TIME SERIES ANALYSIS OF THE EFFECT OF PETROL AND DIESEL PRICES ON THE KENYAN ECONOMY

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[1] ***A research project submitted to Masinde Muliro University of Science and Technology, faculty of Natural Science, department of mathematics in partial fulfillment of the requirements for the award of a Bachelor of Science (Applied Statistics with IT) degree***

DECLARATION

This project is our work and has not been presented for a degree award in any other institution.

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APPROVAL

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ABSTRACT

Petrol and diesel being fossil fuels, they are mainly used in the transportation, manufacturing and processing industries. As input, being the major source of energy, fluctuations in the prices directly affect the level of economy in the country. Recently petrol and diesel have been exhibiting non-stability in their prices, due to changes in demand and supply, seasonality in demand, influence by Organization of Petroleum-Exporting Countries (OPEC). Again, political unrest in the oil producing countries and the government through the Energy and Petroleum Regulatory Authority (EPRA) setting up high taxes on oil prices, that has now led to fluctuations in prices of other products in the country. Many researches have been done on petrol and diesel prices however, minimal research was done on forecasting fuel prices in relation to the Kenyan economy. Our study focuses on the Box-Jenkins (1976) strategy that involves; stages of identification, model estimation, diagnostic checks and forecasting the time series. The objectives of this study are; to analyze the impact of petrol and diesel prices on the Kenyan economy level and to fit a time series model that will help petrol and diesel traders, enabling them to know when to trade their shares with petroleum companies. The analysis of the impact of petrol and diesel prices on the economy level will assist the government to formulate policies and guidelines related to petrol and diesel, which will go a long way to influence the economy level of the country. Whereas the fitted time series model will help petrol and diesel traders to have record of when to buy and sell their shares in petrol and diesel companies. From our research study, we expected results from our data to be stationary, thus we did stationarity tests on it and later on went ahead to fit ARIMA models on it so as to come up with the best model. Through our best fitted ARIMA model, we are to do forecasts to ascertain future petrol and diesel prices together with a forecast on the Kenyan GDP. The breakdown of our working and analysis is documented in chapter of this project paper.

ABBREVIATIONS AND ACRONYMS

EPRA -Energy and Petroleum Regulatory Authority

ERC - Energy Regulatory Commission

MMUST - Masinde Muliro University of Science and Technology

SONAS - School of Natural Sciences

MA - Moving Average process

AR - Autoregressive model

ARMA - Autoregressive Moving Average

ARIMA - Autoregressive Intergrated Moving Average

OPEC - Organisation of the Petroleum Exporting Countries

ADF - Augumented Dicky Fuller

KPSS - Kwiatkowiski-Phillips-Schmidt-Shin test

PACF - Partial Auto Correlation Function

WN - White Noise Process

R - R Programming Software

GDP - Gross Domestic Production

Contents

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Not much has been done in time series and forecasting petrol and diesel prices in Kenya. Bajjalieh, (2010), forecasted diesel fuel prices using a Composite forecasting model, which is an integrated model consisting of the Future-Base Forecasting models and the Structural-Based Forecasts model in Illinois. Researchers have also participated in the forecasting of other energy models. These studies include; a study by Javier et al, (2003) who used the ARIMA models to predict next-day electricity prices in Spain, Prerna (2012), forecasted natural gas price in London using a time series and non-parametric approach, Syed et al, (2012) investigated on the impact of oil prices on food inflation in Pakistan. Kotut et al (2012), looked at the impact of petroleum oil prices fluctuation in Kenya. Ron et al (2012), forecasted the price of oil in Michigan. It is thus clear that little has been done in Kenya and thus this project aims at exploring the under researched market in the country. Now with this study, we will conduct a time series analysis effect of petrol and diesel prices on the Kenyan economy. The purpose of this study is to analyze the impact of petrol and diesel prices on the economy level, to fit a time series model to the petrol and diesel data, and finally to use the fitted model to forecast petrol and diesel prices in Kenya.

1.2 Statement of the problem

Prior to 2002, the petrol and diesel prices were stable, but this has not been the case in the recent years. Recent developments in the energy sector have made it impossible to forecast petrol and diesel prices. This is because both price and variability have dramatically increased. According to Nyongesa (2016), in the 2008 global financial crisis, the international demand of oil went down and the prices of crude oil decreased, however the prices of petrol and diesel have remained high than the recent past. Non-stability of petrol and diesel prices is the major challenge for this study. This is due to but not limited to; changes in demand and supply, seasonality in demand, influence by Organization of Petroleum-Exporting Countries (OPEC), political unrest in the oil producing countries and the government through the Energy and Petroleum Regulatory Authority (EPRA) setting up high taxes on oil prices. All these have led to the rise in price of other products in the economy.

1.3 General Objective

The general objective of this study is to determine a time series analysis effect of petrol and diesel prices on the Kenyan economy.

1.4 Specific Objectives

The purpose of this project is;

(i) To analyze the effect of petrol and diesel prices on the Kenyan economy.

(ii) To fit a time series model to the petrol and diesel prices data in Kenya

(iii) To use the fitted model to forecast the petrol and diesel prices.

1.5 Significance of the study

This study is significant in two ways; first, the analysis of the impact of petrol and diesel prices on the economy level is to assist the government to formulate policies and guidelines related to petrol and diesel that is to go a long way to influence the economy level of the country. Secondly, the fitted time series model is to help petrol and diesel traders to have record of when to buy and sell their shares in petrol and diesel companies.

