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AN EMPIRICAL ANALYSIS OF PETROLEUM PRODUCTS DEMAND IN NIGERIA: A RANDOM TREND APPROACH

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ABSTRACT: *The main objective of this study is to estimate petroleum products demand using a random trend approach with aim of deriving improved and more robust estimates of price and income elasticities. The study specifies the random trend model of petroleum products demand as a two-step stochastic process. The estimates of model parameters for each petroleum products, in Nigeria are obtained by applying maximum likelihood in conjunction with Kalman filter. The study revealed that the introduction of random trend reduces the estimate of the coefficient of the lagged dependent variable in the three petroleum products relative to no trend model. As a result, price and income elasticities of petroleum product demands are higher in the short run and long run relative to constant intercept model. The introduction of random trend leads to improvement in the mean square errors of within sample forecasts.*

KEYWORDS: Elasticity, Kalman Filter, Maximum Likelihood and Energy Demand.

JEL: D12, Q4 AND Q41

INTRODUCTION

The Nigeria's economic policies and growth have been influenced by energy sector for more than four decades particularly the oil sector. Since the global energy crisis of 1972/73, the energy sector, particularly the petroleum subsector of the Nigerian economy has become the most important source of revenue, particularly foreign exchange earnings. Although, crude oil production and export commenced in Nigeria in 1958, the oil sector of the economy did not achieve its present pre-eminent position until the mid-1970s, a rise aided by rising national production level and the hike in international price resulting from 1973 Arab-Israel war. The period of 1970 to 1980 represent Nigeria's oil boom era in term of production, export and earnings from exports. Peak production in the boom era was achieved in 1979 with a yearly production of 845.463 billion barrel representing an average daily production of 2.3bpd (CBN, 2008).In view of the strategic nature of the petroleum industry as the predominant source of global energy, it has become a prime source of revenue generation to many countries, particularly in Nigeria. The oil sector contribution to Gross Domestic Product (GDP) at current basic prices was as low as 0.9 percent of GDP in 1961. With increase in exploration and production related activities consequent on the boom of the 1970s the sector contribution to GDP has risen to 28.48 percent by 1980.The slump in world price of crude-oil and the bust created dampened growth in the Nigerian oil sector throughout the 1980s. The industry contribution to Nigeria GDP commenced its impressive recovery from 1989 fiscal year. Its contribution to GDP increased to 37.46 percent in 1990. The sector continued its impressive performance throughout the 1990s such that by the year 2000, its percentage contribution stood at 47.72percent. Also, oil export to total export was 2.3 percent as at 1960, this rose to 92.6 percent in 2010 .As impressive as the growth in Nigeria's production and export of crude oil might be, Nigeria's foreign trade record shows that petroleum products import out of national import has continued to rise over the years due to poor state of her refineries. Nigerian petroleum sector is the engine room of growth drives the entire Nigerian economy and society (Iwayemi, 2001); however, the legacy of oil has also imposed economic costs on the economy such as price distortions, volatilities, Dutch disease, corruption and inefficiencies. The major impediment to the development of energy sector is the lack of incentive to encourage private individuals to participate in the sector. The fixing of the prices of energy products discourages private investment in the downstream sector. It is also noted that a large proportion of households in Nigeria does not have access to modern energy products despite the huge resources spent by government on energy subsidies. Over 60 percent of households in Nigeria still use traditional fuel for cooking and lighting. Low accessibility to energy products especially electricity and petroleum products has made a lot of Nigerians to lose confidence in successive governments.

The total energy demand, either with respect to the whole economy or to a specific sector, has received widespread attention in the last forty years as a result of the international oil crises of 1973 and 1979. Today, this topic is still of interest due to global warming, associated with greenhouse gases and their link to energy consumption. Previous studies which present a synthesis of previous works on total energy demand models are Ziemba et al (1980), Donnelly (1987) and Hawdon(1992).The quest for more accurate estimates of such key energy parameters is critical importance in the projection of future energy demand in particular, the energy market trends in general. Second is the role of these parameters in the design of policies for dealing with the negative environment externalities of the energy sector. Third is the fact that understanding energy demand dynamic through improve and robust estimates of energy demand parameters is essential for more informed and successful energy policy decision making and implementation. (Iwayemi, et 2007). The objective of this paper is to estimate petroleum products demand in Nigeria using random trend approach. Specifically compare the result of modelling the intercept as random trend with constant intercept model. To achieve this objective, this study applied the approach introduced by Hunt et al (2003) to model the intercept in petroleum product demand function as random trend. The last twenty years or so there has been an over-reliance on the co-integration technique, which is not always the right tool for the job of estimating energy demand function. Harvey (1997) states in general, the emphasis on unit roots, vector auto regression and co-integration has focused too much attention on tackling un-interesting problems by flawed methods. But this study will not dwell on that due to scope constraint. The structural time series model used to represent the random shift in demand relies only on a few parameters and yet it is quite general in the sense that it rests several well known models such as random walks, fixed trends or trends at all (Andrews 1999; Khalaf and Kichian, 2005).

