PETROLEUM PRODUCTS DEMAND ELASTICITIES AND THEIR IMPLICATIONS FOR PETROLEUM SUBSIDY IN NIGERIA

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Abstract

Despite the tremendous contributions of petroleum products to the Nigerian economy, having appropriate pricing policy has been a contentious issue and remains one of the most complex socio-economic policy issue in Nigeria. This motivated this study, which estimates the demand elasticities of the two subsidised petroleum products in Nigeria (gasoline and household kerosene) between 1980 and 2010 and analyse their implications for the petroleum products subsidy in Nigeria. Lagged endogenous dynamic modelling approach to regression analysis is used due to the derived nature of energy demand. The findings revealed that the demand for gasoline is price and income inelastic in both the short-run and the long-run, and income is most important determinant of gasoline demand. On the other hand the demand for kerosene is income elastic in the long-run but have negative income elasticity coefficient. Overall the demand for both gasoline and kerosene are more responsive to changes in income than prices. The results implied that deregulating gasoline price may have positive socio-economic and environmental implications, whereas deregulating kerosene price may have negative socio-economic and environmental implications.

Key words: Gasoline, Kerosene, Demand elasticity, Subsidy, Dynamic model

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Introduction

Energy plays a decisive role in the development process of countries; it not only powers nearly every production process, but it is also an important and fundamental component of the household's consumption basket (Nadeem, 1990). In Nigeria for instance, approximately 4.4 quadrillion Btu of energy was consumed in 2010,beside traditional biomass and waste, petroleum products accounted for 72%, natural gas 22% and hydroelectric power 6% (EIA, 2012). Consequently, it may be ascertain that petroleum products constituted a significant share of Nigeria's energy mix. According to Fawibe (2009), petroleum account for over 78% of Nigeria's national commercial energy consumption and has been the engine of growth fuelling the entire economy.

However, despite the role being played by petroleum to the Nigerian economy, having appropriate policy for the downstream petroleum sector of Nigeria especially on pricing, has been contentious issue; oil subsidy remains one of the most complex socio-economic policy issue in Nigeria. A regulated subsidised pricing regime is operated since the mid-1970s, which has tremendous cost on the industry and the economy at large.In addition to this, subsidy has also discouraged competition and stifled private investment in refineries, encouraged smuggling of petroleum products across neighbouring countries, put pressure on foreign exchange rate, and caused supply shortages (Adenikinku and Fobobi, 2006; CBN, 2007).

The burden of subsidy on the national treasury and the inability to attract investment in the mid and downstream sector of the Nigerian petroleum sector has caused successive regimes to attempt to deregulate the downstream petroleum sector (Fawibe, 2009). These attempts however, are being strongly opposed by the labour unions, civil society organisations, opposition political parties and other segments of society. Given the roles petroleum products play to the Nigerian economy and the controversies surrounding their appropriate pricing;suggests that estimating the elasticities of demand of the products is of paramount important for policy making. Unlike previous studies, this research focused on the implications of the demand elasticities on the petroleum price subsidy, which despite the enormous role it might play in explaining the demand for petroleum products in Nigeria has not received the attention it deserved by researchers.

Petroleum products demand elasticities: A review of related literature

Liu (2004) applied a dynamic model to estimate elasticities for members of the Organization for Economic Cooperation and Development (OECD). He found that electricity, natural gas and gas-

oil price elasticities are in general larger than income elasticities, while income elasticities are lower in residential sector than in the industrial sector. Further, in a recent study on Europe using the same approach and taking into account increase in diesel-powered cars, Pock (2010) found the coefficients of price and income elasticities of gasoline demand to be lower in absolute terms. However, different energy dynamics and policies of countries call for research on individual countries. In this regard, Tanishita (2005) conducted a study on gasoline demand elasticity in Japanese cities in which he found that income elasticity decreased from 1980's to the 1990's in both major and non-major cities and price elasticity decreased in major cities. In a study on developing and emerging market countries who are accounting for an increasing share of global energy consumption, Ramanathan (1999) used co-integration approach to estimate gasoline demand in India and found it to be price inelastic and income elastic both in the short and long run. Recently, Rao and Rao (2009) conducted a survey of gasoline demand in Fiji, which was found to be both price and income inelastic. The result on income elasticity differed with the one found in India and Pakistan, likely due to the small size of the Fiji's economy.