CHAPTER 2: LITERATURE REVIEW

2.1 Energy Sector in Kenya

Petroleum is the most important source of energy in Kenya. Petroleum fuels do get imported in form of crude oil for domestic consumption through the port of Mombasa and refined in the same region at Changamwe. Fluctuations in international prices have directly affected domestic prices in the country. The international price of Murban crude oil rose by approximately 46% from US$ 62.05 per barrel in December 2006 to US$ 90.60 per barrel in December 2007 and about US$ 140 per barrel in August 2008, before decreasing to less than US$ 50 by March 2009. The total quantities of petroleum imports registered a growth of 16.4 % to stand at 3691.8 thousand tonnes in 2007. The total import bill of petroleum products also rose by 7.1% in 2007 compared to 8.9% in 2006 according to Kutot, et al (2012). In Kenya, the energy market is as a result of the government creating an energy policy that encourages the development of an energy industry in a competitive manner. In Kenya, the market is regulated by the Energy and Petroleum Regulatory Authority (EPRA) to protect consumer rights and avoid monopolies. EPRA was initially Energy Regulatory Commission (ERC). EPRA has established under the Energy Act, 2019. It is recommended by John M. et al (2012), that for monitoring and evaluation purposes in the performance of the energy sector, the Energy Regulatory Commission (ERC) could use the consumer satisfaction index level to evaluate whether the regulatory policies and their implementation are bearing fruit where a high index would be associated with good performance and vice versa. Following the operationalization of the Energy Act, 2019, the Energy Regulatory Commission (ERC) became Energy and Petroleum Regulatory Authority (EPRA) with an expanded mandate of inter alia regulation of upstream petroleum and coal. Currently, the objectives and functions of EPRA as given in Section 10 of the Energy Act 2019 include regulating the importation, exportation, transportation, refining, storage and sale of petroleum and petroleum products. Ngeno, et al (2017) did a study, to assess the effect e-procurement on effective supply chain management process in energy sector in Kenya. The result of this study was that; yes, the e-procurement affects the effective supply chain management process in energy sector in Kenya. Therefore, EPRA provides licenses of petroleum imports, export, transport, storage, refining and sale. Construction permits are also issued by EPRA for all petroleum related facilities in order to check proliferation of substandard sites. As part of its mandate, the EPRA fixes the fuel prices at the 15th of every month. Epra, (2019).

2.2 Price Control in the Energy sector

Literature has attempted to document the effect of changes in crude oil prices and exchange rates on oil retail prices (Manning, 1991; Really et al., 1998). A rise in crude oil prices to a high of US 147 dollars per barrel (in the second half of year 2008) led to a sharp rise in the retail price of premium petrol in Kenya to over Ksh. 100 per litre (Petroleum Insight, 2009). Kilian (2008) contends that most economies in the world are largely affected by global increase in petroleum product prices, which influence retail prices. International crude oil prices rose sharply in the second half of year 2008 to a high of US 147 dollars per barrel causing a sharp rise of oil products in Kenya; in the last quarter of year 2008, crude oil prices plummeted a great deal to an average of about US $45 per barrel (Petroleum Insight, 2009). The volatility of the Kenyan shilling further complicates the situation for the oil-marketing firms who have to do their settlement in foreign currency. The Borenstein, Cameroon and Gilbert (1997) study found some evidence of price asymmetry between gasoline prices and changes in crude oil prices. The US dollar- Kenya shilling exchange rate is similarly key in explaining retail pricing of petroleum products in Kenya since imported petroleum products are settled in US dollars and the same appreciated over the Kenya shilling in the better part of year 2008 and 2011 (National Energy Policy, 2012).

EPRA has introduced oil price controls to help regulate the energy sector, which is a restriction on the price that should be charged on oil products and energy in the market. The oil-marketing sector plays a significant role in the economic growth of Kenya considering that oil is an essential commodity in industrial production, transportation and generation of water, electricity amongst other products. Hardwick, et al (1999) indicate that oil marketing is characterized by oligopoly with only a few firms controlling the market, besides the sector being associated with barriers to entry and exit and the high volume of threshold that the firms are required to maintain. The oil-marketing sector received increased attention in Kenya following the rise of international crude oil prices in the period 2007-2008 which prompted the oil-marketing firms to pass on the cost to consumers. When the oil retail prices declined towards the end of year 2008, the firms did not reciprocate to reduce the retail prices for their oil products. This prompted the Kenyan government (through the Energy Regulatory Commission) to introduce price controls to regulate retail prices of selected oil products. Kilian (2009) attributes the sharp price increase in 2007–2008 to the combination of increased demand and stagnant supply, linking the increase in oil demand to the fast growth of emerging economies such as China and India.

The aim of price control is to make essential commodities easily available to the public. Such commodities include maize, maize flour, wheat, wheat flour, rice, cooking fat, sugar, kerosene, diesel and petrol. The pricing of oil products is often a complex process which is controlled by the relevant government department. When the price controls were introduced in Kenya, kerosene became expensive and the government had to reduce taxes on kerosene. According to Petroleum Insight (2012), in year 2011, sales for diesel were 1,769,029m3, petrol 781,032m3 and sales for kerosene were 340,603m3. Grant, et al (2006) indicate that the price of crude oil is the most significant factor in determining retail prices for petroleum products besides the interaction of forces of demand and supply. Despite the ERC setting the maximum pump prices for selected products, the retailing firms have a leeway in determining the actual oil retail prices bearing in mind their unique conditions, international crude oil prices, exchange rate changes among other factors. This has often led to a fluctuation in average monthly retail prices for several oil products. Job O., et al (2017).

