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The Role of Fossil Fuel Subsidy Reforms in the Nexus Between Fossil Fuel Consumption and Economic Growth in Nigeria: Evidence from Two-Stage Least Squares (2SLS) and Granger Causality Approaches

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ABSTRACT

The fossil fuel reformes has become a global imperative strategy to achieve the modern economic growth objectives in the face of rapid changes in industrial revolution, and socio-economic challenges, with focus to the developing economies. This motivated the empirically analysis of the role of fossil fuel subsidy in the nexus between fossil fuel consumption and economic growth in Nigeria from 1973 to 2024. This Study employs a Two stage least squares (2SLS) to resolve the endogeneity problem in the previous studies and also estimate ordinary least squares and Granger causality as a robustness check for the existing studies. Findings reveal that a 1% increase in PMS fuel consumption through the instrumental variables during the partial fuel subsidy removal has increased economic growth by 37.22% whereas, a 1% increase in PMS fuel consumption through the instrumental variables during the full fuel subsidy removal has decreased the economic growth by 0.34% in this study. This study recommends emphasize on premium motor spirit price, exchange rate, number of refineries, and real GDP per capita in the pursuit of fuel subsidy reform to directly and indirectly promotes fuel consumption and economic growth by the Nigeria energy stakeholders, especially the government.

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Introduction

Fossil fuel consumption has continued to receive global attentions since the emergence of the first industrial revolution in the Mid–18th century as the source of modern economic growth and economic development for both developed and developing economies [1,2]. Notably, the primary fossil fuels including coal, crude oil, and gas globally account to 82% of the World's total energy production, but their consumptions have continued to vary over years [3]. The persistent global changes in economic and social objectives, from industrial revolution 1.0 to 4.0 are attributed to crude oil consumption by 33.1%, coal consumption by 27%, and natural gas consumption by 24.3% [4]. In spite of these variations in the fossil fuels consumption, fossil fuel consumption generally remains the main driver for rapid economic growth, industrialization, globalization, infrastructural development, lowering inflation rate, improving living standards, and accelerating massive employment generation for every nation [5].

However, these benefits of fossil fuels consumption between developed and developing economies are divergent in the fossil fuel literature. Many developed countries have significantly benefited from fossil fuel consumption in terms of steady increase in GDP growth, tax revenue as a percentage of GDP, higher employment generations and sustainable development, even in the midst of early 1970s global energy price hike [6]. For instance, China and India are the largest exporters of coal, while China, after United States (US), is a major importer of oil. Between 1979 and 2023, China's fossil fuel consumption has hovered the GDP growth rate around 8.93% while the unemployment rate has declined dramatically from 15.7% in 1979 to 5.2% in 2023 [7].

In contrast, the developing countries including Nigeria that is the 9th largest exporter of crude oil and largest natural gas reserves in Africa, have all consumed a significant fossil fuel for exports and not for local use like the developed countries. Unfortunately, these persisting decreasing demand for fossil fuels for local use in developing countries have caused a slower GDP growth rate, higher unemployment rate, arising public debt, infrastructural deficiency gap and depreciating currency [8]. For instance, the Nigeria's average GDP rate has persistently declined from 26% in 1970 to 2.86% in 2023 due to decreasing demand for fossil fuels for local use [9]. This trend suggests that fossil fuel consumption is not automatic to economic growth but depends on extent of local use of fossil fuels to drive nation's economic growth.

In Nigeria context, fossil fuel subsidy is a deliberate government policy to boost local use of fossil fuel commodities to accelerate economic growth and achieve macroeconomic objectives, as witnessed in the developed countries. In 1977, the Nigeria government first introduced fossil fuel subsidy to only premium motor spirit (PMS) and diesel from crude oil to mitigate the stagflation impacts on Nigerian economy. This suggests that fossil fuel subsidy is a determinant of fossil fuel consumption and economic growth respectively. This event earmarks the linkage among fossil fuel subsidy, fossil fuel consumption, and economic growth and a novel contribution to the existing literature.

This novel research in the energy literature has been less researched. Rather many studies have looked at the empirical relationship between fossil fuel consumption and economic growth [10,11]. These studies fail to recognize the role of fossil fuel subsidy on the relationship between fossil fuel consumption and economic growth in the literature.

Recent research has acknowledged fossil fuel subsidy reform as a preconditions of the nexus between fossil fuel consumption and economic growth in the prevailing uncertainty global economy. Prior to incessant global economic shocks, fossil fuel subsidy provisions by all governments at her expenses have automatically stimulate fossil fuel consumption and economic growth. In contrast, fossil fuel subsidy provisions by many governments have hampered country's economic growth while fossil fuel consumption increased significantly during the persisting global economic shocks.

To contend this argument, many recent studies focused on fuel subsidy reforms impact and not on the nexus between fossil fuel consumption and economic growth in the literature [12-14]. All these studies, except, employed bottom-top, descriptive and comparative analyses, and systematic literature review to draw inferences. Their studies neither account for the time series influence on the fossil fuel subsidy reforms impact nor the cross-country heterogeneity comparisons. In addition, the existing research ignored the importance of control variables that would have influenced the fossil fuel subsidy reforms decision indirectly and directly on unlimited consequences.

The study of pioneered the cause and effect of fossil fuel subsidy on economic growth to the best of my knowledge in the literature. Similarly, this study first employed an econometric technique when compared with earlier studies on fossil fuel subsidy reforms impact. The existing research only considered fossil fuel subsidy as a mere monetary value spent on fossil fuel commodities and not what determine the value of fossil fuel subsidy, in terms of fossil fuel subsidy reform. The use of vector autoregressive error correction model (VECM) and impulse response acknowledged the importance of time effect of fossil fuel subsidy on economic growth, which is merely an empirical-based study, and not a policy-driven empirical study. Although fossil fuel subsidy is a determinant of economic growth, however, fossil fuel subsidy, which is proxy as price affects quantity first, according to the conventional laws of demand. Therefore, this existing research ignored fossil fuel consumption which is one of the predominant determinant of fossil fuel subsidy.

To mitigate relevant variables omission and recognize the time difference of fossil fuel subsidy in the previous research, this study empirically investigates the role of fossil fuel subsidy reforms in the nexus between fossil fuel consumption and economic growth in Nigeria. Compared to earlier studies, the fossil fuel subsidy reforms are limited to petroleum (fuel) subsidy reforms due to inaccessibility of data. Similarly, this study differs from previous studies with three distinct fuel subsidy reform periods- pre-fuel subsidy, partial fuel subsidy removal, and full fuel subsidy removal. Unlike earlier studies of fossil fuel consumption and economic growth relationship that employed dynamic causality and causal directionality, this study employed a two-stage least squares (2SLS). The choose of the 2SLS methodology is to avoid endogeneity problem and account for omitted variable bias and estimation errors in the investigation of fossil fuel subsidy reforms effect on the nexus between fossil fuel consumption and economic growth. The fossil fuel subsidy reform which is a moderation variable has both direct association with fossil fuel consumption according to law of demand, and indirect association with economic growth respectively. Besides the 2SLS that is a pioneer methodology, this study employs ordinary least squares (OLS) and Granger causality like earlier studies of nexus between fossil fuel consumption and economic growth for robustness check in the literature.