The random trend model adopted to estimate price and income elasticity for petroleum products using aggregates and disaggregates approach using annual data covers 1980-2010. The specific products that considered are automotive gas oil (Diesel), premium motor spirit (petrol) and dual purpose kerosene (household kerosene) measured in tonnes per capita. The rest of this paper is organised into four sections. Following this introduction is section two. It features conceptual, theoretical and empirical issues. The research methodology is discussed in section three; Empirical result and analysis of regression results are contained in section four. Summary and some concluding remarks are including in section five.

CONCEPTUAL, THEORETICAL AND EMPIRICAL ISSUES

Since most macro variables are highly trended, deterministic trends are used in unit root tests and in the estimation of the models with cointegration techniques. The implication of allowing for deterministic trend is that if the model is shocked, after some departures from the trend, the variables would return to their trend values. Cointegration techniques ensure this by estimating the model so that the residuals are stationary. Therefore, shocks have no permanent effects on the trend in the equilibrium relationships. Ventosa-Santaularia and Gomez (2007) proved that it is incorrect to carry out standard hypothesis testing on the deterministic trend parameter estimated with Dickey-Fuller (DF)-type tests when there is a unit root since the limiting distribution of its t-statistic is neither asymptotically normal with unit variance nor nuisance-parameter-free when the innovations are not independent and normal distribution.The Cointegration approach can only accommodate a deterministic trend and deterministic seasonal dummies. In contrast Harvey (1997) argued that unless the time period is fairly short, these trends cannot be adequately captured by straight lines. In other words, a deterministic linear time trend is too restricting. Harvey suggests that time series models should incorporate slowly evolving stochastic instead of deterministic trends. Such models are known as the unobserved components models or structural time series models. Models with stochastic trends i.e., structural time series models are useful in some instances. Firstly, it may be hard to identify multiple structural breaks in the deterministic trend when the sample size is small. Secondly, in structural time series models, standard classical methods of estimation can be used to estimate the effects of additional explanatory variables (Rao 2007)

In standard economic models, individual decision-making is based on the assumptions of rational behaviour and self-interest, according to which individuals make choices that maximize their well-being or utility under the constraints they face. These assumptions are often supported by empirical evidence: people facing policy incentives will respond generally in a manner consistent with welfare maximisation. The main economic factors driving energy demand in households are prices and income. It is also known from basic economic theory that there is a close link between price elasticity and substitution possibilities. A household facing higher energy prices can typically use a whole array of different ways to lessen the impact of the price increase on their budget. Because these substitution possibilities vary across households the price elasticity's varies across the population. Therefore demand for energy is generally quite price-inelastic. Income is a key driver of energy demand, if the relative price of energy increases, the reductions of demand are expected (Huntington, H. 1987). Pricing will induce a change in consumption decisions. It is widely accepted among analysts that the quantity demanded of a good or service has an inverse relationship with the price. This general perception derives as much from common sense as from economic theory and basic data observation. Given the significance of this phenomenon, economists have developed a specific concept called price elasticity which measures the relative change (%) in quantity demanded for a good or a service, in response to a relative change (%) in price. Price elasticities can be useful for studying the expected demand growth of a good or service, and for analysing the impact of different government actions with respect to prices such as tariffs, taxes or consumption-related subsidies. The positive link between the consumption of a good or service and the income is also widely acknowledged. That is the relative change (%) in quantity demanded which results from a relative change (%) in the income.

Petroleum products demands like any other commodities are a multivariable relationship, that is it is determined by many factors simultaneously. The traditional theory of demand has concentrated on four of the determinants the price of petroleum products, price of other energy, income of the consumers and habit. The traditional theory of demand examines only the final consumers demand for durable and non durables. It is partial in its approach in that it does not examine the demand in other markets. The serious difficulties that associate with such estimating function are the aggregation of demand over individual and over commodities makes the use of index numbers inevitable. Furthermore, there are various other estimation problems which impair the reliability of the statistically estimated demand functions. The most important of these difficulties arise from simultaneous change of all determinants, which makes it extremely difficult to assess the influence of each individual factor separately. However, there has been a continuous improvement in the economic technique.There is a considerable economic literature on energy demand. Although the first empirical papers can be traced back to the 1950s, the energy crises of the 1970s led to a subsequent larger interest .One of the most comprehensive surveys of energy demand modelling was prepared by Douglas R. Bohi (1981) for the Electric Power Research Institute. (EPRI). The overall purpose of the study was to examine price elasticities, the study is an excellent overview of demand modelling since price elasticities are usually output derived from an overall analysis of demand determinants. An update of this study was prepared in 1984 by Bohi and Zimmerman. Madlener (1996) attempts to update the earlier Bohi work, as well as breaking the existing econometric literature into a number of useful different categories. These include studies associated with log-linear functional forms, transcendental logarithmic (translog) functional forms, qualitative choice models (also known as discrete choice models), household prod uction theory (end-use modelling) and pooled time series – cross sectional models. A first general approach consists of estimating the energy using aggregate demand analysis model on prices and income (GDP) and climate conditions (Narayan and Symth 2005; Hondroyians 2004). The second group uses micro economic data to estimate the demand for energy goods (Hanemann 1984; Bernard 1996; Baker 1995 and Vaage 2000). Allowing some additional explanatory variables as the stock of durable goods (heating systems stock of electric appliances, etc) housing (size, age of house, insulation etc) and household characteristic (number of members age, income etc).Though literature has a long standing on energy demand; there is still a paucity of research on energy demand in Africa and Nigeria in particular. Previous studies have concentrated on aggregate approach. Also the fact that some of these studies have been done long ago makes a new study in this area very imperative. In addition the review studies focus on cointegration approaches.