The big question however is, do the price controls on these commodities achieve what they are intended to? Price controls have an effect of distorting the allocation of natural resources; this is because they reduce the entry and investment of resources in the long run. (Job O. et al, 2017) Kenol-Kobil and Total Kenya are among the major oil firms in the country which consistently performed better in the period before and after the implementation of price controls. The two are the only listed oil marketing firms at the Nairobi Securities Exchange. Total Kenya is one of the major oil marketing companies in Kenya with over one hundred and seventy service stations country wide and a large market share. The company has often experienced an increase in net turnover by up to 10% despite the rise in international oil prices and the impact of the depreciating Kenya shilling against the US dollar (www.total.co.ke). The key players in the Kenyan oil industry include: Kenol-Kobil, Total Kenya, Shell, Oil Libya, National Oil and GAPCO (Petroleum Insight, 2011). Three major oil marketing firms (Kenol-Kobil, Total and Shell) have large market share of over 50% of the market share in the oil industry in Kenya; by September 2012, the multinational oil marketers were controlling 51.4% of the market share that is Kenol - Kobil 19.4%, Total 17.9% and Shell 14.1% (Petroleum Insight, 2012).

If petrol and diesel prices are controlled and fixed, such that they appear cheaper, there will be an increase in demand for the fuel. However, the fuel firms will not be willing to supply more at the low prices as they pose a threat to their profits, which will lead to a shortage of petrol and diesel supply in the country.

2.3 Effects of petrol and diesel Prices to the Economy

In Summary,

- The rise in fuel prices is likely to have a trickle-down effect on the cost of living experienced by the ordinary Kenyan
- Prolonged reduced consumer spending, due to the economic downturn is a sign of worse times ahead.

Petrol and diesel are important fuels to the economy in that most of the sectors depend on them for running their machines. They are used in the transport sector, agricultural sector, industrial sector and many other sectors, to run machines and locomotives

The Energy and Petroleum Regulatory Authority reviewed the prices of fuel upward to historic highs. The recent reviews did push the pump prices of petrol, diesel and kerosene to unprecedented highs of KES 134.72, KES 115.60 and KES 110.82 in Nairobi (Karen K., 2021). Unfortunately, historically high fuel prices, combined with the current economic downturn wherein consumer purchasing power is diminished, may spell further woes for the ordinary citizen.

This will attract more investors in the country and thus more businesses will be set. The GDP will in turn go up for the investments will have stimulated it. A high GDP translates to an improvement in economic growth in a country. Matatu owners hike fares in view of the increased fuel costs, driver-partners in the multitude of ride-sharing platforms available within the Kenyan market are always threatening to go on a go-slow in view of the same, as well as an increase in prices of ordinary commodities such as bread, milk and maize flour. All these considered translate to less income in the hands of the ordinary Kenyan and consequently reduced consumer spending (Karen K., 2021).

A decrease in the level of investments as a result of petrol and diesel prices is an inhibiting factor to economic growth as the GDP in the country will be low. From an economics perspective, prolonged reduced consumer spending, whether resultant of the economic downturn occasioned by the COVID-19 pandemic, or increasing fuel prices, is a sign of worse times ahead. Indeed, the same is often considered a herald of depressed economic growth. In the Kenyan context, this may lead to decreasing demand for ordinary goods and services, which in turn may have a negative impact on tax revenues generated and remitted to the Government's coffers (Karen K., 2021).

From a business perspective, increased costs of fuel will likely translate to reduced investments and plateaued growth on the back of increased business costs. This is particularly true to businesses engaged in energy dependent industries such as manufacturing, transportation and construction. An increase in the cost of fuel will have a direct impact in the cost of electricity, thereby increasing the cost of running energy dependent machinery and equipment (Karen K., 2021).

2.4 Inflation on the petrol and diesel Prices

Kenya's inflation rose to a 19-month high in September on the back of the rising cost of basic products such as fuel, food and electricity, signaling a painful cost pinch on budgets for households and businesses amid the Covid-19 pandemic impact (Constant M., 2021).

Inflation — a measure of changes in the cost-of-living year-on-year — climbed to 6.91 percent from 6.57 percent in August as bad weather, high cost of global fuel prices and supply constraints affected commodity prices (Constant M., 2021). Inflation is an increase in the price of a collection of goods and services over a certain time period. (Constant M., 2021),The Kenya National Bureau of Statistics (KNBS) report showed that food prices rose 10.63 percent in September 2021 compared with the previous year. 12 The higher costs are largely on account of biting dry weather conditions in more than 10 counties, making it the second back-to-back double-digit growth.

The KNBS data shows, over the last year, the price of cabbages has risen by 30.76 percent a kilo, spinach 20.99 percent, Sukuma-wiki (kale) 16.93 percent, tomatoes 11.67 percent, and carrots are up 9.10 percent, (Constant M., 2021). Factors causing inflation in Kenya include but not limited to; a rise in the cost of production, weakening of the Kenyan shilling with respect to the dollar, increase in money supply, increase in government expenditure among others. Petrol and diesel being among the raw materials in production, increase in their prices leads to the increase in the cost of production. This in turn leads to the producers increasing prices to maintain their profits. The government of Kenya has tried to maintain the prices through EPRA, though it has at times been difficult to keep them low due to the energy crisis in the global market.

Through the previous studies, it is evident that studies have been made related to the petrol and diesel prices in Kenya, however it is also clear that a time series analysis and forecasting effect of petrol and diesel prices on the Kenyan economy has been minimally covered across these studies. Hence our project study seeks to conduct a time series analysis and forecasting of petrol and diesel prices on the Kenyan economy. And through the analysis, we are to determine a time series and forecasting model for this study.

CHAPTER 3: RESEARCH METHODS

3.1 Research Design

For this research study we have used a time series and forecasting research design. This is because the petrol and diesel prices have a tendency of changing with time. Monthly petrol and diesel prices from December 2010 to December 2019 were used as sufficient time series data and are fitted in an ARIMA model to obtain estimates that help to forecast the petrol and diesel prices in the future period using past data.

