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RESEARCH PAPER

Price and Income Elasticities of Domestic Petroleum Consumption in Nigeria

Sa'ada Abba Abdullahi[a,*] , Sabiu Bariki Sani[b]

a. Department of Economics, Baze University, Abuja, Nigeria
b. Department of Economics, University of Abuja, Abuja, Nigeria

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Abstract
This paper estimates the price and income elasticities of domestic petroleum consumption in Nigeria using the Johansen cointegration and vector error correction model approaches. The paper used annual time series data for domestic petroleum consumption, petroleum price, and real income over the period 1985 to 2018. The result indicates the existence of a long-run cointegration relationship between domestic petroleum consumption and the independent variables. The estimates of the long-run price and income elasticities are -0.212 and 0.293 which suggest that petroleum consumption is both price and income inelastic in Nigeria. The short-run analysis indicates that the elasticity coefficient of price is insignificant while income is negative -0.628 but significant. The result of the Granger causality test shows evidence of short-run and long-run unidirectional causality running from income to domestic petroleum consumption. The results imply that there is a need for a strong policy that will improve the efficiency of the electricity sector and promote the use of power-saving machines and technology to reduce domestic petroleum consumption that may result from an increase in per capita income in Nigeria.
Keywords: Petroleum Consumption, Price Elasticity, Income Elasticity, Cointegration, Nigeria.
JEL Classification: C22, D12, E21, Q31, Q48.

Introduction

Nigeria has the largest petroleum industry in Africa and is the sixth-largest producer of petroleum products in the world. It has oil and gas proven reserves of worth 37 billion barrels and 192 trillion cubic feet respectively (OPEC, 2019). Over the five decades, the petroleum industry has played an overriding role that makes the sector not only the backbone of the economy but the main source of the nation's economic growth through the provision of foreign exchange revenue. Petroleum contributes about 60% of the foreign exchange revenue and more than 70% to the GDP in Nigeria (CBN, 2018). The high dependence of Nigeria on oil makes any shock in the international oil prices have a serious effect on its economy. In addition, the price of petroleum products in the country remains relatively low and regulated by the government which leads to higher consumption rates compared to many other developing countries and therefore makes the pricing of petroleum products a major policy issue of concern (Saad and Shahbaz, 2012).

Over the years, the demand for petroleum products in Nigeria has increased continuously due to urbanization, economic growth, increase in population, and rapid industrialization among others. However, the insufficiency and the inefficiencies in the existing oil refineries

*. Corresponding author email: saada.abdullahi@bazeuniversity.edu.ng

make the country unable to meet domestic petroleum demand. These challenges among others have turned Nigeria into the world's largest importer of refining petroleum products among the world oil-producing nations. Statistics reported that the value of oil import has increased in Nigeria from $11,218.26 million in 2010 to $19,022.21 million in 2012 from where it declined and reached $8.1514 million in 2018 (CBN, 2018). The total oil production during these periods was $2.088 billion in 2010, $2.09 billion in 2012 from where it declined to $1.88 billion in 2018 (NNPC, 2018). In 2015, the Federal Government implements the removal of oil subsidies and allows market forces to determine retail prices. They made the national oil company responsible for fuel imports and swallowing the difference between its costs and the price at the pump a term described by the Nigerian government as "Under-recovery". Initially, the petroleum prices were reduced from N86.50 per liter to N87 per liter, before adjusting it upwards to N141. The price was further adjusted upwards to N145 per liter where it remains for a long despite the variations in the international price of crude oil. Recently, the sharp dropped in the global crude oil price as a result of the impact of the coronavirus pandemic makes the petrol price be adjusted again to N123.50 per liter (Udo, 2020). This call for the need for strong policy may promote efficient energy use and conservation, and regulate the prices of petroleum products in Nigeria.

Petroleum demand elasticity is how economic analysts forecast changing petroleum consumptions as consumers' income changes or predict petroleum consumption responses to price as petroleum is taxed or subsidized. Four major petroleum demand elasticities can be studied. This includes income elasticity, own-price elasticity, cross-price elasticity, and structural and demographic elasticity. First, petroleum elasticity is an important tool that can be used to guide in making effective policy decisions that will affect consumption with regards to price and income. Second, the elasticity estimates can help to explain the market power of the oil producers and price volatility in response to shocks and corroborate elasticity estimates in energy studies (Krichene, 2002). Third energy elasticities can be used to design effective policies for dealing with negative environmental externalities in the energy sector (Iwayemi, 2007).