Iwayemi et al (2007) using multi variable cointegration approach for 1977 to 2006 annual data confirm the conventional wisdom that energy consumption responds positively to changes in GDP and negative respond to change in energy price. Gasoline has the highest long run income elasticity followed by total energy demand. The lowest long run income elasticity has recorded by diesel in absolute terms. In similar run, kerosene has the highest long run price elasticity followed by diesel in absolute term. Onwioduokit and Adenuga (1998) employed cointegration techniques to estimate elasticities for proportions of GDP contributed by agriculture, manufacturing and services. Their empirical findings reveal that urbanization was one of the principal factors that have a positive impact on the consumption of liquefied petroleum gas and premium motor spirit. De vita et al., (2006) using database of end-user local energy data and Auto Regressive Distributive Lag (ARDL) bound testing approach to cointegration to estimate the long-run elasticities of Namibian energy demand function at both aggregate level and by type of energy (electricity, petrol and diesel) for the period 1980 to 2002, their result shows that energy consumption respond positively to GDP and negatively to price and temperature. However, previous studies in Nigeria do not model intercept as random trend. As a consequence, the price effects obtained may not be accurate and may lead to a wrong assessment on the effectiveness and costs of energy policies.Thus create an important gap to be filled in this study.

RESEARCH METHODOLOGY

The Structural Time Series Model (STSM) is adopted in this study, since it is consistent with interpretation of the underlying Energy Demand Trend (UEDT). In particular, it allows for time estimation of a non-linear UEDT that can be negative, positive or zero over the estimation period.

The Model

Let us consider the following petroleum products demand model which can be derived from the partial adjustment framework.

$$X_t = U_t X_{t-1}^{a_1} + XP_t^{a_2} + Y_t^{a_3} e^{\varepsilon_t} \qquad (1)$$

Where e = limit of $\left(1+\left(\frac{1}{n}\right)^{n}\right)$ as n approaches infinity and all other variables are as defined below.

The log transformation of equation (1) gives

$$\ln X_t = \ln U_t + a_1 \ln X_{t-1} + a_2 \ln XP_t + a_3 \ln Y_t + \varepsilon_t \qquad (2)$$

Following from equation (2) we generate equation (3), (4) and (5) for the three petroleum products, therefore we have

MODEL I: Automotive Gas Oil (AGO)

$$\ln AGOC_t = U_t + a_1 \ln AGOC_{t-1} + a_2 \ln P_t AGO + a_3 \ln Y_t + \varepsilon_t. \qquad (3)$$

MODEL 2: Premium Motor Spirit (PMS)

$$\ln PMSC_t = U_t + a_1 \ln PMSC_{t-1} + a_2 \ln P_t PMS + a_3 \ln Y_t + \varepsilon_t. \qquad (4)$$

MODEL 3: Dual Purpose kerosene (DPK)

$$\ln DPKC_t = U_t + a_1 \ln DPKC_{t-1} + a_2 \ln P_t DPK + a_3 \ln Y_t + \varepsilon_t. \qquad (5)$$

The variables are defined as follows:

X_t = aggregate petroleum products consumption

XP_t = Weighted average petroleum product real price.

Y_t = Real GDP per Capita

PMSC = Premium Motor Spirit Consumption

AGOC = Automotive gas oil consumption

DPKC = Dual purpose kerosene consumption.

PAGO = Real Price of automotive gas oil

PPMS = Real Price of premium motor spirit

PDPK = Real Price of dual purpose kerosene

U_t = random trend

ϵ_t.= random error term

a_1, a_2, a_3 are structural parameters of interest.

The random error term ε_t is assumed to be normally and independently distributed (NID) with mean 0 and variance σ^2_ε.

Following Hunt et al. (2003) the random trend is assumed to evolve according to the following stochastic process:

$$U_t = U_{t-1} + \beta_{t-1} + n_t \quad \text{and} \quad n_t \sim \text{NID } (0, \sigma^2_n.) \qquad (6)$$

$$\beta_t = \beta_{t-1} + \varepsilon_t \quad \text{and} \quad \varepsilon_t \sim \text{NID } (0, \sigma^2_\varepsilon.) \qquad (7)$$

Equation (6) represents the level of the trend and equation (7) represents its stochastic slope. This is a general and yet parsimonious parametric specification of an evolving random trend. Several well known cases are subsumed under equation (6) and (7) according to the values that are taken by $\mu_0, \beta_0, \sigma_n^2$ and σ_ε^2.

If $\beta_0 = 0, \sigma_\varepsilon^2 = 0$ and $\delta_n^2 \neq 0$ we have random walk. If $\beta_0 \neq 0$, σ^2_ε=0 and $\sigma^2_\varepsilon \neq 0$, we get constant trend. Once the influence of fundamental variables such as energy price, income and other explanatory variables have been taken into account, which is known about how energy intensity is evolving over time as a result of technological change in particular. The model specified here is quite flexible and impose no constraint on the speed and the level of adjustment as we encounter in models with a constant trend as no trend at all.

