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Forecasting the Demand for Petroleum Products: A Guide to Long Term National Strategic Planning in Ghana

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Abstract: Forecasting is the process of using the patterns contained in past data to predict future values. Forecasts are numerical estimates of the future levels of sales, demand, inventories costs, imports, exports and prices among others; for a firm, an industry, a sector of the economy, or the total economy. The objective of forecasting is to assist management to plan requirements for marketing efforts, materials, personnel, production, services, capital acquisition, construction and finances. The data for the petroleum products were obtained from National Petroleum Authority (NPA) and that of inflation rates as well as the exchange rates were obtained from Ghana Statistical Service (GSS). The data were analysed using statistical software such as Minitab, Excel or SPSS. The main approach to the analysis was exploratory data analysis. Various techniques in times series such as moving averages, exponential smoothing etc were used to model and forecast the demand for Petroleum Products from 1999 – 2007 and also how inflation, exchange rates, population etc may impact on the economy of Ghana. Two Econometric models were actually developed and comparison with regard to their R2, Adjusted R2, t-statistics were made using non-natural and natural logarithms for the models. Based on the analysis carried out it was found out that, the best model to be used in forecasting was the model without the natural logarithms. Another finding that came to light was that, some of the independent variables were not quite significant which might impact on the demand for the various petroleum products when analysing with respect to the their R2 and t-statistics values. The results of the R2, Adjusted R2, Predicted values clearly again showed that LPG was the petroleum product which was more demanded, followed by the Gasoil etc. The study also revealed that, Inflation, Exchange Rate, Expump Price and Urban Population could affect the demand for the various product and consequently on the Economy of Ghana. From the study, the irregular nature of the variation of the demand for the petroleum products may be attributed to the problem of under production therefore; there is the need to step up production in order to ensure constant supply of the products for economic activities to be pursued.

Keywords: Forecasting; Strategic planning; Demand; Guide; Petroleum products.

1. Introduction

Forecasting is the process of using the patterns contained in past data to predict future values. Forecasts are numerical estimates of the future levels of sales, demand, inventories costs, imports, exports and prices among others; for a firm, an industry, a sector of the economy, or the total economy. The objective of forecasting is to assist management to plan requirements for marketing efforts, materials, personnel, production, services, capital acquisition, construction and finances. Wise educated and well – prepared forecasts should be accurate enough to allow for better planning and control that could not be accomplished without the forecast. Thus, forecasting is the making of projections about future performance based on historical and current data. It is the process of analyzing current and historical data to determine future trends. Demand forecasting is one of the main inputs when developing long-term strategic plans. There are several forecasting techniques and among these are moving averages and exponential smoothing methods, regression models, advanced time series methods of filtering and Box-Jenkins procedures the Delphi Technique and qualitative forecasts (Jeffrey, 1991). Petroleum product forecast is the estimation of the amount the petroleum products such as the LPG, Gasoil, Premium, Kerosene, Premix, Fuel oil etc being distributed by the Tema oil refinery (TOR) in collaboration with National Petroleum Authority (NPA). Forecasts therefore project the amount of petroleum products that will be demanded or needed over a certain period

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and beyond. Thus forecasts mainly look at petroleum products requirements from 1999-2007 and beyond. A demand forecast is a prerequisite when planning how much new generation capacity may be needed, which generation resources are applicable, and which distribution systems of the petroleum products should be expanded, and also the way and manner the rate of inflation, exchange rates, prices and population may impact on the economy of Ghana. In this research, forecasting demand models were developed by analyzing the trend of the monthly time series of petroleum products from 1999-2007, to examine how exchange and inflationary rates, population etc may impact on the demand for petroleum products in the economy of Ghana.

2. Theoretical Issues

2.1. Definition of Forecasting

Forecasting is the making of projections about future performance based on historical and current data. It is the process of analyzing current and historical data to determine future trends. Demand forecasting is one of the main inputs when developing long-term strategic plans. There are several forecasting techniques and among these are moving averages and exponential smoothing methods, regression models, advanced time series methods of filtering and Box-Jenkins procedures the Delphi Technique and qualitative forecasts (Jeffrey, 1991).

2.3. Time Series

Time series methods are statistical techniques that make use of historical data accumulated over a period of time. They assume that what has happened in the past will continually reoccur in the future. Thus, a time series represents a variable observed across time. The time increment can be years, quarters, months, or even days. This long-term movement in the time series is called a trend. The trend (TR) is a steady increase or decrease in the time series. If a particular time series in neither increasing nor decreasing over its range of time, then it contains no trend. The trend reflects any long-term growth or decline in the observations. For example, a trend may be due to inflation, exchange rates, increases in population, increases in personal income, market growth or decline, or changes in technology. Each of these factors could have a long-term effect on the variable of interest and would be reflected in the trend in the corresponding time series. This long-term growth or decay pattern can take a variety of shapes. If the rate of change in Y from one time period to the next is relatively constant, the trend is a linear. Thus we have a trend:

$$TR = b_o + b_1 t \quad \text{-----------(1)}$$

(for some b_0 and b_1) where the predictor variable is t

When the time series appears to be slowing down or accelerating as time increases, then a nonlinear trend may be present. It may be a quadratic trend.

$$TR = bo + b_1 t + b_2 t^2$$

or a decaying trend

$$TR = b_0 + b_1 \left(\frac{1}{t}\right) \quad \text{-----------(2)}$$

$$\text{Or} \quad TR = b_0 + b_1 e^{-t} \quad \text{-------------(3)}$$

Forecasting using time series data has both advantages and disadvantages. The primary advantage of using time series analysis is that often one can describe his variable of interest, Y, by using only a sample of past observations. Inherent to this type of forecasting procedure is the assumption that past patterns will continue into the future. The disadvantage of time series forecasting is that the past observations often contain patterns that are difficult to extract and, as a result, the models can become very complex (Su Dongsui, 2000).

The linear trend equation is an application of simple linear regression, whereas the quadratic trend uses a multiple regression using two predictors, t and t^2. For the purposes of our study the time series method to be adopted would be the moving averages and exponential smoothing.

2.4. Moving Averages

Forecasting time series by the method of moving averages involves calculating the average of the sample observations and then employing that average as the forecast for the next period. The number of sample observations included in the calculation of the average is specified at the initiation of the forecasting process. We use the term moving average because as each new sample observations become available a new average is calculated by dropping the oldest sample observation and the newest one. As each new average is calculated, it becomes the forecast for the next period and the process continues.

Let us consider the set of observations $x_1, x_2, x_3\ldots$, we define moving totals of order n by the sums $x_1 + x_2 + \ldots + x_N$, $x_2 + x_3 + \ldots x_3 + x_4 + \ldots x_{N+2}, \ldots$ and moving averages of order n by the sequence of arithmetic means.

$$\frac{x_1 + x_2 + \ldots + x_n}{n}, \frac{x_2 + x_3 + \ldots + x_{n+1}}{n}, \frac{x_3 + x_4 + \ldots x_{n+2}}{n}$$

The moving average method is stated algebraically as follows:

$$F_{t+1+} = \frac{x_1 + x_{t-1} + \ldots + x_{t-n+1}}{n}$$

$$= \frac{1}{n}\left(\sum_{t=t-n+1}^{n} x_t\right)$$

Where t is the most recent observation and t + $_1$ is the next period. This formula requires that the forecaster has the values of the past n observations. Appling the concept of adding a new observation and dropping the oldest observation, we can restate the formula as

$$F_{t+1} = \frac{1}{n}\left(\sum_{i=t-n}^{t-1} x_i\right) + \frac{1}{n}\left(x_t - x_{t-n}\right)$$

$$= F_t + \frac{x_t}{n} + \frac{x_{t=n}}{n}$$

Thus, the formula for the moving average is simply an adjustment of the forecast F_t in the previous period. Obviously F_t in the previous period. Obviously, if n is increased, the smoothing effect becomes greater because a much smaller adjustment is made for each new time period.

2.5. Exponential Smoothing

As a result of limitations to the use of moving averages, exponential smoothing is a method that simplifies forecasting calculations and has small data requirement. Unlike moving averages, this technique uses all the proceeding observation to determine smoothed value for a particular time period. Thus, the exponential smoothing technique is also a method that weighted the recent data more strongly than old data. It is one of the most successful forecasting methods and may be modified efficiently for use with data that have trend and seasonal patterns (Russell and Taylor, 2003). The larger the weight given to the recent data, the more sensitive the forecast will be a recent demand but provides a smaller amount of smoothing. Double exponential smoothing technique (Holt's exponential model) adds a trend factor to the smoothing equation in the linear smoothing. The equations used in adjusted (double) exponential smoothing technique may be written as:

$L_t = \alpha D_t + (1 - \alpha) (L_{t-1} - T_{t-1})$ Smoothed demand level value for period t
$T_t = \beta (L_t - L_{t-1}) + (1 - \beta) T_{t-1}$ Smoothed demand trend value for period t
D_t = actual demand value in period
Forecast value for period (t + m) is given by
$F_{t+m} = L_t + T_t$ xm.
The two smoothing parameters α and β should be positive and less than or equal to one. The Holt-Winter technique is an extension of the Holt's model and uses an additional equation to estimate the seasonal component of the time series.

2.6. Evaluation of Error in Forecasting

The error in period t was defined as the actual value X_t less the predicted value F_t: Thus,
$E_t = X_t - F_t$

An examination of the error in forecasting permits the forecaster to evaluate whether the technique accurately mirrors the pattern exhibited in the sample observations. One generally accepted technique for evaluating exponential smoothing (and many other) techniques is the mean square error (MSE).

$$\text{MSE} = \frac{\sum(e_t)^2}{n} = \frac{\sum(x_t - F_t)^2}{n}$$

This measure defines error as the sum of square of the forecast errors e_t, divided by the sample size, that is, the number of forecast periods. The relatively wide range of MSE values indicates the important role of α in exponential smoothing Root Mean Square (RMS) in defined as the square root of MSE. Thus,

$$\text{RMS} = \sqrt{\frac{\sum(e_t)^2}{n}}$$

A third method for calculating forecast error, is the mean absolute percentage error (MAPE), is based on the assumption that the severity of error is linearly related to its size. It is defined by

$$\text{MAPE} = \frac{\frac{\sum|e_t|}{t}}{n} \times 100\%$$

$$= \frac{1}{n}\left(\frac{\sum|e_t|}{t}\right) \times 100\%$$

As a measure of forecast error, MAPE is less valid than either MSE or RMS.

2.7. Adaptive-Response-Rate Single Exponential Smoothing

Since specification of the smoothing constant is a problem associated with exponential smoothing, a method that does not require specification of α has a distinct advantage. Adaptive-response-rate single exponential smoothing (ARRSES) is attractive when a great many items have to be forecast. By the term "adaptive", we mean that this method can change the value of an unspecified α on an ongoing basis, requiring a different smoothing constant. Thus, the ARRSES forecasting is given by

$$F_{t+1} = \alpha x_t + (1-\alpha) F \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

$$\alpha = \left|\frac{E_t}{M_t}\right| \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$E_t = \beta e_t + (1-\beta) E_{t-1} \ldots\ldots\ldots\ldots\ldots.. (3)$$

Is the smooth error

$$M_t = \beta \,|\, e_1 \,|\, + (1-\beta) M_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Is the absolute smoothed error

$$e_t = x_t - F_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

is the error factor.

Note that equation (1) indicates that the forecast F_{t+1} is a linear combination of the previous period's observed value and forecast. The smoothing constant is the absolute value of E_t, divided by M_t. E_t is a linear combination of the forecaster error (e_t) and the smoothed error e_{t-1} in the previous period M_t is the absolute smoothed error and is linear combination of the forecast error and the absolute smoothed error in the previous period. Generally, β is assigned the value 0.2, indicating that in equation (3) and (4) the first term is given a much smaller weight than the second term. With β = 0.2, the second term is given four times importance.

2.8. Brown's Linear Exponential Smoothing

This method provides an additional correction similar to that of linear moving averages. In this method, the difference between single and double smoothed values is added to the single smoothed value and adjusted for the pattern in the data. The equations for these adjustments are: The smoothing equation is

$$S_{t+1} = \alpha\, X_{t-1} + (1-\alpha) S_t \text{ - First Smoothing}$$

$$S^I_{t+1} = S_{t+1} + (1-\alpha) S_t - \text{Second Smooting}$$

The overall forecast is given by

$$a_t = 2S_t - S^1_t$$

$$b_t = \frac{\alpha}{1-\alpha}\left(S_t - S^1_t\right)$$

Now forecasting for the future is given by

$$F_{t+m} = a_t + b_t m$$

Where m is the number of periods for forecast.

2.9. The Winter's Exponential Smoothing Model

Winter's model is a three parameter linear and seasonal exponential smoothing model. It is an extension of Holt's model and uses an additional equation to estimate the seasonal component of the time series. Winter's model is the appropriate model to use when the data has both trend and seasonal components. The model uses four equations for forecasting.