This paper examines the price and income elasticity of domestic petroleum consumption in Nigeria. The majority of the previous studies focused on the determinants of crude oil export or import demand and the international oil market. To our knowledge, there are very few studies that investigated the effect of price and income on domestic petroleum consumption in oil-producing developing countries like Nigeria. The few previous studies in Nigeria include Dayo and Adegbulugbe (1987), Iwayemi (2007), Saad and Shahbaz (2012), and Sulaimon (2014) whose period of study does not extend 2012, and their findings offer's mixed conclusion. This paper differs from these studies because it provides new evidence on petroleum consumption and its primary determinants of price and income using more recent data from 1980 to 2018, covering the period when there was the removal of oil subsidy, a regime that has been for decades in Nigeria.

This paper is of great importance because Nigeria is an oil-producing country that has been using subsidies on its refined oil for a long to make petroleum demand affordable and available to its citizens. The paper will contribute to the literature in the following ways: First, it is important to understand the petroleum demand elasticities to know how domestic consumption is influenced by changes in price or income, and whether oil consumption is a driving force for the economy or not. More so, it can assist policymakers to analyze and forecast the responses of domestic petroleum consumption to the reduction or removal of the oil subsidy in Nigeria. It will also provide information that can guide in designing policies related to forecasting future supply and demand of petroleum products. Finally, it will provide knowledge on how consumers respond to change in petroleum price which is one of the important tools used in setting petroleum tax or energy policy as stated by Schulte and Heindl (2017).

The paper is structured as follows: section 2 reviews literature related to the study area. Section 3 deals with the methodology and data for the study. Section 4 presents the empirical results and discussion. Section 5 concludes and summarizes and offers recommendations from the main findings of the research.

Literature Review

A large number of studies have estimated the energy demand elasticities in both developed and developing countries using different approaches. Some of the earliest studies on crude oil demand include Dahl (1986), Baker et al. (1987), Dayo and Adegbulugbe (1987), Hunt and Manning (1989), Ibrahim and Hurt (1990), Dahl (1994), Rao and Parikh (1996), Alsahlawi (1997), Gately and Streifel (1997), Ramanathan (1999).

Ghouri (2001) applied the Almond polynomial distributed lag model to estimate the oil demand elasticities in the USA, Mexico, and Canada. The long-run estimate indicates that the income elasticity was 0.98, 0.84, and 1.08 in USA, Mexico, and Canada respectively. The result also indicates that the three countries have an inelastic price in the long run and its estimated value is greater in the absolute term in the short run. Gately and Huntington (2001) examined the determinants of price and income demand of energy and oil in selected OECD and non-OECD countries. They found that the OECD countries have long-run income and price elasticity of oil demand of 0.56 and -0.64 respectively. The result of the non-OECD countries indicates the price elasticity of -0.18 while income elasticity is 0.53 in the long run. Krichene (2002) examined the world demand and supply of oil and natural gas and the result indicates that the demand and supply for both crude oil and natural gas were highly-priced inelastic in the short run while in the long run, the income elasticities were significant for both crude oil and natural gas demand. Cooper (2003) using a multiple regression model found that crude oil demand in 23 selected countries is price inelastic in both the short-run and long-run price elasticity. Iwayemi (2007) using the cointegration approach examined both the aggregated and disaggregated petroleum demand function in Nigeria. The result shows that energy consumption is negatively influenced by changes in price and positively by income in both the short-run and long-run. The result of the disaggregated analysis shows that gasoline and diesel have the highest short-run income and price elasticities. Altinay (2007) investigates the Turkish short-run and long-run elasticity of crude oil demand using the autoregressive distributed lag (ARDL) bounds testing approach. The result shows that the oil demand is income inelastic in the short run, while in the long run, the estimated value of price and income are 0.64 and 0.61, respectively. Narayan and Smyth (2007) applying the panel cointegration techniques found that oil demand in the Middle- East is both price and income elastic. The estimated value of the long-run price elasticity ranges between 0.071- 0.002, while the income elasticity ranges from 0.204- 1.816. Ghosh (2008) using the ARDL bounds testing approach found that crude oil demand in India is price inelastic with a value of -0.63 in the long run. Ziramba (2009) examined the demand for imported crude oil in South Africa using the Johansen cointegration and found that the long-run income and price elasticity were both inelastic -0.147 and 0.429. Using the same approach, Xiong and Wu (2009) found that crude oil demand in China has a long-run income elasticity of 0.647 and a price elasticity of -0.365. Bhattacharyya and Blake (2009) examined the domestic demand for petroleum products in seven MENA countries, namely Algeria, Iran, Kuwait, Libya, Saudi Arabia, UAE, and Qatar using the dynamic regression analysis. The four petroleum products analyzed were namely gasoline, diesel, kerosene, and fuel oil. The result of both the short-run and long-run analysis indicates that the demand for all the petroleum products does not lie in the price or income elastic regions within MENA countries.