The log linear model with lag dependent variables with or without a constant trend has been used extensively to model petroleum product demand. The introduction of the lag structure is an ad hoc way of taking into account the fact that stock of energy using equipments is adjusting slowly overtime in response to various factors including energy prices (Walkers and Wirl, 1993; Arsenault et al., 1995;Gately and Huntington,2002; Griffin and Schulman 2005).

The solution to equation (7), for example is

$$\beta_1 = \beta_0 + \sum_{i=1}^{t} \varepsilon_t$$

Where β_o is initial value of this parameter.

The important point to note is that random shocks have a permanent effect on slope parameter. A similar interpretation can be given to equation (6) where random shocks have permanent effects on the level of trend. Note that both parameters evolve over time and capture the cumulative effects of the two random shocks n and ε. If the variances of these error terms one zero i.e. $\sigma_n^2 = 0$ and $\sigma_\in^2 = 0$, they are no more stochastic shock and the trend becomes deterministic. The equation to be estimated therefore consist of equation (3) with (4) (5) (6) and (7). All the disturbance term are assumed to be independent and mutually uncorrelated with each other. The hyper parameters have an important role to play and govern the basic properties of the model. The hyper parameters, along with the model are estimated by maximum likelihood and from these the optimal estimates of β_t and U_t are estimated by the Kalman filters which represent the latest estimates of the level and slope of the trend.

The optimal estimates of the trend over the whole sample period are further calculated by the smoothing algorithm of the Kalman filters. For model evaluation, equation residuals are estimated (which are estimates of the equation disturbance term, similar to those from ordinary regression) plus a set of auxiliary residuals include smoothened estimates of the equation disturbances (known as the level residuals) and smoothened estimates of the slope disturbance (known as the slope residuals). Further, to avert the problem of 'spurious regression', the time series characteristics of the variables using the Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and Phillips-Perron (P-P) tests were first examined. Basically, the idea is to ascertain the order of integration of the variables as to whether they are stationary I(0) or non-stationary; and, therefore, the number of times each variable has to be differenced to arrive at stationarity.

The standard DF test is carried out by estimating the following;

$$y_t = \rho y_{t-1} + x_t^{'}\delta + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

After subtracting y_{t-1} from both sides of the equation:

$$\Delta y_t = \alpha y_{t-1} + x_t^{'}\delta + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where $\alpha = \rho - 1$

The null and alternative hypotheses may be written as:

$H_0 : \alpha = 0$

$H_1 : \alpha < 0$

The simple Dickey-Fuller unit root test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances ε_t is violated. The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the y series follows an AR(P) process and adding P lagged difference terms of the dependent variable y to the right-hand side of the test regression:

$$\Delta y_t = \alpha y_{t-1} + x_t^{'}\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots \beta_p \Delta y_{t-p} v_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

The usual practice is to include a number of lags sufficient to remove serial correlation in the residuals and for this; the Akaike Information Criterion is employed.

Phillips and Perron (1988) propose a non-parametric alternative method of controlling for serial correlation when testing for a unit root. The P-P method estimates the non-augmented DF test equation (9), and modifies the t-ratio of the α coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$t_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0}\right)^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{\frac{1}{2}} s} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Where $\hat{\alpha}$ is the estimate, and t_α the t-ratio of α, $se(\hat{\alpha})$ is the coefficient standard error, and s is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance in equation (9) (calculated as $(T - K)s^2$ where k is the number of regressors). The remaining term, f_0, is an estimator of the residual spectrum at frequency zero.

EMPIRICAL RESULTS

Table 1: Descriptive Statistics of Petroleum Products

STATISTICS	CAGO	CDPK	CPMS	PAGO	PDFK	PPMS
Mean	1018627.22	1422992.50	4228338.20	1060.39	949.77	1100.78
Minimum	256158	686719	1861618	0.11	0.15	0.153
Maximum	2368115	2161368	8644263	7800	6950	6500
Std. Dev	694380.59	379318.01	1610653.82	1774.87	1635.48	1635.33
Observation	30	30	30	30	30	30

Source: Author computation

Table 1 above shows the consumption of AGO as ranging from the lowest value of 256,158 metric tonnes to 2,368,115 metric tonnes with a mean value of 1,018,627.22 metric tonnes. DPK exhibits a mean value of 1,422,992.5 metric tonnes, while the mean consumption of PMS, for the sample period is 4,228,338.20 metric tonnes. .