All along studies were on net oil importing countries; this may influence the nature of the responsiveness of petroleum products demand to changes in income and prices, due to foreign exchange fluctuations and volatility in prices of crude oil in international oil market. Thus, studies on net oil-exporting countries are highly desirable. In response to this, Eltony (1996) used pooling and testing procedures to estimate the demand for gasoline in the Gulf Cooperation Council (GCC) countries; he found the demand to be income and price inelastic in both short and long run. Similar results was found by Al-Faris (1997) and Bhattacharyya and Blake (2008) in the GCC and the Middle East and North Africa (MENA) regions;this confirmed the features of most oil exporting countries, where petroleum subsidy renders the demand to be price inelastic.

On an individual country basis, Eltony and Al-Mutairi (1995) estimated the demand for gasoline in Kuwait using co-integration approach, the found that, gasoline demand is price inelastic in the short and long run, where as it is income inelastic in the short-run and income elastic in the long-run. Recently, Sa'ad (2009) employed the same approach to study gasoline and diesel demand in Indonesia and found that total products demand was more responsive to changes in income than real prices. However, different pricing policies of the countries, the volatile nature of oil market and technological advancement, warrant more specific and up to date studies. To this end, Vita, et al. (2005) used bounds testing approach to study electricity, gasoline and diesel demand in

Namibia, they concluded that energy consumption responds positively to changes in income and negatively to changes in prices. A similar and more specific result was found in South Africa by Akinboade, et al. (2008) who used co-integration approach to conclude that gasoline demand is price and income inelastic.

Iwayemi, et al. (2009) formulated and estimated petroleum products demand function for Nigeria using co-integration technique, the overall results revealed that the demand for petroleum products is price and income inelastic; however, kerosene and gasoline have relatively higher short-run income and price elasticities. This confirmed the results found in other net oil exporting countries, such as Kuwait, GCC and MENA regions etc. However, co-integration technique used by Iwayemi, et al. (2009) and majority of other studies has various limitations. For instance according to Bhattacharyya and Blake (2008), co-integration relationships may be a "pretty unlike occurrence" and even if these relationships exist, Ordinary Least Square (OLS) yields super-consistent results.

The Demand and pricing of petroleum products in Nigeria

Average daily consumption of petroleum products in Nigeria in 2008 stood at 35.66 million litres. Of this figure, Premium Motor Spirit (PMS) or gasoline accounted for 72.8% and Household Kerosene (HHK) 7.5% (NNPC, 2009). The end use of energy (petroleum products in particular) in Nigeria has shown that household sector account for about 50% of demand while the industrial and the transport sectors account for 30% and 15% respectively (Kupolokun, 2009). This phenomenon could be explained by the continued shrinkage of the industrial sector of Nigeria over the years, due to inadequate power supply, thus leaving the household sector as the major consumer of energy.

An important feature of the Nigeria's energy demand and in particular petroleum products, is the rapid increase in consumption;for petroleum products, this increase appeared to be in favour of gasoline (PMS) and kerosene (DPK), which are the major subsidised petroleum products. The key factors responsible for this rapid growth in consumption of petroleum products are rapid income expansion due to strong oil export performance andsubsidised-low energy prices; fast growing importation of fuel inefficient second hand vehicles; acquisition of private electric generators in response to unstable power supply; high population and urbanisation growth rates and smuggling of petroleum products to neighbouring countries among others (Adenikinku and Folabi, 2006; Iwayemi, et al. 2009).

Although Nigeria operated a deregulated oil price regime from 1960-1973, a uniform regulated pricing was introduced in the mid-1970s and government took over the downstream sector of the petroleum industry, which altered the market condition. Consequently, petroleum products prices exhibited a period of stable nominal prices interrupted by sudden price changes, which occur when government is compelled to revise them upward (Adenikinku and Folabi, 2006; Fawibe, 2009).

In Nigeria there has been a policy of keeping the prices of petroleum products low to extend their use to the poorsince oil is considered a national cake, this trend continued until 1986 when market reforms under the structural adjustment programme (SAP) greatly decontrolled the prices (Oladosu and Adegbulugbe, 1994). This culminated into a substantial price increase in 1993, which remain a turning point in the pricing of petroleum products in Nigeria. Subsequent governments raised the prise through unsuccessful deregulation attempts; the recent one being in 2012 when the price was fully deregulated to ₦ 141 per litre, but was reverted to ₦ 97 per litre due to pressure from the labour unions and other non-governmental organisations. Currently the petroleum products pricing regulatory agency (PPPRA) is responsible for determining the pricing policy of petroleum products and regulating their supply and distribution. The PPPRA employed a fixed pricing formula based on a pricing template of import parity prices, plus mark-ups for transportation, distribution, and marketing and guaranteed margins.

