP_t + \lambda_3 OP_t \quad \{2\}$$

With the instrument list: **[C GDP OILDIFF OP_{t-1} TGE_{t-1} *TI]***

TGE_t	=	total government expenditure
TGE_{t-1}	=	one year lagged value of total government expenditure
TGR	=	current year value of total government revenue
POP	=	current year value of population
OP	=	crude oil price for the current year
GDP	=	gross domestic product at current prices
OILDIFF	=	difference between the supply and demand of crude oil
TI	=	total investment
OP_{t-1}	=	crude oil price for the previous year
AR	=	autoregressive term
MA	=	moving average term

φ_0, φ_1, φ_2, φ_3, λ_0, λ_1, λ_2 & λ_3 are the parameters to be estimated.

Table 1. The data characteristics

S/N	Variable	Definition	Source	Year	Unit of Measurement
1.	TGE	Total Government Expenditure	Central Bank of Nigeria (CBN) Statistical Bulletin [16]	1986-2015	Billions of Naira
2.	TGR	Total Government Revenue	Central Bank of Nigeria (CBN) Statistical Bulletin	1986-2015	Billions of Naira
3.	POP	Population	OPEC Statistical Bulletin	1986-2015	Millions Inhabitants
4.	OP	Oil Price	OPEC Statistical Bulletin	1986-2015	Billions of Dollars
5.	GDP	Gross Domestic Product	OPEC Statistical Bulletin	1986-2015	Millions of Dollars
6.	OILDIFF	Difference between Oil Supply and Demand	Calculated using data obtained from OPEC Statistical Bulletin	1986-2015	1,000 b/d
7.	TI	Total Investment	World Economic Outlook (WEO) [17]	1986-2015	`Billions (% to GDP)

Table 1 presents the variables' definitions along with their sources, research period and unit of measurement.

The specified models, after estimation, are evaluated by conducting several diagnostic tests which include (i) test for autocorrelation presence in the series,(ii) test for correlation between error term and regressors, (iii) normality test to check for the distribution of the series, (iv) endogeneity test to investigate if the regressors are determined within the model or otherwise, (v) redundant variable test to check if the specified variables are

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required for the model estimation (vi) and orthogonality test to diagnose each of the series for their validity status. Decision rule is set at 5% level of significance, using their probability values.

4. Empirical results and discussion

Section 4 presents the results of unit root test, and model estimations using the two methods specified in Section 3. The essence of commencing analysis by conducting unit root test is to determine the form of the model before estimation. Time-series analysis requires stationary data series for estimation, and this is obtained by conducting unit root test. Table 2 shows the results of the unit root test conducted on all the data series, as a basic requirement for time-series analysis. This is followed by Equation 3 and 4, putting into effect the outcome of the unit root test on the specified models, along with the order of ARMA specification. The order of AR and MA as derived from computing PACF and ACF are as follows; order of AR, PACF= 2, and order of MA, ACF= 2, therefore AR (2) and MA (2) are required for specification.

Table 2. Results of the unit root test

ORDER	VARIABLES (SERIES)						
	TGE*	TGR*	POP**	OP*	GDP*	OILDIFF*	TI*
Level	-	-	-	-	-	-	-
D1	+	+	-	+	+	+	+
D2			+				

*DI=First Differenced, D2=Second Differenced, * = stationary at D1, ** = stationary at D2*

$$DTGE_t = \lambda_0 + \lambda_1 D(TGR_t) + \lambda_2 D(POP_t, 2) + \lambda_3 D(OP_t) + AR(2) + MA(2) \quad \{3\}$$

$$DTGE_t = \lambda_0 + \lambda_1 D(TGR_t) + \lambda_2 D(POP_t, 2) + \lambda_3 D(OP_t) \quad \{4\}$$

With the instrument list: $C\ D(GDP_t)\ D(OILDIFF_t)\ D(OP_{t-1})\ D(TGE_{t-1})\ D(TI_t)$

The summary statistics of model estimation using OLS-ARMA method is presented in Table 3. The s-error and t-statistics support the accuracy of the coefficient (by a simple arithmetic multiplication), and P-value is considered in this study as the major element of the decision rule. The variables D(POP,2) and D(OP) are only significant to explain D(TGE). This suggests that population and oil-price are the only significant determinants of government expenditure in the model because their probability values are less than 5 percent. As a result, a growth of population by an inhabitant requires government expenditure to increase by 5.77 units. Secondly, a unit increase in oil price will induce government to increase its expenditure by 0.08 units. In other words, fiscal response to an increase in population is higher than that in oil price shock. Note that government spending has both demand and supply sides factors. This may mean that government spends more than what is generated. This is because oil price as a determinant is on the supply side (income generation), while population is on the demand side (need for sustainability). In this context, oil price as a determinant is an injection to the economy. The mechanism of Population as a determinant is a leakage to the economy. However, the later theoretically postulates a strategy to increase aggregate demand which could also be of advantage to the economy in terms of employment generation, and thus, economic expansion.