Updating the exponential smoothed series.

$$S_t = \alpha \frac{X_t}{I_{t-L}} + (1-\alpha)(S_{t-1} + b_{t-1})$$

Where α is the length of seasonality i.e. the number of quarters or months in a year.

Update the seasonality estimate

$$I_t = \beta \frac{X_t}{S_t} + (1-\beta) I_{t-L}$$

Where I is the seasonality adjustment factor.
Update the trend estimate

$$b_t = \alpha(S_t - S_{t-1}) + (1-\alpha)b_{t-1}$$

Forecasting m periods into the future

$$F_{t+m} = (S_t + b_t m) I_{t-L+m}$$

The difference between the exponentially smoothed series of Winter's and Holt's is that in Winter's X_t is divided by I_{t-L} and this removes the effects of seasonality. The seasonal component is also smoothed exponentially. The update of the trend is the same as that of Holt's.

2.10. Fitting a Trend

In this section we used mathematical equations to fit a trend in the form of the line of best fit. Method of fitting mathematical curves is perhaps the best and most objective method of determining trend. In this method, an appropriate type of mathematical equation is selected for trend, and the constants appearing in the trend equation are determined on the basis that equation is facilitated by a graphical representation of the data.

If the plotted data show approximately a straight line tendency on an ordinary graph paper, the equation used is:

$$y = a + bx \ldots\ldots\ldots\ldots(1)$$

If they show a straight line on a semi-logarithmic graph paper, the equation used is:

$$\log y = a + bx \ldots\ldots\ldots\ldots(2)$$

Sometimes a parabola or higher order polynomial may also be fitted

$$y = a + bx + cx^2 \ldots\ldots\ldots\ldots\ldots(3)$$

Special types of curves are also used in certain cases.

$$y = a + bc^x \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The constants appearing in the equations referred to at *(1)* to *(3)* above are obtained by applying the principle of least squares. This states that the values of constant should be such as to make the sum of the squares of vertical distances from the trend line as small as possible. The method of fitting mathematical curves can be used for forecasting the future trend. This method also involves considerable numerical calculations. Supposing a polynomial of degree *k* in *t* is chosen to represent the trend *T*, viz.

$$T_1 = a_0 + a_1 t + a_2 t^2 + \ldots + a_k t^k, \ldots\ldots\ldots(5)$$

The normal equations for determining the unknown constants a_0, a_1, a_2, ….a_k will be

$$\left.\begin{array}{ccccccccccc} \sum y & = & na_0 & + & a_1\sum t & + & a_2\sum t^2 & + & \ldots & + & a_k\sum t^k \\ \sum ty & = & a_0\sum t & + & a_1\sum t^2 & + & a_2\sum t^3 & + & \ldots & + & a_k\sum t^{k+1} \\ \sum t^2 y & = & a_0\sum t^2 & + & a_1\sum t^3 & + & a_2\sum t^4 & + & \ldots & + & a_k\sum t^{k+2} \\ \ldots & & \ldots & & \ldots & & \ldots & & \ldots & & \ldots \\ \sum t^K y & = & a_0\sum t^K & + & a_1\sum t^{K+1} & + & a_2\sum t^{K+2} & + & \ldots & + & a_K\sum t^{2K} \end{array}\right\} \ldots(6)$$

Using the estimates obtained from equations (6), we can get the trend value for any given time *t* by substituting that value of *t* in (1).

Obviously, for linear trend,

$$T_1 = a_0 + a_1 t, \ldots\ldots\ldots\ldots\ldots(7)$$

and there will be two normal equations, viz.

$\Sigma y = na_0 + a_1\Sigma t$

and $\Sigma ty = a_0\Sigma t + a_1\Sigma t^2$

For quadratic trend,

$$T_1 = a_0 + a_1 t + a_2 t^2, \ldots\ldots\ldots\ldots(8)$$

and the normal equations are

$\Sigma y = na_0 + a_1\Sigma t + a_2\Sigma t^2$

$\Sigma ty = a_0\Sigma t + a_1\Sigma t^2 + a_2\Sigma t^3$

and $\Sigma t^2 y = a_0\Sigma t^2 + a_1\Sigma t^3 + a_2\Sigma t^4$

Based on equations (7) and (8), having known the values of *t* you can predict for the value of T. The implication here is that when we can establish a quadratic model curve for the further analysis let say, $Y_t = a_0 + a_1 t + a_2 t^2$ for the equation from 1999-2007.

2.11. Quadratic Exponential Smoothing

The quadratic Exponential Smoothing for trend analysis is given by the following equations.

First Smoothing Equation is given by

$S_t = \alpha X_t + (1-\alpha) S_{t-1}$

Second smoothing equation is given by

$S_t^{11} = \alpha S_t^{I} + (1-\alpha) S_{t-1}^{II}$

Overall forecast equation is given by

$a_t = 3S_t - 3S_t^I - S^{II}_{t-1}$

Linear Trend equation is given by.

$$b_t = \frac{\alpha}{2(1-\alpha)^2}\left[(6-5\alpha)-(10-8\alpha)S_t^1+(4-3\alpha)S_t^{II}\right]$$

Quadratic trend equation is given by.

$C_t = (S_t - 2S_t^I + S_t^{II})$

Forecasting into the future is also given by.

$F_{t+m} = a_t + b_{tm} + 0.5\,(C_{tm})^2$

2.12. Regression Analysis

Regression analysis is a statistical technique that can be used to develop a mathematical equation showing how variables are related. Thus, regression analysis is a statistical technique that seeks to establish a relationship between a dependent variable (y) and independent variables (x). Historical or Secondary data on the independent and dependent variables are analysed to determine the strength of the relationship. Where we find a strong relationship between the two variable (y) and (x) the independent variable (x) can be used to forecast for the future. However, Regression analysis is potentially the most accurate forecast technique available, but it requires a large amount of the data. Two models of regression analysis are simple and multiple regression analysis. In simple linear regression, we use only one predictor variable (x) to describe the behaviour of the dependent variable (y). Also, the relationship between x and y is assumed to be basically linear. The simple linear regression model is stated as follows:

$$y = \beta_0 + \beta_1 x + e$$

Where $(\beta_0 + \beta_1 x)$ is the assumed line about which all values of x and y will fall, called the deterministic portion of the model and e is the error component, referred to as the random part of the model. However, multiple regression is used to explain or predict the behaviour of a certain dependent variable using more than one predictor variable. The form of the model is

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\beta_1 X_k + e$$

Where $X_1, X_2\ldots\ldots\ldots X_k$ are K independent (predictor) variables and e is the error associated with this model and $\beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\beta_1 X_k$ can be classified as the deterministic component. When using a multiple linear regression equation as seen above. What does β_2 represent? Very simply, it reflects the change in y that can be expected to accompany a change of one unit in X_2 provided all other variables (namely, X_1 and X_2) are held constant.

2.13. Delphi Method

Delphi method is a forecasting technique applied to subjective nature of demand values. In view of globalization in India, Indian companies have difficulty in estimating the demand of their products mainly because of possible mixed reactions of customers towards various attributes of a specific product which is manufactured by multilateral firms and indigenous firms. Under such situation, one has to resort to subjective estimates. Technology forecasting is another example where there is no qualitative data based on which the future technology can be predicted. In this situation, we will have information at various stages of technological advancement for a particular application which can be used for predicting the future technology for that application.

In Delphi method of forecasting, several knowledgeable persons are asked to provide subjective estimates of demands or forecasts of possible advances of technology. The expert may provide several opinions. The essential precautions to be followed in this method are as follows:

1. Panel members must be unknown to each other.
2. The initial questionnaires should be unambiguous and it should explain every matter about which opinion is sought.

After getting the opinions from the panel members, they are to be compared for similarity. If the variation among the opinions is too much, the summary of opinions is to be circulated again among the members without mentioning the names of persons who provided opinions. Generally, 50 percent of the estimate is considered as the basis for comparison. The panel members whose opinions differ significantly from the middle 50% of the estimate will be asked to reconsider their opinions. Still, if they want to stick to their original opinions, they will be asked to provide rationale for the same. So, the Delphi method is an iterative process until the panel converges on a specific value or a range of values as defined by the required accuracy or arrived at consensus on the matter under consideration (Panneer Selvan, 2008).

2.14. Autoregressive Forecasting Techniques

This section examined yet another method of forecasting, a method that can be used when time series variable is related to past values of itself. By regressing y_t on some combination of its past values, we are able to derive a forecasting equation. So we return to multiple linear regression, except now the dependent variable is y_t and the predictor variables are the past values, y_{t-1}, y_{t-2},This forecasting technique is auto regression. We are essentially regressing the time series variable on itself.

Suppose we attempt to predict the values of y_t, using the previous two observation. The prediction equation is:

$y_t = b_0 + b_1 y_{t-1} + b_2 y_{t-2}$, t = 3, 4, 5….

The values of b_0 b_1 and b_2 are the least squares regression estimates, obtained from any multiple linear regression computer packages. There are two predictor variables here: the lagged variables y_{t-1} and y_{t-2}. The equation above is a second-order autoregressive equation because it uses first two lagged terms. In general, a pth=order autoregressive equation is written.

$$\hat{y}_t = b_0 + b_1 y_{t-1} + b_2 y_{t-2} + \ldots b_p y_{t-p}$$
$$t = p+1, p+2, \ldots\ldots$$

2.15. Demand and Supply of Petroleum Products: International Perspectives

Iran is richly endowed with oil and gas reserves. With a share of 1 percent in the world population its share in total world reserves of oil and gas are 5 percent and 14 percent respectively. The government is by far the major supplier of energy, producing over 95 percent of all energy supplied. The National Iranian Oil Company (NIOC) is responsible for supply of all petroleum products, it operates several refineries and imports refined products to meet local demands In the past Iran has been at times a net exporter of refined products, but since the destruction of the Abadan refinery in 1980 by Iraqi artillery, it has consistently imported an average of about 150 tb/d per year. Although consumption of petroleum products has grown very fast, their share in total energy supply has declined over the years owing to rationing in the 1980s and increased supply of natural gas. In 1989 petroleum products accounted for 73 percent of total energy demand, compared to 83 percent in 1967. Natural gas increased its share from 1 percent to 22 percent in the same period. Rationing and a declining economy only slowed down the pace of increase in consumption of petroleum products in the 1980s. While GDP in 1989 was 12 per cent below its real value in 1977 consumption of petroleum products was up by 78 percent even outpacing population which grew by about 40 percent between the same years. Energy efficiency has declined for the past twenty years. Between 1972 and 1989 a period of rising world energy prices, energy intensity (defined as the ratio of refined product consumption to GDP) doubled in Iran while in OECD countries it fell by nearly one-quarter. Moreover, Iran was already using more energy per unit of production in 1972 than the average for OECD: 5.9 barrels per $1000 of non-oil GDP (5.2 barrels per $1000 of GDP) compared to 4 barrels for GECD.

2.16. Prices of Petroleum Products

Before March 1995, only gasoline prices had been adjusted upwards. As a result, differentials between products have widened since the revolution, reflecting, as Sterner (1989) has noted for other countries, the shift in the social basis of political power. Thus, in 1995, at 100 rials per litre the price of gasoline (which is nearly twenty times its price in 1979), was five times the price of gas oil and kerosene and ten times the price of fuel oil. Politically, the gasoline price has been the easiest to adjust. It was first increased by 200 per cent in 1980 and then along with other products by 66 per cent in 1987. In March 1995 all refined product prices were doubled. It is difficult to compare these prices with those in the world market because of the multiplicity of the exchange rates. In 1995 there were at least three rates, the official rate of 1750 rials per dollar, the export price of 3000 and the black market price of about 3700. If we take the exchange rate of 3000 applied to exports as our measure of the opportunity cost of foreign exchange, after the doubling of prices in March 1995, the dollar prices of refined products ranged from about 2 cents per gallon for fuel oil to 9 cents per gallon for gasoline, all only a fraction of their respective border prices. The major substitute for petroleum products in Iran is natural gas, which is increasingly used in electricity generation, household and commercial use, and to a lesser extent, in industrial use. As the world's second largest owner of gas reserves, Iran is in a position to substitute gas for a large part of its petroleum use. A major obstacle to doing so is the low price of petroleum products. Until 1987 competing oil products were cheaper than natural gas. For example, fuel oil was 2 rials per litre compared to 5 rials per cubic metre for natural gas, making fuel oil 60 per cent cheaper per BTU. Price adjustments since 19l57 have made natural gas slightly more competitive. In 1994, at 5 rials per litre fuel oil was just equal in heat cost to natural gas, but, taking into account the cost of equipment change, it may not have been profitable to switch. Kerosene which was 60 per cent cheaper per BTU than natural gas in 1987 was in 1991 priced at the same rate. Still higher prices for petroleum products are necessary to increase substitution and take full advantage of the cheaper natural gas.