Nigeria's experience with subsidies of petroleum products

Like in other countries where energy prices are subsidised, in Nigeria also subsidy entails many socioeconomic and environmental costs. Most disturbing of these costs is the fiscal burden, which is becoming unbearable to the government. Subsidy payments for 2012 is over ₦ 1.3 trillion (Balouga, 2012) which is over 27% of the N 4.749 2012 budget. Furthermore, low prices of petroleum products in Nigeria resulting from subsidy has discouraged competition and stifled private investment in refineries, thus, leading to the importation of the bulk (80-90%) of domestic consumption. This puts additional pressure on the exchange rate and the demand of foreign exchange, for instance, according to the Central Bank of Nigeria (CBN) as much as 29% of its foreign exchange sales in January 2009, was used to finance the importation of refined petroleum products (Adeoye, 2010).

Subsidised prices of petroleum products in Nigeria, has also caused huge price disparity between Nigeria and its ECOWAS neighbours, thus, encouraging cross-border smuggling of the products.

Prices in other ECOWAS countries are far greater than Nigerian prices. This coupled with porous borders has made smuggling of petroleum products from Nigeria a thriving business. In fact, it is estimated that as much as 30% of Nigeria's oil supply is smuggled to these countries,moreover, subsidies help in keeping prices of fuel fixed at below market clearing level, thus, not signalling to consumers the real cost of energy use, thereby leading to over consumption and therefore more greenhouse gas emissions (Adenikinku and Folabi, 2006).

Methodological issues

Secondary sources of data were explored to collect data on the relevant research variables. Data on total annual consumption of petroleum products and each of PMS and HHK as well as their pump prices (in local currency) for the period 1980-2010, is obtained from the OPEC annual statistical bulletins. However, the prices are adjusted for inflation using the composite consumer price index (CCPI) as the deflator; the CCPI and the real GDP at 1990 constant basic prices were obtained from the CBN annual report and financial statement. In order to compute per-capita GDP and products consumption, Nigeria's annual population data was obtained from the World Bank (2010) data catalogue.

Lagged endogenous dynamic modelling approach to regression analysis is used as against a simple static modelling, this is because the latter cannot capture the complex process of adaptation to changes in prices and income and will not show the important differences in the rate of adjustment between short and long run (Bhattacharyya and Blake, 2008). The dynamic model is used due to the fact that petroleum products demand is indirect;they are consumed with energy using equipment, which are often long-lived and therefore complete adjustment can take a considerable amount of time (Dahl, 1993). This is as a result of stock adjustment mechanism; habit persistence; earlier commitments; costs involved in replacing existing capital stock etc. (Al-Faris, 1997; Crotte, et al. 2010).

However, violation of some of the assumptions of the OLS may invalidate the results of the model; assumptions such homoscedasticityandno autocorrelation are particularly significant for model stability. Some of the consequences of not conducting such tests include the failure to detect the presence of heteroscedasticity and autocorrelation, which generate inefficient estimators, wrong standard errors and depressed t and F statistics values. Consequently, some diagnostic and specification tests are conducted.

The model is specified in natural logarithm, that is log-log (log-linear or double log) form to represent the long-run demand for petroleum products, this is because it yields elasticities in a convenient form; takes care of heteroscedasticity; removes non-linearity to some extent; normalises the data and no information is lost by taking the natural logarithm of variables(Vogelvang, 2005; Huisman, 2009). The model is thus specified as follows:

$$LnPMSC_t = \beta_0 + \beta_1 LnPMSP_t + \beta_2 LnRPCI_t + \beta_3 LnPMSC_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$LnHHKC_t = \beta_0 + \beta_1 LnHHKP_t + \beta_2 LnRPCI_t + \beta_3 LnHHKC_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$\boldsymbol{\beta_1}$, and$\boldsymbol{\beta_2}$are the short-run price and income elasticities and $\boldsymbol{\beta_3}$ is the coefficient of adjustment. The long-run elasticities are computed using the following formulae adopted from (Vogelvang 2005), $\boldsymbol{\beta_1/\ 1-\beta_3}$, and $\boldsymbol{\beta_2/\ 1-\beta_3}$, where $\boldsymbol{1-\beta_3}$ is the speed of adjustment to the long-run equilibrium. Other components of the model are: $PMSC_t$and$HHKC_t$ per-capita gasoline and kerosene consumptions in litres;$PMSP_t$and$HHKP_t$pump prices of gasoline and kerosene in Naira per litre; $PMSC_{t-1}$and $HHKC_{t-1}$lagged per-capita gasoline and kerosene consumptionsand$RPCI_t$real GDP per-capita in Naira;$\mu_t$is the error term. The demand models specified in equations (1 and 2) are fitted to time series data and estimated using the ordinary least square (OLS) method; this is because it gives unbiased estimators and have minimum variance among the class of linear unbiased estimators, it also yield consistent estimates in lagged endogenous dynamic model (Gujarati, 2003).

Gasoline (PMS) demand model results and analysis

The results in table 1.1 below indicated that PMS demand is price and income inelastic in both the short-run and the long-run, these results is similar to what Iwayemi et al. (2009) found in their study on petroleum products demand elasticities in Nigeria. Individually, is only per-capita income that is statistically significant in determining PMS demand; this has shown that price is not an important determinant of PMS demand. However, an F-test of joint significance, with a ρ-value of (0.0001) revealed that price, income and the lagged value of PMS consumption are jointly significant in explaining PMS demand, going by the adj. R^2 (0.53) value, they accounted for 53% of all the variations in PMS demand. The results also revealed that PMS demand is more responsive to changes in price and income in the long-run than in the short-run; this has confirmed the theoretical basis of energy demand, which is derived from the demand of

consumer durables and thus takes some amount of time to respond to changes in prices and income.

Table 1.1. Results of PMS dynamic model

Variables	SR-Coefficients	LR-Coefficients	t-statistic	ρ-value
C	-1.8799	-	-1.5493	0.1344
Ln(PMSP)	-0.1140	-0.1238	-1.1690	0.2539
Ln(RPCI)	0.6694	0.7269	3.0135	0.0060
Ln(LagPMSC)	0.0791	-	0.3331	0.7419

Source: Author's computation (using E-Views)

The coefficient of the lagged PMS consumption (0.0791) indicated that, its demand responds very slowly to changes in prices and income; this means consumers take time and save from an increased income, before they acquire gasoline-using equipment such as cars, it also takes time for consumers to adjust their consumption habit when the price increases.

Kerosene (HHK) demand model results and analysis

Table 1.2 revealed that, demand for kerosene is price inelastic and income elastic, but the sign of the income elasticity is contrary to theoretical expectation.

Table 1.2. Results of HHK dynamic model

Variables	SR-Coefficients	LR-Coefficients	t-statistic	ρ-value
C	3.0382	-	1.3357	0.1942
Ln(HHKP)	-0.0535	-0.2335	-0.8173	0.4218
Ln(RPCI)	-0.3039	-1.3265	-1.2911	0.2090
Ln(LagHHKC)	0.7709	-	5.2324	0.0000

Source: Author's computation (using E-Views)

Even though price and per-capita income are individually not significant in explaining kerosene demand, they are however jointly significant in doing so going by the ρ-value (0.0000) of the

joint F-test. The adj. R^2 (0.86) indicated that, the independent variables explained 86% of all the variations in kerosene demand. The coefficient of the lagged kerosene consumption, which is positive and less than one agreed with the theoretical a priori assumption that as an energy commodity, the demand for kerosene do not respond instantly to changes in prices and income.

Diagnostic and specification tests results

The residuals of the model are assumed to be homoscedastic; that is they have constant variance; this implies that the conditional variance of the dependent variable (consumption of petroleum products) remains the same regardless of the values taken by the independent variables. The results of the White test for heteroscedasticityfor both PMS and HHK models (ρ-values: 0.6855 and 0.1188) revealed that, the residuals of the models are homoscedastic at all levels of significance.

Breusch-Godfrey Lagrange Multiplier (LM) test of autocorrelation is carried out to test for the presence of first order autocorrelation in the residuals of the model. The error terms are assumed not to be automatically or serially correlated, that is the error terms relating to each independent variable, are not influenced by other error terms. The results of the test (ρ-values: 0.2811 and 0.1501) revealed that there is no positive autocorrelation in the PMS and HHK models at all levels of significance.