3.2 Source of Data

The data that we used, are those that are monthly sourced by the Energy and Petroleum Regulatory Authority (EPRA). These data on both Petrol and diesel are available in the EPRA website www.epra.go.ke,(2019) and R programming language was used to analyze and produce outputs for this project study.

3.3 ARIMA Model

In forecasting, ARIMA is one of the mostly used time series model. Unlike others it does not assume knowledge of any underlying structural relationships or economic model. It is assumed that values of the past series and the previous random error terms have information for the purposes of forecasting. The major advantage of ARIMA is that it requires data on the time series in question only. Prerna, (2012) provides that the ARIMA model is a modification of the ARMA model. ARMA models is a combination of the Auto Regressive (AR) and Moving Average (MA) models. The application of the ARIMA model to time series analysis is due to Box and Jenkins (18). The ARIMA model was applied in this study to forecast the petrol and diesel prices using monthly prices data from the Energy and Petroleum Regulatory Authority (EPRA).

3.4 Model Specification

This section provides a general outlook of the Moving Average (MA) model, the Autoregressive (AR) Process, the Autoregressive Moving Average Process (ARMA) and the Autoregressive Integrated Moving Average (ARIMA) process.

Moving Average model (MA)

Moving Average models were as a result of an invention by Slutsky in 1937, Makridaskis et al, (1995).An MA process is one in which the current value of a time series depends upon current and past random error variables.A first order MA process can be expressed as

$$Y_t = \theta_1 \epsilon_{t-1} + \epsilon_t$$

In general,a q th - order moving average model (MA) is non-stationary and has the general form as;

$$Y_t = \mu + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + ... + \theta_q \epsilon_{t-q}$$

$$\sum_{i=0}^{q} \theta_i \epsilon_{t-i}, \epsilon_t \sim WN(0, \sigma^2)$$

Y_t= Response (dependent) variable at time t

μ=Constant term of the process

$\theta_1, \theta_2, ..., \theta_q$= Coefficients to be estimated

ϵ_t= Error term at time, where

$$\epsilon_t \sim WN(0, \sigma^2)$$

$\epsilon_{t-1}, \epsilon_{t-2}, ..., \epsilon_{t-q}$=Error terms in the previous periods that are incorporated in the response variable.

Autoregressive (AR) Process

Autoregressive (AR) models were first introduced by Yule in 1926, Makridakis et al, (1995). An AR process is one in which the current value of a time series depends upon the past values of a time series and the random error. A first order AR process can be expressed as:

$$Y_t = \phi_1 Y_{t-1} + \epsilon_t, \epsilon_t \sim WN(0, \sigma^2)$$

In general, a pth-order autoregressive model AR (p)is non-stationary and has the general form given by;

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + \epsilon_t$$

$$= \sum_{i}^{p} \phi_i Y_{t-i} + \epsilon_t, \epsilon_t \sim WN(0, \sigma^2)$$

where Y_t =Response (dependent) variable at time t

$Y_{t-1}, Y_{t-2}, ..., Y_{t-p}$= Response variable at time lags

$$t-1, t-2, \ldots, t\breve{}p$$

, respectively

$\phi_0, \phi_1, \phi_2, ..., \phi_p$ = Coefficients to be estimated

ϵ_t =Error term at time t. Where

$$\epsilon_t \sim WN(0, \sigma^2)$$

Auto Regressive Moving Average model: ARMA (p,q)

The ARMA model is as a result of combination of the AR and MA models by Wold in 1938, Makridakis et al, (1995).He showed that ARMA processes can be used to model all time series as long as the appropriate order of p, the number of AR terms and q, the number of MA terms was appropriately specified. An ARMA (p, q) has the general form given as;

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + ... + \theta_q \epsilon_{t-q}$$

Auto Regressive Integrated Moving Average model ARIMA (p,d,q)

The ARIMA model is a modification of the ARMA models arrived at by transforming the time series data to Stationarity. ARIMA models became highly popular in the 1979s among academics, in particular when it was shown through empirical studies *Cooper*, (1972) that they could outperform the large and complex econometric models, popular at that time, in a variety of situations. If we difference the time series d,then the model becomes stationary *Ransang*, (2006). By applying ARMA (p,q) to it, we say the original time series Auto Regressive Integrated Moving Average model (p, d, q) where p is the number of autoregressive terms, d is the number of non-seasonal differences and q is the number of lagged forecast errors in the prediction equation. Stationarity in the model can be detected by considering the use of the Auto Correlation Function graph (ACF).If a graph of the time series values either cuts off or dies down fairly quickly, then the time series should be considered stationary. If however the graph of the ACF dies down extremely slowly, then the time series values should be considered non-stationary. If the original time series is stationary, d = 0 and the ARIMA model reduces to ARMA model. The difference linear operator is given by; $\triangle Y_t = Y_t - Y_{t-1} = Y_t - BY_t = (1 - B)Y_t$

The stationary series is obtained as the dth difference ($\triangle^d$) of Y_t , $W_t = \triangle^d Y_t = (1 - B)^d Y_t$

The ARIMA model thus has the general form given by;

$\phi_p(B)(1 - B)^d Y_t = \mu + \phi_q B \epsilon_t$

or

$\phi_p(B) W_t = \mu + \phi_q B \epsilon_t$

3.5 Box Jenkins-Method

The study focused on the Box-Jenkins (1976) strategy that involves stages of identification, model estimation diagnostic checks and forecasting the time series. The stages are analysed in the below subsections.

3.5.1 Model Identification

This stage involved determining whether the series was stationary or not and determining the tentative model by observing the behavior of the autocorrelation (ACF) and partial autocorrelation function (PACF) and the resulting correlograms (Al-Zeaud, 2011). Correlograms are the plots of the ACFs and PACFs against lag length. The correlogram can be given as;

$$\rho_k = corr(Y_t, Y_{t-k})$$

where ρ_k is the autocorrelation of the k^{th} series.