2.17. Modeling Approach for Petroleum Products

The modeling approach is guided by the objective to study the role of price and income in energy demand. Several points should be raised with respect to the choice of the estimation model.

Constant elasticity we use the popular log-linear equation which assumes that price and income elasticities are constant. This is a bit unsettling when we note that in our sample the range of price and income change are rather large, but the convenience of interpretation and the advantage of non-linear estimation make this worthwhile.

Simultaneity bias: In general demand and supply should be estimated jointly, but in our case product prices are exogenous and their supply adjusts (mainly through exports and imports) to clear the market. Nominal product prices are fixed by the government and overall inflation is not affected by demand and supply for petroleum products.

Therefore the real prices of products are exogenous and the observed quantity-price data trace the demand curve. The only exception is for kerosene for the period in which the marginal price was the black market price (see below).
Cross price effects: Testing for cross price effects is hampered by the strong collinearity between the real price series. To prevent multicollinearity from reducing the precision of the own price and income effects, we teased for the most likely substitutes. For accounting for variation in the price of kerosene or fuel oil, which are, in any case, mostly picked up by the other two prices.
Population: The choice to include population as a determinant of demand is based on whether one believes that the number of people influences demand over and above aggregate income. In all cases I tested for this by including population as an explanatory variable; only in the case of kerosene was there any indication that population that population influenced consumption. For estimation we employ dynamic reduced form equations. we tested both static and dynamic forms and the data strongly favoured the latter. The static version assumes that demand adjusts quickly to price and income changes, so that we can write:

$$Q_1 = a + b_1 + bP_1 + cY_1 + dP_t^{sub}, \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where Q_t is consumption, P_r is price and P_t^{sub} is the price of a substitute. In the dynamic version, desired demand Q_t is determined by price and income, and actual consumption Q_t adjusts to the desired level only partially in each period (i.e. each quarter). This version makes more a priori sense because refined products are used in conjunction with fixed capital. Thus, assuming that actual demand responds to desired demand with a lag, we can write,

$$Q_t = Q_{t+1} + \lambda(Q_t^* - Q_{t-1}), \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where λ is the speed of adjustment. The estimated demand function is then:

$$Q_t = a\lambda + b\lambda P_t + c\lambda Y_1 + d\lambda P_t^{sub} + (1 - \lambda)\, Q_{t-t} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

2.18. Inflation: The Ghanaian Perspective

National Consumer Price Index (NCPI) figures released by the Ghana Statistical Services revealed a mark down in headline inflation by 0.2% to 10.2% -a trend in line with our projection (albeit 0.1% lower). The food component of the national basket sustained a major decline (-0.7% y/y and -1.5% m/m) on account of improved food supply on the markets. The increase in the non-food basket (0.2% y/y and 0.7% m/m), however failed to ignite inflationary pressures as the magnitude could not match that exerted by the food basket. In line with our expectations, the effect of the July and August rains that caused severe flooding in the Northern and Upper regions, destroying up to 70% of arable lands, did not impact food supply during the period in question. The vegetables & tubers, bread & cereals and fish sub-components were the major force that exerted a downward pressure on food inflation. The non-food basket's increase was mainly fuelled by Housing & Utilities sub-component with a 2.4% y/y gain and the Transport sub-component (1.8% y/y). Despite the y/y growth in Housing & Utilities sub-component, its m/m records declined by 0.2%. Regional distribution of inflation also revealed a downward pressure being exerted by heavy weight Greater Accra Region (-3.1 y/y). Ashanti Region, the second weightiest contributed -1.2% y/y. The conventional increase in liquidity during the fourth quarter is not expected to be any different in the final lap- of the year. The impact of the Northern & Upper Regions flooding is expected to hit the supply cycle from mid to the latter end of November considering the time it takes to cultivate and harvest tomatoes (2-3 months) and groundnuts (3-4 months). Crude oil prices are set to go up even further on the world market on account of a combined effect of supply concerns and upward demand pressures. On the supply side, OPEC has projected a decline in the production of non-member countries due to lower expected production levels in Mexico and Brazil. While this could lower world supply of crude oil, geopolitical tensions between Turkey and Kurdish rebels could interrupt oil production/supply in and from the region. On the demand side of the scale, apart from the seasonal stockpiling of crude oil especially for the winter season, OPEC again, has projected an increase in demand by 100,000 bid in the fourth quarter. US crude inventories have declined which re-emphasises an increased demand, hence market concerns. In order to contain seasonal stockpiling among other supply concerns, the Organization has announced an increment in production levels by 500,000 bid effective November 1. This notwithstanding, we do not anticipate crude oil prices to drop within the month hence we expect the National Petroleum Agency (NPA) to revise petroleum prices upwards on November 1, 2007. The year-long load shedding was halted on October 1, 2007 and has brought respite to households and businesses as funds originally committed to supplementing energy will now be diverted to other productive uses, all things remaining the same. This should result in a drop in the import volumes of crude oil albeit not reducing the import bill. Pending increment in utility tariffs also sets the tone for the disruption of the non-food basket.

2.19. Stages Involved in Developing a Model

A model is an abstraction of reality. Thus, a model is a representation of an actual system using either a physical or mathematical rendering. Regression is the statistical model we use when the explanatory variable is continuous. However, if the explanatory variable were categorical we would use analysis of variance. An example of a model is the linear equation to forecast the demand of a product. The model of a system will help the analyst have better insight into the system. Modeling is an art which cannot be taught in a definite way. The main objectives of modeling with regard to regression model are twofold.

1. To estimate the parameters of a model.
2. To estimate how good the model is at describing the data (Panneer Selvan, 2008).

2.20. Specification of the Model

One of the most important (can often neglected) parts of the exercise is selecting which of the many possible we should fit to the data. The principle of parsimony tells us that we should fit the simplest possible model. In practice this means that we should fit the model with the smallest possible number of parameters. The null model is that there is relationship between y and x, i.e. that y is a constant y = a If there is relationship between y and x, then the next simplest assumption is that the relationship between y and x is linear.

$$Y = a+bx$$

Where a response variable y is hypothesised as being a linear function of the explanatory variable x, and the two parameters a and b. in the case of simple linear regression, the parameter a is called the intercept (the value of y when x = o) and b is the slope of the line (or the gradient, measured as the change in y in response to unit change in x). The aims of the analysis are as follows:

1. To estimate the value of the parameters a and b
2. To estimate their standard errors
3. To use standard errors to assess which terms are necessary within the model (that is whether the parameter values are significantly different from zero).
4. To determine what fraction of the variation in y is explained by the model and how much remains unexplained (Crawley (2001), Statistical computing, an introduction to data analysis using S-plus)

2.21. Model Building

Model building is the process of actually construction a mathematical equation in which some or all of the independent variables are used in an attempt to explain the variation in the dependent variable. Suppose we have a model constructed mathematically in an exponential for such as: $y= ae^{bx}$, Thus this suggest that there is an exponential relationship between y and x, then it would be reasonable to suppose that log of y would be linearly related to x:

$$\text{In } y = \text{In } a + bx$$

Now suppose that the error ε in y is multiplicative with a mean of O constant variance,

$$Y = ae^{bx}(1+\varepsilon)$$

Then they will also have a mean of O in the transformed model. But if the errors are additive,

$$Y = ae^{bx} + \varepsilon$$

Then error variance in the transformed model will depend upon the expected value of y. in a case like this, it is much better to analyse the untransformed response variable and to employ the log link function, because this retains additives assumption of errors. When both the errors distribution and functional form of the relationship are unknown, there is no single specific rationale for choosing any given transformation in preference to another.

The aim is pragmatic, namely to final a transformation that gives:

1. Constant error variance
2. Approximately normal errors
3. Additivity
4. A linear relationship between the response variables and the explanatory variables.
5. Straight forward scientific interpretation (Crawley, 2001).

2.22. Model Diagnosis

This is the process of analyzing the quality of the model constructed by determine how well the model fits data. Examination of output values such as the coefficient of determination R^2, and the estimate of the standard deviation of the model errors helps in the diagnosis process. Assessment is also carried out on the extent to which the models assumptions appear to be satisfied, if the model is unacceptable in any of these areas, another model need to be adopted or re-specified. Thus, one needs not to build a sophisticated model provided a simpler one will provide enough results (Groebner, 2005; Mentzer and Moon, 2005; Russell and Taylor, 2003).

2.23. The Coefficient of Determination R^2

The coefficient of determination R^2 measures the proportion of variation in the dependent variable that is explained by its relationship to all independent variables in the model. However, most researchers prefer using the adjusted R^2 as a measure of goodness of fit since adding independent variables to the regression model will always increase R^2 even if the variables have no relationship with the dependent variable, coefficient of determination is given by

$$R^2 = \frac{SS_y - SSE}{SS_y}$$

2.24. Effect on Parameter Estimates

The effect of colinearity on the estimates of regression coefficients may be best seen from the expression giving the standard errors of those coefficients, thus standard errors give a measure of expected variability for the coefficient estimates the smaller the standard errors the better the coefficient tends to be estimated. It may be shown that the standard error of the coefficient, bj is given by

$$Se(bj) = S\sqrt{\left(\frac{1}{1-R^2 j}\right)\left(\frac{1}{\sum_{i=1}^{n} X_{ij} - \overline{x_j}}\right)^2} ------(\alpha)$$

Where, as before $R^2{}_j$ is the R^2 value obtained from regressing the jth predictor variable on all other predictors. Equation (α) shows that, with respect to co linearity, the standard error will be smallest when $R^2{}_j$ is zero, that is, the jth prediction is not linearly related to other predictors. Conversely, if $R^2{}_j$ is nearer 1 than the standard error of b_j is large and estimate is much more likely to be for from the true value of β_j. The quantity

$$ViF_j = \frac{1}{1-R_j^2}$$

is called the variance inflation factor (VIF). The variance inflation factor is a method of measuring multicollinearity. It is a measure of how much the variance of a estimated regression coefficient increases if the independent variables are correlated. The larger the value of VIF for a predictor Xj is, the more severe the collinearity problem. As a guideline, many researchers recommend that a VIF greater than 10 suggests a collinearity difficulty worthy of further study. This is equivalent to flagging predictors with R_j^2 greater than 90^o (Cryer and Miller, 1990).

2.25. The F-Test

F- Test is used for analyzing variance. Thus, it is another method for testing whether the regression model explain a significant proportion of variation in the dependent variable. The overall ability of a set of predictor variables (for all the predictor variables) to explain the variation in the response variable can be tested simultaneously. Suppose in the model.

$$E(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k$$

We wish to test whether $X_g + 1, X_g + 2....X_k (k > g)$ significantly contribute to the variation in y. This is equivalent to testing whether the associated regression coefficients $\beta_g + 1, \beta_g + 2,....\beta_k$ are equal to O. The hypotheses therefore are

$$H_0 : \beta_g + 1 = \beta_g + 2 = ... = \beta_1 = O$$

H_1 : At least one of the β_s is not equal to O

The test statistic is F, given by

$$F = \frac{(\mathrm{SS_E}\ (\text{Reduced Model}) - SS\ (\text{Full Model})/(\mathrm{k - g}))}{\mathrm{SS_E}(\textit{Full}\ \text{Model})/(n-k-1)}$$

and F has an $F-$distribution with degrees of freedom $k-g$ and $n-k-1$. The term SS_E denotes the error sum of squares. Thus, SS_E (Full Model) denotes the error sum of squares of the full model.

$$E(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k$$

And SS_E (Reduced Model) denotes the sum of squares of the reduced model

$$E(y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k$$

Note that k-g is the number of coefficients equated to zero in the null hypothesis, k the number of predictor variables and n the number of observations (Gordon and Howard, 2006).

2.26. Significance of Independence of the Model

To determine which exogenous variables are significant, we test the significance of each independent variable using significance level of may be $\alpha = 0.03$

2.27. Standard Deviation of the Model

The standard deviation of the regression model measures the dispersion of observed dependent variable values around values predicted by the estimated regression model. Two large standard deviation of the model error, S_2 does not provide adequate precision for confident prediction. Generally, if the range $\pm\ 2S_E$ is acceptable for practical purposes the estimate for the standard deviation of the model error might be considered acceptable (Groebner, 2005).

2.28. Analysis of Residuals

The analysis of residuals is applied to learn about the correctness of the regression model. However, there are some problems that could be encounter during the graphical analysis of residuals and among these are:

1. Non-zero mean
2. Non –constant variance
3. Dependence of residuals
4. Error terms not normally distributed

2.29. The Durbin Watson Statistic (DW)

Another statistic frequently used to detect autocorrelation in regression residuals is the Durbin-Watson Statistic, which calculated as

$$DW = \frac{\sum_{t=1}^{n}\left(\hat{e}_t - e_{t-1}\right)^2}{\sum_{t=1}^{n}\hat{e}_t^{\,2}}$$

By straight forward algebra it can be shown that, to a good first approximation DW = $2(1-r_1)$ where r_1 is the log Autocorrelation in the residuals. Thus if the residuals are not auto correlated so that $r_1 \simeq$ O, DW is expected to be about 2. If the residuals are strongly positively auto correlated with $r_1 \simeq -1$, then DW $\simeq$ O. If the residuals are strongly negatively auto correlated with $r_1 \simeq 1$, then DW $\simeq 4$. Values of DW near 2 support independence of the error terms, values of DW away from 2 and near the extremes of 0 or 4 support the hypothesis of auto correlated errors nearly all statistical software calculates the Durbin-Watson Statistic automatically (Cryer and Miller, 1991).

