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Asymmetric Impact of Oil Price and Income in Nigeria UEDT, 1980 – 2019: The NARDL Approach

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Abstract
The study adopted the NARDL model study transportation fuel demand and its asymmetric effects of oil price and income variation on demand for gasoline fuel and diesel fuel in Nigeria. It pays attention to the short-run and long-run nonlinearities demands and supply conditions via positive and negative partial sum decomposition of oil price and income. Variables used in the study are a mixture of I (0) and I (1) series which justified the use of the Bounds test approach to cointegration. Thus, the result of the Bounds test affirms the existence of a long-run equilibrium relationship. Alternatively result of the NARDL model showed that both gasoline and diesel prices and income have short-run and long-run asymmetric effects on gasoline and diesel fuel demand by the transport sector in Nigeria. However, the degree of responsiveness of both gasoline and diesel fuel demand to changes in oil price and income is more on changes in income than changes in oil prices in the short run. It confirmed that population has a strong influence on passenger fuel demand than freight fuel demand which affirms the theory. It, therefore, recommends that government should embark on more structural policies that could control oil prices and stimulate economic activities in Nigeria.
Keywords: Asymmetric oil price, income, Disaggregated Transpiration fuels Demand in Nigeria, UEDT and Nonlinear Auto Regression Distributed Lag (NARDL).
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1. Introduction

Transportation is another area where energy (oils and Oil products) is consumed. It involves the movement of freight and persons from one location to another. It aims to mitigate the spatial imbalances in the location of resources by controlling the effect of distance. The fewer energy costs per ton or passenger - kilometre, the less important energy transfers. Also, overcoming space in a global economy requires a substantial amount of work and energy. This, by implication, has a consequence on massive economies of scale. The demand for energy i.e., Transportation fuels is a derived demand, rather than direct demand. Through energy appliances as capital, energy only can produce various types of services for which consumers are willing to pay. Therefore, energy demand is inevitably affected by energy efficiency embodied in energy appliances or the way of using energy appliances in as much as energy's value is determined by its ability to provide some set of desired services. The central roles of the transportation sector to economic growth in Nigeria and the relevance of oil in lubricating the economy necessitated the Nigerian government to embark on a radical policy and institutional reforms in the energy sector in 1999. Oil and Gas were on top of the government's reform agenda. In this regard, the national energy policy was approved by the government in 2003. More recently, the Petroleum Industry Bill (PIB) has seen the light of the day. These policies were to provide for a well-synchronized development, utilization, and management of all energy resources in Nigeria. It has been argued consistently, that the contribution of the transport sector to economic growth has been dropping due to fuel prices and income constraints (Rainley, 2002).

2. Oil Demand and Output in Nigeria

A rise in individual incomes and change in lifestyles led to an increase in the demand for private car ownerships by high-income earners, a rise in demand for public transportation by low-income earners and haulage of goods by companies and primary goods producers in rural areas. Therefore, the stock of vehicles, both private and commercial has increased substantially, leading to an increase in energy consumption in the sector. Statistics on vehicle registrations in Nigeria from the Federal Road Safety Commission of Nigeria show that, from 2006 to 2009, over 70% of the newly registered vehicles in Nigeria were small private motor vehicles that use gasoline. During the same period, large commercial vehicles that use diesel constituted about 26%. However, in 2010 the number of small vehicles fell to about 66% and commercial vehicles had increased to about 31%. Based the report from the Nigerian Bureau of Statistics (NBS) in 2019 has estimated the total number of vehicles in the country at about 11.7 million with commercial vehicles holding about 58.08 per cent of the number. According to the report, out of the 11,653,871 million vehicles, commercial vehicles are 6,768,756, representing about 58.08 per cent; private are 4,739,939 (40.67 per cent); government vehicles followed with 139,264 (1.19 per cent); while Diplomatic vehicles accounted for 5,912 (0.05 per cent). Accordingly, the demand for oil products grew from 16,000b/d in 1960 to 35,000b/d in 1980 to 440,000b/d in 2018 (OPEC 2019).

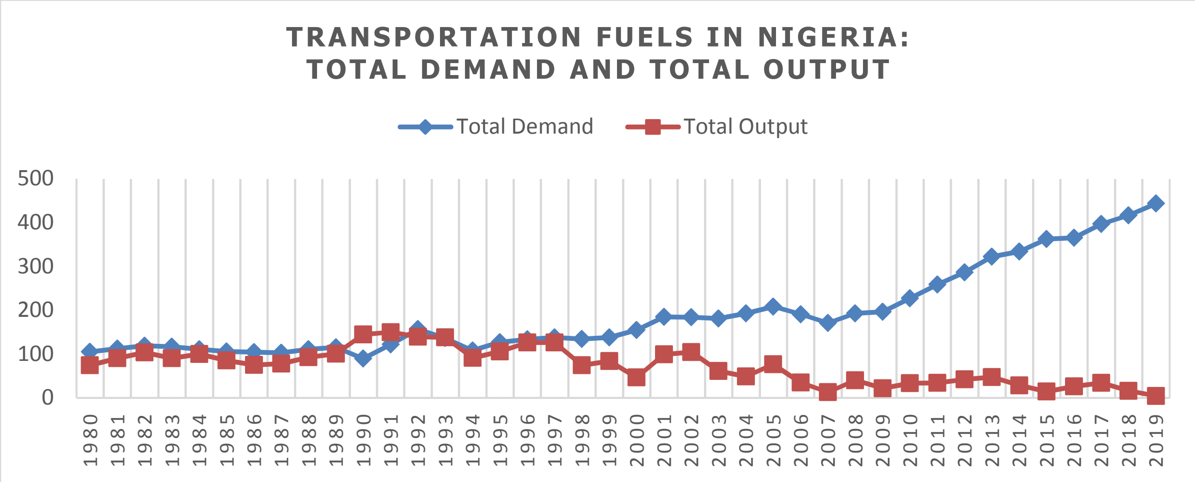

Figure 1. Oil Demand and Output in Nigeria
Source: OPEC 2020 Annual Statistical Bulletin (ASB) and National Bureau of Statistics (NBS) 2019

In addition, the Nigerian government have always maintained a deliberate policy of subsidizing petroleum products. As of 2003 government figures indicated that for every 1 litre of petroleum products sold, about 40% was spent on subsidy. By the end of 2007, the subsidy on petroleum products was up to N450 billion, accounting for about 3% of GDP. Furthermore, in 2011, the Nigerian government spent a record amount on fuel subsidies US$8.4 billion in gasoline subsidies- equivalent to 4.1 per cent of GDP ("A Citizens' Guide to Energy Subsidies in Nigeria).

In the early 1980s, when the revenues from oil sales became unsustainable, individual personal incomes declined substantially. The Nigerian government was forced to introduce the Structural Adjustment Program which includes the gradual withdrawal of subsidies on petroleum products. Accordingly, the Nigerian Government started a gradual withdrawal of fuel subsidies, from 1986 to 2016, more than 20 times the government adjusted the pump prices of petroleum products. However, most of the increase in the prices of products were followed by a backlash from labour unions and the general public, sometimes the government will be forced to reverse its decision, as it happened in January 2012. Notwithstanding, the subsidy withdrawal program continued, by 2014, the government of Nigeria has completely withdrawn subsidies on diesel which led to a serious decline in diesel demand as shown in figure two below while the gasoline subsidies withdrawn was forced to reverse the price by the labour union as a result of unfavourable economies situation.