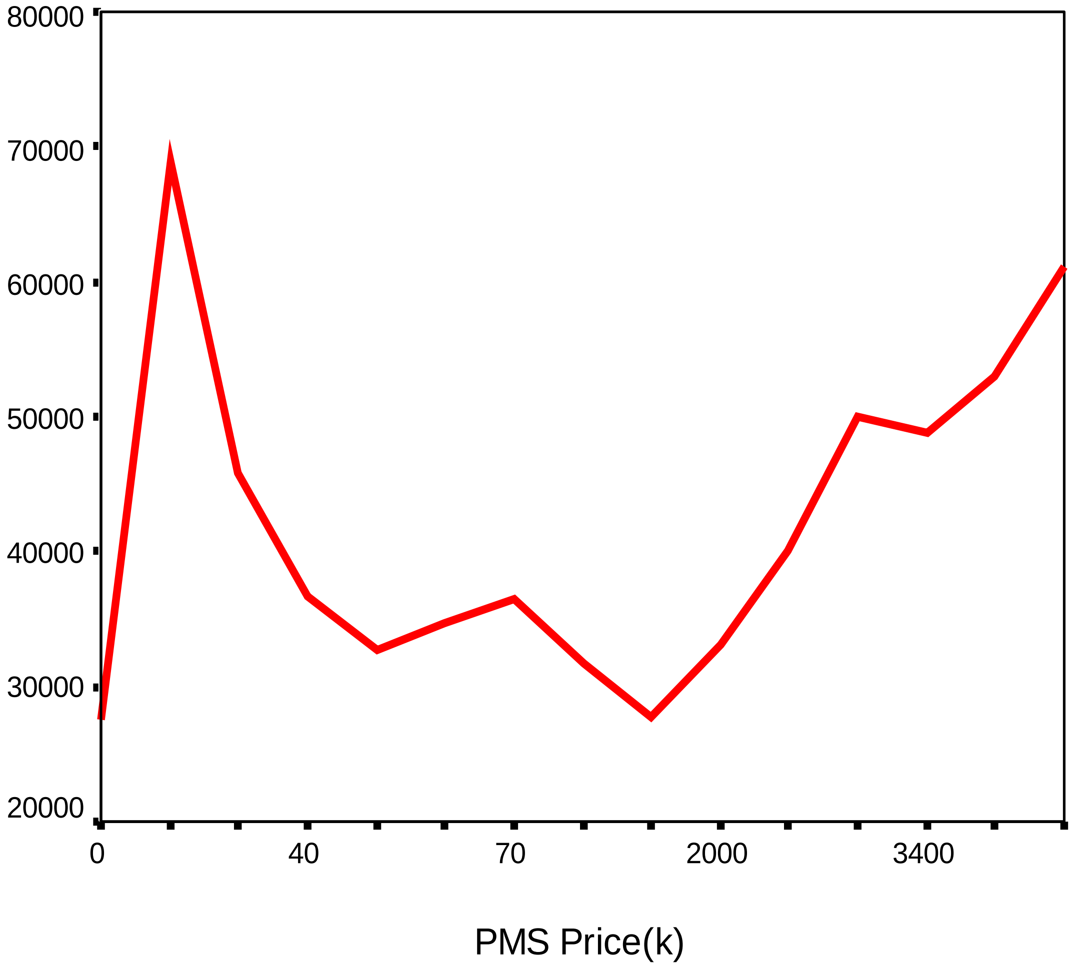
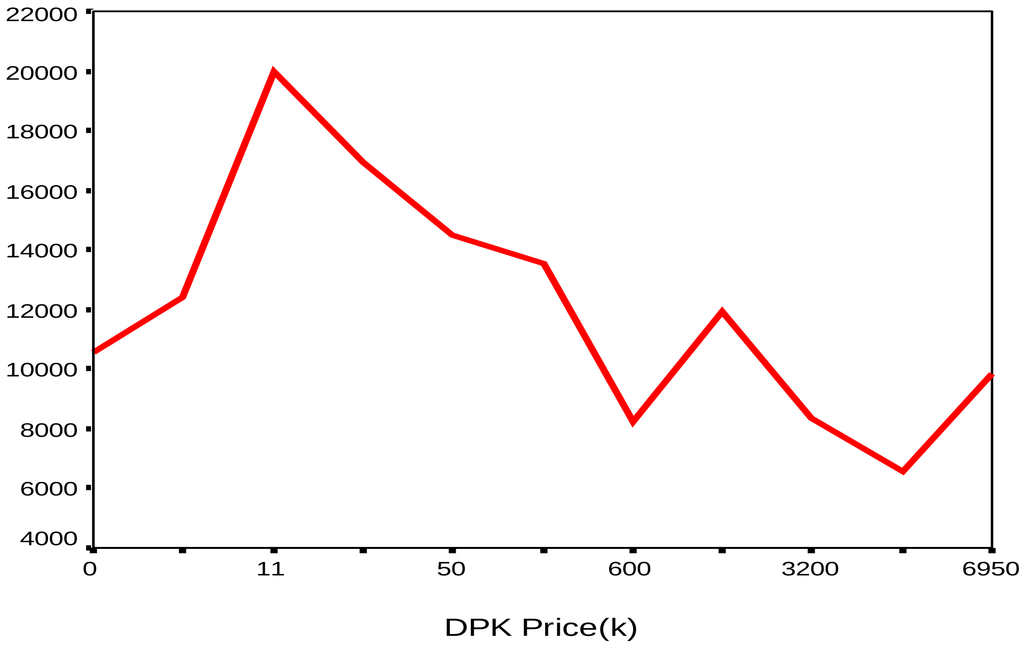