Table 3. Summary statistics of model estimation using OLS-ARMA method

Statistical Terms	Variables					
	C	D(TGR)	D(POP,2)	D(OP)	AR(2)	MA(2)
Coefficient	0.728666	0.024918	5.775034	0.087671	0.543388	0.448977
S-Error	0.950499	0.025582	2.302296	0.035852	0.346729	80005.41
T-Stat	0.766614	0.974048	2.508380	2.445382	1.567183	5337.714
P-Value	0.4523	0.3417	0.0209***	0.0238***	0.1328	0.0000***

D(POP,2), D(OP) and MA(2) are significant at 5 percent

In Table 4, oil price is the only statistically significant variable to explain government expenditure because its probability value is less than 5 percent. This implies that an increase in oil price will induce oil revenue to

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increase, and since oil revenue contributes a giant share to the federal government revenue, thus, this in turn will induce total government expenditure to increase. In the same vein, the model shows that shocks in oil price will affect the total government expenditure by 0.15 units. Likewise in Table 3 regarding oil price as a determinant of government expenditure, the implication is that government responds insignificantly to oil price shocks. The reason could be a huge decline in the Nigerian crude oil exports. Another likely reason is the increasing exchange rate inducing the national currency to depreciate in value, consequently reducing oil revenue significantly, and in turn leading to low government revenue as compared to what is required to attain a sustainable development in the economy.

Table 4. Summary statistics of model estimation using 2SLS-GMM method

Statistical Terms	Variables			
	C	D(TGR)	D(POP,2)	D(OP)
Coefficient	0.754278	0.111039	0.899158	0.154437
Standard Error	0.609699	0.060056	5.815520	0.065641
T-Stat	1.237132	1.848921	0.154613	2.352759
P-Value	0.2280	0.0768	0.8784	0.0272***

D(OP) is significant at 5 percent

Table 5 presents the overall diagnostic results of the two models estimated along with their distinct methods. It should be noted that the null hypothesis is desirable for all the tests summarized in Table 5, and decision is set at 5 percent level of significance, using probability values. The results of the model estimated using OLS-ARMA method shows that the model passed the heteroskedasticity and normality tests. However, the model is suffering from serial correlation because the probability value obtained from serial correlation is less than 5 percent. Note that MA (2) is specified in the model objectively to control for heteroskedasticity, and it is significant (based on its p-value). This confirms that the MA (2) specification in the model is efficient to control for heteroskedasticity. On the contrary, the AR (2) is found to be insignificant because its p-value is greater than 5 percent, and this is supported by the evidence of serial correlation presented in Table 5 confirming the inefficiency of the AR(2) specification to control for serial correlation. The diagnostic result using the second method (2SLS-GMM) shows that the model is free from serial correlation and heteroskedasticity. However, the model appears to be not normally distributed because its probability value is less than 5 percent. Econometricians have argued that normality test is not a serious problem in time-series analysis, unlike in the case of serial correlation and heteroskedasticity. The model with 2SLS-GMM is preferred to the one with OLS-ARMA because it passed serial correlation and heteroskedasticity tests. Consequently, the model estimated with OLS-ARMA method is not reliable for accurate decision making. Furthermore, the extension of the diagnosis on the model using 2SLS-GMM, shows that the instruments specified in Equation 3 are orthogonal for the estimation, implying that the series are relevant in the model. Note that, the orthogonality test is only conducted on instrumental variables, while endogeneity test is conducted on regressors. They are required diagnostic tests to be conducted when estimating with GMM. Finally, the regressors are endogenously determined, meaning they are determined within the model (instrumental variables were effective).

Table 5. Summary statistics of the diagnostic tests

S/N	RESIDUAL TERMS	OLS-ARMA	2SLS-GMM
1.	Serial Correlation	0.0009	0.7689
2.	Heteroskecasticity	0.1820	0.0503
3.	Normality	0.666811	0.0000

So far, evidences established in the data estimated prove that government responds to oil price shocks insignificantly (based on the low parameter estimate). This could imply that oil revenue responds insignificantly to oil price shocks, in turn has little effect on total federal government revenue, thereby contributing very little amount to government expenditure. The reason for this could be traced to the rising exchange rate causing the naira value to depreciate, consequently declining oil revenue and gains from international trade as a whole. Other reasons could be oil revenue embezzlement (corruption), shortage in the Nigeria crude oil supply for exportation.

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5. Conclusion and recommendation

The study concludes that government responds insignificantly to oil price shocks for the following reasons; oil revenue embezzlement, rising exchange rate, shortage in the Nigerian crude oil supply for export. It was discovered that government expenditure has been reducing in recent years due to low oil revenue which is the major source of government revenue in Nigeria. Daily report supports the evidence of this study that Nigeria's crude oil export to Europe and Asia, two of the country's key markets, declined by 6.6 million barrels in September 2014, further reducing the country's oil revenue at a time the plunge in global oil prices entered its third month [18]. It is recommended that Nigeria government should develop its productive capacity in order to increase its supply of crude oil for exportation. Secondly, diversifying the economy is necessary at this stage so that crude oil won't just be the only major product to export for revenue generation. If there is an increase in the supply of the country's products for exportation, the government revenue will always have the tendency to increase, and thereby increasing government expenditure significantly.

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