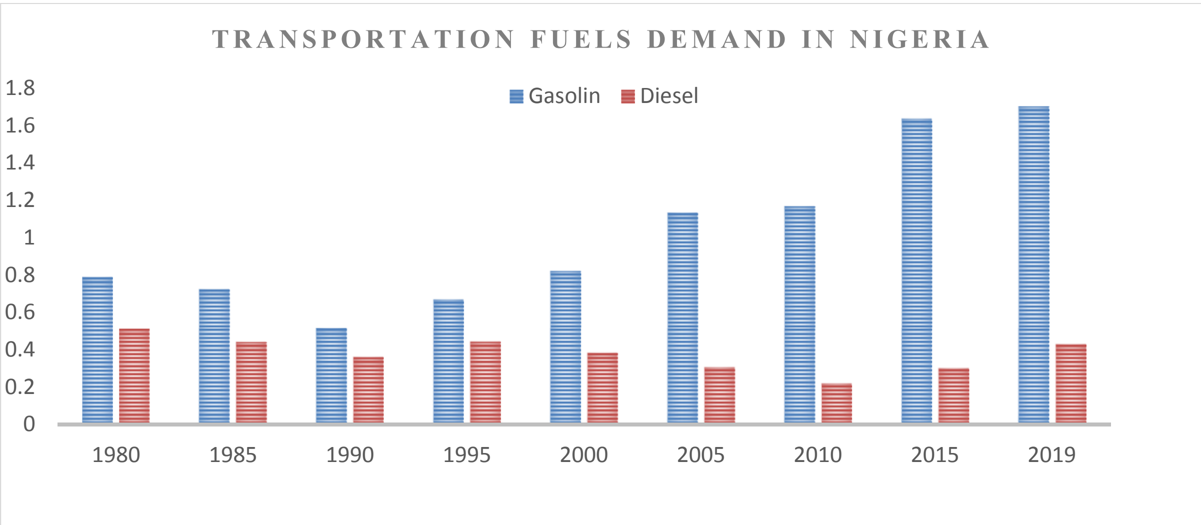

Figure 2. Transportation fuels Demand in Nigeria.
Source: OPEC 2020 Annual Statistical Bulletin (ASB) and National Bureau of Statistics (NBS) 2019

These fluctuations in oil prices and income can be modelled by the NARDL approach to the asymmetric impact of oil prices and income on disaggregated Transportation fuel demand in Nigeria. The aim is to look at the response of consumers to each historic adjustment in the prices of a product. In modelling and estimating the oil demand functions in this study, the estimation period took into cognizance of two broad periods; first is the period from 1980 to 2004, this is the beginning of the study period when prices of oil products were completely under subsidy regime through the period when the Government started subsidies withdrawal. The second period is from

2005 to 2019 is the period when the Government of Nigeria completely withdrew the subsidy on diesel and anticipated the best time for the gasoline subsidy removal.

Nevertheless, income is a stimulating factor that determines the demand for transportation which in turn may lead to demand for transportation fuel, also it is not impossible that all changes in income could immediately lead to an increase in transportation. Most increases in income may lead to an increase in savings and other forms of investment which may not immediately affect the transportation sector. As such, the relationship between income and economic growth indicators may not always be symmetric, there could be a non-linear/asymmetric relationship between income and transportation.

Therefore, the impact of adjustments and fluctuations of real oil prices on demand for oil products can best be estimated through the asymmetric price and income response and Underlying energy demand trend for Nigeria Transportation fuel demand which is the NARDL approach to the asymmetric impact of oil prices and income on disaggregated transportation fuel demand in Nigeria. This method will arguably unravel not only the impact of real prices and incomes, but also unobservable factors such as vehicles fleet, lifestyle, and energy efficiency. Understanding of these factors is very important for policymakers as necessary parameters are needed to evaluate potential impacts of energy pricing policies on energy demand as well as planning the expansion of refineries, removal gasoline subsidy and to guide the energy and environmental policy agenda for the Government of Nigeria.

The oil demand and fuel type in Nigeria consist of petroleum products, electricity and biofuel. In Nigeria, the most prominent fuel type is petroleum products which consist of gasoline (PMS) and diesel (AGO), these are considered as fuels that drive transportation in Nigeria. The transport system consists of land, Air and water transport these three modes of transport convey both passengers and freights. For these modes of transport to be effective there is a need for PMS and AGO. The framework, therefore, expresses the influence of fuel type on the various transport systems which in the long run influences transportation fuel demand in Nigeria. The figure below presents the framework for analysing transportation fuel demand in Nigeria as shows that transportation fuel is driven by fuel type and transport system.

2.1 Asymmetric Response of Changes in Price and Income on Energy: An Overview

A similar progression of taking advantage of greater flexibility over time can be sketched for a price increase in heating oil: turning down the thermostat, buying more sweaters, closing off rooms, putting in temporary insulation, cleaning the furnace, installing permanent insulation, and replacing the furnace. Note that some investments in capital stock are not quickly reversible – consumers do not immediately replace the fuel-efficient automobile or rip out insulation when prices fall. A substantial and long-lived price increase followed by an equal price decrease that returns the price to its original level will not necessarily return consumption to its original level. Consequently, price elasticities are not necessarily symmetric concerning price increases and decreases. Additionally, consumers almost certainly look ahead to anticipate future prices in making decisions concerning changes in their capital goods, though the empirical estimation is almost always based only on current and past prices. It is assumed in the study of (Gately & Huntington, 2002) that a country's per-capita energy and oil demand are determined by changes in income and price. These effects on demand may be asymmetric. That is, the demand reducing the effect of price increases may not necessarily be completely reversed by a comparable reduction in price. Likewise, the demand-increasing effect of an increase in income may not necessarily be completely reversed by a comparable decrease in income.

2.2 The Demand for Energy

Transportation fuels (oil and oil product) is a derived demand, rather than direct demand. These can be constrained to income and prices and other control factors. Because of this, the demand function for a good describes the relationship between the quantities demanded of it and the factors that influence it. That is, individual demand for a commodity depends mostly on the price and income i.e $Q_x = f(P_x, I)$. The demand theory further expresses an inverse relationship between quantity demanded and price and a proportional relationship between quantity demanded and income. Relevance of this theory to this study. The theory discusses demand as determined by price, income and other control factors. In this study, we are looking at demand for fuel by the transport sector in Nigeria which could also be determined by the price of fuel and income of those who demand transportation. Therefore, the demand theory as expressed in (Varian, 1992) best explained the focus of this study.

The theory of consumer behaviour has been formulated entirely in economics in terms of consumer preference. Given this, utility is seen only as a way to describe preference. Economics, gradually came to recognize that all that mattered about utility as far as the choice was concerned was whether one bundle had a higher utility than another. How much higher didn't matter as such. Originally, preference was defined in terms of utility. Saying good x was preferred to y meant that good x has a higher utility than goody. However, the preference of the consumer is the fundamental description useful for analyzing choice, and utility is simply a way of describing preference. It is because of this that a utility function is defined as a way of assigning a number to every possible consumption of goods x and y such that more preferred goods get assigned a larger number than less preferred bundles. It is on this basis that the Cobb-Douglas utility theory was developed to address the relationship between utility and commodities consumed. The Cobb-Douglas utility theory is relevant to this as utility is synonymous to demand. The demand could be related to transportation fuel demand which could be determined by price and income.

3.0 Model specification and Estimation Techniques

This section presents the model employed in the study. It also presents the estimation frameworks technique and description of data employed for the study.