In spite of the aforementioned contributions to the existing literature, this study answers the following questions as follows: first, what is the effect of pre-fuel subsidy, partial fuel-subsidy removal, and full fuel subsidy removal on the nexus fuel consumption and economic growth respectively in Nigeria? Second, what is the causal directionality between fossil fuel consumption and economic growth during the pre-fuel subsidy, partial fuel subsidy removal and full fuel subsidy removal reforms respectively in Nigeria?

The rest of this study is structured as follows. Section 2 reviews relevant literature. Section 3 discusses the stylized facts. Theoretical framework and methodology are explained in section4. The results and discussion are in section 5, and conclusion and recommendations are outlined in section 6.

Literature Review

Conceptual Clarification

Fossil fuel, fossil fuel consumption, fossil fuel subsidy reforms and economic growth are the main distinctive concepts used in this study. Importantly, the first three concepts relate to non-renewable energy discourse and the last concept, economic growth is a country's overall economic performance indicator.

The term fossil fuels generally refer to all primary energy resources from the earth's crust that are in the unprocessed energy form, such as crude oil, coal, natural gas, bitumen, and other heavy oils. In this study, fossil fuels imply all non-renewable energy commodities, such as premium motor spirit (gasoline), natural gas (LNG), kerosene, and diesel, that are converted from energy resources and only the premium motor spirit (PMS) commonly known as petroleum represent the fossil fuel in this study. Fossil fuel consumption is another concept used in this study. Fossil fuel consumption simply refers to the quantity of fossil fuel commodities used for industrial, construction, transportation, and for other economic activities. In this context, the fossil fuel consumption is expressed in monetary value through the product of premium motor spirit quantity used and the PMS per unit [15]. Fossil fuel subsidy reforms are another concept used in this study, which refers to continuous changing government actions/decisions on fossil fuel consumption through fossil fuels domestic prices to households and industrial sectors in an economy. Technically, fossil fuel subsidy refers to a monetary value relief on current market prices for fossil fuel commodities at the expense of government spending over other competing socio-economic demands. In this study, fossil fuel subsidy reforms are measured in three reform phases- pre-fossil fuel subsidy, partial fuel subsidy removal, and full fuel subsidy removal. On the other hand, economic growth is another concept used in this study that relates to country's economy performance indicator. Economic growth refers to a continuous increase in gross domestic product (GDP) over a stated periods. This study emphasis on the real GDP growth rate to measure the economic growth.

In sum, these concepts are related and indicate a great level of interdependence in the literature.

Theoretical Review

The nexus between fossil fuel consumption and economic growth is rooted from the theoretical philosophy of Hotelling's Theory, while the fossil fuel subsidy reforms in the nexus between fossil fuel consumption and economic growth is drawn from the endogenous growth theory.

On one hand, the theory of depletion of natural resources developed by Harold Hotelling in 1931 postulates that exhaustible resources limit economic growth [16]. This theory identifies two reasons for a limit's economic growth.

First, the depreciation or depletion of the exhaustible assets, such as fossil fuels, basic minerals, forests, freshwater, among others. Prior to late 20th century, the depletion of the exhaustible assets is natural and inevitable. This presumes that all naturally endowed countries have limited economic growth. This suggests why many natural endowed countries like United States (US), Russia, Saudi Arabia, among others continue to invest in research and technology to discover more natural resources, invest in reservoir for massive storage capacities, and encourage foreign trade for these depleting resources with attractive exchange rate, all motivated to prolong their economic growth. Surprisingly, many developed countries with high use of these depleting resources witnessed a spontaneous rapid economic growth and population growth.

The second reason of the Hotelling's theory for limits economic growth is the over-exploitation of the depleting natural resources. The resultant is related to Malthusian population growth and the limits to Growth theories in the 20th century. These periods were characterized with population growth faster than economic growth, increased global warnings, climate change, high emissions, and the incessant global shocks ranging from war, economic, insecurity, and health pandemic, all limits economic growth rate across all economies [17].

On the other hand, the endogenous growth theories led by others endogeneity theories, recognize the role of internally-driven factors to recover from disequilibrium and achieve a steady economic growth rate [18-20]. In bid to recover from the Hotelling's theory of limits economic growth in the context of the nexus between fossil fuel and economic growth, the fossil fuel subsidy reforms driven by the government is associated to the endogenous growth theory. This suggests that the role of fossil fuel subsidy in the nexus between fossil fuel consumption and economic growth fills the existing theoretical research gap in the non–renewable energy literature in this study.

Empirical Review

The study of the role of fossil fuel subsidy in the nexus between fossil fuel consumption and economic growth are drawn in three empirical strands. The first strand focuses on the nexus between fossil fuel consumption and economic growth. While the second strand discusses the fossil fuel subsidy, the third strand highlights the cause and effect of fossil fuel subsidy on economic growth.

Extant studies in the first strand examined the nexus between fossil fuel consumption and economic growth [21-23]. All studies were panel data analyses in different continents and countries, except that investigated a single–country study. In addition, these studies all employed causality tests ranging from Granger causality to Toda and Yamamoto. These studies found that fossil fuel consumption cause gross domestic product (GDP) in developed countries and not in developing countries. Also this study found that the casual estimation methods differ among these studies. While used VECM to estimate short run and long run nexus, the study of employed autoregressive distributed lag (ARDL), and non-linear autoregressive distributed lag (NARDL) respectively. Similarly, the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS), estimation methods were used in the study of estimate short and long run nexus between fossil fuel consumption and economic growth in the West African sub–region. Furthermore, only disaggregated the fossil fuel consumption into different types of fossil fuels consumption.

The second strand highlight the few studies that focuses on fossil fuel subsidy reforms and their implications. In the study of assessed the socio-economics of the 2023 fuel subsidy removal in Nigeria. The employed a country comparative method and provided fourteen consequences of fuel subsidy removal. Similarly, the study of evaluated fuel subsidy removal and its implications on economic rights of Nigeria. The study employed a qualitative review. He found that fuel subsidy has negatively affect people social welfare and recommends a reversal of this policy to ameliorate the people hardship. Also, the study of examined the effect of fuel subsidy removal on socio-economics development of characteristics of Niger state, Nigeria. They employed a descriptive statistics of mean and standard deviation. They found that fuel subsidy removal has a negative impact on socio-economic conditions. Unfortunately, none of these second strand studies were empirically driven that test hypotheses before drawing a conclusion.