The autocorrelation coefficient (ACF) measures the correlation between a set of observations and a lagged set of observation it a time series. The sample autocorrelation coefficient is given by,

$$r_k = \frac{\sum(Y_t - \bar{Y})(Y_{t+k} - \bar{Y})}{\sum(Y_t - \bar{Y}_t)^2}$$

where Y_t =The data from the stationary time series Y_{t+k} =The data from k time period ahead of t $\bar{Y}$ =The mean of the stationary time series

The estimated partial autocorrelation function (PACF) is used as a guide together with the estimated autocorrelation function in choosing one or more ARIMA models that fit the data available. The idea of Partial autocorrelation is that we want to measure how Y_t and Y_{t+k} are related. The following equation gives a good estimate of the partial autocorrelation;

$$\hat{\varphi}_{11} = r_1$$

$$\hat{\varphi}_{kk} = \frac{r_k - \sum_{j=1}^{k=1} \hat{\varphi}_{k-1}, j r_{k-j}}{1 - \sum_{j=1}^{k=1} \hat{\varphi}_{k-1}, j r_j}, k = 2, 3, ...$$

$$\hat{\varphi}_{kj} = \hat{\varphi}_{k-1,j} - \hat{\varphi}_{kk}\hat{\varphi}_{k-1,k-j}, k = 3, 4, ..., j = 1, 2, ..., k-1$$

If a graph of the ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series should be considered stationary. If the ACF graph dies down extremely slowly, then the time series values should be considered non-stationary. If the series is not stationary, it needs a logarithmic transformation and then converting it to a stationary process by differencing.

3.5.2 Estimation of Parameters

The maximum likelihood estimator method was used to estimate the parameters of the model. However, the least square method could also be used to get the estimates. This method was based on the computations of the innovations the values of the stationary variable. The least- square method minimize the sum of squares,

$$min \sum_t \epsilon_t^2$$

Solving the estimation problem entails writing the above equation in terms of the observed data and the set of parameters (θ, ϕ, σ). An ARMA (p,q) process for the stationary transformation can be expressed as;

$$\epsilon_t = Y_t - \delta - \sum_{i=1}^{p} \theta_i Y_{t-i} - \sum_{i}^{q} \theta_i \epsilon_{t-i}$$

3.6 Forecasting using the Model

This stage involves getting the precise estimates of the coefficients of the ARIMA model in the identification stage. By fitting the time series data to the ARIMA model, these estimates are obtained . This stage also provides some warning signs on the adequacy of the model whereby if the model does not satisfy the adequacy conditions, it is rejected.

3.6.1 Model Application

Not much was done in forecasting petrol and diesel prices. Bajjalieh (2010) forecasted diesel fuel prices using a Composite forecasting model which is an integrated model consisting of the Future-Base Forecasting models and the Structural-Based Forecasts model in Illinois.Researchers have also participated in the forecasting of other energy models. These studies include; a study by Javier, Rosario, Francisco and Antonio (2003) who used the ARIMA models to predict next-day electricity prices in Spain, Prerna (2012) forecasted natural gas price in London using a time series and nonparametric approach, Syed, Muhammad, Amir and Ammar (2012) investigated on the impact of oil prices on food inflation in Pakistan, Kotut, Menjo and Jepkwony (2012) looked at the impact of petroleum oil price fluctuation in Kenya and Ron, Kilian and Robert (2012) forecasted the price of oil Michigan. It is thus clear that little has been done in Kenya and thus this project aims at exploring the under researched market in the country.

3.7 Data Analysis

R statistical software was used to run and analyze the time series data in order to obtain estimates that were used to forecast future petrol and diesel prices. The raw data obtained from EPRA was entered into the software and was run for the ARIMA process. For the data to be run, it must have undergone log transformation to make it easier to transform the data to Stationarity.

The values of the parameter estimates for the model were obtained from the output of the run data. The analysis also involves drawing time plots and other descriptive statistics. The diagnostic test values; the Mean Squared Error (MSE) has also been obtained from the analysis.

3.7.1 Assumptions

In this study we assumed that both petrol and diesel affect the country's economy directly, hence any change on these products prices, automatically causes a change in the economy and living standards in a country.

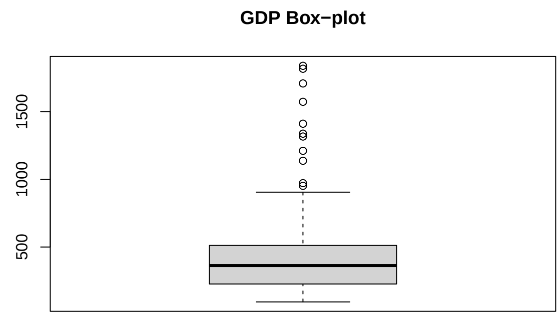
We also assumed that the other products of petroleum are likely to cause a change in the economy level of the country however small. These other petroleum products consist of Kerosene, bitumen, tar, plastics among many other products.