Symmetric Effect of Price Increase on fuel Demand **Asymmetric Response of Price Increase on fuel Demand**

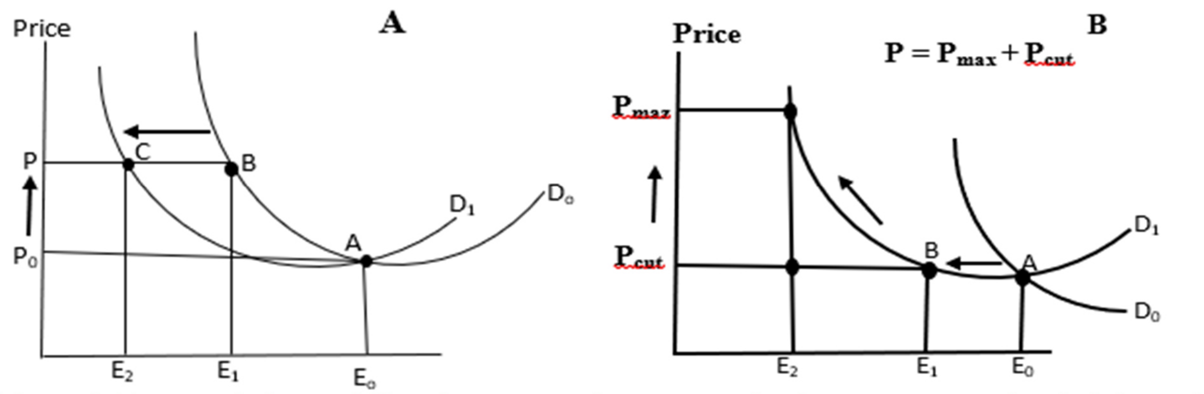

Figure 5. Framework for modelling the asymmetric response of price on transportation fuel demand. Source: Designed by Author (2021)

Figure 5, panel A, presents the restricted simple symmetric modelling of increase in real prices on demand for fuel, increase in price from P_0 to P_1, *ceteris paribus*, will bring about a slight decrease in the demand for petroleum products, from point A to B, this is represented by the short-run price elasticity. Movement from A to B leads to an immediate response to price changes, this sometimes refers to disembodied technical efficiency. In response to an increase in prices, transporters may change their driving habits such as ways of driving vehicles to save fuel, this will not affect the technical characteristics of the vehicles. Hence, it will only lead to a movement along the same demand curve. The fuel demand will decline from E_0 to E_1. However, a sustained and substantial rise in the prices of petroleum products will lead to a historic shift of a demand curve from D_0 to D_1 and a substantial decrease in consumption from E_1 to E_2. Recall in economic theory, a shift in the demand curve is mostly caused by factors such as income other than price. While the movement along the demand curve is caused by a change in price. As such, in panel A, the decline may be as a result of embodied technical progress that brings about the diffusion of new and more energy-efficient vehicles or a change in income. This will be captured by the long-run price elasticity. The implication here is that the figure assumes that both embodied and disembodied technical efficiency is captured by the long-run price and income elasticity of demand.

Panel B presents the modelling of asymmetric response on demand for petroleum products. Panel A did not distinguish the effect of a rise in prices and the fall in prices on fuel demand. Panel B is the most general unrestricted modelling of energy demand, this panel did not only incorporate the effects of the price increase and technical progress (and exogenous factors such as income) on demand for petroleum products but also show the response of demand to a rise or fall in real prices. Some scholars argue that technical efficiency and asymmetric price changes could be either substitutes or complements. However, the beauty of this model is the attempt to separate the response of demand to increase or decrease in prices which cannot be captured in the previous frameworks. Fig B presents the modelling framework for asymmetric price change, from the figure, we ignored price recovery, price in this framework is maximum and minimum prices this is because fluctuation in petroleum prices in Nigeria is not consistent with the happenings at the international markets. Point A is the initial equilibrium price and quantity. A slight price increase will lead to a movement along the same demand curve, the quantity demanded will shift from E_0 to E_1, and the further increase will bring about an additional decrease in demand to point E_2 with a new equilibrium at C. This scenario best explains the case of fuel price in Nigeria where fuel price increase has not been constant but fluctuating. Also, fuel prices in Nigeria are mostly determined by international fuel prices.

Symmetric effect of income changes on fuel Demand **Asymmetric response of income on fuel demand**

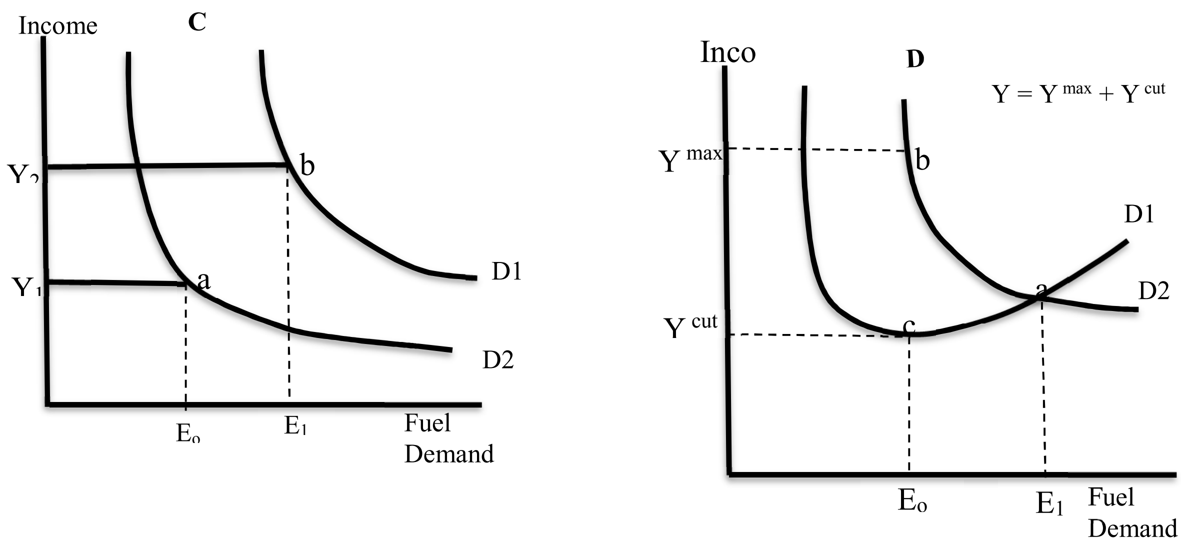

Figure 6. Framework for modelling Income asymmetric on transportation fuel demand.
Source: Designed by Author (2021)

Figure 6 panel C present a simple asymmetric model of change in income on transportation fuel demand. According to the traditional theory of demand, a change in income has a proportional relationship between income and demand on normal goods and an indirect relationship between income and demand on inferior goods. Panel C shows that fuel demand is a normal good as an increase in income leads to a shift in fuel demand from E_0 to E_1 establishing a shift in the demand curve from point A to B. This effect can be considered asymmetric as it shows a one-way effect of change in income on fuel demand.

Panel D presents the framework for modelling the asymmetric response of transportation fuel demand to change in income. Panel C only expressed a one-way relationship where an increase in income will lead to an increase in fuel demand. On the other hand, Panel D shows the response of fuel to a rise and fall in income. Income may not necessarily keep increasing, there could be a wage cut due to economic recession in a country. As such, a fall in income may arise which could lead to a decrease in demand. According to theory, such good could be regarded as a normal good. The beauty of this framework is that it separates the response of fuel demand to either increase or decrease in income which was not captured in Panel C. From Panel D, income in this framework could be maximum or minimum income. This is because cyclical economic characteristics are possible in an emerging economy like Nigeria. Therefore, Part A is the initial equilibrium income and quantity of fuel demanded. A slight increase in income, *ceteris paribus* will lead to an increase in fuel demand. This brings about a shift from E_0 to E_1. Also, a slight decrease in income, *ceteris paribus,* brings about a decrease in demand from point A to C. Therefore, the effect of both positive and negative changes in income may lead to either increase or decrease in fuel demand.

3.1 Model specification:

The model for this study is based on the theoretical disposition that demand is inversely related to price and proportional to income. This yields a demand function of the form:

$$Q_t = f\,(P_t, Y_{et}) \qquad 1$$

Where: Q_t is the quantity demanded, P is price, Y is income, T is time-variant and f is the functional notation
Equation 1 further assumed the presence of a demographic variable, a population which is introduced as a distorted variable that could influence demand in equation 1.

$$Q_t = f\,(P_t, Y_t, D_t) \qquad 2$$

Where D_t population over time.
The model in equation 2 can be modified to capture transportation fuel demand (TFD), price of fuel (PR), income (YC) and population (PO).

$$TFD_t = f\,(PR_t, YC_t, PO_t) \qquad 3$$

The econometric form of equation 3 can be presented thus:

$$TFD_t = a_0 - a_1PR_t + a_2YC_t + a_3PO_t + \mu_t \qquad 4$$

Where a_1, a_2, and a_3 are the coefficient of the variables and μ_t is the error term.
In equation 4, the μ_t assumed the absence of serial correlation, heteroscedasticity and error term is normally distributed.