Figure 1: Trends of per capita Premium Motor Spirit Consumption

Source: Author computation using E-view 7



Kerosine Consumption

Figure 2:Trend of Per Capita Dual Purpose

Source: Author computation

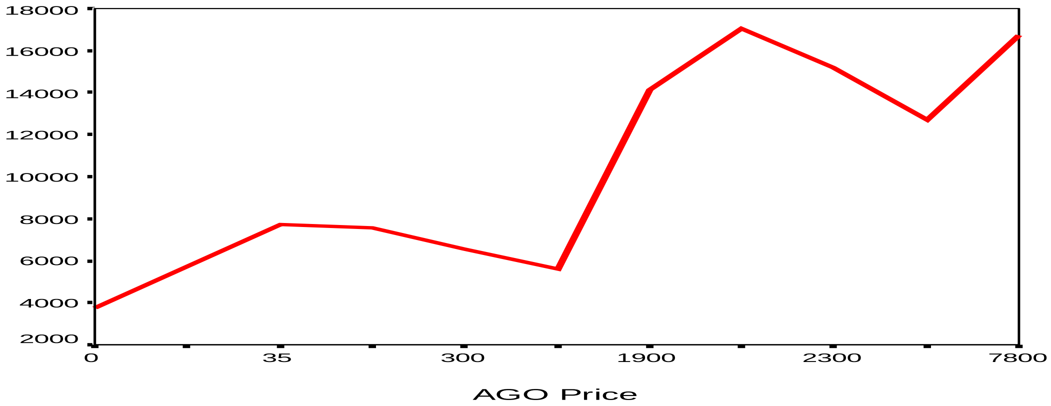


Figure 3: Per Capita Consumption of Automotive Gas Oil

Source: Author computation

It can be seen in the above figures that the trend of per capita consumption of PMS rose for the period 1977 to 1980, after which it fell to up to 1999 and an upward drift is noted for the remaining period. This is coherent with the fact that epileptic power supply has made a lot of people to purchase power generating plant that is using petrol engine since cost of diesel is high. It can also be as a result of rising income which led to massive importation of fairly used vehicles with high consumption of fuel. Overall, the per capita consumption of dual purpose kerosene (DPK) is decreasing over the sample period. This decrease in consumption could be as a result of substituting household gas (LPO) for kerosene due to increase in income of the consumers. It can also be linked to the fact that a lot of low income earners that cannot afford the high cost of kerosene have changed to traditional fuels like charcoal, fuel wood and sawdust. Finally, improved industrialisation activities have led to increased per capita consumption of automatic gas oil due to incessant power supply.

Stationarity Test

The time series behaviour of each of the series is presented in Table 2 below, using the ADF and P – P tests.

Table 2: Unit Root Tests

Variable	ADF	P – P	Decision
DLnPCRGDP	-2.0260	-2.2308	I (1)
DlnPCAGO	-1.7645	-1.5963	I (1)
DLnPCDPK	-2.1078	-2.1427	I (1)
DLnPCPMS	-2.3600	-2.5035	I (1)
DLnRPAGO	-2.1705	-1.8217	I (1)
DLnRPDPK	-1.5712	-1.8217	I (1)
DLnRPPMS	-2.3983	-1.9947	I (1)
Critical values 1% = -3.6892 5% = 2.9719		Critical values 1% = -3.6892 5% = 2.9719	

Source: Author computation

The results presented in table 2 above depicts that all the variables are homogenous of order one. Therefore, they are made stationary by first difference prior to subsequent estimations to forestall spurious regressions.

Random Trend Model

Table 3 shows the estimation results; for the sake of comparison we also present in table 4 the estimation results for the model with constant intercept. Although the no trend model is nested within the more general stochastic trend. We cannot apply the standard log-likelihood ratio test procedure to determine whether there is a statistically significant difference between the random trend and no trend model. The random trend model collapses to the no trend model at the boundary of the admissible parameter space. i.e. σ^2_n and $\sigma^2_\varepsilon \geq 0$ but when σ^2_n and σ^2_ε are zero, the distribution of U_t and B_t become degenerate (Bernard et, 2005).

The estimate of σ^2_n and σ^2_ε are extremely small, while the estimate of σ^2_ε is relatively larger and of the same wide of magnitude as the estimate of σ^2_ε in the no trend model, so most of the randomness that emerges is captured by the slope of the random trend which is itself a random walk.

Table 3: Petroleum products Demand: Random Trend

	Kerosene (DPK)	Diesel (AGO)	Petrol PMS
Lagged of Dep. Variable	0.1874 (3.8034)**	0.22812 (0.1466)	0.0970 (2.0408)*
Income	0.4095 (2.5248)**	1.5607 (93.6789)**	0.1665 (5.211)**
PDPK	-0.01266 (-2.4436)*		
PAGO		-1.01064 (-113.4540) **	
PPMS			-0.0156 (-9.4580)*
σ^2_η x10^{-12}	2.10	1.20	3.10
σ_ε^2	0.0052	0.00012	0.00062
σ^2_e x10^{-12}	1.32	1.626	4.06
Log-likelihood	324.7497	287.5434	7.12

Note: t-values in parentheses and * (**) Significant at 0.05 (0.01)

Source: Author computation

Table 4: Petroleum Products Demand: No Trend

	Kerosene (DPK)	Diesel (AGO)	Petrol PMS
Constant	-0.0039 (-0.6040)	0.0052 (0.7905)	0.00005 (0.0110)
Lagged of Dependent Variable	0.5315 (4.5701)**	0.6653 (53.2701)**	0.2138 (1.0486)
Income	0.0727 (0.9343)	0.0228 (10.3027)*	0.0622 (21.1099)**
PDPK	-0.0074 (-1.4105)		
PAGO		-0.0056 (-4.1258)*	
PPMS			-0.0080 (-2.3859)*
σ^2_e	0.001	0.010	0.0005
Log-likelihood	59.403	56.911	67.66