Saad and Shahbaz (2012) investigated the price and income elasticities of demand for oil products in African Member Countries of OPEC including Nigeria using the ARDL bound testing cointegration approach. The result indicates mixed evidence across the countries in both the long run and short run. For Nigeria, the result shows that income has a positive and significant impact on petroleum consumption in the long run while prices are negative and significant in the short run. Sulaimon (2014) estimates the price and income elasticity of energy demand for Nigeria both at the aggregate level and by product type (fuel, diesel, and kerosene) using a multivariate cointegration approach. The result indicates that the price and income elasticities are -0.0054 and 0.364 in the long run while in the short run, the elasticities were insignificant in explaining petroleum demand in Nigeria. Dees (2015) investigate the world oil market development and risks, employing the dynamic ordinary least squares method to estimate the long-run coefficient while the error correction model (ECM) is used to estimate the short-run dynamics. The results show that long-run income elasticity range from 0.17- 0.98 while in the short run the income elasticity ranges from 0.0001- 0.82. The short-run price elasticity on the other hand is very inelastic approaching zero. Ozturk and Arisoy (2016) using the Time-varying parameters (TVP) found that Turkey's crude oil import demand has high-income elasticity of 1.182 while the price elasticity is statistically insignificant. Sa'ad (2016) applying the ARDL model found that both the total petroleum products and gasoline in Indonesia respond more to changes in income than the price which suggests that they are income elastic. Asfar et al. (2018) investigate the price and income elasticities of crude oil demand in India, China, and Pakistan. They applied the ARDL bounds testing approach and found that the estimates of the price and income elasticities were elastic in the long run than the short run in almost all the countries.

This paper will investigate the price and income elasticities of domestic petroleum consumption in Nigeria. From the review, we can see that majority of the previous studies concentrated on developed Asian and Middle-Eastern countries. The analysis of most of these studies focused on crude oil demand and the world oil market. There is little evidence to our knowledge on petroleum demand in Sub-Saharan Africa and especially in oil-producing developing countries like Nigeria.

Data and Methodology

Data

The paper employs annual time series data for the real gross domestic product (Y), petroleum consumption (QP), and petroleum price (P) covering the period 1985-2018. The choice of the study period is based on the availability of data and to capture the period when petroleum subsidy was removed in Nigeria. Data on real GDP is obtained from the Central Bank of Nigeria Statistical Bulletin (2018) while petroleum consumption and petroleum price are sourced from the National Bureau of Statistics report (2018). The petroleum consumption is total domestic petroleum consumption in thousand barrels per day, petroleum price is the domestic price of petroleum per liter and the income is a real gross domestic product for Nigeria. For possible interpretation of the coefficients into elasticities and to reduce the problem of heteroskedasticity all the variables were transformed into natural logarithm form.