According to (Promise, Isa, Ojosu, & Olayande, 2015), (Bhattacharyya & Timilsina, 2009), in their framework for analyzing transportation fuel demand, transportation is divided into passenger transport and freight transport. Passenger transport demand uses more gasoline fuel and freight transport uses more diesel. As such, this study disaggregated transportation fuel demand into Gasoline fuel demand and diesel fuel demand.

$GA_t = \alpha_0 - \alpha_1 PRG_t + \alpha_2 YC_t + \alpha_3 PO_t + \mu_t$ 5

$DE_t = \beta_0 - \beta_1 PRD_t + \beta_2 YC_t + \beta_3 PO_t + \mu_t$ 6

Where in Equations 5 and 6, GA_t and DE_t are Gasoline and Diesel fuel demand over time, α_1, α_2 and α_3 are parameters of the GA demand model. β_1, β_2 and β_3 are parameters of the DE demand model. Other variables were as earlier defined.

3.2 Estimation Technique

The estimation technique was adopted from the work of Joshua (2019) who employed Nonlinear Autoregressive Distributed Lad (NARDL) technique to examine the short-run and long-run asymmetric effects of oil price and income dynamics on sectoral output in Nigeria. The NARDL model is an extension of the ARDL model developed by (Pesaran, Shin, & Smith, 2001) which was developed by Shin et al. (2014).

The choice of this framework is predicated on the fact that it yields valid results in as much as none of the variables is integrated at order two, [I (2)]; it has an inherent technique (Bounds test) which checks for long-run cointegration among variables; it has the ability to incorporate the lags of both the dependent and independent variables in the same equation; and it allows for positive and negative partial sum decompositions of the explanatory variable. Furthermore, the NARDL framework is adopted in this study with the belief that positive and negative changes in oil price and income may have different impact on transportation fuel demand in Nigeria. In the work (Moshiri & Banijasham, 2012), they alluded that while oil price increase may promote economic growth by making financial resources needed for investment available, they may also inhibit economic growth through poor policy-making, rent-seeking and currency appreciation. In addition, to prevent spurious regression, this study will adopt the Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) unit root tests and the Bounds test for cointegration. The Wald test would be conducted to investigate the existence of asymmetry in oil price, income and transportation fuel demand. Furthermore, the estimated models will also be subjected to post-estimation test to ensure that they conform to the assumptions of the Classical Linear Regression Model (CLRM). Specifically, this study will run the normality, serial correlation, heteroscedasticity as well as correct specification tests. As stated in equation 3, the empirical model in its general form can be specified as follows:

$TFD_t = f\,(PRf_t, YC_t, PO_t)$ 7

The model in equations 4, 5 and 6 was specified in the asymmetric form:

$$TFD_t = \alpha_0 - \alpha_1^+ PRF_t^+ - \alpha_2^- PRF_t^- + \alpha_3^+ YC_t^+ + \alpha_4^- YC_t^- + \alpha_5 PO_t + \varepsilon_t \qquad 8$$

Where TFD_t is transportation fuel demand over time, PRF is the price of fuel, YC is income and PO is population respectively. The asymmetric form of equations 5 and 6 as.

$$GA_t = \alpha_0 - \alpha_1^+ PRG_t^+ - \alpha_2^- PRG_t^- + \alpha_3^+ YC_t^+ + \alpha_4^- YC_t^- + \alpha_5 PO_t + \varepsilon_t \qquad 9$$

$$DE_t = \beta_0 - \beta_1^+ PRD_t^+ - \beta_2^- PRD_t^- + \beta_3^+ YC_t^+ + \beta_4^- YC_t^- + \beta_5 PO_t + \varepsilon_t \qquad 10$$

Where in eqn 9, GA is gasoline fuel demand by passenger transport over time, PRG is the price of gasoline, YC is income proxied by GDP and PO is population. In eqn 10, DE is diesel fuel demand by freight transport over time, PRD is the price of diesel over time. YC and PO were as defined in eqn.

Taking the natural log of equations 11 and 12.

$$\ln GA_t = \alpha_0 + \alpha_1^+ \ln PRG_t^+ - \alpha_2^- \ln PRG_t^- - \alpha_3^+ \ln YC_t^+ + \alpha_4^- \ln YC_t^- + \alpha_5 \ln PO_t + \varepsilon_t \qquad 11$$

$$\ln DE_t = \beta_0 + \beta_1^+ \ln PRD_t^+ - \beta_2^- \ln PRD_t^- - \beta_3^+ \ln YC_t^+ + \beta_4^- \ln YC_t^- + \beta_5 \ln PO_t + \varepsilon_t \qquad 12$$

Equation 11 and 12 shows that the oil price and income have been decomposed into $\alpha_1^+ \ln PRG_t^+, \alpha_2^- \ln PRG_t^-, \alpha_3^+ \ln YC_t^+ and \alpha_4^- \ln YC_t^-$ in equation 11 and $\beta_1^+ \ln PRD_t^+, \beta_2^- \ln PRD_t^-, \beta_3^+ \ln YC_t^+ and \beta_4^- \ln YC_t^-$ denote positive and negative changes in oil price and income in equation 12, respectively. $\ln PO_t$ is a distorted variable that represents the population. This may have an impact on transportation fuel demand as an increase in population is expected to increase the movement of people which can be facilitated by transportation.

And the NARDL version of the asymmetric effect of oil price and income dynamics on transportation fuel demand disaggregated into Gasoline and Diesel demand is expressed following Shin et al (2014) as follow:

$$\Delta \ln GA_t = \alpha_0 + \alpha_1 \ln GA_{t-1} - \alpha_2^+ \ln PRG_{t-1}^+ - \alpha_3^- \ln PRG_{t-1}^- + \alpha_4^+ \ln YC_{t-1}^+ + \alpha_5^- \ln YC_{t-1}^- + \alpha_6 \ln PO_{t-1} + \sum_{i=1}^{p-1} \phi \Delta \ln GA_{t-1}$$

$$-\sum_{j=0}^{q-1}\phi^{+}\Delta\ln PRG_{t-1}^{+}+\sum_{j=0}^{q_2-1}\phi_j^{-}\Delta\ln PRG_{t-1}^{-}+\sum_{j=0}^{q_3-1}\phi^{+}{}_j\Delta\ln YC_{t-1}^{+}+\sum_{j=0}^{q_4-1}\phi^{-}{}_j\Delta\ln YC_{t-1}^{-}+\sum_{j=0}^{q_5-1}\phi_j\Delta\ln PO_{t-1}+\varepsilon_t \quad 13$$

$$\Delta\ln DE_t=\alpha_0+\alpha_1\ln GA_{t-1}-\alpha_2^{+}\ln PRD_{t-1}^{+}-\alpha_3^{-}\ln PRD_{t-1}^{-}+\alpha_4^{+}\ln YC_{t-1}^{+}+\alpha_5^{-}\ln YC_{t-1}^{-}+\alpha_6\ln PO_{t-1}+\sum_{i=1}^{p-1}\phi\Delta\ln DE_{t-1}$$

$$-\sum_{j=0}^{q-1}\phi^{+}\Delta\ln PRD_{t-1}^{+}-\sum_{j=0}^{q_2-1}\phi_j^{-}\Delta\ln PRD_{t-1}^{-}+\sum_{j=0}^{q_3-1}\phi^{+}{}_j\Delta\ln YC_{t-1}^{+}+\sum_{j=0}^{q_4-1}\phi^{-}{}_j\Delta\ln YC_{t-1}^{-}+\sum_{j=0}^{q_5-1}\phi_j\Delta\ln PO_{t-1}+\varepsilon_t \quad 14$$

Equations 13 and 14 are an extension of 11 and 12. Equations 13 and 16 can be re-parameterized to include an unrestricted error correction term.