The third strand discusses the cause and effects of fossil fuel subsidy in the nexus between fossil fuel consumption and economic growth. Examines the trends, impacts and reforms of fossil fuel subsidies in Indonesia. Findings showed that removal of all fossil fuel subsidies have significantly impact on GDP and efficient energy sector in Indonesia. Furthermore, the findings reveal that removal of fossil fuel subsidy is expected to decline energy consumption by over 10% in 2030 and an estimated reduction of CO2 emission by over 9% in 2030. On the contrary, Foo, in their study, what are the determinants of fuel subsidies in Asia–Pacific Economic Cooperation Countries? Their study employed OLS and Fixed Effects estimation techniques for the study period 1991 [24]. They found that fuel subsidies removal has caused a rise in domestic prices of oil and gas. Also, they found that fuel subsidies removal has a positive impact on the Asia–Pacific Economic Cooperation economy and populace when there is a democracy ability to control corruption, transparency and sound governance.

Unlike earlier fuel subsidy removal reform, investigated the impact of fossil fuel subsidy on economic growth in Nigeria. Their study employed Vector Autoregressive Regression (VAR) and impulse response analysis. They found that fossil fuel subsidy temporarily increases per capita income as well as reduces unemployment rate in the short run, while in the long run, fossil fuel subsidy is not sustainable for per capita income and employment generation in Nigeria.

Taking a cursory review of these existing studies, there is no study that has empirically examine the role of fuel subsidy reforms in the nexus between fossil fuel consumption and economic growth in Nigeria. Therefore, this study aims to address the empirical gap in the existing research.

Stylized Facts about Fossil Fuel Subsidy Reforms in Nigeria

Prior to the fuel subsidy reforms, the Nigeria petroleum sector was characterized with a boom era between 1973 and 1976. On January 1st 1973, the Nigeria's Naira and Kobo currency became a legal tender officially, changing from the British Pounds and Shillings. Surprisingly, a one Naira was equivalent to a two pounds (i.e. £2 =

N1) (in the same year). In 1973, average domestic price of premium motor spirit (PMS), commonly called petrol, was 6 kobo per liter while the cost of Brent Crude Oil per liter was 1kobo per liter and the margin per liter was 5kobo as a PMS tax per liter and income to the Nigerian government in the oil market. Not until 1977, the Nigerian Government PMS tax revenue sharply rose from N0.2 billion Naira in 1973 to N2.09 trillion Naira in 1974 and consistently rose to N2.13 trillion Naira and N2.39 trillion Naira in 1975 and 1976 respectively, while the average annual PMS per liter slightly rose from 6 Kobo in 1973 to 85 Kobo in 1975, despite the global oil price shock in 1973.

In 1977, the Nigeria Government followed other governments worldwide and introduced first fuel subsidy reform to mitigate the 1970s stagflation effects on Nigerians. The first partial fuel subsidy reform slightly increased the PMS per liter from 84 Kobo to 85 Kobo, but the Nigerian Government PSM tax revenue marginally declined from N2.39 trillion Naira in 1976 to N2.27 trillion Naira in 1977, as exhibited in Figure 1.

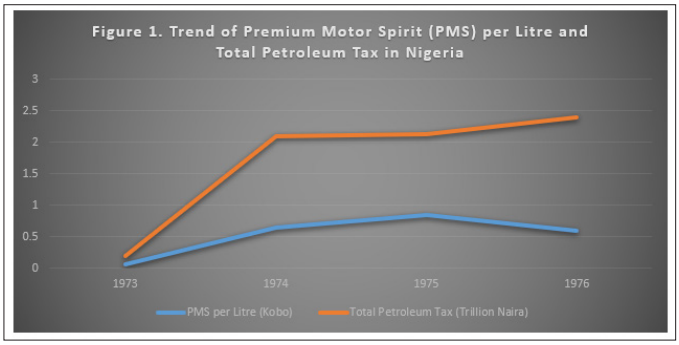

Figure 1: Trend in Premium Motor Spirit per Liter and Total Petroleum Tax in Nigeria (Pre-Fuel Subsidy Reform)

Source: Authors' Chart, 2024

Between 1977 and 1986, the two successive Nigerian government continued with PMS subsidy reform but the domestic PMS prices rose from 9Kobo in 1977 to 20K in early 1986. Furthermore, the new Nigerian Government under Ibrahim Babaginda Administration continued with partial removal of fuel (PMS) subsidy and in same rose PMS prices sharply from 20k to 39.5k per liter.

Not until January 1, 2012, a full removal of reform was announced by Nigeria's Federal Government (FGN) and doubled the PMS price from N65 per liter to N145 per liter. Remarkably, the full fuel subsidy removal was supported by a short-term relief through the Government SURE (Subsidy Reinvestment and Empowerment) policy. The strong political resistance forced the reversal of the fuel subsidy reform from full fuel subsidy to partial fuel subsidy and slashed the PMS price drastically from N145 to N97 per liter and in fewer years, the same government, reduced the PMS price to N87 in 2015.

The persisting global oil price volatility and the recent COVID–19 shocks have succeeded to continually soared the global oil prices. In same vein, between 2016 and June 18 2023, the Nigeria government in spite of partial fuel subsidy removal policy, has continually increased the PMS price from N87 in 2016 to N195 per liter due to depreciating Naira, 100% importation of PMS, no functional local refineries, intense insecurity threats among others.

Figure 2 exhibits that Nigeria's fossil fuel subsidy spending between 2005 and 2023 accumulates to N21.857 trillion Naira (NEITI, 2023; PWC, 2023). In comparison, the 2022 fuels subsidy budget is the highest fuel subsidy payment of about N4.4 trillion and accounted to 73.3% of the Federal Government (FGN) budget deficit of 6 trillion Naira in Nigeria.

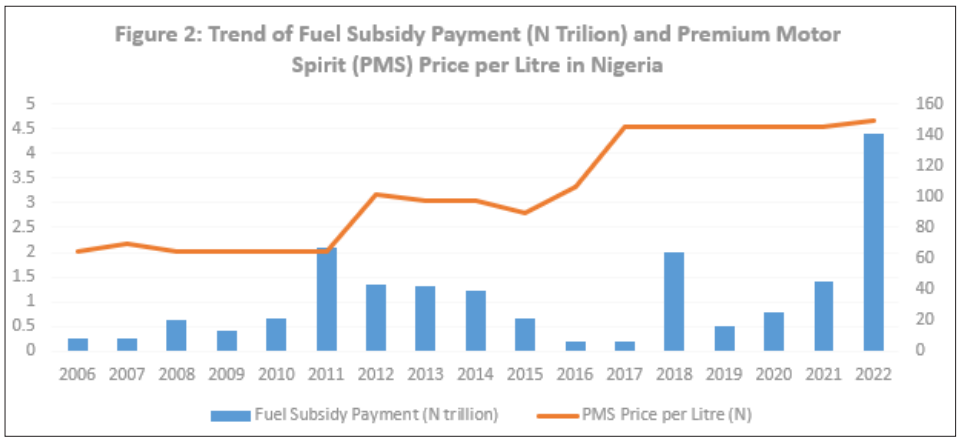

Figure 2: Trend of Fuel Subsidy Payment and Premium Motor Spirit Price per Liter in Nigeria

Source: Authors' Chart, 2024

To reverse this unprecedented high fuel subsidy payment to deficit budget, on June 19, 2023, the new elected–President Bola Ahmed Tinubu, pronounced that "subsidy is gone" at the inauguration ceremony and the PMS price soared astronomically from N195 on June 19 2023 to N1025 as of December 10, 2024. This earmarks in the emergence a full fossil fuel subsidy removal and full deregulated oil and gas sector reform in Nigeria. Surprisingly, this full fossil fuel subsidy removal received no official resistance, unlike the SURE policy in 2012 in Nigeria.