Table 1 presents the summary statistics of petroleum consumption, petroleum price, and income in Nigeria. The result shows that the variables exhibit negative skewness except for petroleum consumption while Kurtosis is greater than 3 for petroleum consumption and petroleum price, meaning that they are lepturkotic. The result of the Jarque-Bera test shows that we cannot reject the null hypothesis at the 5% significant level for each of the times series variables, implying that they are not normally distributed. Figure 1 shows that real income and

petroleum price have an upward trend while petroleum consumption shows no trend over the study period. The plot also shows that the quantity of petroleum consumption and price have breaks like in the years 1994, 2000, 2008, 2011, and 2016 which coincide with some of the periods when major events caused the world crude oil price shocks.

Table 1. Summary Statistics of the Series

	LQP	LP	LY
Mean	5.5937	3.6737	15.353
Median	5.6138	4.0032	15.733
Max	6.0591	4.9488	17.707
Minimum	5.3380	1.17866	11.809
Std. Dev.	0.1465	0.89548	1.9232
Skewness	0.7912	-1.04169	-0.4882
Kurtosis	4.6224	3.69522	1.9503
Jarque-Bera	6.8487	6.43178	2.7405
Prob	(0.0326)	(0.0401)	(0.254)

Source: Research finding.
Note: All the variables are in natural logarithmic, Figures in bracket are probabilities which indicate that all the variables are not normally distributed.