Note: t-values in parentheses and * (**) Significant at 0.05 (0.01)

Source: Author computation

The effect of modelling the intercept as a random trend is to lower the estimate of the coefficient of the lagged dependent variable and to enhance the effects of economic variables; this is particularly the case for the income effect. The random trend has some in-built effects and it can vary from year to year, this reduces the role played by the lagged dependent variable and leaves more room for the fundamental economic variables. The p-values of the co-efficient estimates of lagged dependent variable are lower than 5% in all petroleum products except for kerosene in while they are all very small for income and product prices, except for per capita real income of diesel in the long-run.

The Short Run and Long Run Elasticity of the Estimates for The Random and No Trend

Table 5 shows the short run and long run price and income elasticities estimates for the random trend and the no trend models.

Table 5:Demand Elasticities

	DIESEL (AGO)		KEROSENE (DPK)		PETROL (PMS)	
	S.R	L.R	S.R	L.R	S.R	L.R
RANDOM TREND						
PRICE	-0.0106	-0.1270	-0.0127	-0.0132	-0.0106	-0.0126
INCOME	1.5607	2.0138	0.4095	4.0180	0.1665	0.5133
NO TREND						
PRICE	-0.0056	-0.0077	-0.0074	-0.0112	-0.0080	-0.0110
INCOME	0.00228	0.0057	0.0727	0.1702	0.0622	0.2360

Source: Own estimation

According to commonly used statistical criteria, the results are satisfactory. The estimates of price and income coefficients are acceptable as their sign satisfy a priori theoretical expectation. The lagged dependent variables are significant. It takes a value between zero and one indicating the stability of dynamic adjustment

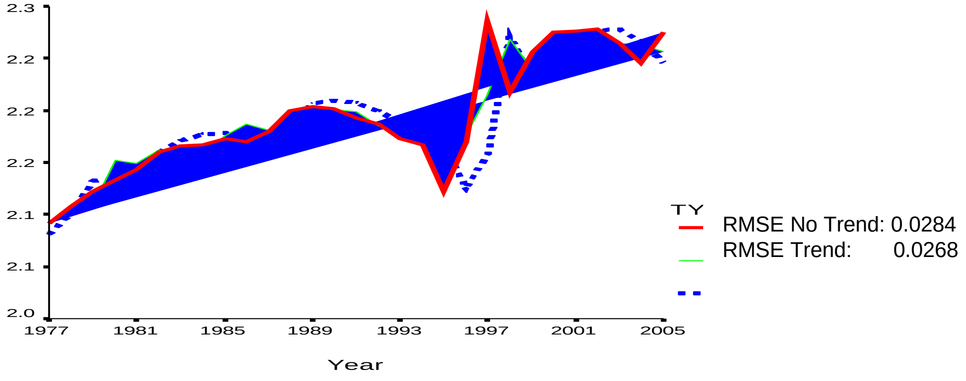


Figure 4: Within Sample Forecasts (AGO)

Source: Own estimation

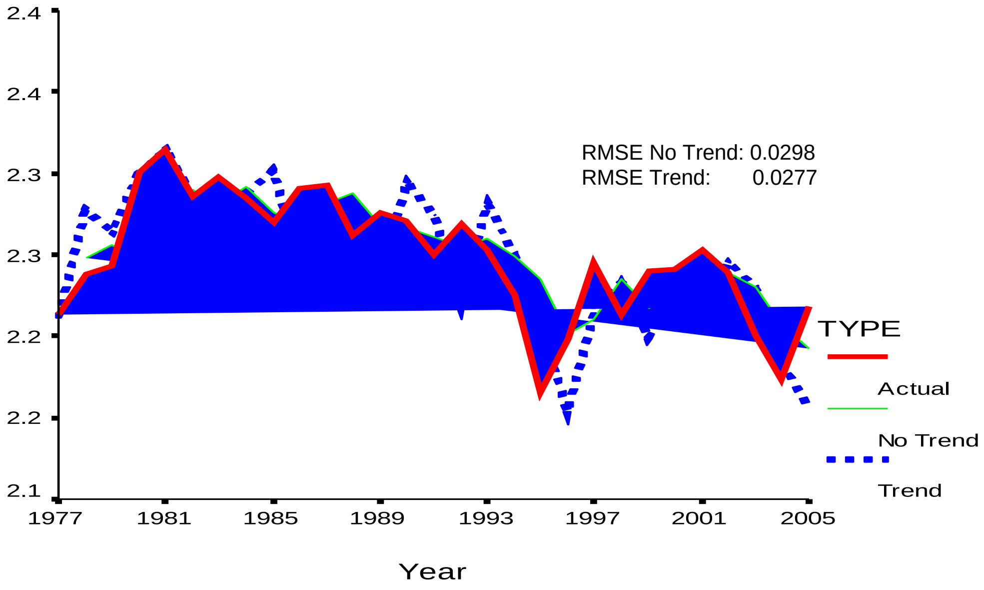


Figure 5: Within Sample Forecasts (DPK)