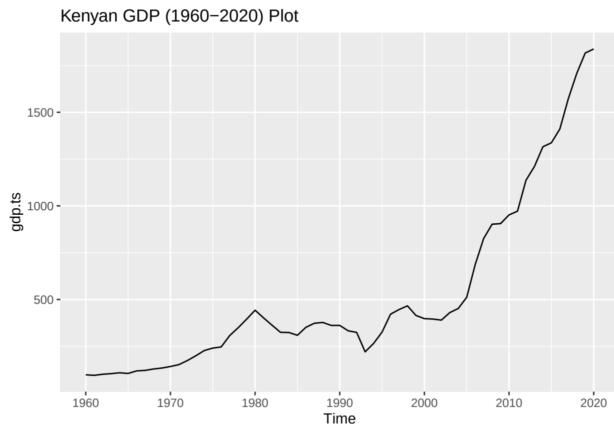
CHAPTER 4: DATA ANALYSIS, INTERPRETATION AND PRESENTATION

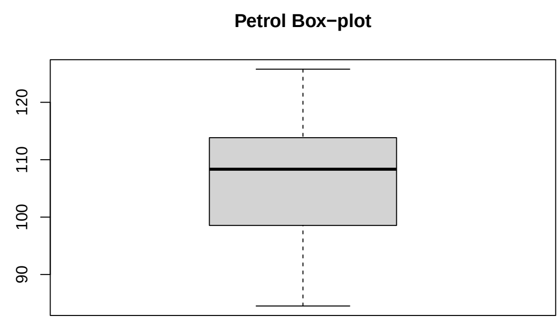
The section specifically discusses the stationarity of the GDP, petrol and diesel and the behavior of the autocorrelation graphs. the section also outlines the estimation results, a comparison of various models and a display of the equation showing the models chosen.diagnostic checks and estimations have also been discussed.

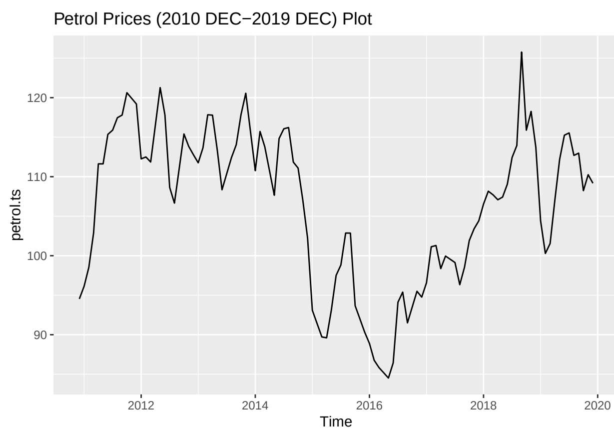
4.1 Preparation of Data

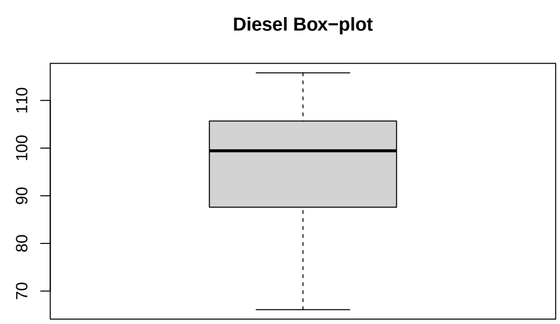
The plemininary analysis done by use of time and box plots as shown, the data for GDP had outliers in specific highs as the economy rose rapidly between the years of 2010 to 2020. From this statement, we also conclude that the kenyan GDP was also at its peak. Petrol and diesel had no outliers.

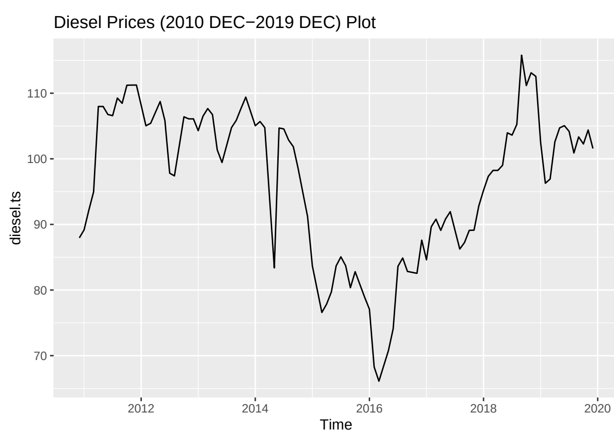












After omitting the outliers the data was in raw format. The data for GDP was annual while petrol and diesel were monthly data from 2010 December up to 2019 December. The dataset was converted to Time series format to ease the analysis for accurate modelling.

4.2 Test for Stationarity

By use of augmented Dickey fuller and kpss tests clearly indicated that gdp,petrol and diesel data were non stationary. According to ADF,all the p-values were greater than 0.05 futher testing KPSS p-values were less than 0.1.

In time series analysis stationary data is analysed or decomposed without differencing while non-stationery data is differenced first. The tie series datasets were differenced to attain stationarity.

Augmented Dickey-Fuller Test

data: gdp.ts Dickey-Fuller = 1.1856, Lag order = 3, p-value = 0.99 alternative hypothesis: stationary

Augmented Dickey-Fuller Test

data: petrol.ts Dickey-Fuller = -1.9548, Lag order = 4, p-value = 0.5954 alternative hypothesis: stationary

Augmented Dickey-Fuller Test

data: diesel.ts Dickey-Fuller = -1.5398, Lag order = 4, p-value = 0.7675 alternative hypothesis: stationary

KPSS Test for Level Stationarity

data: gdp.ts KPSS Level = 1.2226, Truncation lag parameter = 3, p-value = 0.01

KPSS Test for Level Stationarity

data: petrol.ts KPSS Level = 0.49883, Truncation lag parameter = 4, p-value = 0.04193