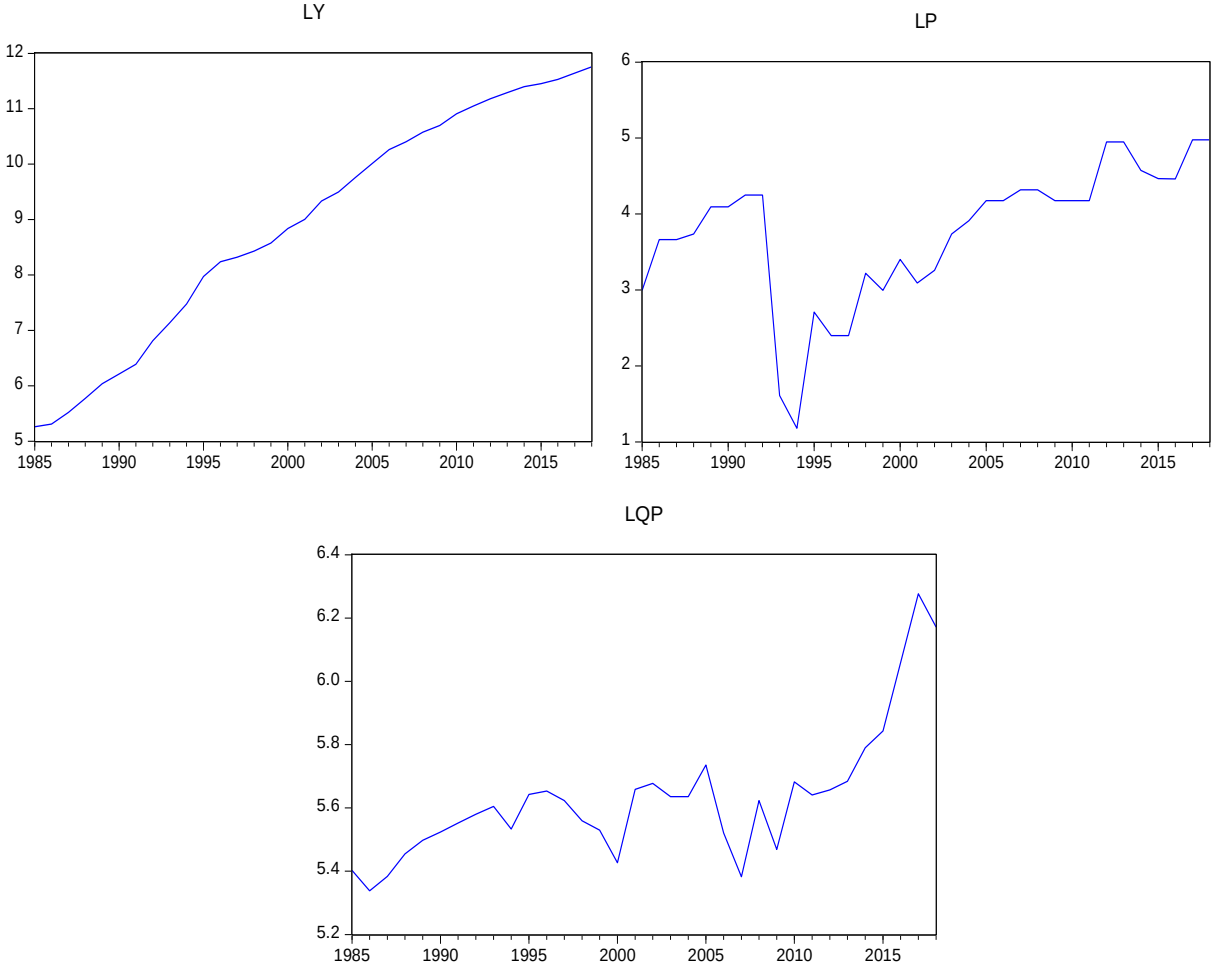

Figure 1. Plots of the Log Values of Income, Petroleum Price and Petroleum Consumption in Nigeria over the Period 1985-2018
Source: Research finding, using Eviews 9, 2019.

Methodology and Model Specification

The standard energy demand model is used to estimate the price and income elasticities of domestic petroleum consumption in Nigeria. The model specified the quantity of petroleum consumption to be a function of its major determinants i.e domestic petroleum price per liter and real income. The model can be specified as follows:

$$Qp_t = f(p, y)$$

The log-linear form of the model can be specified as:

$$LQp_t = \beta_0 + \beta_1 Lp_t + \beta_2 Ly_t + \varepsilon_t \quad (1)$$

Where Qp is the quantity of domestic petroleum consumption, *p* is the domestic price of petroleum per liter, and *y* is the real GDP. The estimated coefficients β_1 *and* β_2 are the price and income elasticities, respectively. In theory, the coefficient of β_1 is expected to be negative because price and quantity demanded have an inverse relationship. On the other hand, income is expected to have a positive relationship with quantity demand and therefore an increase in income will increase the demand for petroleum. Therefore, the coefficient of β_2 is expected to be positive (Ziramba, 2010; Saad, 2009).

However, the economic theory stated that the demand for a product is determined by own price, income, prices of complements and substitute's goods, and consumer preferences. Bhattacharyya and Blake (2009) stated that petroleum demand is a derived demand because consumers gain utility from petroleum products only in combination with other inputs, like cars and stoves, etc. In the case of Nigeria, the major complements of petroleum demand are (cars and generators) while the substitute good is electricity which due to its failure almost all small and medium enterprises rely on generators to operate. Nigeria uses petroleum in the transport system which is mainly road transport, and more than 85% of the vehicles ranging from private, commercial, and interregional busses used petrol. Therefore, the substitution effect is insignificant in Nigeria. Moreover, the absence of time series data that capture the prices of substitute and complements goods makes it impossible to include these factors in our analysis for Nigeria. Bhattacharyya and Blake (2009) showed that it is acceptable to estimate the elasticities of petroleum products using the static model with price and income like equation (1) in the countries where their domestic prices of petroleum products are not determined by market forces but are instead regulated by the authorities. This is the common model used in the analysis of energy demand in many developing countries see, Asfar et al (2018), Ziramba (2010), Saad (2009), Altinay (2007), Chakravorty et al. (2000).

Equation (1) will be estimated using the Johansen and Juselius (1988) cointegration procedure to examine the long-term cointegration relationship and their long-run elasticities. The vector error correction model (VECM) will be used to estimate the short-term relationship and elasticities. The model can be specified as follows:

$$\Delta Qp_t = \beta_0 + \sum_{t-1}^{k} \beta_1 \Delta Qp_{t-i} + \sum_{i-1}^{k} \beta_2 \Delta p_{t-i} \sum_{i-1}^{k} \beta_3 \Delta y_{t-i} + \delta ECT_{t-1} + \varepsilon_t$$

where ECT represents the error correction term which is obtained from the cointegrating vector, δ represents the coefficient that measures the speed of adjustment from the short run to the long-run equilibrium, and ε_t represents the residual. Theoretically, the coefficient δ has to be negative and significant for the variables to converge quickly to form a long-run equilibrium.