In view of these trends of fuel subsidy reforms at different periods in Nigeria, this study aims to empirically investigate how the fossil fuel (PMS) subsidy reforms affect the nexus between fuel consumption and economic growth in Nigeria from 1973 to 2024.

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Theoretical Framework and Methodology

Theoretical Framework

This study uses the AK theoretical model developed by Robert Frankel in 1962 to justify the model specification. The AK theoretical model is one of the endogenous growth theories that assumes that savings (or investment) rate remains constant, or increasing, in spite of the accumulation of physical capital due to innovative technological progress, and not exogenous technological progress, resulting to a long run growth rate [25]. According to this theory, the long run economic growth is a function of physical capital and the technological progress driven by innovation, and the Frankel growth by innovation is expressed in equation (1)

$$Y=AK \quad (1)$$

Where Y is the long run economic growth; A is the technological progress driven by innovation which indirectly induces long run economic growth; and K is the physical capital that directly induces long run.

In line with the objective of this study, the Frankel AK model is modified to incorporate the fuel subsidy reform which is an internally innovation to achieve a long run economic growth. The modified Frankel AK model replaces the A with the fuel subsidy reform, denoted by D and K is also replace with premium motor spirit consumption (PMSC).
Equation (2) displays modified Frankel AK from equation (1) as follows:

$$Y=DPMSC \quad (2)$$

Where D is the fuel subsidy reform, representing the endogenous technological progress that indirectly affects economic growth and PMSC is the premium motor spirit consumption representing the physical capital that directly affects economic growth.

Furthermore, D which is the fuel subsidy reform depends on a number of innovative factors. Based on existing studies, the innovative factors for this study are premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita, denoted as PMSP, PMSC*SP, EXCH, NR, and RGDPPC respectively. Equation (3) shows that fuel subsidy reform is a function of these innovative factors as follows:

$$D = PMSP^{\beta_1} (PMSC^{*} SP)^{\alpha_2} EXCH^{\alpha_4} NR^{\alpha_4} RGDPPC^{\alpha_5} \quad (3)$$

Where D, PMSP, PMSC*SP, EXCH, NR, and RGDPPC represent fuel subsidy reform, premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita respectively. These factors directly influence fuel subsidy reform in this study.

Incorporating equation (3) into equation (2) to produce equation (4):

$$Y = PMSC^{\alpha_1} PMSP^{\alpha_2} (PMSC^{*} SP)^{\alpha_3} EXCH^{\alpha_4} NR^{\alpha_5} RGDPPC^{\alpha_6} \quad (4)$$

In this study, the control variables are public budget deficit and public debt, denoted as PBD and PB respectively. These control variables directly influence economic growth. In addition, these control variables are also other related physical capital that drives long run economic growth.

Incorporating these variables into equation (4) to produces equation (5) as follows:

$$Y = PMSC^{\alpha_1} PMSP^{\alpha_2} (PMSC^{*} SP)^{\alpha_3} EXCH^{\alpha_4} NR^{\alpha_5} RGDPPC^{\alpha_6} PBD^{\alpha_7} PB^{\alpha_8} \quad (5)$$

Where Y, PMSC, PMSP, PMSC*SP, EXCH, NR, RGDPPC, PBD, and PB represent economic growth, premium motor spirit consumption, premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita, public budget deficit, and public debt respectively. These factors are all determinants of a long run economic growth.

In sum, the theoretical framework of Frankel AK for this study establishes that premium motor spirit consumption (PSMC) as the main variable and public budget deficit, and public debt as the control variables, both directly affects economic growth whereas premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita, have indirect impacts on economic growth.

Methodology

The methodology for this study adapts the Frankel AK endogenous growth theory to investigate the role of fuel subsidy reforms on the nexus between fossil fuel consumption and economic growth in Nigeria. The study period spans from 1973 to 2024. The annual time series range from 1973 to 2022, while the monthly time series range from June 2023–September 2024 in this study.

This study decomposes fuel subsidy reforms into three sub–periods, 1973–1976, 1977–2022, and June 2023–September 2024, representing the pre–fuel subsidy, partial fuel subsidy removal and full fuel subsidy removal respectively. All data were sourced from the World Bank Commodity Price, National Bureau of Statistics (NBS), Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA), and Central Bank of Nigeria (CBN). The summary of the variable used for this study is shown in Table 1.

Table 1: Summary of Variables Description

Variables	Symbol	Description	Data Sources
Real Gross Domestic Product	RGDP (Y)	Real gross domestic product is the monetary value of final goods and services at a constant price. The real GDP is proxy as Economic growth.	NBS; CBN
Premium motor spirit consumption	PMSC	Premium motor spirit consumption is the monetary value of petrol or gasoline, which is one of fossil fuel products consumed for household and industrial usage.	NBS; CBN
Interaction of Premium motor spirit consumption and fuel subsidy payment	PMSC*SP	Premium motor spirit consumption subsidy policy is the product of premium motor spirit consumption and premium motor spirit subsidy cost spent for PMS consumption	Authors' computation; World Bank Commodity Price (WBC).
Exchange Rate	EXCH	Exchange rate is the rate at which one currency is exchanged to another country's currency	CBN
Public Budget Deficit	PBD	Public budget deficit is the monetary value of the excess of total public proposed expenditure over total public proposed revenue over a state period, usually a year.	CBN
Premium motor spirit price	PMSP	Premium motor spirit price is the price per liter Premium motor spirit is sold to household and industry at a specific time	NBS;NDMPRA
Number of Refineries	NR	Number of refineries is the total number of refineries that refined fossil fuel in a given period of time	NBS; NDMPRA
Real GDP per capita	RGDPPC	Real GDP per Capita is the average GDP per person at a specific period of time. Real GDP per Capita is real GDP divided by population size in a country	NBS; CBN

Notes: CBN, NBS, NMDPRA, and WBCP represent Central Bank of Nigeria, National Bureau of Statistics, Nigerian Midstream and Downstream Petroleum Regulatory Authority, and World Bank Commodity Price.

Source: Authors' Compilation, 2024

Model Specification

This study employs a modified Frankel AK model to investigate the role of fuel subsidy reform in the relationship between fossil fuel consumption and economic growth in Nigeria. Earlier studies of employed OLS and ARDL-ECM of a single regression equation and their estimations were posed with a high possibility of endogeneity problem because some salient variables that are directly associated with the main explanatory variable, fossil fuel consumption and indirect related to economic growth, which violates the OLS assumption, resulting to a biased OLS estimates.