2.30. Proposed Demand Model for TOR

The petroleum demand model for TOR was developed as seen below.

2.31. Independent Variables

The demand for petroleum products such as Gasoil, kerosene, petrol diesel LPG to mention just a few more often than not depend on exchange rates, Ex-pump price and at times inflation rates. Thus, according to the law of demand, it states that whenever, there is an increases in the price of a commodity consumers tend to demand less, all other things being equal and vice versa. Also, the demand for the petroleum products may depend on the population and availability of fleet of cars within the economy at a specific period. The provision of reliable and affordable petroleum products plays a vital role in the sustainable economic growth of nations globally. In the mid-1990s, Ghana initiated development plan aim at transforming the economy from a low-income level to a middle income status by the year 2020. To achieve these objectives, adequate and reliable supply of fuel is required to drive the economy. This is due to the economic impact of energy production coupled with exchange rates as well as inflation rates. The demand for the petroleum products has affected the prices of goods and services these demands have come about a result of the degree of urbanization (the percentage of the total population who live in urban areas) is therefore expected to demand more of the products.

2.32. Estimated Econometric Demand Model for the Various Petroleum Products

The indicators that were used for the econometric modeling of the demand projections for the various petroleum products in Ghana consisted of inflation rates, exchange rates, Expump price and urban population. Historic data for the inflation rates weighted price of petroleum products, exchange rates in terms of dollars ($) and population growth for Ghana over the period 1999 to 2007 were used for the modeling. Statistical technique used was regression analysis in the development of the modeling equations for the various products. The general econometric equation used was of the form.

$$E_D = a(GDP) + b(I_{f\text{-}r}) + c(E_{c\text{-}x}) + d(Q_{\text{-}z}) + e(P_{\text{-}n}) + k \ldots\ldots\ldots\ldots \quad (1)$$

$$\text{In}E_D = a\text{In}(GDp) + b\text{In}(I_{f-r}) + c\text{In}(E_{c-x}) + d\text{In}(Q_{\text{-}z}) + e\text{In}(P_{\text{-}n}) + K \ldots\ldots\ldots \quad (2)$$

Where a, b, c, d and e are coefficients
K= constant or the error term.
In (GDP) = gross domestic product
$InI_{f\text{-}r}$ = inflation rates
$In(E_{c-x})$ = exchange rates
$InQ\text{-}_{z}$= Ex pump price of petroleum products
$In(P_{-n})$ = urban population.
E_D = Econometric Demand for Petroleum Products
Thus, these are the independent variables and E_D is the response or dependent variable so that any change in the independent variable may have an impact on the demand (E_D) for the petroleum products. Therefore forecast for the various product could be predicted. This is also in the form of multiple regression where the demand (E_D) for the petroleum products depend on more than two independent variables stated above.

3. Research Approach

3.1. Research Design

Secondary data or historical data of Petroleum Products Demand, percentages of consumption, inflation rates and exchange rates were collected from reliable institutions. Statistical techniques were used to develop a model for the demand forecasting of the petroleum products such as LPG, kerosene, gasoil to mention just as few using the secondary data from 1999 to 2007. Thus based on this, various graphs were drawn with the help of SPSS, Excel or Minitab statistical soft to analyse the trend for the demand for petroleum products and predict beyond the stated period. Now, a complied or composite graph was also drawn with the same software mentioned above in order to analyse which of these products were more demand as the economy is growing. Also, with the help of the data on inflation rates as well as the exchange we were able to compare or analyse how the trend for the demand of the petroleum products would affect the rates of inflation in the economy of Ghana. In much the same way, the historical data of exchange rates would also be compared with the demand for the petroleum products and its impact on the economy as well.

3.2. Petroleum Products Demand (Consumption)

The Petroleum Products demand data was obtained from the National Petroleum Authority (NPA). This included the consumption of the Petroleum Products from 1999 to 2007. These data was used to enable us analyse the trend for the demand of these products. The data is therefore presented in table 1, which can be found in appendix 8, Table 1.

3.3. Inflation Rates

Data on inflation rates from 1999 to 2007 were collected from the Ghana Statistical Service (GSS) in Accra. Again the data is presented in Table2 at appendix 9.

3.4. Exchange Rates and Expump Prices of the Various Petroleum Products

The data on exchange rates from 1999 to 2007 was also collected for Bank of Ghana (BOG), Accra. The data on Expump prices of the various Petroleum Products from 1999-2007 was collected from National Petroleum Authority (NPA) in Accra. This was also in the form of historical data and it is presented in the table below: This was a historical data and it is also seen in Table 3, 4, 5, 6, 7, see appendices 10, 11, 12 and 13 respectively.

3.5. Urban Population Growth in Ghana

The data on urban population of Ghana showing the trend from 1999-2007 was obtained from the Ghana statistical service (GSS). The table below presented the percentage urban population in Ghana.

Table-7.

Year	% Urban Population
1999	43.95
2000	43.80
2001	44.67
2002	45.55
2003	46.46
2004	47.38
2005	48.31
2006	49.27
2007	50.25

(**Source:** Ghana Statistical Service)

However, forecasting values for the trend of urban population value could also be obtained from 2007 and beyond based on the data available.

3.6. Gross Domestic Products (GDP) Growth Rate

The table below also presents the GDP growth rates figures from 1999-2007

Table-8.

Year	GDP Deflator 1993 = 100	GDP current prices	GDP at constant 93 (million cedis)	GDP Growth Rate
1999	415.2	20,579,800.0	4,956,900.00	4.43
2000	428.0	27,152,700.0	5,142,100.00	3.74
2001	709.5	38,014,000.0	5,358,068.20	4.20
2002	837.2	46,875,000.0	5,599,181.27	4.50
2003	1,030.6	60,705,000.0	5,890,338.69	5.20
2004	1280.56	79,804,000.0	6,231,978.34	5.80
2005	1472.30	97,268,000.0	6,606,520.24	6.01
2006	1659.19	116,663,126.0	7,031,319.49	6.43
2007	1897.10	140,994,320.0	7,432,104.70	5.70

(**Source:** Bank of Ghana)

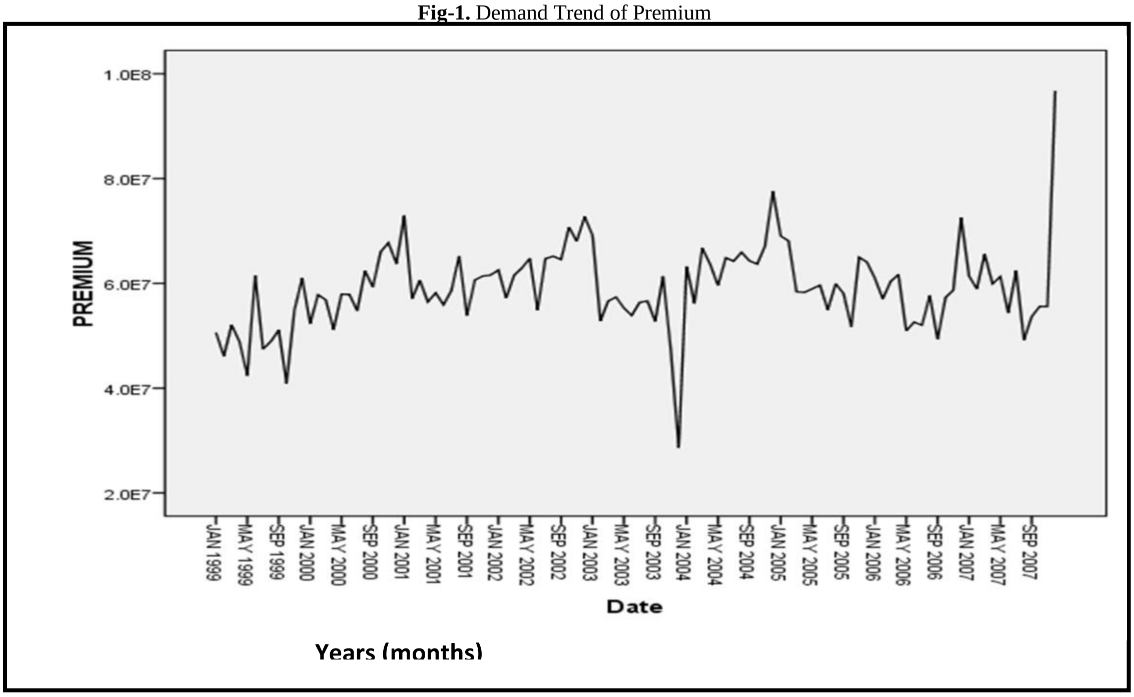
4. Results and Discussion

This section deals with the demand or the consumption trend and model analysis of the various petroleum products such as premium, kerosene, Gasoil and LPG to mention just a few. Again, two models were developed from 1999-2007 of the various petroleum products and that comparison of the R^2. Adjusted R^2, predicted values were analyzed. Again, forecasting for the Petroleum Products were also developed and discussed based on the regression models.

4.1. Demand Trend Analysis of Premium.

This section deals with the trend of the consumption or demand for the premium from 1999 to 2007. Thus, the fig 1 shows the trend analysis of the consumption or demand for the premium. However, detailed analysis of the trend can be seen below Fig. 1.

Fig-1. Demand Trend of Premium

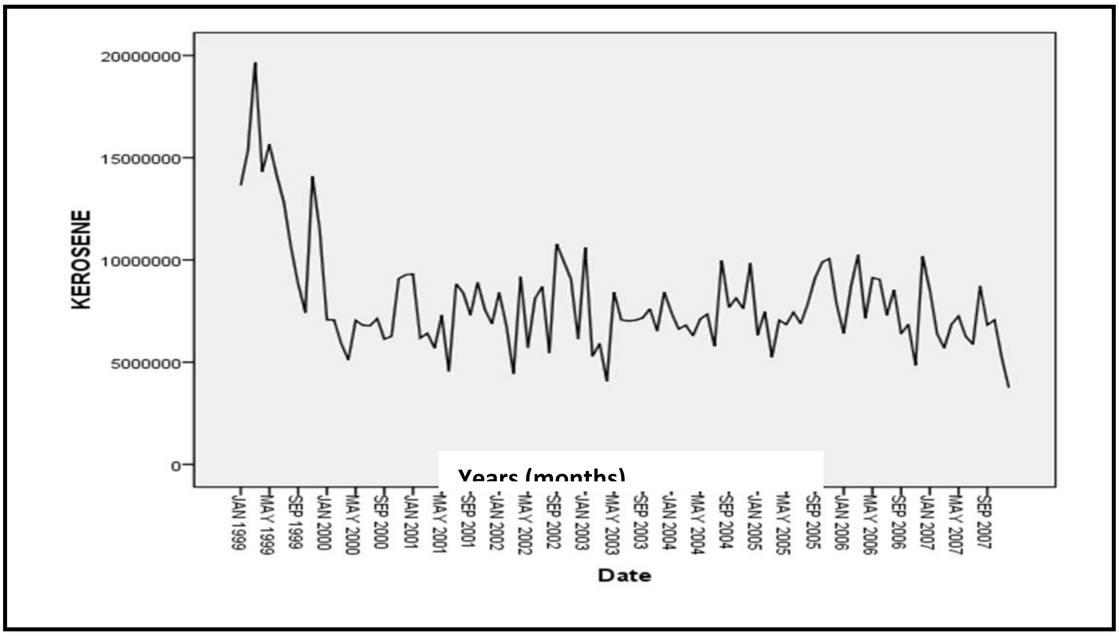


From Fig. 1, it could be observed that, there was generally a seasonal variation for the demand or consumption of the premium from 1999 to 2007. However, there was an increase in the demand for the premium in the years May, 1999, January 2000, to mention just a few and some amount of low demand for the premium were also recorded as we could observe in Fig. 1. The trajectory of the graph clearly indicating an irregular variation of the trend of the Premium over the years. In January 1999, the demand for the Premium fell slightly and then rose up and fell again. This situation persists so far as the trend of the demand for premium is concerned. From the graph, the lowest Demand for premium fell in January 2004 and the highest therefore was registered in January, 2005. Based on this trend, we could generally observe that, there was an irregular variation in the trend of the demand for Premium.

4.2. Demand Trend Analysis of Kerosene

This section also shows the trend of consumption or the demand for kerosene from 1999 to 2007. Thus, Fig. 2 represents the trend of the consumption of kerosene.