The VECM can be used to detect the granger causality relationship between the variables. Engle-Granger (1987) stated that if two or more variables are cointegrated, there should be at least one causality relationship between one. The joint F-test via the VECM can be used to test for both the short-run and long-run Granger causality relationship between the variables. The t-statistic of the coefficients δ and β_2, β_3 indicates the significance of the long-run and short-run causality effects, respectively. If the coefficient δ is statistically significant, it implies that long-run granger causality holds while the significant of β_2, β_3 explaining the existence of short-run Granger causality.

Empirical Results and Discussions

Unit Root Test

The paper employs the Augmented Dickey-Fuller (ADF) (1979) unit root test conducted with the trend and intercept specification to examine the stationarity of the time series variables. Table 2 indicates that we cannot reject the null hypothesis of the unit root at the 5% significant level for all the variables petroleum consumption, petroleum price, and real income. This result implies that all the variables are I (I) process. However, the result also indicates that these variables are all stationary in their first difference. Since the variables have the same order of integration, we applied the Johansen cointegration test to investigate the long-run price and income elasticities of petroleum consumption in Nigeria.

Table 2. Result of the ADF Unit Root Test

Variables	Level	First difference
LQP	-2.3621(-3.5629)	-7.1571*(-3.5684)
LP	-2.5091(-3.5806)	-5.2372*(-3.5742)
LY	-0.6233(-3.5629)	-5.1139*(-3.5742)

Source: Research finding, using Eviews 9, 2019.

* denotes rejection of a unit root null hypothesis based on MacKinnon's critical value at 5% level. The values in parentheses of the t-statistics are the levels and difference critical's at 5% level.

Long Run Analysis

Table 3 presents the estimated result of the long-run cointegration relationship using the Johansen approach. The results of both the trace and maximum eigenvalue statistics indicate that there is at least one cointegrating vector. We, therefore, reject the null hypothesis of no cointegration at a 5% significant level for both the trace and maximum eigenvalue tests. The result implies that there is a long-run cointegration relationship between petroleum consumption, price, and real income in Nigeria. The result of the estimated long-run price and income elasticities can be interpreted from the normalized cointegrating coefficients reported in Table 4. Equation (3) represents the long-run relationship between petroleum consumption and the independent variables.

$$LQp_t = -0.2122Lp_t + 0.2931Ly_t \quad (3)$$
$$t\text{-}ratios \quad (2.451)^* \quad (4.950)^*$$

The result of the normalized cointegrating coefficients shows that the signs of the elasticities for both price and income are in line with economic theory. The long-run price and income

elasticities are statistically significant with the values -0.212 and 0.293, respectively. The coefficient of the price elasticity shows that a 1 unit increase in price will decrease petroleum consumption by 0.21%. This implies that petroleum demand will decrease with an increase in prices even with the subsidy removal in Nigeria. Saad and Mohammed (2012) got a negative but insignificant price elasticity -0.0642 for Nigeria in the long run. However, Sulaimon (2014) and Iwayemi (2007) found insignificant price elasticity in Nigeria.

Table 3. Result of Johansen Cointegration Test

Null hypothesis	T-statistic	5% Critical Value
Trace		
r=0 *	41.37579	29.79707
$r \leq 1$	12.17059	15.49471
$r \leq 2$	2.461897	3.841466
Max eigenvalue		
r=0 *	29.20521	21.13162
$r \leq 1$	9.708690	14.26460
$r \leq 2$	2.461897	3.841466

Source: Research finding, using Eviews 9, 2019.

* denotes rejection of the null hypothesis at the 0.05 level. Both the Trace and Maximum eigenvalue tests indicate 1 cointegrating eqn(s) at the 0.05 level.

Table 4. Result of Johansen Normalized Cointegration Coefficients

LQP	LP	LY
-1	-0.21228	0.29318
Std. error	-0.0866	-0.0591
t- ratios	2.45102*	4.95049*

Source: Research finding, using Eviews 9, 2019.

Note: * indicate significance at 5% level. Log-likelihood is 70.60757. The signs of the normalized coefficients are of the actual relationship between the variables and petroleum consumption.