To avoid the endogeneity problem in the OLS regression and also in the ARDL-ECM of a single regression equation, this study employs a two stage least squares (2SLS). Furthermore, this study conducts endogeneity and J-statistic tests to validate the use of 2SLS in this study. First, the endogeneity test confirms if an explanatory variable is endogenous. The explanatory variable that is endogenous variable implies that this variable indirectly affects the dependent variable, hence, this endogenous variable is omitted from the OLS estimation and thus, justify the need for a 2SLS estimation. Second, the J-statistic test verify if these instrumental variables are valid, indicating that the instrumental variables have a strong association with the endogenous variable (i.e. COV (Z1¬, X) 0) and also the instrumental variables are exogenous and indirectly affect the dependent variable, suggesting that the instrumental variables are not correlated with the error term of the regression model (i.e. COV (Z1, e) = 0 [26-28].

The model specification for this study is drawn from the modified Frankel AK theory shown in equation (5) and transformed into a baseline econometric OLS regression in equation (6) as:

$$InY_t = \beta_0 + \beta_1 PMSC_t + \beta_3 PMSP_t + \beta_3 (PMSC^* SP)_t + \beta_4 EXCH_t + \beta_5 NR_t + \beta_6 RGDPPC_t + \beta_7 PBD_t + \beta_8 PB_t + \varepsilon_t$$

Lastly, the OLS equation (6) is transformed into a Two Stage Least Squares (2SLS) in equation (7) as:

$$InY_t = \beta + \eta PMSC_t + \alpha InIV_t + \varphi CV_t + \varepsilon_t \quad (7)$$

Where β and η are coefficients of constant parameter and main explanatory variable, premium motor spirit consumption (PMSC) respectively. While α and ψ are coefficients of a set of instrumental variables and control variables. The instrumental variables are premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita, represented as PMSP, PMSC*SP, EXCH, NR, and RGDPPC respectively. And the control variables are public budget deficit and public debt are represented as PBD and PD respectively. The error term of the model is represented as e_t.

Therefore, the estimated 2SLS and OLS models in equations (8) and (9) from equation (7) and (6) are to estimate the role of fossil fuel reforms in the nexus between fossil fuel consumption and economic growth in Nigeria as follows:

$$RGDP_t = \propto_0 + \propto_1 PMSC_t + \propto_2 PBD_t + \propto_3 PD + e_t \quad (8)$$

$$InRGDP_t = \beta_0 + \beta_1 PMSC_t + \beta_3 PMSP_t + \beta_3 (PMSC^* SP)_t + \beta_4 EXCH_t + \beta_5 NR_t + \beta_6 RGDPPC_t + \beta_7 PBD_t + \beta_8 PB_t + \varepsilon_t$$

Results and Discussion

Preliminary Results

The preliminary results present the descriptive statistics, and correlation matrix for this study. Tables 2-3 present the descriptive statistics and correlation matrix in this study.

Table 2: Descriptive Statistics of the Variables

Variables	Reforms	Mean	STD	JB	OBS
RGDP	Pre-Fuel subsidy	21.6	7.9	2.1	48
	Partial Fuel subsidy Removal	348493.0	504579.4	42.3***	46
	Full Fuel subsidy Removal	5506.1	1837.9	6.27	16
PMSC	Pre-Fuel subsidy	152.2	77.9	10.18***	48
	Partial Fuel subsidy Removal	14312.6	5021.2	2.78	46
	Full Fuel subsidy Removal	14967.1	3415.6	6.96**	16
PBD	Pre-Fuel subsidy	9.2	90.1	4.98*	48
	Partial Fuel subsidy Removal	-44350.4	80005.6	39.7***	46
	Full Fuel subsidy Removal	0.93	0.18	2.7	16
PD	Pre-Fuel subsidy	0.16	0.06	6.3**	48
	Partial Fuel subsidy Removal	5948.6	9262.2	86.2***	46
	Full Fuel subsidy Removal	N/A	N/A	N/A	N/A
PMSP	Pre-Fuel subsidy	0.54	0.38	8.05**	48
	Partial Fuel subsidy Removal	45.2	51.4	6.4**	46
	Full Fuel subsidy Removal	703.0	113.3	9.9***	16
PMSC*SP	Pre-Fuel subsidy	N/A	N/A	N/A	N/A
	Partial Fuel subsidy Removal	2.74E+13	7.24E+13	957.9***	46
	Full Fuel subsidy Removal	151325.7	389813.2	39.7***	16
EXCH	Pre-Fuel subsidy	0.63	0.03	63.9***	48
	Partial Fuel subsidy Removal	105.8	118.4	9.9***	46
	Full Fuel subsidy Removal	1154.5	351.3	2.07	16
NR	Pre-Fuel subsidy	1.00	0.00	N/A	48
	Partial Fuel subsidy Removal	3.7	0.94	37.9***	46
	Full Fuel subsidy Removal	5.6	0.50	2.71	16
RGDPPC	Pre-Fuel subsidy	169.13	6.07	6.59**	48
	Partial Fuel subsidy Removal	1822.7	436.8	4.6*	46
	Full Fuel subsidy Removal	250.3	83.5	6.3**	16

Notes: STD, JB, and OBS represent standard deviation, Jarque-Bera, and observations. RGDP, PMSC, PBD, PD, PMSP, PMSC*SP, EXCH, NR, and RGDPPC indicate real gross domestic product, premium motor spirit consumption, public budget deficit, public debt, premium motor spirit price, interaction of premium motor spirit consumption and fuel subsidy payment, exchange rate, number of refineries, and real gross domestic product per capita respectively.

Source: Authors' computation from EViews 10, 2024

Table 2 results present the descriptive statistics for the variables in the pre–fossil fuel subsidy, fossil fuel partial subsidy removal and fossil fuel full subsidy removal periods in Nigeria. First, the average result shows that the interaction of premium motor spirit consumption and fuel subsidy is the highest average spending of N2.7 trillion during the partial fuel subsidy removal period, follow by average spending of real *GDP per capita* and the least average spending of N0.16 million for public debt. Further, the overall average results reveal that the average premium motor spirit consumption of N152.2 million and N15.0 trillion are far higher than the average real GDP expenditure of N21.6 million and N5.5 trillion at the partial and full fuel subsidy removals respectively in Nigeria. On the standard deviation results, all these variables, except exchange rate, public debt and number of refineries in the pre–fossil fuel subsidy era, exhibit high variability in this study. In addition, the interaction of premium motor spirit consumption and fuel subsidy payment under partial and full fuel subsidy removals are the highest variability when compared with other included variables. Furthermore, the Jarque–Bera tests for all variables reject the null hypothesis of a normal distribution, except the real *GDP* which is the most stable distribution before fuel subsidy removal and during the fuel subsidy full removal reform periods in Nigeria. Lastly, the number of observations for the variables has a balance dataset for each period in this study.