$$\Delta\ln GA_t=\gamma\varepsilon_{t-1}+\sum_{i=1}^{p-1}\phi\Delta\ln DE_{t-1}-\sum_{j=0}^{q-1}\phi^{+}\Delta\ln PRG_{t-1}^{+}-\sum_{j=0}^{q_2-1}\phi_j^{-}\Delta\ln PRG_{t-1}^{-}+\sum_{j=0}^{q_3-1}\phi^{+}{}_j\Delta\ln YC_{t-1}^{+}+\sum_{j=0}^{q_4-1}\phi^{-}{}_j\Delta\ln YC_{t-1}^{-}+\sum_{j=0}^{q_5-1}\phi_j\Delta\ln PO_{t-1}+\varepsilon_t$$

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$$\Delta\ln DE_t=\partial\varepsilon_{t-1}+\sum_{i=1}^{p-1}\phi\Delta\ln DE_{t-1}-\sum_{j=0}^{q-1}\phi^{+}\Delta\ln PRD_{t-1}^{+}-\sum_{j=0}^{q_2-1}\phi_j^{-}\Delta\ln PRD_{t-1}^{-}+\sum_{j=0}^{q_3-1}\phi^{+}{}_j\Delta\ln YC_{t-1}^{+}+\sum_{j=0}^{q_4-1}\phi^{-}{}_j\Delta\ln YC_{t-1}^{-}+\sum_{j=0}^{q_5-1}\phi_j\Delta\ln PO_{t-1}+\varepsilon_t$$

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Where: γ is the coefficient of the error correction term ε_{t-1} in equation 15 and ∂ is the coefficient of the error correction term ε_{t-1} in equation 16. Equations 15 and 16 are the model to be estimated. The models express the asymmetric impact of oil price and income on gasoline and diesel demand in the transport sector.

3.3 Data Sources and Description:

The annual time series data used in this study consist of data for gasoline and diesel for Nigeria over the period from 1980 to 2019. The products consumption in millions of barrels of oil (bbl) divided by the population to give per capita series comes from the databank of the Organization of Petroleum Exporting Countries (OPEC). The real gross domestic products are in 1980 constant prices in Naira divided by the annual population to give per capita income are sourced from the databank of the Central Bank of Nigeria and National Bureau of Statistic (NBS) 2019. The nominal prices of each product deflated by the consumer price index and index to (1980=100) are sourced from OPEC databank 2019.

4 Preliminary Analysis of Result and Discussion of Finding

The preliminary analysis of the data used, NARDL estimations of result using Eviews 10 and the effects of the UEDT in transportation fuel demand results was also presented. Thus, pre-estimation analyses, such as descriptive statistics, unit root test and cointegration test, are run to determine the appropriate statistical technique for estimation as well as knowing the properties of each variable to avoid preventing spurious regression. Table 1 presents the summary of descriptive statistics of the variables employed in the gasoline and diesel demand model. Descriptive statistics provides the characteristics of the sample data. That is, it gives a true picture of the expected estimated result. The result shows the average gasoline demand, gasoline price and income are 0.064, 4.736 and 12.369, respectively. While the average diesel demand, price of diesel and population are given as 1.009, 5.140 and 4.852, respectively. It is also apparent that the average value of the population is 4.864. This means that the expected estimate of the coefficient of our variables falls within the range of the means. Furthermore, a cursory look shows that all the variables are normally distributed as revealed by the probability values of their respective Jarque-Bera statistic. The value of skewness shows that all the variables are statistically significant. That is, they are not statistically different from zero. In addition, the standard deviation is low for all variables.

Table 1. Descriptive Statistics of variables in Gasoline and Diesel Demand Model

Column1	LNGA	LNPRG	LNYC	LNPO	LNDE	LNPRD
Mean	0.064	4.736	12.369	4.852	1.009	5.140
Median	0.132	4.859	12.180	4.846	0.958	5.372
Maximum	0.608	5.486	12.848	5.339	0.357	6.251
Minimum	0.662	3.603	11.975	4.391	1.733	3.842
Std. Dev.	0.331	0.492	0.311	0.280	0.332	0.813
Skewness	0.498	0.577	0.354	0.065	0.298	0.257
Kurtosis	2.128	2.547	1.434	1.844	2.785	1.631
Jarque-Bera	2.920	2.558	4.426	2.256	0.670	3.565
Probability	0.232	0.278	0.085	0.324	0.715	0.168
Sum	2.558	189.424	494.748	194.099	40.359	205.604
Sum Sq. Dev.	4.280	9.449	3.771	3.063	4.293	25.806
Observations	40	40	40	40	40	40

Source: Authors Computation Year 2021 Using Eviews 10 output.

Customarily, when a time-series analysis is to be carried out, it is expedient to carry out a unit root test to check the time-series properties of the variables to be estimated to guard against spurious regression. For this study, the Augmented Dickey-Fuller (ADF) unit root test approach is employed to examine the order of integration of each variable. To adjudge any variable stationery, its probability value must be less than 5 per cent (0.05) or its ADF test statistic must be greater than the test critical values in absolute terms at all levels of significance.

Table 2. Unit Root Test for variables in Gasoline fuel demand Model

Augmented Dickey-Fuller (ADF) Test							
VARIABLE	**At Level**	**Critical Values**	**Prob**	**At First Diff**	**Critical Value**	**Prob**	**Remarks**
LnGA	-0.448	-2.939	0.891	-6.322	-2.943	0.000	I(1)
lnPRG	-1.715	-2.939	0.416	-6.274	-2.943	0.000	I(1)
LnYC	-0.769	-2.941	0.816	-7.905	-2.943	0.000	I(1)
PO	-3.906	-2.941	0.001	-1.952	-2.941	0.306	I(0)

Source: Authors Computation Year 2021 Using Eviews 10 output.

Table 3. Unit Root Test for variables in Diesel fuel demand Model

Augmented Dickey-Fuller (ADF) Test							
VARIABLE	**At Level**	**Critical Values**	**Prob**	**At First Diff**	**Critical Value**	**Prob**	**Remarks**
LnDE	-1.615	-2.939	0.466	-5.96	-2.941	0.000	I(1)
lnPRD	-1.078	-2.939	0.715	-5.843	-2.943	0.000	I(1)
LnYC	-0.769	-2.941	0.816	-7.905	-2.943	0.000	I(1)
PO	-3.906	-2.941	0.001	-1.952	-2.941	0.306	I(0)

Source: Authors Computation Year 2021 Using Eviews 10 output.

Tables 2 and 3 presents the result of the stationarity test of the gasoline and Diesel model. The results of the ADF unit root test for both models show that log of gasoline fuel, price of gasoline and income are stationary at first difference. While the log of the population is stationary at level. Similarly, log of Diesel fuel, price of diesel and income are stationary at first difference. While the log of the population is stationary at level. These results show that none of the variables is stationary at the second difference, I(2), thus giving credence to the use of the NARDL framework developed by Shin et al. (2014). Accordingly, this study proceeds to investigate the long-run relationship among the variables using the Bounds test cointegration approach.

Table 4. Results of Bounds Test for Cointegration

Sign. Level	**Critical Value**		**Gasoline Model**	**Diesel Model**
	Lower (I_0) Bounds Test	**Upper (I_1) Bounds Test**	**Computed F-Statistics**	**Computed F-Statistics**
1%	3.657	5.256	9.71	6.562
5%	2.734	3.92	K = 5	K = 5
10%	2.306	3.353	n = 37	n = 37

Source: Authors Computation Year 2021 Using Eviews 10 output.

Following the results of unit root tests presented in Table 2 and 3 which shows that all the variables are either stationary at level or first difference, the Bounds test approach to cointegration is done. It tests the null hypothesis of no cointegration among the variables with the decision rule that the null hypothesis should be rejected if the value of the computed F-statistic exceeds the upper bound critical value, accepted if it falls below the lower bound critical value and adjudged inconclusive should it falls between the lower and upper bound critical value. Accordingly, Table 4 shows the rejection of the null hypothesis and accept the existence of a long-run relationship among variables in the gasoline and diesel model. This is because the computed F-statistic of 9.710 and 6.562 exceed the upper bound at a 5 per cent level of significance. Given the results of the Bound test, the short-run and long-run NARDL models are estimated.