Fig-2. The Trend of Consumption of Kerosene

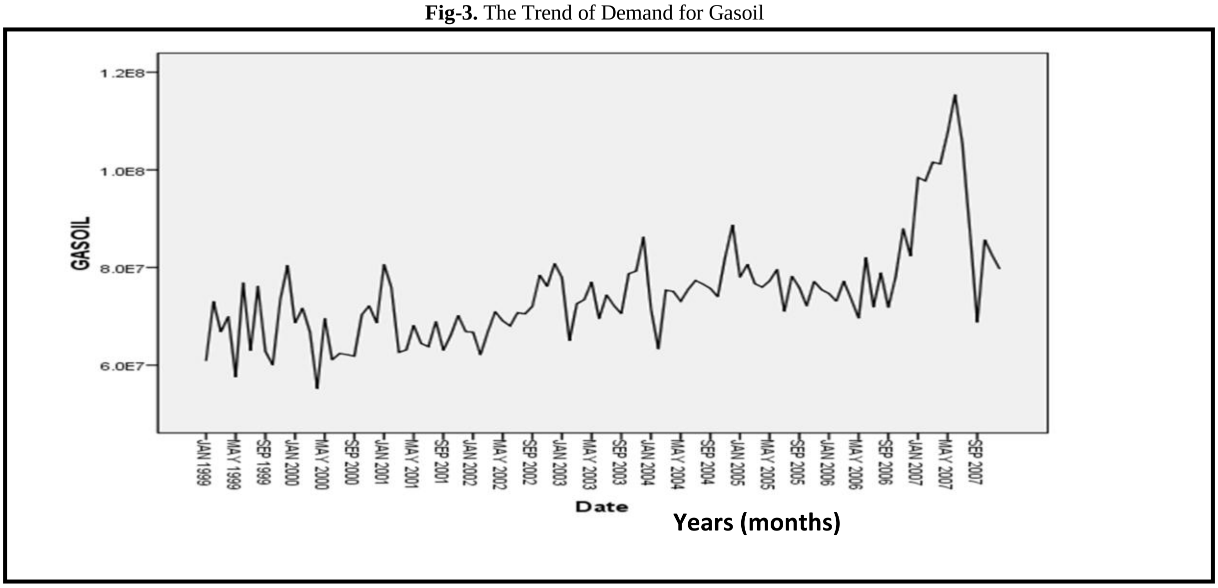


It could also be seen from Fig. 2 that, there was generally an irregular decreasing trend of the consumption of the kerosene from 1999 to 2007. Thus, there was an increasing trend of the demand for kerosene from January, 1999 up to May, 1999. However, there was a significant sharp increase of the demand for kerosene between May, 1999 and September, 1999. The demand for kerosene them moved upward significantly in the year, January 2000. It then fell sharply up to May, 2000. The trend therefore showed an irregular seasonal variation of an increasing and decreasing pattern of the demand for kerosene from September, 2000 up to September, 2007.

4.3. Demand Trend Analysis of Gasoil

The Fig.3 below shows clearly the consumption pattern of Gas oil as the Economy moved from 1999 to 2007.

Fig-3. The Trend of Demand for Gasoil

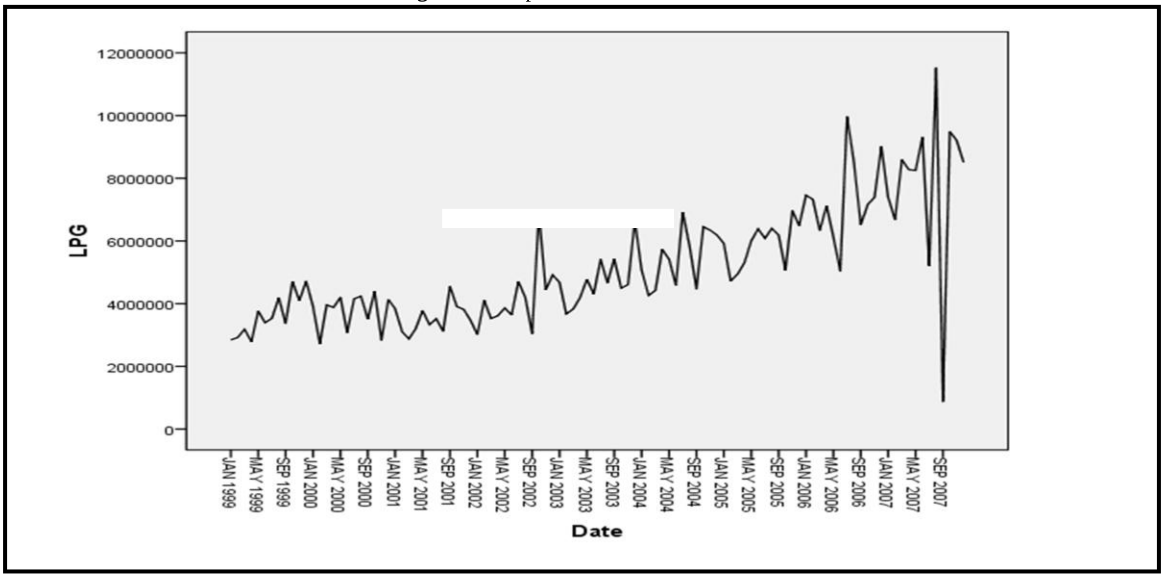


From Fig. 3, it could be seen that, the trend of the demand for the Gasoil showed an again irregular increasing variation generally from 1999 to 2007. Again, we could observe that, there was an increase the trend for the consumption of Gasoil in January, 1999 and fell slightly in between January 1999 and May 1999, the situation therefore surged upwards with an irregular variation between May, 1999 and September, 2000. The highest demand for the Gasoil appeared to have occurred January 2000, January 2001, September 2000, September 2003, January 2005 and reached its peak at May, 2007 respectively, whilst the rest of the years recorded a downward trend. In short, there was a general variation trend for the consumption of the Gasoil as a petroleum products between the said period.

4.4. Demand Trend Analysis of LPG

The section here also depicts the trend of the consumption of LPG from 1999 to 2007. The Fig. 4 shows the trend of the demand for LPG in the Economy of Ghana within the said period.

Fig 4. Consumption Pattern of Gasoil



In Fig. 4, it could be observed that, there was in general, an irregular variation in increasing trend of the demand for LPG from January, 1999 up to September 2007. The irregular increase or rise in the variation of the consumption of LPG started from January, 1999 with slight increasing trend up to September 1999 and fell sharply to January, 2000. The situation therefore, reversed by moving up a little bit sharply showing an irregular rise in variation from May, 2000 until it reached September, 2002. The demand for the LPG then rose up significantly in January, 2003 and fell heavily showing another irregular variation rise in trend between the period May, 2003 and January, 2006. After January, 2006, there was, however, a sharp increased in the demand or LPG as the Economy keep on growing with again an increasing irregular variation trend between September 2006 and May 2007. This meant that, the pattern for the consumption of the LPG then changed from May, 2007 recording the highest demand for the LPG. It then fell drastically in September, 2007 and then rose up again indicating the usual irregular variation in the trend for the consumption of the product. We can therefore, say that, generally there was an irregular rise and fall for the demand for the LPG from 1999 to 2007, which showed an exponential consumption pattern.

4.4. Exponential Smoothing Model and Forecast Using Time Series Modeler

This section also talks about the use exponential smoothing model to forecast beyond the said period using time series modular (Expert Modular) for the various petroleum products.

4.5. Exponential Smoothing for Premium Model

This section however, shows the exponential smoothing trend of the premium which is made up of observed, fitted and forecast trend.

Fig-5. Premium Model 1

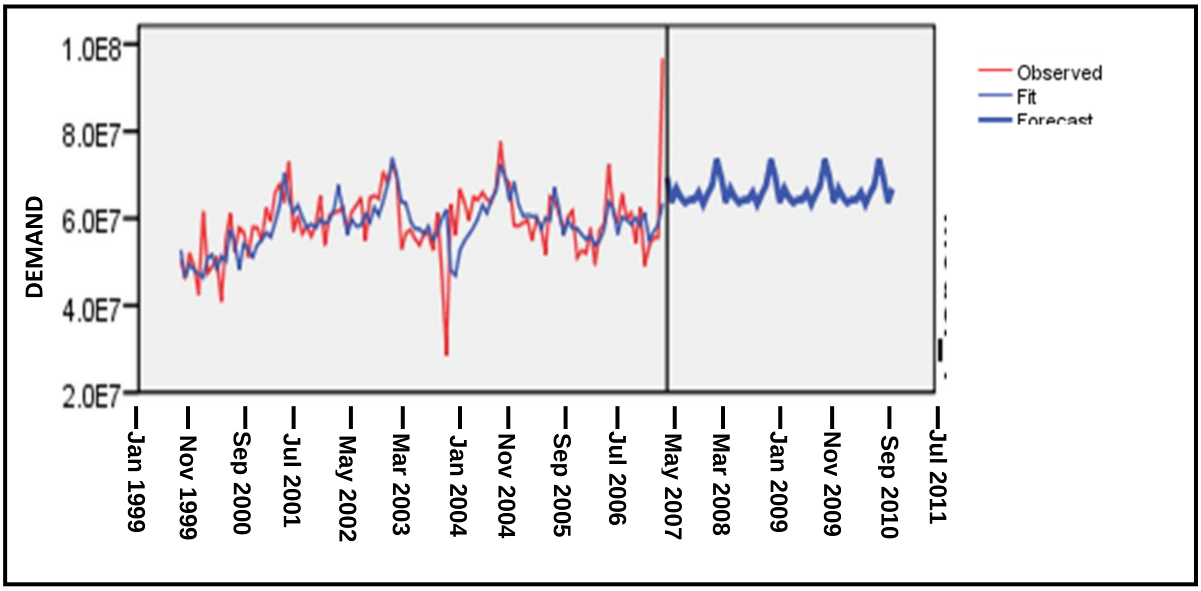


Fig. 5 illustrates the exponential smoothing trend of the premium model 1. This is made up of the observed trend, the fitted trend (Premium Model) and the forecast beyond the period under consideration. From Fig. 5 above, we could see that the fitted trend is smoother than the observed one. The fitted trend also showed some irregular variation of the demand for the premium and a bit smoother than the trend of the observed one (previous one). Comparatively, the deviation of the observed trend is more pronounced than the fitted trend. The trend analysis of the fitted model also followed almost the same scenario. Again, the predicted or the forecast values could be observed beyond the stated period under consideration, that is, from 2008 upwards and the forecast values could be read from the graph and more detailed values could be seen in the time series modular in appendix 12. However, from the graph the forecast values also showed an increasing irregular variation trend as the years go by. The implication here is that as the Economy of Ghana is moving forward, the demand for the premium is not fixed but rather it keeps on varying in an increasing trend. Since the forecast trend for demand for premium is higher, therefore any shortage in premium could bring the Economy of Ghana to stand still.

4.6. Exponential Smoothing of Kerosene Model

This section also deals with the exponential smoothing trend of the kerosene and its forecast.