KPSS Test for Level Stationarity

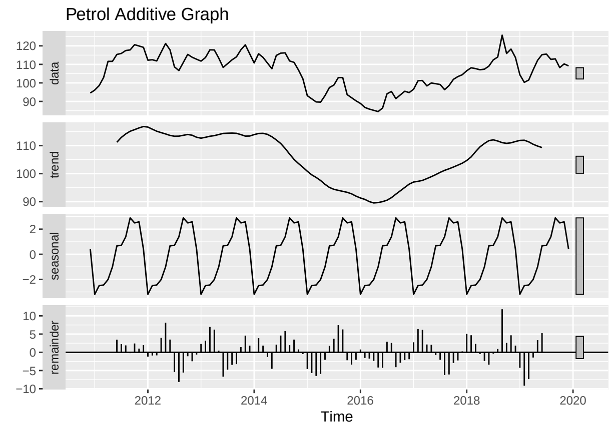
data: diesel.ts KPSS Level = 0.49717, Truncation lag parameter = 4, p-value = 0.0423

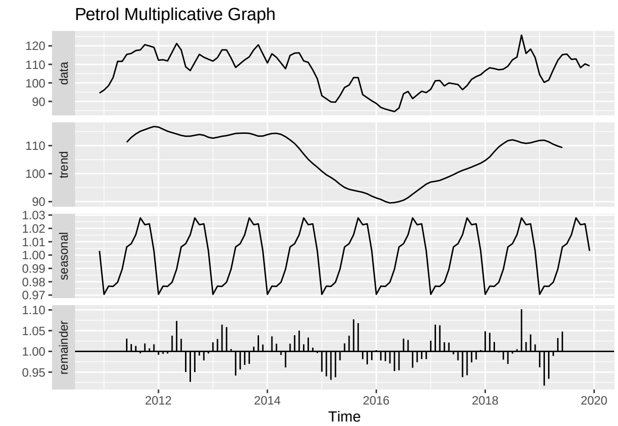
4.3 Time series Decomposition

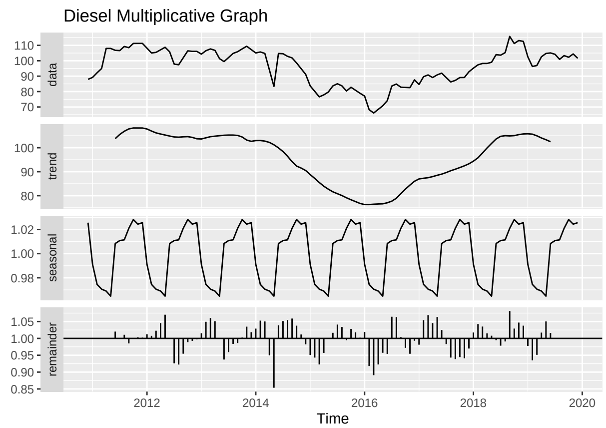
Time series decomposition aids in visualizing the observed, trend, seasonality and residuals in the data.

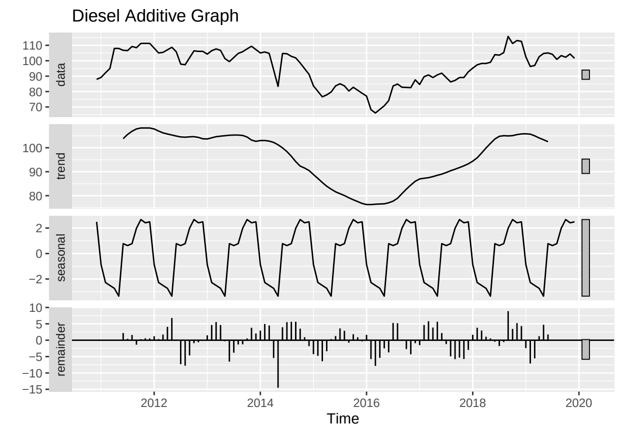
Petrol
Checking the decomposition in petrol, we observe the data and notice a trend which falls then rises creating a basin like trend while seasonal shows an oscilation like data and the remainder which is the residiuals.

This trend is seen through out all the three data graphs which their trend is either rising or falling.



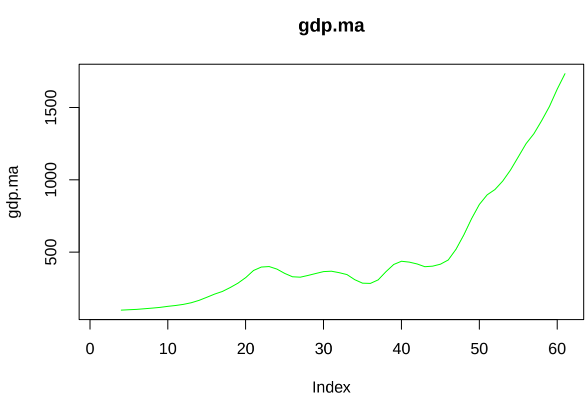


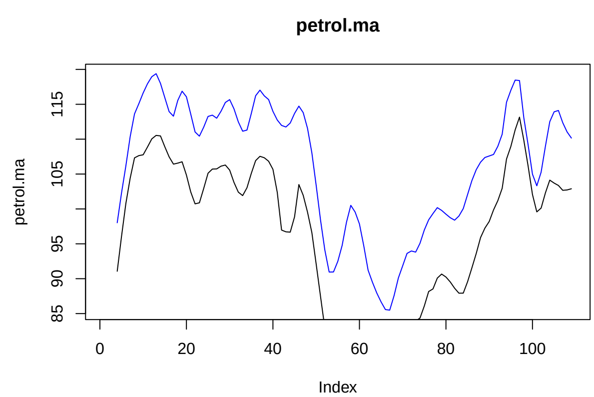




4.4 Getting Moving Averages

Moving averages in time series help in smoothing the observed data, plotting them out will give a really smooth data graph. The higher the moving average, the smoother the curve.We used a 4 moving average.