Results in Table 3 show degree of associations for variables in pre–fossil fuel subsidy, fossil fuel partial subsidy removal, and fossil fuel full subsidy removal periods. All periods show low correlation coefficients among the included variables and none of the correlation coefficient exceeds 0.80, hence, there is a low possibility of multicollinearity problem in this study.

Table 3: Correlation Matrix of the Variables for the Three Fuel Subsidy Reforms

Variable	Reform Periods	RGDP	PMSC	PBD	PD	PSMP	PMSP*SP	EXCH	NR	RGDPPC
RDGP	Pre-fuel subsidy	1.000								
	Partial fuel subsidy removal	1.000								
	Full fuel subsidy removal	1.000								
PMSC	Pre-fuel subsidy	-0.787	1.000							
	Partial fuel subsidy removal	0.515	1.000							
	Full fuel subsidy removal	0.787	1.000							
PBD	Pre-fuel subsidy	0.251	-0.134	1.000						
	Partial fuel subsidy removal	0.083	0.07	1.000						
	Full fuel subsidy removal	0.252	0.13	1.000						
PD	Pre-fuel subsidy	-0.434	0.649	-0.78	1.000					
	Partial fuel subsidy removal	0.625	0.66	0.11	1.000					
	Full fuel subsidy removal	-0.434	0.65	-0.78	1.000					
PMSP	Pre-fuel subsidy	-0.730	0.688	-0.044		1.000				
	Partial fuel subsidy removal	0.717	0.75	0.15	0.86	1.000				
	Full fuel subsidy removal	-0.730	0.69	-0.044	0.314	1.000				

PMSP*SP	Pre-fuel subsidy	NA	NA	NA	NA	NA	NA			
	Partial fuel subsidy removal	0.204	0.30		0.57	0.33	1.000			
	Full fuel subsidy removal	NA	NA	NA	NA	NA	NA			
EXCH	Pre-fuel subsidy	0.736	-0.564	0.331	-0.418	-0.624		1.000		
	Partial fuel subsidy removal	0.699	0.78				0.42	1.000		
	Full fuel subsidy removal	0.736	0.56			-0.624		1.000		
NR	Pre-fuel subsidy	NA	N/A	N/A	N/A	N/A		N/A	N/A	
	Partial fuel subsidy removal	0.371	0,45	0.18	0.48	0.49	0.28	0.53	1.000	
	Full fuel subsidy removal		N/A	N/A	N/A	N/A		N/A	N/A	
RDGPPC	Pre-fuel subsidy	-0.008	0.580			0.222		0.073	N/A	1.000
	Partial fuel subsidy removal	0.564	0.58	0.33	0.57	0.80	0.15	0.70	0.03	1.000
	Full fuel subsidy removal	-0.008	0.58	0.45	0.194	0.22		0.58		1.000

Source: Authors' computation EViews 10, 2024

Table 4: Unit Root Tests of the Variables for the Three Fuel Subsidy Reforms

Variables	Augmented Dickey Fuller (ADF) Unit Root Test								
	Pre-Fuel Subsidy (1973- 1976)			Partial-Fuel Subsidy Removal (1977-2022)			Full-Fuel Subsidy Removal (June 2023-Sept. 2024)		
	Level	1st Difference	Order of Integration	Level	1st Difference	Order of Integration	Level	1st Difference	Order of Integration
RGDP	-1.62	-6.698***	I(1)	-3.698***	-7.49***	I(0)	-1.80	-3.11**	I(1)
PMSC	-1.62	-6.84***	I(1)	-1.89	-7.34***	I(1)	-2.97*	-3.04**	I(0)
PMSP	-1/473	-6.63***	I(1)	0.97	-5.99***	I(1)	1.83	-0.65	Non-stationary
EXCH	-2.05	-11.62***	I(1)	3.24	-4.36***	I(1)	-0.17	-4.83***	I(1)
NR	N/A	N/A	N/A	-2.83*	-7.16***	I(0)	-1.249	-3.74***	I(1)
RGDPPC	-1.892	-6.68***	I(1)	-0.964	-4.64***	I(1)	-1.80	-3.11**	I(1)
PMSC*SP	N/A	N/A	N/A	-0.67	-4.20***	I(1)	-2.54	-3.99***	I(1)
PBD	-1.073	-6.662***	I(1)	-2.37	-7.07***	I(1)	-1.08	-3.69***	I(1)
PD	-0.34	-6.96***	I(1)	9.05	-11.36***	I(1)	N/A	N/A	N/A

Notes: *, **, and *** represent 10%, 5%, and 1% level of significance; NA represents data not available.
Source: Authors' computation EViews 10, 2024

Table 4 results find that all variables except premium motor spirit price (PMSP) in the full fuel subsidy removal, are stationarity at level or first order difference at all levels of significance. Additionally, Table 4 results reveal that only partial and full fuel subsidy removals variables exhibit a mixed order of integration of zero I(0) and one, I(1). This suggests that the ADF unit root test results confirm distortions and divergence among the variables in the short-run of the fuel subsidy reform periods in this study.

Table 5: Cointegration Tests for the Three Fuel Subsidy Reforms

Fuel Subsidy Reforms	Cointegration Test Method	Variable	Statistic Values	Critical Values
Pre-fuel subsidy	Johansen test	ALL	TS=9.82	29.79 @5%
Partial fuel subsidy removal	ARDL Bounds test	ALL	F=22.56*** K=8	I(0)@ 1% =2.62; I(1)@1%=3.77 I(1)@5%=2.11; I(1)@5%=3.15 I(0)@10%=1.85; I(1)@10%=2.85
Full fuel subsidy removal	ARDL Bounds test	ALL	F=2.23 K=6	I(0)@ 1% =2.88; I(1)@1%=3.99 I(0)@5%=2.27; I(1)@5%=3.28 I(0)@10%=1.96; I(1)@10%=2.94

Notes: *, **, and *** represent 10%, 5%, and 1% level of significance; TS, F and K represent trace statistic, F-Bounds statistic, and degree of freedom
Source: Authors' computation EViews 10, 2024

Table 5 results display the cointegration tests for the three fuel subsidy reforms. Table 5 finds that the trace statistic value of 9.82 is below the critical value of 29.79 at 5% level of significance, hence, the null hypothesis of no long relationship cannot be rejected in the pre-fuel subsidy periods. Additionally, Table 5 finds that only the partial fuel subsidy removal F-Bounds value of 22.56 exceeds both the upper and lower Bounds critical values, hence, a long run relationship prevails among the variables during the partial fuel subsidy removal. This suggests that only the disequilibrium among the variables in the partial fuel subsidy removal can be corrected and converged to a stable relationship in the long run in this study.