Fig-6. Kerosene Model 2

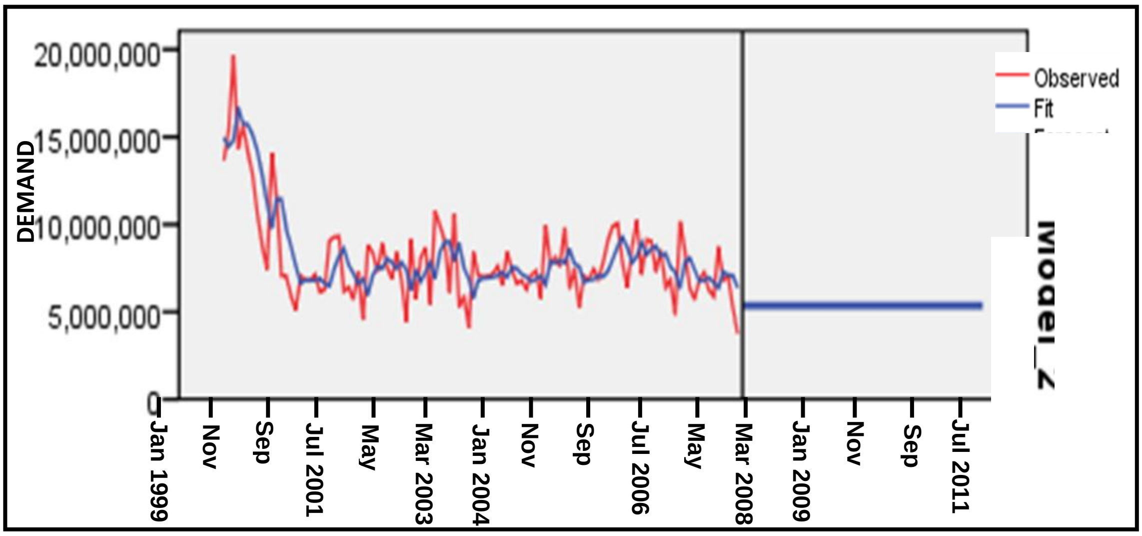
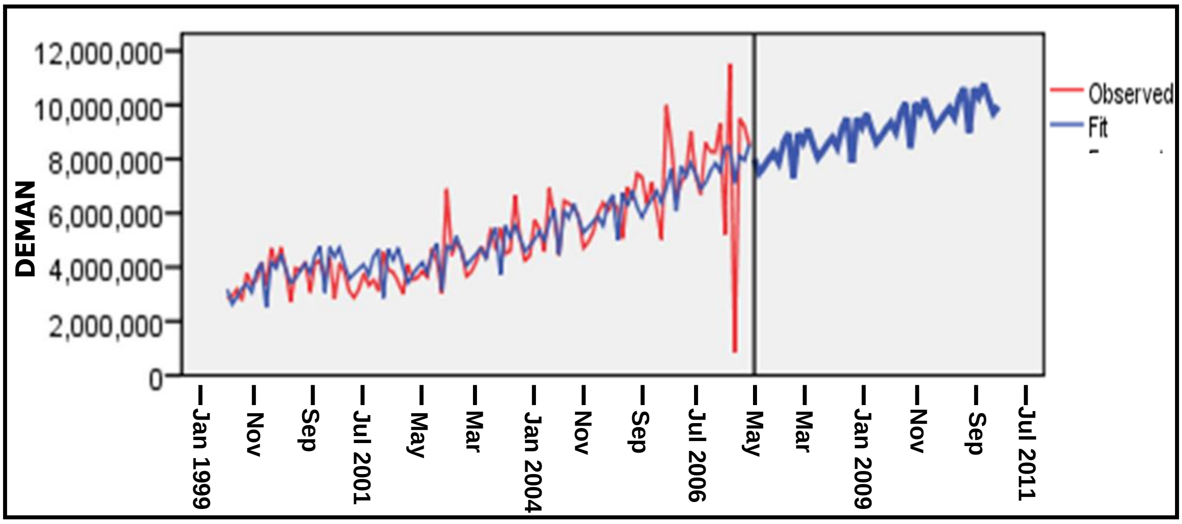


Fig. 6 also shows the exponential smoothing of kerosene and its forecast values from 2008 upwards. We could observe from the graph that, it shows a decreasing irregular variation of the trend of the Demand of the kerosene. However, once again the fitted trend (model) is more smoothier than the observed situation. Besides, the forecast trend tends to be almost uniform or constant. The reason that could be assigned to such a situation is the fact that there has been an improved electrification programmes all over the Economy of Ghana and that only the rural forks tend to demand more of the kerosene as compared to the urban centres. However, any shortages in the kerosene in the system will affect the rural areas in the Economy of Ghana.

4.7. Exponential Smoothing for LPG Model

In this section, discussions were carried on the exponential smoothing for LPG and its forecast by the use of time series modeler.

Fig-7. LPG Model

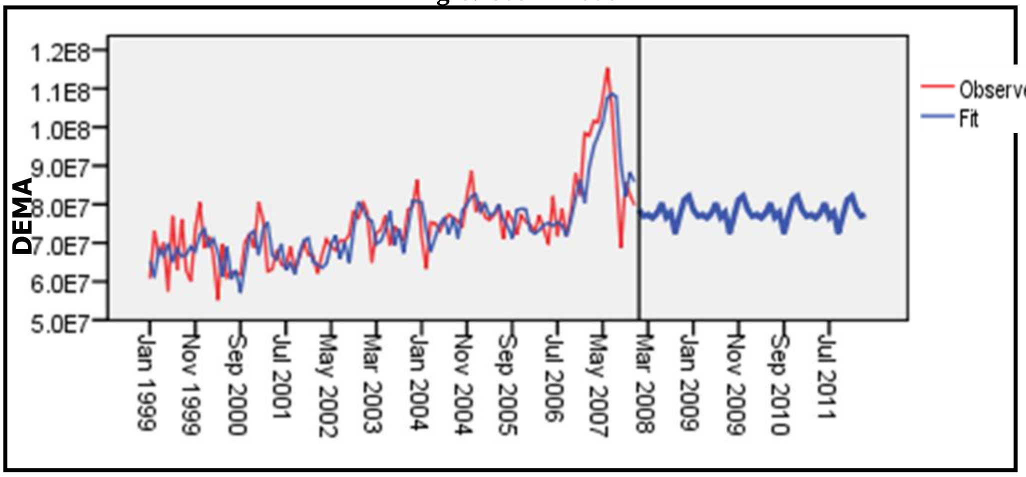


From fig. 7, the exceptional smoothing of LPG increases with increasing irregular variation of the trend exponentially. In addition, the forecast trend also increases exponentially. The implication here is that in the Economy of Ghana more people trend to demand more of LPG for cooking even as a fuel in the cars to mention just a few. The forecast trend therefore, shows that, the demand for the LPG is on the increase and any shortfalls in the production of the LPG would affect the economic activities of citizens in Ghana.

4.8. Exponential Smoothing of Gasoil

This section also touches on exponential demand trend of Gasoil as well as its forecast.

Fig-8. Gas il Model 4



From fig. 8, the analysis of the trend of the exponential smoothing is similar to the previous analysis carried on the observed trend analysis. The only difference here is the fitted exponential smoothing, however, trends to be more smoothier than the observed situation. The trend for the forecast also appears to show irregular variation increasing and decreasing trend. The implication here is that the demand for the Gasoil is not fixed but rather it changes over time. From the exponential trend analysis carried out so far we could observe from the graphs that LPG is more demanded, followed by Gasoil, Premium and Kerosene respectively. However, any drawbacks in the products and availability of these aforementioned petroleum products could impact positively or negatively on the Economy of Ghana.

4.9. Forecast Valves for Petroleum Products

Table-9.

Petroleum Products	Year/Month and Forecast Values				
	March 2008	**January 2009**	**November 2009**	**September 2010**	**July 2011**
Premium	7 E 7	7 E 7	7 E 7	6 E 7	6 E 7
Kerosene	5354832	5354832	5354832	5354832	5354832
LPG	7729424	8555340	6778708	842310	9541E7
Gasoil	8 E 7	8 E 7	8 E 7	8 E 7	8 E 7

(**Source:** Author's Own Work)

From table 10 the results or the values displaced clearly indicated that, the demand for LPG is higher, followed by Gasoil etc.

4.10. The Model Analysis of the Various Petroleum Products

This section deals with the models that would be used in the forecasting of the demand for the various petroleum products during the period 2007 to 2008 and beyond are discussed below.

4.11. The Demand Model for Premium Gasoline as Dependent Variable

Premium gasoline is a transport fuel primarily used for cars. The model for its consumption is presented as seen below:

$$\text{Premium Demand} = \underset{(3.062)}{33.506(GDP)} + \underset{(.309)}{33378.954}$$

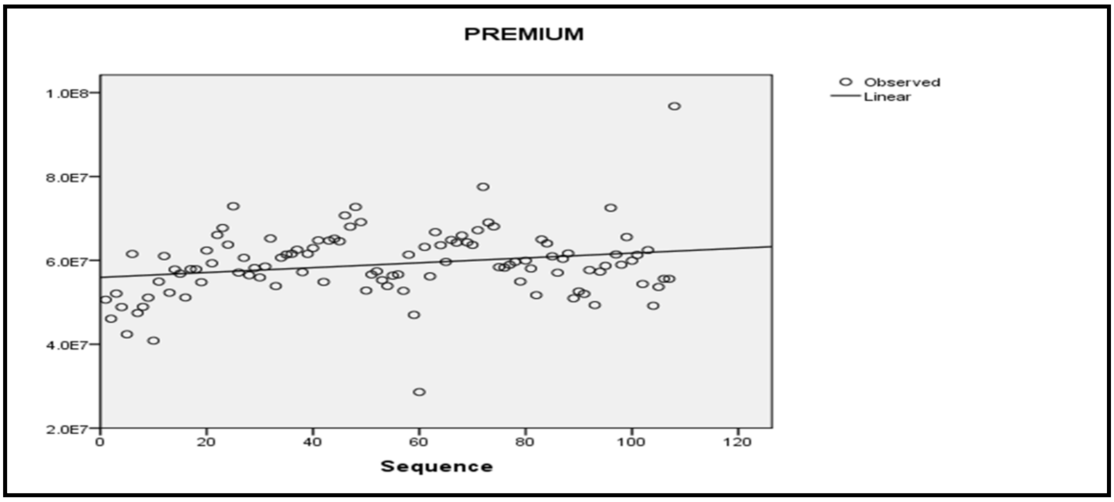
$$\text{(Inflation)} + \underset{(1.748)}{970.323(\textit{Exchange}\ \text{Rate})} +$$

$$\underset{(-3.670)}{4821.119(\textit{Expump}\ \text{Price})} - \underset{(-1.641)}{6.37E7(\text{Urban}\ \textit{Populaiton})} + \underset{(1.362)}{1.678E8}$$

$$\text{R}^2 = 0.180 \quad \text{Adjusted}\ R^2 = 0.140 \quad \text{Pr}\textit{edicted}\ \text{Value} = 5.9\text{E}7$$

The above figures in brackets represent t-statistics values which indicate the significance of the variables. The Expump price has a negative value indicating that it is not a significant variable. Also it could be inferred from the premium model that the urban population has negative t-statistics value which clearly showing that it is once again not a significant variable. The analysis here is that these two parameters will not have much impact on the demand for the premium gasoline. Based on the demand model for premium gasoline, it implies that GDP, inflation and exchange rate would therefore impact either positively or negatively should any changes occur in the aforementioned independent variables which consequently may impact on the economy of Ghana. A graph of the demand model for premium is shown below which shows a linear trend based on the equation of the model with an observed trend being scatter point. The linear trend therefore showed an increasing trend.

Fig-9. Premium Demand Curve Fitting



4.12. The Demand Model for InPremium as Dependant Variable

This section also talks about the analysis of demand model for natural logarithm linear equation for premium gasoline (InPremium). This analysis however, is compared to the previous one to see which of these models are quite feasible and justifiable by comparing their R^2 and others. Thus, the demand model for InPremium is seen below:

$$\text{InPremium Demand} = \underset{(2.624)}{3.179\,\text{In GDP}} + \underset{(0.754)}{0.041\text{InInflation}}$$

$$+\underset{(1.379)}{0.057\text{InExchange Rate}} - \underset{(0.754)}{6.642\text{Urban Population}}$$

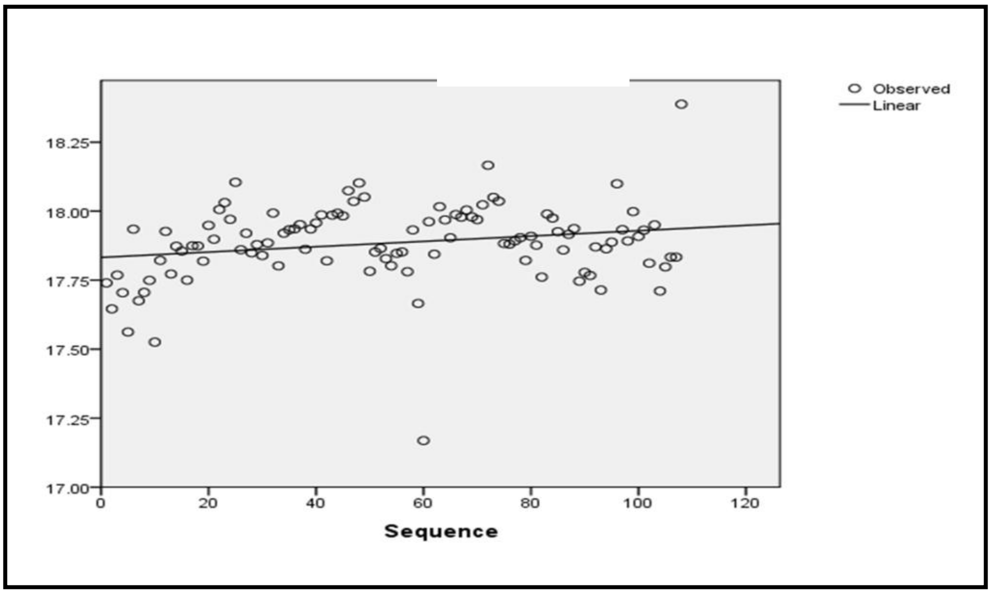
$$+\underset{(1.379)}{0.057\text{In Exchange Rate}} - \underset{(-1.947)}{6.642\text{Urban Population}}$$

$$-\underset{(-1.186)}{0.129\,\text{InExpum Price}} - \underset{-(.612)}{5.782}$$

$$R^2 = 0.113 \quad \text{Adjusted } R^2 = 0.069, \quad \text{Predicted Value} = 17.8852$$