Drawing policy implications from the results of the model requires it to be specified in correct functional form and no important variable(s) be omitted. To test this, the Ramsey RESET test was conducted. The results (ρ-values: 0.7957 and 0.1220) revealed that the models were correctly specified and all the important variable(s) are included. This means that the log-log functional form used is a good fit for the data and that pump prices of petroleum products, per-capita and lagged consumption are adequately explaining changes in the consumption of petroleum products.

Discussion of findings and policy implications

Demand for gasoline in Nigeria is price and income inelasticin the short and in long-runs, moreover, its demand is more responsive to income changes than price changes in the short and long runs; this is due to the fixed price regime operational in Nigeria and lack of absolute substitutes to gasoline, this also means it is consumed by people in the high-income bracket. This implies that, most of the benefits of subsidy on PMS consumption in Nigeria accrue to people in the highest income category, as was reported by Balouga (2012) that, in Africa 87.2% of total

benefits of gasoline subsidy accrues to the richest 20% of households. Thus, deregulating PMS will have positive implications for economy in the following ways.

Firstly, it will redistribute income to some extent by making the rich who mostly consume it pay its full price, secondly, given that PMS constitute over 70% of petroleum products consumption, the huge government spending on subsidy running into billions of Naira, can be diverted to projects that will benefit the entire populace. Thirdly, unnecessary consumption of gasoline due to low subsidised price will disappear, thereby reducing CO_2 emissions.

This study found that kerosene demand in Nigeria is price inelastic in both the short and long runs; conversely the demand is income inelastic in the short-run and income elastic in the long-run. However, the income elasticity is negative signifying that as real GDP per-capita increases consumption of kerosene decreasese. This implied that kerosene is an inferior fuel at high level of income; it is substituted by liquefied petroleum gas (cooking gas). Moreover, this has pointed out to the widening income inequality in Nigeria, thus, whereas the rich substitute kerosene with cooking gas, the poor whose real income has fallen, substitute kerosene with fuel wood, which accounts for as high as 77% of total energy consumed by the households in Nigeria (Kuplokun, 2009).

Therefore, deregulating kerosene in Nigeria might have negative environmental and social implications. Although, kerosene's price inelastic demand makes it suitable for deregulation, but the demerits of doing so may out weight the benefits, due to the following reasons. Firstly, price increase that may result from removing the subsidy will hurt the poor more than the rich, thus, keeping the subsidy can serve as an income-redistributing mechanism where the poor are afforded the opportunity to use a more superior fuel than the traditional fuel wood they are mostly using. This argument is supported by the findings of an IMF position paper by Cust and Neuhoff (2010), that kerosene subsidies are typically more evenly distributed amongst income group.

Secondly, withdrawing subsidy from kerosene will push the poor to use more and more fuel wood, thus, aggravating the problems of deforestation, desertification and global warming, which are progressing at an alarming rate in Nigeria. Given that kerosene constituted a negligible proportion of total petroleum product consumption (usually less than 10%) in Nigeria, to maintain its subsidy will not cost the federal government much in monetary terms.

Conclusions

This study examined the short and long-runs price and income elasticities of petroleum products (PMS and HHK) and their implications to petroleumsubsidy in Nigeria, from the results obtained, the following conclusions are arrived at. More gasoline is consumed at high level of income signifying that, people in the high-income category consume more gasoline than those in the low-income category, thus removing PMS subsidy will have favourable socio-economic and environmental impacts by reducing income disparity, discourage unnecessary consumption and thereby reduce CO_2 emissions, encourage investment in the sector and check smuggling of gasoline to neighbouring countries.

The study also found that less of kerosene is consumed at high level of income; this is because of the negative substitution effect where by kerosene is substituted with liquefied petroleum gas (cooking gas) as income increases, thus, kerosene in Nigeria is an inferior fuel source at high-level of income. Therefore, removing kerosene subsidy, although economically feasible, may have some negative socio-economic and environmental implications, if deregulation resulted in price increase. People in low-income group will be forced to substitute kerosene with the traditional fuel wood there by aggravating deforestation, desert encroachment and global warming, in addition to endangering their lives. More so, the disparity between the rich and the poor will widen; as the rich move up to superior fuel (cooking gas), the poor move down to more inferior fuel (fuel wood).

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