Estimation Results

Table 6: Estimated OLS and Two Stage Least Squares (2SLS) of Fossil Fuel Consumption–Economic Growth Nexus Results

Dependent Variable: RGDP	Model I (Pre-Fossil Fuel Subsidy)		Model II (Partial Fuel Subsidy Removal)		Model III (Full Fuel Subsidy Removal)	
Estimation Methods	OLS	2SLS	OLS	2SLS	OLS	2SLS
Instrumental Variables		PMSP, EXCH, RGDPCI		PMSP, PMSC*SP, NR, EXCH, RGDPCI		PMPS, PMSC*SP, NR, EXCH, RGDPCI
PMSC	-0.08*** (-8.53)	-0.06***	15.14 (0.96)	47.22* (1.87)	-0.34*** (-3.39)	-0.48*** (-3.75)
PBD	0.013 (1.852)	(-6.29)	-0.83 (-1.10)	-0.542 (-0.67)	-2696.4 (-1.43)	-1740.72 (-0.84)
Constant	33.25*** (21.34)	0.015*	-80359.24 (-0.40)	-457178.7 (-1.48)	13128.33***	143399*** (6.86)
PD		(1.801)	29.47*** (3.42)	17.80 (1.56)	(7.023)	
Endogeneity test		31.23***		3.11 [0.008]		4.70 [0.03]
J-Statistic		(18.14)		7.14 [0.13]		7.24 [0.12]
Weak instruments				5.76 [5.25]		4.40 [18.4]
Diagnostic tests:		8.71[0.003]				
R2:	0.642	33.29 [0.000]	0.427	0.371		0.544
F-Stat	0.40.32***	31.90[16.85]	10.42***	10.38***	0.603	10.64***
Jarque-Bera	0.33 [0.00]		279.15 [0.000]	279.4 [0.000]	9.36***	0.969 [0.62]
(Normality)	76.62 [0.000]	0.625	1.27 [0.29]	3.89 [0.14]	1.67 [0.43]	2.45 [0.294]
LM Serial	30.22 [0.000]	23.58***	0.001[0.972]	0.02 [0.90]	1.42 [0.283]	0.552 [0.59]
Correlation	3.00E+12 [0.00]	11.24 [0.003]	3.33 [0.002]	2.34 [0.02]	1.10 [0.362]	0.537 [0.60]
Breusch-Pagan		37.46 [0.00]			1.12 [0.28]	
Ramsey		2.858 [0.068]				
		1.32E+12 [0.000]				

Notes: *, **, and *** represent 10%, 5%, and 1% level of significance; parenthesis and brackets represent t-statistic and probability values.
Source: Authors' computation EViews 10, 2024

Table 6 results present the estimated OLS and 2SLS estimations of the role of fuel subsidy reforms in the nexus between fossil fuel consumption and economic growth for the three fuel subsidy reform periods in Nigeria.

Results of endogeneity tests in Table 6 reveals that the premium motor spirit (PMS) fuel consumption is not exogenous in three models because the P-values are all less than 5% level of significance, hence the null hypothesis of fuel consumption is exogenous is rejected and (PMS)fuel consumption is endogenous in this study. This endogeneity problem in (PSM) fuel consumption makes the OLS estimate inaccurate and the two stage ordinary least squares (2SLS) estimate is preferred to report in this study.

Furthermore, Table 6 finds that the J-statistic values for the three models,, except model 1, are at p-value greater than 5% level of significance, hence, the null hypothesis of instrumental variables are exogenous to the error term of the models and a strong associations between instrumental variables and the main explanatory variable, PSM consumption cannot be rejected. This suggests that models

II and III confirm the validity of the instrumental variables for the 2SLS estimates in this study.

Results of 2SLS in Table 6 reveals that PMS fuel consumption through the instrumental variables has a positive significant impact on economic growth during the partial fuel subsidy removal, whereas, PMS fuel consumption through the instrumental variables has a negative significant impact on economic growth during the full fuel subsidy removal in Nigeria. Additionally, Table 6 finds that a 1% increase in PMS fuel consumption through the instrumental variables during the partial fuel subsidy removal has increased economic growth by 37.22% whereas, a 1% increase in PMS fuel consumption through the instrumental variables during the full fuel subsidy removal has decreased the economic growth by 0.34% in this study. In addition, the 2SLS results in models II and III find that the instrumental variables, premium motor spirit price, exchange rate, number of refineries, interaction of premium motor spirit consumption and PMS fuel subsidy payment, and real GDP per capita, are valid and indirectly impact economic growth in Nigeria.

This finding in Table 6 is consistent with in their study of the effect of petroleum price and energy consumption on GDP in Malaysia. On the contrary, found only fossil fuel consumption as a direct determinant of economic growth without the role of fuel subsidy reforms like premium motor spirit price, exchange rate, number of refineries, interaction of premium motor spirit consumption and PMS fuel subsidy payment, and real GDP per capita in this study.

The diagnostic tests in Table 6 shows only model 3 conforms to all the OLS assumptions and thus, the most reliable and dependable results for inference in this study. The coefficients of determination of the estimated 2SLS shows that all variables for the three models, except model 2 are strong predictors of the dependent variable, economic growth in this study. The F-statistic tests results in Table 6 affirms that all the overall 2SLS models are statistically significant at 1% level of significance to draw inference in this study. The Jarque-Bera tests in Table 6 finds that a null hypothesis of normal distribution cannot be rejected for only model 3 in this study. This suggest that the model 3 error terms follow the assumed normal distribution during the full fuel subsidy removal period in Nigeria. Results of Breusch-Godfrey serial correlation LM and Breusch-Pagan-Godfrey tests in Table 6 finds that the null hypothesis of no serial correlation and no heteroskedasticity cannot be rejected at p-value greater than 5% in models 2 and 3 only in this study. Like normality tests results, the Ramsey reset tests in Table 6 finds that the null hypothesis of no model specification error cannot be rejected at p-value greater than 5% level of significance for model 3 only.

In summary, the estimated model 3 outperforms models 1 and 2 in all the four diagnostic tests, hence, the model 3 is the most reliable to draw inferences in this study. This implies that full fuel subsidy removal has caused a negative significant relationship between fuel consumption and economic growth between June 2023 and September 2024 in Nigeria.