Considering the natural logarithmic linear Demand Equation or model for Premium, we could observe that, both urban population and expump price have negative t-statistics value thereby indicting an insignificant variable. It therefore meant that, these two parameters have little impact on the demand for InPremium. Now, comparing the coefficients of the models of Premium demand and InPremium Demand, we could observe that, the coefficients of the variables of the Premium Demand Model are quite higher than the InPremium Demand Model. Also, the coefficient of Determination R^2 of that of Premium Demand Model is higher than that of InPremium Demand Model. Thus, the linear trend of InPremium Demand also shows an increasing trend. This is clearly shown in Fig. 10 below:

Fig. 10. Inpremium Demand Curve Fitting



4.13. The Demand Model for Kerosene as Dependent Variable

This section has to do with the analysis of the demand model of kerosene. Kerosene is a fuel that is basically used for lighting and cooking. Based on the ever increasing electrification projects in Ghana, the demand for kerosene is, however, on the decline. Thus, the demand model is therefore seen below:

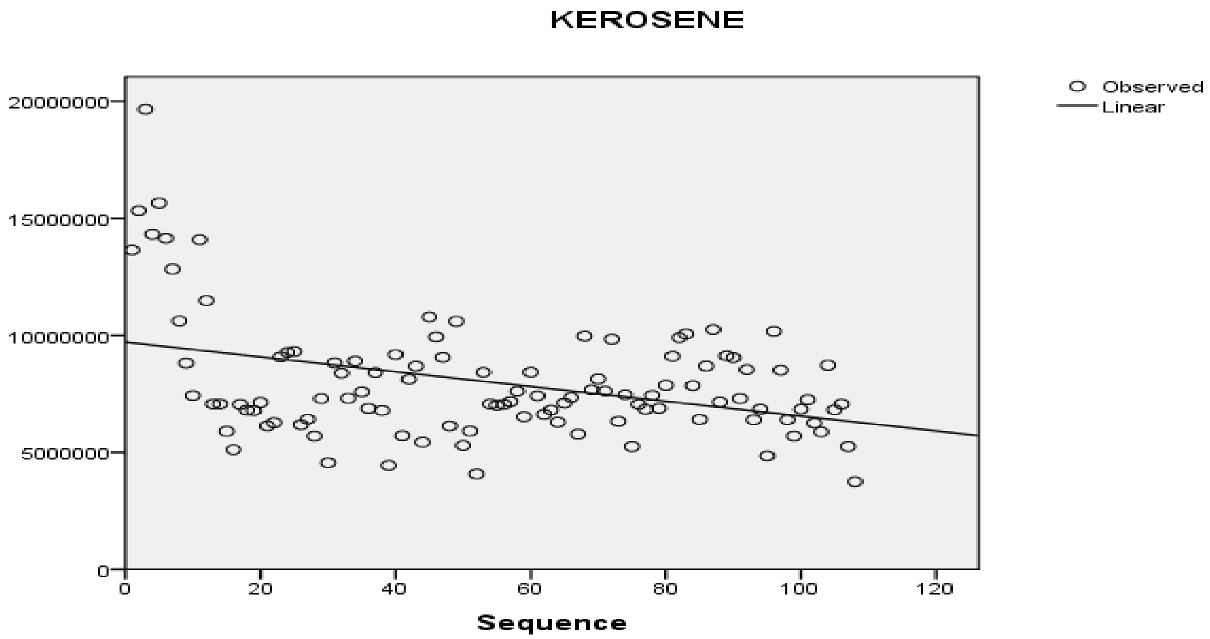
$$\text{Kerosene Demand} = \underset{(-4.498)}{-12.722\text{GDP}}$$

$$\underset{(-2.200)}{63604.881\,\text{Inflation}} - \underset{(-3.533)}{516.776\,\text{Exchange Rate}}$$

$$- 127.68 \text{ Expump Price} \quad + \quad 4.747\text{E}6 \text{ Urban Population}$$
$$(-.331) \qquad\qquad\qquad (4.644)$$
$$R^2 = 0.438 \quad \text{Adjusted } R^2 = 0.410 \quad \text{Predicted Value} = 7.99E6$$

The above linear equation represents the demand model for kerosene. The t-statistics in brackets for GDP, inflation, Exchange rates, Expump Price for kerosene are all negative indicating that, they are not all that significant. However, the t-statistics in bracket for urban population is positive, thus, showing which is quite significant. Based on the kerosene demand model, so far as independent variables or parameters are concerned, the urban population may have an impact on the demand for the kerosene. Even though the rest of the independent variables might have an impact, it would not be well pronounced as compared to the urban population. Thus, the way these parameters might impact on the demand for the kerosene in the economy of Ghana may depend largely on the increase in the population as compared to the rest of the economic indicators mentioned above. The graph for the econometric demand trend moves in a decreasing trend indicating that most of the independent variables have their statistics values as well as the R^2 being negative.

Fig-11. Kerosene Demand Model Curve Fitting



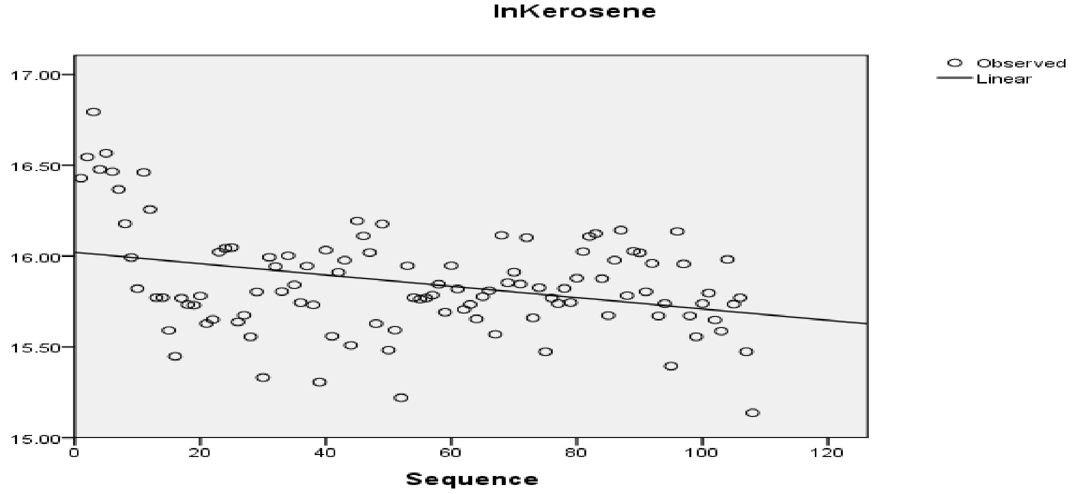
4.14. The Demand Model for In Kerosene as Dependent Variable

This section once again deals with the InKerosen Demand Model. Thus, the section seeks to compare this model with the previous one so as to come out with the best model between the two. The model for InKerosene Demand is represented below:

$$\textit{InKerosene} \text{ Demand} = -6.299 \text{ In GDP}$$
$$(-2.957)$$
$$0.047 \text{ InInflation} \quad + \quad 0.054 \textit{InExchange} \text{ Rate}$$
$$(-0.519) \qquad\qquad (0.813)$$
$$+ 21.949 \text{ InUrban Population} - 0.424 \text{In } \textit{Expump} \text{ price} \quad + \quad 32.854$$
$$(4.059) \qquad\qquad (-0.424) \qquad\qquad (2.047)$$
$$R^2 = 0.434 \quad \text{Adjusted } R^2 = 0.406 \quad \text{Pr}\textit{edicted} \text{ Value} = 5.8507$$

From the demand model or the equation above only exchange rate and urban population that have positive t-statistics signifying that these two variables are more significant. However, the rest are all not all that significant because their t-statistics because their t-statistics are negative. It meant that the demand for kerosene might depend much on the exchange rate and that of urban population which may in the long run have an effect on the economy of Ghana. Thus, when the urban population as well as the exchange rates goes up the demand for the kerosene will be high and vice versa which impact either positively or negatively on the economy of Ghana. Also, the value of R^2 for the InKerosene Demand Model is lower than the previous one. The graph is also displaced below

Fig-12. Inkerosene Demand Model Curve Fitting



4.15. The Demand Model for LPG as Dependent Variable

In the Economy of Ghana, LPG is primarily used for cooking in households, commercial industries, hotels to mention just a few. However, the use of LPG is more often than concentrated in the urban areas among both middle and higher income groups. Also, industries also use it as a source of fuel for their processes. Its use is also growing rapidly in the transport sector as a substitute for fuel for petrol. Thus, the model for the demand of LPG is as seen below:

$$\text{LPG Demand} = \underset{(0.706)}{1.301 GDP} - \underset{(-0.996)}{17105.278\,\text{Inflation}}$$

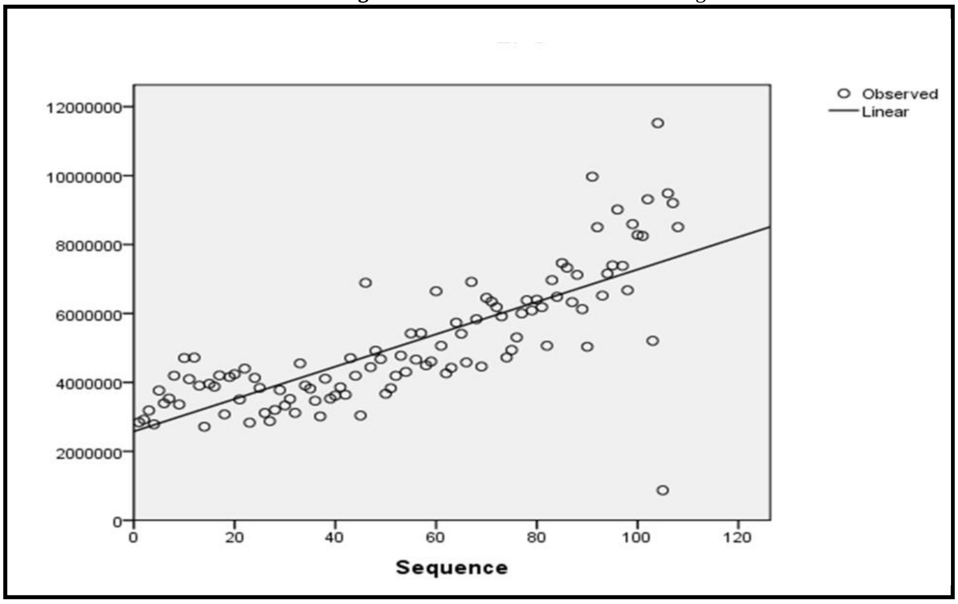
$$-\underset{(-1.036)}{91.567\,\text{Exchange Rate}} + 46437.205\,\text{Urban}$$

$$\underset{(0.073)}{Population} + \underset{(0.934)}{186.878\,\text{Expump Price}} - \underset{(-0.236)}{4.599E6}$$

$$R^2 = 0.628 \quad \text{Adjusted } R^2 = 0.609 \quad \text{Predicte Value} = 5.14E6$$

From the above LPG demand model, we could observe that GDP, urban population and Expump price have positive t-statistics values respectively indicating their significance on the demand for LPG on the Economy of Ghana. However, inflation and Exchange Rate have negative t-statistics values showing an insignificant on the demand for LPG. This implies that the demand for LPG depends on the GDP, urban population as well as the Expump price. The analysis here is that, whenever there is an increase in GDP, urban population and Expump price increase or decrease the demand for the LPG would be affected which would in effect impact positively or negatively on the Economy of Ghana. The graph of LPG is seen below indicating an increasing trend for the demand for clearly points to the fact that the demand for the LPG tends to be more than the rest of the Petroleum Products.