4.1 Presentation and interpretation of the NARDL Estimated Models

Table 5. NARDL Lag length selection

Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	262.2253	NA	6.92e-12	-14.34585	-14.1699	-14.28444
1	294.9170	56.30235*	2.76e-12*	-15.27317*	-14.39343*	-14.96612*
2	308.8920	20.96260	3.20e-12	-15.16067	-13.57715	-14.60798
3	316.0333	9.124874	5.74e-12	-14.66851	-12.38121	-13.87018

Source: Authors Computation Year 2021 Using Eviews 10 output.

Table 5 shows the lag length selection criteria for estimating the NARDL model. All the criteria selected a 1 period lag for estimation.

The results of the estimated NARDL model for gasoline and diesel fuel demand by the transportation sector are presented in table 6 to table 9. Table 6 and Table 7 present the short-run and long-run NARDL results of the gasoline fuel demand model and table 8 and table 9 present the short-run and long-run NARDL results of the diesel fuel demand model.

Table 6. Gasoline Fuel Model:
NARDL Short-Run Asymmetric Model, Dependent Variable: (DLNGA)

ARDL Error Correction Regression				
Dependent Variable: D(DLNGA)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DLNPRG_POS)	-0.120801	0.046618	-2.591295	0.0111
D(DLNPRG_NEG)	-0.235151	0.089123	-2.638508	0.0141
D(DLNYC_POS)	0.603605	0.214222	2.817661	0.0099
D(DLNYC_NEG)	0.769688	0.226631	3.396217	0.0034
D(LNPO)	0.580802	1.190555	3.047949	0.0055
CointEq(-1)*	-1.251513	0.153545	-8.150766	0.0000
R-squared	0.746299		Adjusted R-squared	0.70538

Source: Authors Computation Year 2021 Using Eviews 10 output.

The result of the gasoline fuel demand in table 6 depicts that the coefficient of the error correction term follows a priori expectation in that the estimated coefficient is less than one, negative and statistically significant at a 5 per cent significance level. This implies that the speed of adjustment of the gasoline demand model from short-run shock to their long-run equilibrium is perfect and fast as approximately 100 per cent of the shock to their determinants in the previous period is accounted for in the present period. The result also shows that positive gasoline price change hurts gasoline fuel demand by the transport sector. Specifically, an increase in gasoline price by 1 per cent will, on average lead to about a 0.12 per cent decrease in gasoline fuel demand. In other words, the price elasticity of demand for gasoline fuel is about 0.12 meaning it is price inelastic demand. The result is in line with the finding of (Sa'ad, 2008) and (Alves & Bueno, 2003). This implies that passenger transportation that uses more gasoline may be discouraging to demand more fuel due to an increase in fuel price. The implication is, the burden of higher fuel prices will be transferred to commuters in the form of higher transport fares.

On the other hand, a negative change in gasoline price has a significant and inverse relationship with gasoline demand. Approximately, the result shows that a 1 per cent decrease in gasoline price will, on average lead to about a 0.24 per cent increase in gasoline demand by passenger transportation in Nigeria. That is the price elasticity of demand for a negative price change is 0.24. Meaning, the degree of response of gasoline fuel demand to passenger transportation is more in negative price changes than positive price changes. However, the result is inconsonant with the traditional law of demand and with the asymmetric relationship.

Similarly, the estimated NARDL short-run gasoline fuel demand model shows that positive change has a positive and significant effect on gasoline fuel demand. Specifically, a 1 per cent increase in income will, on average lead to about a 0.60 per cent increase in gasoline fuel demand. Meaning, the income elasticity of demand for gasoline fuel is 0.60. This is positive and further reveal the degree of response of change in gasoline demand due to a 1 per cent increase in income. The estimated short-run result further revealed that a negative change in income leads to a decrease in gasoline demand by passenger transportation. That is, 1 decrease in income will, on average lead to about 0.77 per cent decrease in gasoline fuel demand by passenger transportation. That is the income elasticity of demand for gasoline fuel is 0.77. The result shows that the degree of response of gasoline fuel demand by passenger transportation is more in negative income changes than positive price changes (Sa'ad & Shahba, Accounting for Asymmetric Price Response and Underline Energy Demand Trends in Transportation fuel Demand for Nigeria: Using ARDL, 2018). However, the result is inconsonant with the traditional law of demand and with an asymmetric relationship where there could be both positive and negative effects of income changes on gasoline fuel demand. This result is in line with the findings of Sa'ad (2018).

The estimated coefficient of the distorted variable (population) in the model is significant and shows that a population change will bring about an increase in transportation fuel demand in the short run. Approximately, 1 per cent increase in population will, on average lead to about a 0.58 per cent increase in gasoline fuel demand. This result is in line with a priori expectation and the result confirmed that population has a strong influence on passenger fuel demand in Nigeria.

The NARDL long-run gasoline fuel demand model in table 7 further revealed that a positive change in the price of gasoline will lead to a decrease in gasoline fuel demand. A 1 per cent increase in gasoline price will, on average lead to about a 0.12 per cent decrease in gasoline fuel demand. Meaning the price elasticity of gasoline fuel demand, in the long run, is 0.12. A negative change in the price of gasoline, on average, brings about a 0.11 per cent increase in gasoline fuel demand. It is indicative that the degree of responsiveness of gasoline fuel demand to changes in gasoline price is higher in the positive change in price than the negative price change. The long-run result is in line with the theory of demand and the asymmetric relationship between gasoline fuel demand and gasoline price. Similarly, the long-run NARDL gasoline fuel demand model revealed that a positive change in income leads to an increase in gasoline fuel demand. 1 per cent increase in income will, on average lead to about a 0.47 per cent increase in gasoline fuel demand. Also, a negative change in income brings about a decrease in gasoline fuel demand. This is a case of a proportional relationship. 1 per cent decrease in income in the long-run will, on average brings about a 0.11 per cent decrease in gasoline fuel demand.

This result is in line with the theory of demand and income elasticity shows the case of normal goods. However, the degree of responsiveness of change in gasoline demand to a positive or negative change in income is higher in positive change than the negative change. This result is also in line with the study of Sa'ad (2018) who posited that both diesel and gasoline are responsive to changes in income.

Finally, the estimated coefficient of the distorted variable, population introduced into the gasoline fuel demand model is not significant and did not conform to a priori expectation. Though significant, a 1 per cent increase in population, on average, leads to about a 0.49 per cent decrease in gasoline fuel demand in the long run. Possibly, in the long run, the increasing population may decide to demand gasoline to power their private cars than patronizing public transportation. These possibilities in the long-run demand may not have been captured in the transportation fuel data in Nigeria. This may in the long run affect the expected outcome of the result

Table 7. Gasoline Fuel Model:
NARDL Long-Run Asymmetric Model, Dependent Variable: (DLNGA)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNPRG_POS	-0.123	0.060	-2.039	0.051
DLNPRG_NEG	-0.106	0.042	-2.521	0.033
DLNYC_POS	0.471	0.231	2.036	0.047
DLNYC_NEG	0.108	0.608	2.133	0.060
DLNPO	-0.493	0.147	-3.346	0.001
C	0.003	0.347	0.009	0.993

Source: Authors Computation Year 2021 Using Eviews 10 output.

Table 8 present the short-run NARDL diesel demand model. The diesel fuel demand model explains the freight transportation fuel demand. The result shows that an insignificant and positive change in the price of diesel brings about a decrease in diesel fuel demand as the sign of the estimated coefficient is negative. Specifically, a positive change in the price of diesel by 1 per cent will, on average lead to about a 0.15 per cent decrease in the demand for diesel fuel by freight transportation in Nigeria. A negative change in the price of diesel will lead to a significant increase in the demand for diesel by freight transportation. That is, a 1 per cent decrease in the price of diesel will, on average lead to about a 0.15 per cent increase in diesel demand by freight transportation. This result shows that the degree of responsiveness of diesel fuel demand to a positive and negative change in diesel price is more on the negative change that the positive change. The result also shows that a change in diesel demand to a positive change in income is significant and will lead to an increase in the demand for diesel fuel. Approximately, 1 per cent change in income will, on average lead to about a 0.29 per cent increase in diesel demand by freight transportation. Similarly, a 1 per cent negative change in income will, on average lead to about a 0.18 per cent decrease in diesel fuel demand. The positive change in income is in line with a priori expectation. While the negative change in income failed the a priori test and the result is not significant. By implication, the degree of response of change in diesel fuel demand to a positive change in income is 0.29 per cent and significant. The short-run NARDL diesel fuel demand model further revealed that the estimated coefficient of the population is insignificant and failed the a priori test.