Table 7: Granger Causality Test Results

Causal Direction	Model I (Pre- Fuel Subsidy)	Model I (Partial Fuel Subsidy Removal)	Model III (Full Fuel Subsidy Removal)
PMSC → RGDP RGDP → PMSC	0.159 0.014	4.12* 1.91	1.97 2.49
PBD → RGDP RGDP → RBD	0.427 1.049	3.11* 17.81***	1.22 2.89*
PMSP → RGDP RGDP → PMSP	0.347 1.40	11.38*** 0.12	1.11 0.09
EXCH→ RGDP RGDP → EXCH	3.25** 4.04**	5.28*** 2.33	1.17 0.94
NR → RGDP RGDP → NR	NA NA	0.60 0.74	4.20** 7.06***
RGDPPCI → RGDP RGDP → RGDPPCI	0.34 0.03	3.42** 0.15	0.18 0.18
PBD → PMSC PMSC → PBD	0.04 1.33	0.45 0.44	9.39*** 7.56***
PMSP → PMSC PMSC → PMSP	0.003 1.064	5.29*** 1.43	0.84 0.10
EXCH → PMSC PMSC → EXCH	0.424 1.815	5.20*** 0.31	0.37 2.16
NR → PMSC PMSC → NR	NA NA	0.20 2.11	5.65** 7.06***
RGDPPCI → PBD PBD → RGDPPCI	0.46 0.08	1.38 0.76	n/a n/a
EXCH → PMSP PMSP → EXCH	0.02 4.18**	3.00* 1.88	0.68 2.38
NR → PMSP PMSP → NR	NA NA	0.36 1.39	0.64 0.19

RGDPPCI → PMSP PMSP → RGDPPCI	0.455 0.145	0.64 0.78	0.09 1.11
NR → EXCH EXCH → NR	NA NA	0.10 1.24	8.02*** 0.32
RGDP_PCI → EXCH EXCH → RGDPPCI	0.195 2.088	0.22 2.14	0.94 1.17
RGDPPCI → NR NR → RGDPPCI	NA NA	0.14 9.85***	7.06*** 4.20**
PMSC*SP → RGDP RGDP → PMSC*SP		0.21 1.23	0.08 0.69
PD → RGDP RGDP → PD		3.70** 0.26	
PMSC*SP → PMSC PMSC → PMSC*SP		1.53 1.53	0.45 1.34
PD → PMSC PMSC → PD		4.92*** 0.44	
RGDPPCI → PMSC PMSC→ RDGPPCI		4.15** 0.28	
PBD → PMSC*SP PMSC*SP → PBD		0.31 0.36	1.85 0.00009
PD → PMSC*SP PMSC*SP → PD		9.85*** 0.06	
PMSP → PMSC*SP PMSC*SP → PMSP		2.95* 1.67	0.39 0.39
NR → PMSC*SP PMSC*SP → NR		1.86 0.26	0.64 0.0001
EXCH → PMSC*SP PMSC*SP → EXCH		4.18** 0.43	3.27* 2.01
RGDPPCI → PMSC*SP PMSC*SP → RGDPPCI		2.62* 0.08	0.69 0.08
PD → PBD PBD → PD		0.10 3.32**	
PMSP → PBD PBD → PMSP		0.55 0.47	0.49 0.23
NR → PBD PBD → NR		0.15 0.35	12235.8 0.10
EXCH → PBD PBD → EXCH		1.02 2.09	0.44 8.26***
RGDPPCI → PBD PBD → RGDPPCI		1.38 0.76	2.89 1.22
PMSP → PD PD → PMSP		1.28 0.50	
NR → PD PD → NR		0.39 1.77	

EXCH → PD PD → EXCH		0.31 1.12	
RGDP_PCI → PD PD → RGDP_PCI		0.06 4.53**	
RGDP_PCI → PMSC PMSC → RGDP_PCI			2.49 1.99

Notes: *, **, and *** represent 10%, 5%, and 1% level of significance.
Source: Authors' computation EViews 10, 2024

Table 7 results reveal that a unidirectional and bidirectional causalities exist among variables during the three fuel subsidy reforms in Nigeria. The Granger causality tests find a significant unidirectional causality from fuel consumption to economic growth at 10% level of significance only during partial fuel subsidy removal. Additionally, Table 7 finds a significant bidirectional causality between exchange rate, number of refineries, public budget deficit, and economic growth in the three fuel subsidy reforms in Nigeria. Also, Similarly, Table 7 finds both unidirectional and bidirectional causalities among public budget deficit, number of refineries, real GDP per capita, exchange rate, premium motor spirit price and fuel consumption in this study. This results imply that fuel subsidy reforms cause both fuel consumption and economic growth than fuel consumption that cause only economic growth in this study [29-45].

Conclusion and Recommendations

The study investigated the role of fossil fuel subsidy reforms in the nexus between fossil fuel consumption and economic growth in Nigeria. Unlike existing studies, the study is the first to empirically analysis all the three fuel subsidy reform phases, the pre-fuel subsidy, partial fuel subsidy removal, and full fuel subsidy removal on the nexus between fuel consumption and economic growth in Nigeria. Similarly, the study employs a pioneer estimation technique, the two stage least squares (2SLS) and Granger causality. The study employs 2SLS to avoid the endogeneity problems in the previous studies and also to analyses extant factors that directly affect fuel consumption and indirectly affects economic growth. The study also employed Granger causality like existing research. The study employed a decomposed study periods varying with the fuel subsidy reform phases. These study periods for pre-fuel subsidy, partial fuel subsidy removal, and full fuel subsidy removal are 1973-1976, 1977-2022, and June 2023 to September 2024 respectively.

The study concludes that PMS consumption through the instrumental variables, premium motor spirit price, exchange rate, number of refineries, interaction of premium motor spirit consumption and PMS fuel subsidy payment, and real GDP per capita, has a positive significant impact on economic growth during the partial fuel subsidy removal, whereas, PMS fuel consumption through the instrumental variables, premium motor spirit price, exchange rate, number of refineries, interaction of premium motor spirit consumption and PMS fuel subsidy payment, and real GDP per capita, has a negative significant impact on economic growth during the full fuel subsidy removal in Nigeria. On comparison among the fuel subsidy reforms, this study infers that only full fuel subsidy removal has a consistent negative significant relationship between fuel consumption and economic growth between June 2023 and September 2024 in Nigeria. Additionally, the study concludes that fuel subsidy reforms cause both unidirectional and bidirectional causalities between fuel consumption and economic growth than fuel consumption that cause a unidirectional causality only with economic growth in this study.

This study contributes a new empirical knowledge by analyzing different fuel subsidy reforms in the relationship between fuel consumption and economic growth using a two–stage least squares (2SLS) as well as a valuable policy implications of the current fuel subsidy reform on fuel consumption and economic growth in Nigeria. These findings offer the following recommendations; first, the Nigeria energy policymakers should prioritize premium motor spirit price, exchange rate, number of refineries, and real GDP per capita in the pursuit of fuel subsidy reform to directly and indirectly promotes fuel consumption and economic growth as evident in the Granger causality results. Second, the shrinking fuel consumption-economic growth is notable and significant in the full fuel subsidy removal and to recover and achieving a stable nexus between fuel consumption and economic growth depends on proactive decisions on the study's instrumental variables by the Nigeria stakeholders. Third, the Nigeria's fiscal budget should be reviewed for prudency and accountability to reduce leakages and promote efficient resources mobilization and allocations to the fuel subsidy reforms agenda that will leads to swift recovery from deficits and fiscal surplus for economic growth.

This study focused on the premium motor spirit (PMS) fuel subsidy reforms and the nexus between PMS consumption and economic growth in Nigeria. Further research can extend the scope of this study and consider other fossil fuel subsidy reforms and the nexus between different fossil fuel consumptions on economic growth in Nigeria. In addition, future research should consider cross-country study, rather than the single country study investigated.

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