Fig-13. LPG Demand Model Curve Fitting



4.16. The Demand Model for InLPG as Dependent Variable

In this section, we would be discussing linear model of InLPG Demand and compared with LPG Demand Model. An analysis would be carried out in order to compare and contrast the two models which is feasible for justification. Now, the model is represented as follows:

$$\text{InLPG Demand} = \underset{(-0.504)}{-1.559\,InGDP} - \underset{(-1.411)}{0.142\ \text{InInflation}}$$

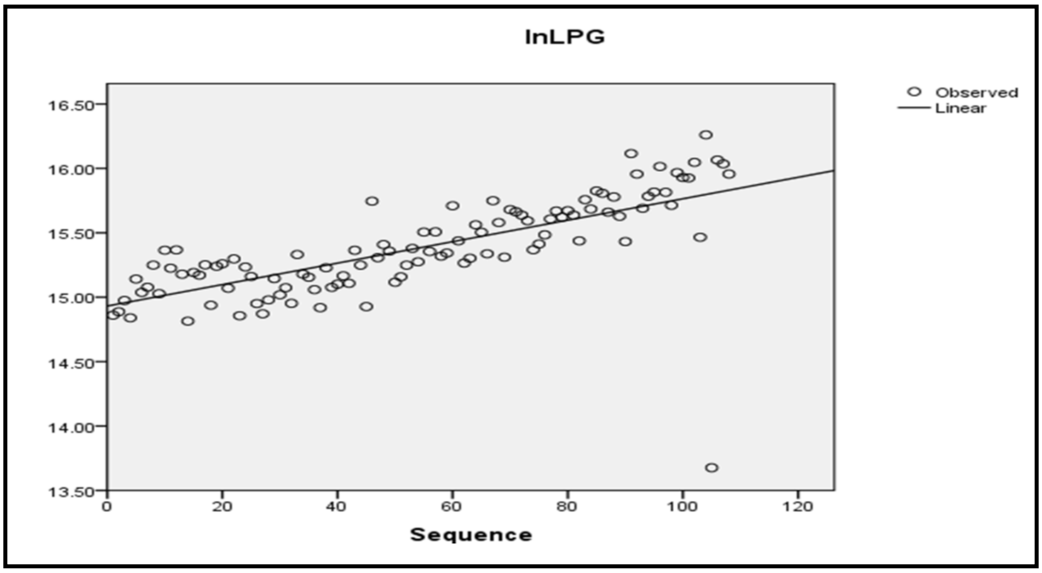
$$\underset{(-0.864)}{-0.066\ \text{InExchange Rate}} + \underset{(0.720)}{5.212\ \text{InUrban Population}}$$

$$\underset{(1.488)}{+0.343\ \text{InExpump Price}} + \underset{(0.783)}{17.904}$$

R^2 = 0.490   *Adjusted* $R^2 = 0.465$ Pr*edicted* Value $= 15.3855$

Based on the analysis of the model above, Urban Population and Expump Price registered a positive t-statistics values accounting for a significant demand for the LPG whilst GDP, inflation, Exchange Rate recorded negative t-statistics values indicating that these variable are not significant on the demand for the LPG. The impact on the economy of Ghana is that the demand for the LPG is more often than not dictated by urban population as well as the expump price which has a direct positive impact on the demand for LPG. Also, the graph of the In LPG is also shown below.

Fig-14. InLPG Demand Model Curve Fitting



4.17. The Demand Model for Gasoil as Dependent Variable

This section again also touches on the analysis of the Demand Model for Gasoil as dependable variable. Hence the equation for the model is therefore seen as follows:

$$\text{Gasoil Demand} = \underset{(1.273)}{13.728\,\text{GDP}} + \underset{(1.322)}{137001.288\,\text{Inflation}}$$

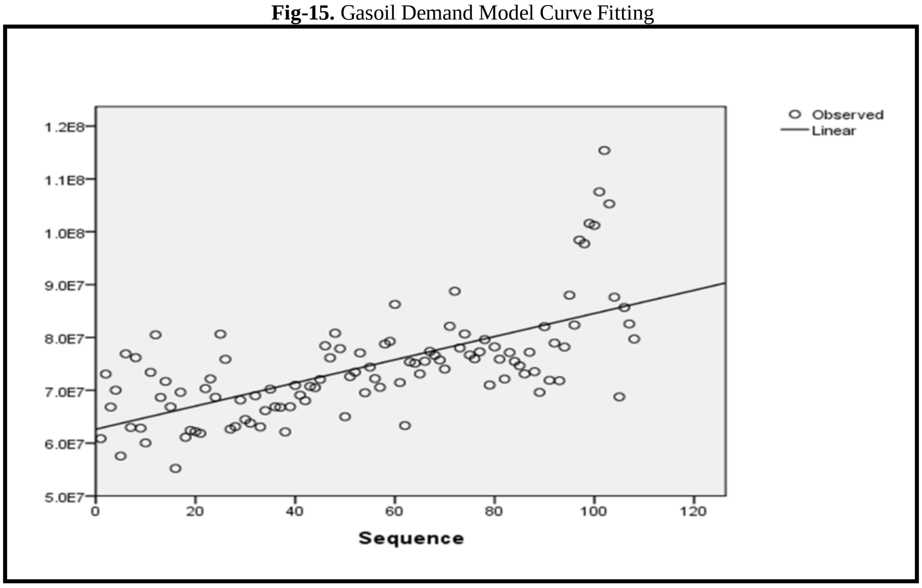
$$-\underset{(-3.227)}{1730.801\,\text{Exchange Rate}} - \underset{(-2.880)}{3606.719\,\text{Expump Price}}$$

$$+\underset{(1.085)}{4.074E8\,\text{Urban Population}} - \underset{(-1.480)}{1.740E8}$$

$$R^2 = 0.544 \qquad \text{Adjusted } R^2 = 0.521 \qquad \text{Predicted Value} = 7.46E7$$

The above model is a linear demand equation for Gasoil. From the analysis carried out so for we could observe that whenever the coefficient of the variable become positive the t-statistics also results in positive value and vice versa. This is implied that there is a correlation or relationship between these two variables. Now, based on the previous analysis it meant that when the t-statics for the variables are positive it implied that, these independent variables were significant and vice versa. This, however, implies that, the demand for the Gasoil depends much on the GDP, inflation and urban population. The impact on the Economy of Ghana is that as GDP keeps on growing coupled with an increasing inflation and urbanization the demand for the Gasoil would therefore go up. Below is the graph of Gasoil Demand model.

Fig-15. Gasoil Demand Model Curve Fitting



4.18. The Demand Model for InGasoil as Dependent Variable

This section deals with the model development of InGasoil Demand and its analysis and comparison with the Gasoil Demand based on the independent variables. Thus the equation for the model is represented below:

$$\text{InGasoil Demand} = \underset{(0.507)}{0.425\,\text{InGDP}} + \underset{(1.614)}{0.057\text{InInflation}}$$

$$-\underset{(-1.238)}{0.033\,\mathit{InExchange}\text{ Rate}} + \underset{(1.673)}{3.829\,\mathit{InUrban}\text{ Population}}$$

$$-\underset{(-2.259)}{0.171\,\mathit{InExpump}\text{ Price}} - \underset{(-0.256)}{1.725}$$

$$R^2 = 0.527 \qquad \text{Adjusted } R^2 = 0.504 \qquad \text{Predicted Value} = 18.1186$$

From the model we therefore observe that GDP, inflation and urbanization have positive t-statistics values whilst, Exchange rate and Expump price have negative t-statistics values indicating the significant and insignificant of the variables on the demand for Gas oil respectively. However, the negative Expump price implies that the price in Inelastic and so the demand for the Gasoil depends much on the variables with positive t-statistics values. Thus, any shortfall in the GDP, inflation and urban population might have economic consequences so far as the demand for the Gasoil is concerned. The graph displayed below is the linear demand trend of InGasoil

Fig-16. InGasoil Demand Model Curve Fitting Comparison of the Results of the Various Demand Models

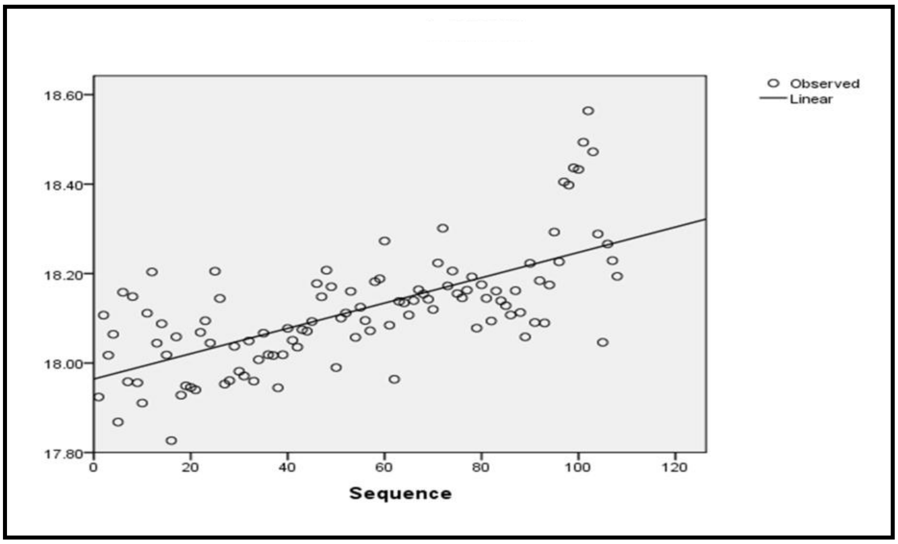


Table-10.

	Premium	InPremium	Kerosene	InKerosene	LPG	In LPG	Gasoil	InGasoil
R^2 values	0.180	0.113	0.438	0.434	0.628	0.490	0.544	0.527
Adjusted R^2 Values	0.140	0.069	0.410	0.406	0.609	0.465	0.521	0.504
Predicted Values	5.91E7	17.8852	7.99E6	15.8507	.14E6	15.3855	7.46E7	18.1186

(**Source:** Author's Own Work)

4.19. Justification for Selecting Econometric Demand Equation or Model

Two econometric demand equations were developed and analysed with respect to the R^2, Adjusted R^2 and predicted values. For the various models in selecting the best relation for the modelling. The following two equations were considered as follows:

1. E = aGDP + bInflation + cExchange rate + dUrban Population + eExpump price + k….. (1)
2. In E = In GDP + bInflation + cIn Exchange rate + dInUrban population + eInExpump price + Z…….(2)
   From the table above, the values for R^2, Adjusted R^2 in equation (1) were higher than equation (2). Hence the justification is that the equation (1) is the best model for the econometric equation.

4.20. Discussion of the Result in Table 10

In this section we would be discussing the result tabulated as follows:

1. The coefficient of determination R^2 for Premium is higher than InPremium.
2. The value of R^2 for kerosene is also higher than that of the Inkerosene.
3. The R^2 value for LPG is clearly higher than its InLPG etc across the table 11.
4. However, the Adjusted R^2 value for premium, kerosene, LPG and Gasoil are higher than its corresponding natural logarithms of the variables mentioned above as we move across the table.
5. Similarly, regarding the forecast or the predicted values it also followed similarly scenario. Based on these results we could therefore say that the best model is the econometric demand model in equation (1) and any changes in the variables might have an impact on the economy of Ghana.

5. Conclusion

5.1. Findings of the Study

The general trend for both the observed and the fitted model showed an irregular variation demand for the petroleum products. We could also observe that the LPG is more demanded, followed by Gasoil, Premium and Kerosene respectively. The trend for the demand for the petroleum products based on the analysis of the exponential smoothing using the times series modeler revealed that, the trend also exhibited irregular variation but the fitted model was much smoother than the observed one. The extension for the forecast section of the graph clearly confirmed the trend for the forecast as exhibited in the table 10.Various Econometric Demand Models were developed for the petroleum products. Two Econometric models were actually developed and comparison with regard to their R^2, Adjusted R^2, t-statistics were made using non-natural and natural logarithms for the models. Based on the analysis carried out it was found out that, the best model therefore was the model without the natural logarithms. Another finding that came to light was that, some of the independent variables were not quite significant which might impact on the demand for the various petroleum products when analysing with respect to the their R^2 and t-statistics values. Based on the analysis, the various predicted values for its corresponding petroleum product were found. Again, comparison of the results of the analysis of the various petroleum products demand models were displaced or shown on table 11. The results of the R^2, Adjusted R^2, Predicted values clearly again showed that LPG was the petroleum product which was more demanded, followed by the Gasoil etc. We also saw how GDP, Inflation, Exchange Rate, Expump Price and Urban Population could affect the demand for the various product and consequently on the Economy of Ghana. Finally, both the exponential smoothing model and Econometric Demand Model for the various petroleum products indicated that LPG, Gasoil, Premium and Kerosene were demanded in that order.

Recommendation

The following were the recommendations made based on the findings stated above:

The irregular nature of the variation of the demand for the petroleum products may be attributed to the problem of under production therefore, there is the need to step up production in order to ensure constant supply of the products so that constant Economic activities could be pursued. The demand for the LPG the highest followed by Gasoil etc. therefore implying that a lot of people as well demand or use it for cooking or as fuel. This trend implies that the rate of deforestation could be reduced in order to bring about afforestation. The Econometric Demand Model developed for the various products might depend on either two or more of the independent variables such as the GDP, inflation, and the exchange rate. Thus, whenever there is a shortfall in any of these variables it may affect the demand for particular products and consequently affect the Economy of Ghana. For the two models developed for TOR, it was clear that the one without the natural logarithm relation was the best model for the organization based on the analysis of their R^2, predicted values and Adjusted R^2 values respectively. Lastly, the comparison of the exponential smoothing forecast values as well as the Econometric Demand Model for the various products clearly revealed that, so far as the Economy of Ghana is concerned, the demand for LPG is highest, followed by Gasoil, premium and kerosene. Forecasting the demand for petroleum products might bring into focus planning how much new generation capacity may be needed as well as the expansion of the distribution systems of the petroleum products.

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