Source: Own estimation

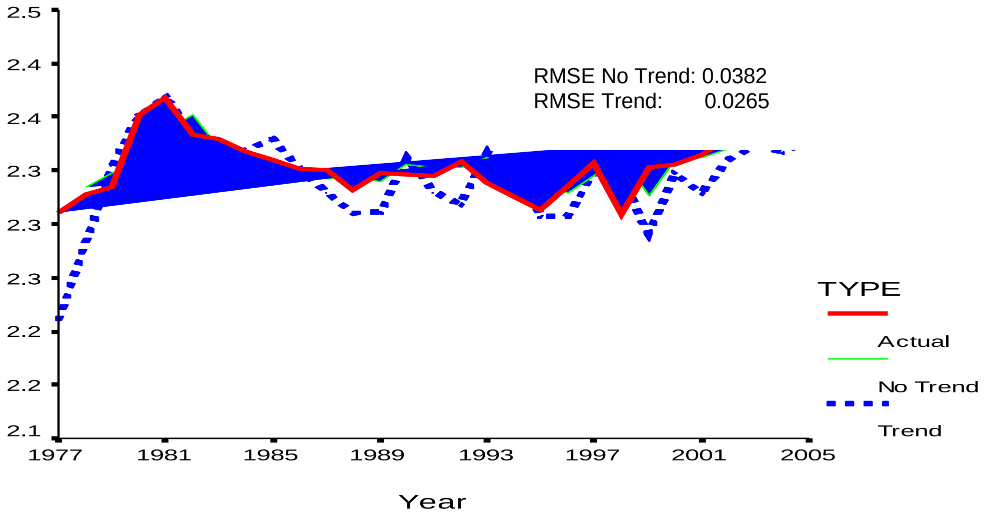


Figure 6: Within Sample Forecasts (PMS)

Source: Own estimation

The above figures (4 to 6) show within sample forecasts on the basis of parameter estimates of random trend and no trend model. It can be seen that the random trend model parameter estimates yield a closes fit in all the three petroleum products, this is also corroborated by its lower Root Mean Square Error (RMSE) in all the forecasts. The estimated model is mainly used for forecasting. To evaluate the model's forecasting ability. This study considers trend and no trend model of random approach and estimate the root mean square error (RMSE). The random trend model parameter estimate yield a closes fit in all the three petroleum products. This is also corroborated by its lower root mean square error (RMSE) in all forecasts. For forecasting purposes, in an ideal forecasting model, RMSE would be the smallest possible, i.e. the relative forecasting error should be the lowest possible. The estimates of this co-efficient are extremely small in random trend model for all the three petroleum products. This mean the random trend model forecast well.

The price and income elasticity estimates of the random trend model are statistically different from zero at the 5% significance level in long-run and short-run. For the no trend model, the price elasticity estimates of premium motor spirit (PMS) and automotive gas (AGO) are statistically different from zero at 5%. In the long-run, only the income of automotive gas oil (AGO) is not statistically different from zero. All the income and price elasticities estimate of random trend model are larger than those of no trend model.It can be observed in the random trend model that, the long run price elasticities for diesel is -0.1270 while corresponding long-run income elasticities is 4.0180. Also, the long-run income elasticity for gasoline is 2.0138. These estimates are higher than those reported by Iwayemi et al (2007). They found long-run income elasticity (0.100) and long-run price elasticity of 0.108. In Onwiodukit and Adenuga (1998), diesel has the highest long-run income of 1.96 and gasoline has the highest long-run price elasticity (-0.86).

In this study, Diesel has the highest long-run price elasticity (-0.1270) and income elasticity (4.0780). This really different from results obtained in the study conducted by Iwayemi et al. (2007) in which diesel has lowest long-run income elasticity of -0.100.The long-run income elasticity for kerosene estimated in this study is very close to those reported in Iwayemi et al. (2007). The differences recorded in the magnitude of these studies may be attributed to differences in the methodology adopted. The random trend process has memory and this tend to decrease the role of lagged dependent variable and give more room for fundamental economic variable especially income. This may account for high income elasticities obtained in this study.

The price elasticities for gasoline and kerosene are lower than those reported in Iwayemi et al (2007). This can also be attributed to methodology adopted (STSM) which incorporate "Technical progress". The higher price elasticities reported in Iwayemi et al (2007) and Onwiodukit and Adenuga (1998) can be attributed to failure to incorporate technical progress in their model. According to Hunt et al. (2003) the failure to incorporate technical progress will results to an over estimation of the price elasticity.

SUMMARY AND CONCLUSIONS

The major findings of the study can be summarized as follows: modelling the intercept as a random trend reduces the role of the lagged dependent variable and augments the effects of fundamental economic variables such as price and income. As a result, income elasticities of petroleum products demands are higher in the short run and long run relative to no trend approach. The random trend displays an upward drift in the consumption of premium motor spirit (PMS), and automotive gas oil (AGO) but a downward one in the consumption of dual purpose kerosene (DPK). The random trend process has memory and this tend to decrease the role played by the lagged dependent variable and leave more room for income as an explanatory variable. The introduction of a random trend leads to improvement in the mean square error of within sample forecasts.

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