This result of the income elasticity coefficient shows that a 1-unit change in income will increase petroleum consumption by about 0.29% in the long run. This suggests that petroleum has characteristics of a normal good in the long run because its demand increased with income growth. Iwayemi (2007) obtained an income elasticity estimate of 0.747, using data covering the period 1977 to 2006 in Nigeria. Saad and Mohammed (2012) also got an estimated income elasticity of 0.55, using data covering the period 1980 to 2008 while Sulaimon (2014) reported income elasticity of 1.16 throughout the study, 1980 to 2012 in Nigeria. All these studies obtained positive and significant income elasticity for Nigeria in the long run. We can say that income has a strong influence on petroleum consumption in Nigeria. The implication of this result is that increase in economic activity that brings an increase in income will lead to an increase in petroleum consumption in Nigeria. This result is not surprising because the inefficiency and inadequate electricity supply make more than 80% of economic activities both small and medium businesses operate using generators which are powered mainly by petrol in Nigeria. Therefore, we can say that increase in income of business and economic activity will lead to an increase in demand for petroleum. The result of the long-run analysis shows that domestic petroleum consumption is both price and income inelastic in Nigeria.

Short-Run Analysis

Table 5 presents the estimated result of the short-run relationship and elasticities using the vector error correction model (VECM). The result shows that the coefficient of the lagged error term is positive with a value of 0.334 but statistically significant at a 5% level. However, the positive sign of the lagged ECT coefficient implies that the variables petroleum consumption, petroleum price, and income do not adjust rapidly to long-run equilibrium. The estimated short-run elasticities show that the coefficient of price is -0.040 but insignificant, while income is -0.628 and significant. This implies that an increase in income will decrease petroleum consumption while price changes have no significant influence on petroleum consumption in the short run consistent with Saad and Mohammed (2012) and Iwayemi (2007). The negative and significant impact of income on petroleum demand suggests that petrol has features of an inferior good in the short run because the increase in income will decrease its demand in Nigeria.

Table 5. Results of the Vector Error Correction Model

Variables	Coefficient	Std.errors	T-statistics
ΔECTt-1	0.334200	0.10839	3.08340*
ΔLQPt-1	-1.059556	0.31480	-3.36586*
ΔLPt-1	-0.040219	0.05169	-0.77810
ΔLYt-1	-0.628772	0.18423	-3.41306*

Source: Research finding, using Eviews 9, 2019.

Note: * denotes significance at 5% level of significant

The results of the VECM can be used to interpret the long-run and short-run causality relationship between the variables. The positive sign of the coefficient of the lagged error correction term indicates that full convergence to the long-run equilibrium does not take place between the variables. However, the significance of the coefficient implies that there is a long-run unidirectional causality running from income to petroleum consumption in Nigeria. The result also shows unidirectional Granger causality from income to petroleum consumption in the short run while the insignificant price coefficient indicates the absence of causality relationship between price and petroleum consumption. Iwayemi (2007) found bidirectional causality between per capita income and gasoline demand in Nigeria. Overall, the result supports the strong influence of income on petroleum consumption in Nigeria.

Conclusion

This paper investigates the price and income elasticities of petroleum consumption in Nigeria using the Johansen cointegration test and vector error correction model. The study used annual time series data over the period 1985 to 2018. The findings indicate that both price and income elasticities are statistically significant in explaining petroleum consumption in the long run. The result indicates that the values of the price and income elasticities are -0.212 and 0.293, respectively which suggest that petroleum consumption is both price and income inelastic in Nigeria. The estimated results of the short-run elasticities show that the coefficient of price is -0.040 but insignificant while income is significant but has a negative sign of -0.628. This suggests that petroleum consumption can respond to income in the short run but the adjustment coefficient is insignificant. The causality test results show the absence of short-run and long-run unidirectional causality from income to petroleum consumption.

This finding implies that government should implement a policy that will improve the

efficiency of the electricity sector which is the major substitute that can reduce the demand for petroleum especially with the removal of oil subsidies in Nigeria. There is a need for a strong policy that will promote the use of power-saving machines and technology to reduce petroleum consumption because the increase in income will lead to an increase in petroleum consumption which is an additional cost to firms and businesses that can affect their profits in the long run. Finally, policymakers should know that price changes though influence petroleum consumption but will not stop people from buying because petrol is a necessary commodity in Nigeria.

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