Table 8. Diesel Fuel Model: NARDL Short-Run Asymmetric Model

NARDL Error Correction Regression				
Dependent Variable: D(DLNDE)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DLNPRD_POS)	-0.150	0.088	-1.700	0.102
D(DLNPRD_NEG)	0.198	0.084	2.367	0.026
D(DLNYC_POS)	0.293	0.115	2.549	0.017
D(DLNYC_NEG)	-0.181	0.115	-1.571	0.129
D(DLNPO)	-16.744	21.574	-0.776	0.445
CointEq(-1)*	-1.250	0.166	-7.547	0.000
R-squared	0.699	Adjusted R-squared		0.650

Source: Authors Computation Using Eviews 10.

Table 9 presents the result of the NARDL long-run asymmetric model. The result revealed that a positive change in the price of diesel, in the long run, will, on average lead to about a 0.21 per cent decrease in diesel fuel demand by freight transportation. In contrast to positive change, a 1 per cent negative in the price of diesel will, on average lead to about a 0.54 per cent increase in diesel fuel demand by freight transportation. Both positive and negative change in the price of diesel is significant and passed the a priori t est. However, the degree of response of change in diesel fuel demand to change in price is more on negative change in price than a positive change in price in the long run. By implication, a reduction in the price of gasoline is favourable in encouraging freight transportation in the demand for diesel in Nigeria.

The result also revealed that the estimated coefficient of income shows that, a positive change in income is significant and a 1 per cent change will, on average lead to about a 40 per cent increase in diesel fuel demand. Inversely, a 1 per cent negative change in income is not significant and will, on average lead to about a 0.07 per cent decrease in diesel fuel demand by freight transportation. Both positive and negative effects of change in income on diesel demand passed the a priori test in the long run. Nevertheless, the degree of response of change in demand for diesel fuel to change in income is more on the positive change in income than the negative change in income. This results in the resolves of Alves and Bueno (2003) who reported a strong income elasticity of demand for gasoline in Brazil. By implication, freight transportation is more susceptible to positive change than a negative change in income in the long run. The estimated coefficient of the population, in the long run, is not significant and a 1 per cent change in population will, on average lead to about a 0.47 per cent increase in diesel fuel demand by freight transportation in Nigeria. This further implies that; freight transportation fuel demand responds more to population growth in the long run than in the short run. By implication, the population has more influence on passenger fuel demand than freight fuel demand in Nigeria.

Table 9. Diesel Fuel Model: NARDL Long-Run Asymmetric Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNPRD_POS	-0.205711	0.099723	-2.062824	0.0117
DLNPRD_NEG	-0.548967	0.141597	-3.876968	0.0014
DLNYC_POS	0.399261	0.176116	2.267034	0.0017
DLNYC_NEG	0.070794	0.159959	0.442577	0.6619
DLNPO	0.468860	0.265560	1.765552	0.0699
C	-0.333265	0.541844	-0.615057	0.5441

Source: Authors Computation Using Eviews 10.

In bringing to bear one of the innovations (test for the asymmetric effect of oil price on transportation fuel demand) of this study, Table 10 presents the results of the tests for short-run and long-run asymmetry in oil prices, income and transportation fuel demand. The wald test is divided into the existence of asymmetry between gasoline price and income and gasoline fuel demand and diesel price and income and diesel fuel demand. The null hypothesis of no short-run and long-run asymmetry will be rejected for both transportation fuel demand if the probability value of F-statistics is greater than 5 per cent (0.05). Otherwise, we conclude on the existence of the symmetric relationship.

Table 10. Short-run and Long-run Wald Test for Asymmetric Relationship Gasoline and Diesel fuel demand Model

GASOLINE FUEL DEMAND				
	Short-Run		Long-Run	
Variables	Value F-Statistics	Prob.	Value F-Statistics	Prob.
GA and PRG	2.021	0.147	5.527	0.296
GA and YC	2.038	0.145	2.936	0.104
DIESEL FUEL DEMAND				
DE and PRD	1.518	0.238	1.740	0.190
DE and YC	0.838	0.444	1.668	0.136

Source: Authors Computation Using Eviews 10.

Table 10 presents the Wald test for both short-run and long-run asymmetric relationships in both the gasoline and diesel fuel demand model. The probability values for both the short-run and long-run gasoline and diesel fuel demand model are greater than 0.05. We, therefore, reject the null hypothesis and conclude the existence of an asymmetric relationship between price, income and transportation fuel demand. This implies that positive and negative oil price and income changes have asymmetric effects on transportation fuel disaggregated into gasoline and diesel fuel demand in Nigeria. This result supports the empirical findings of (Malik, 2010) and (Nusair, 2016) who found that the relationship between an oil price change and output is non-linear. Similarly, the Wald test result is in line with Joshua who showed that oil price has asymmetric effects on the performance of oil and none oil sector in Nigeria (Joshua, 2019).

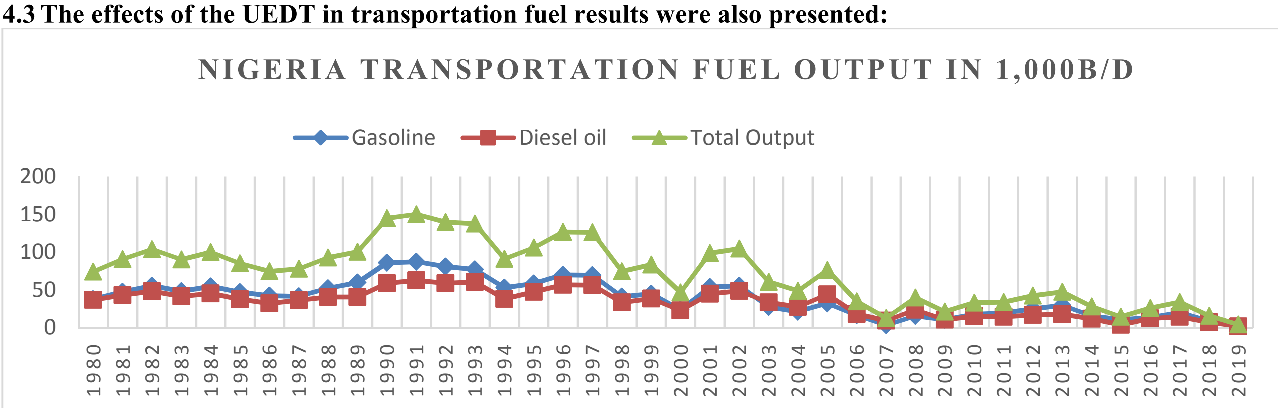
Worthy of note is the results of the post-estimation test which was carried out to check whether the gasoline and diesel models conform to the assumptions of the Classical Linear Regression Models (CLRM). Specifically, this study tests if the models are correctly specified and if error terms are normally distributed, homoscedastic and do not suffer from serial correlation. The results show that gasoline and diesel fuel models pass all the tests thus making their results acceptable and eligible for policy prescriptions. Specifically, the results show the models are correctly specified and their errors are normally distributed as well as the absence of serial correlation and heteroscedasticity. This is shown from the probability values of the Breusch-Godfrey Serial Correlation LM Test, Jarque-Bera Normality test and Breusch-Pagan-Godfrey: Heteroskedasticity Test. The probability values are greater than 5 per cent as shown in table 11 below.

Table 11. Residual Diagnostic Test for Gasoline and Diesel fuel Demand Model

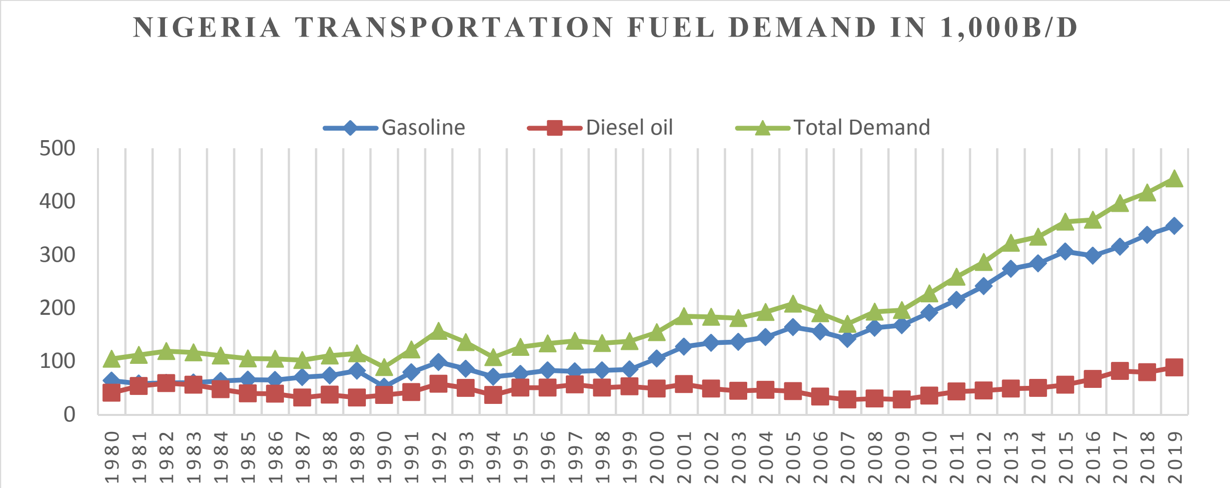
	F-Statistics	Prob.
Breusch-Godfrey Serial Correlation LM Test		
Gasoline Demand Model	2.297	0.123
Diesel Demand Model	0.449	0.644
Jarque-Bera Normality Test		
Gasoline Demand Model	0.499	0.773
Diesel Demand Model	1.078	0.584
Breusch-Pagan-Godfrey: Heteroskedasticity Test		
Gasoline Demand Model	0.802	0.516
Diesel Demand Model	0.864	0.584

Source: Authors Computation Using Eviews 10.

4.3 The effects of the UEDT in transportation fuel results were also presented:



Source: OPEC 2020 Annual Statistical Bulletin (ASB) and National Bureau of Statistics (NBS) 2019.
Figure 7. Nigeria Transportation fuel Output in 1,000B/D Based on NNPC production output.



Source: OPEC 2020 Annual Statistical Bulletin (ASB) and National Bureau of Statistics (NBS) 2019
Figure 8. Nigeria Transportation fuel Demand in 1,000B/D output.

Figures 7 and 8 above show the Nigerian transportation fuel output and demand for the estimated UEDT.

Focusing on the shape of the estimated c for gasoline demand, the percentage annual growth of the UEDT for all specifications are a positive increase in the demand while the output is seriously negative decline led to an imbalance in the demand and supply of the oil product, the shapes of the UEDT for all the specifications are generally positive and upward with some few periods of downwards trends. Figures 7 and 8 show negative downwards and positive upwards trends of the period, with some insignificant fluctuations until 2019. This suggests that the non-technical progress exogenous factors such as unprecedented rise in vehicle stocks, due to the demand for personal mobility, accompanied by traffic congestions in big cities tend to outweigh the positive effects of price deregulation in the oil sector (Saad, S and S I Isa, 2013).

It is important to note that, since the beginning of the Structural Adjustment Period in 1986. When the Nigerian currency was devalued and trade liberalization policies were introduced, all the four vehicle assembly plants closed down, hence people had to rely on imported used vehicles from Europe and America (these used vehicles are sometimes withdrawn from markets due to their low energy efficiency). Currently, over 60% of the vehicles in Nigeria are made up those imported used vehicles.

Another factor that is likely to influence the trend of the UEDT in Nigerian gasoline demand is the issue of smuggling, although Nigeria over the years has been increasing the prices of oil products, however, it has been suggested that other neighbouring countries of Nigeria such as the Benin Republic and Chad in one way or the other heavily depend on smuggled products from Nigeria to meet some part of their local needs, it has been suggested that about 30 per cent of petroleum products in Nigeria find their ways into its neighbouring countries. Indeed, fuel tourism is among the most lucrative and flourishing businesses that are thriving in all the border regions of Nigeria. Hence, it becomes almost impossible to discount the amount of smuggled gasoline from total data of oil consumption, hence the UEDT captures both the two effects.

Figure 8 above shows the shapes of UEDT for diesel demand, Presents the UEDT for diesel demand the UEDT has exhibited an irregular pattern, a positive trend from 1980 to 85, suggesting a boost in construction activities as well industrial demand during that period. However, the UEDT fall sharply until 1990, then the underlying maintains a positive trend until 2000, when it reached a peak, fell sharply due to scarcity which led to adulteration of kerosene to the substitution of kerosene for diesel. However, the UEDT resumes its growth pattern until the end of the estimation period, this is largely due to a dearth in electricity supply that necessities manufacturers and households to own generator sets for their electricity needs.

Although the price of diesel was partially deregulated in 2009, as part of the Programme for deregulation of the oil sector, there is always not enough diesel for domestic consumption. The deregulation of the diesel prices reduced the rate of its smuggling out of the country but encourage adulteration of other products to substitute them for diesel.

4.4 Comparing the Results for Gasoline and Diesel Estimates with Previous Studies:

The estimated elasticities for this study for both gasoline and diesel are slightly different from the previous studies on Nigeria, however, the only paper that used structural time series is A. B Abdullahi (2014), the slope of an underlying stochastic trend for both gasoline and diesel are similar to this study. The estimated long-run price and income elasticities from this study are smaller than the results reported by Akin Iwayemi et al (2010) as well as Sa'ad, S and Salamatu I Isah (2016). However, the long-run price and income elasticities are close to the estimated elasticities by A. B Abdullahi (2014). The possible reasons why the estimated income and price elasticities from this study are slightly smaller than the previous studies on Nigeria is that, apart from separating the effects of technical progress and non-technical progress exogenous factors from the long-run elasticities, which will reduce the sizes of long-run income and price elasticities, secondly, for more than one decade Nigeria has been undergoing economic hardship, which significantly reduces citizen's disposable income. The devaluation of Naira also reduces the purchasing power of the people in Nigeria, furthermore, the industrial sector (a major consumer of diesel) has been operating below 50% capacity over ten years. This affected the demand for diesel. the combination of these three factors affected the demand for petroleum products in Nigeria during the last decade.

5. Conclusion

The novel NARDL framework was used to analyze the asymmetric effect of gasoline oil price and diesel price on gasoline and diesel fuel demand in Nigeria. In both models, distorted variable, the population was introduced to measure the impact of increasing population on transportation fuel demand. Thus, findings from the study show that the demand for gasoline and diesel are inelastic both in the short and long run. This can be attributable to the UEDT from the long-run elasticities and the decline in industrial activities and purchasing power of the consumer. Although both price and income elasticities are statistically significant with correct expected signs, however, their magnitudes are small signifying that there are some other factors apart from prices and real incomes that affects the demand for such products in Nigeria.

By implication, though Nigeria has completely deregulated domestic diesel prices, and real incomes that are not only determinants of the demand for oil in the country. As a matter of necessity Nigeria may consider the introduction of additional taxes to generate more income and reduce Smuggling and adulteration of products, this policy has to be done with caution considering the general decline in the purchasing power of the people and the likely multiplier effects of such policy of introducing more taxes. Hence some safety nets and palliative have to be introduced by the government to cushion the likely effects of the new taxes on gasoline and diesel.

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