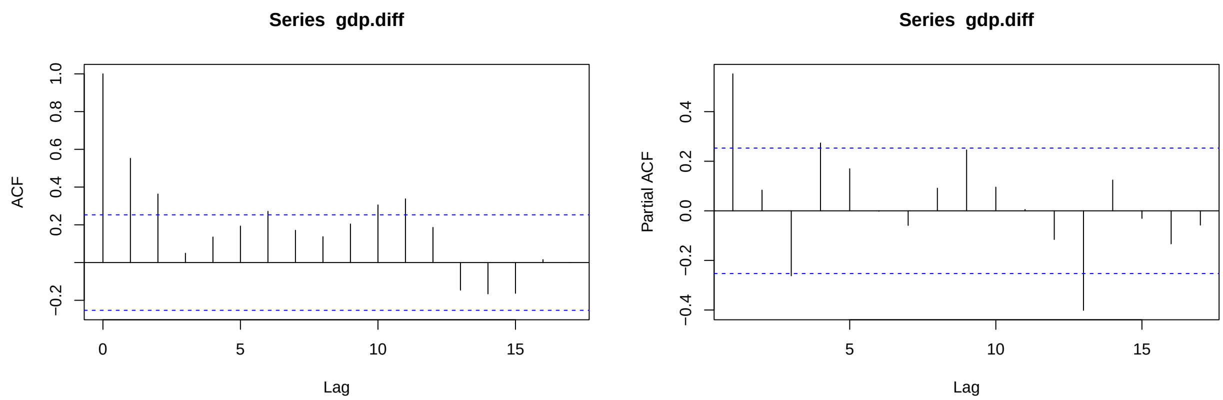




4.5 ACF and PACF plots

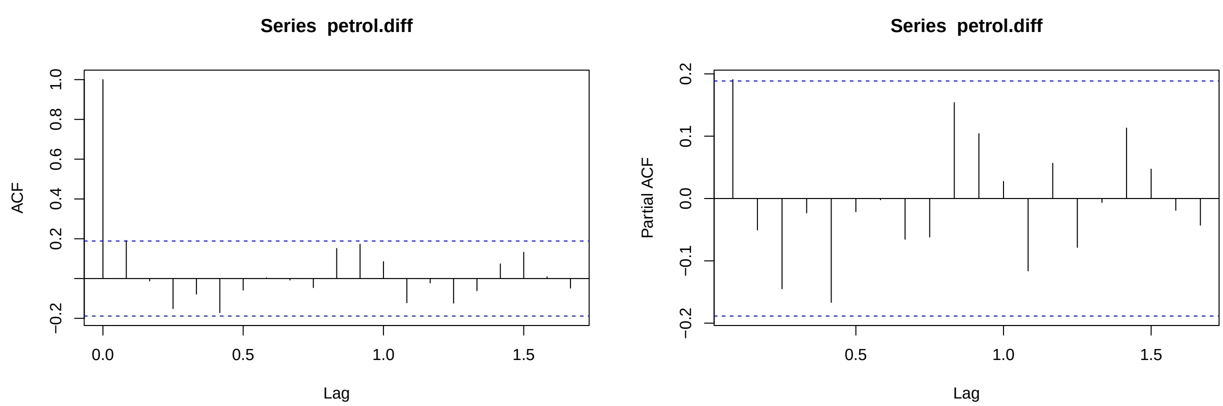
The dataset was non-stationary GDP and Petrol were differenced once while Diesel was differenced twices to to attain stationarity. The ACF plot shows the order of moving averages while the PACF plot shows the order of AR. Each lag above the confidence interval which is the blue dotted line is considered as the order of the MA or AR and the number of differencing is used as the I in the ARIMA model.

GDP ACF



The ACF plot for the differenced GDP gives MA of order 1,2,3,6,10,11 and AR of 1,4,13 these orders give the following possible ARIMA model to be used as seen below. (1,1,1) (1,1,2) (1,1,3) (1,1,6) (1,1,10) (1,1,11)

Petrol ACF

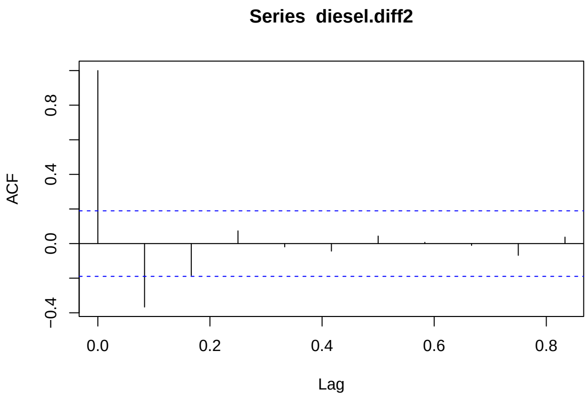


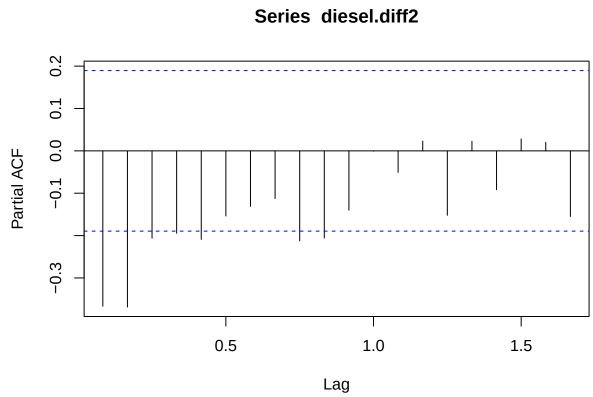
Petrol gives the ACF and PACF which gives the model of AR of order 0,1 and MA of order 1,2,3

(0,1,0) (0,1,1) (1,1,0) (1,1,1)

Diesel ACF

Diesel ACF gives the MA of 0,1 and AR of 1,2,3





4.6 Fitting the ARIMA Model

When fitting the model we have the following from the ACF and PACF plots of gdp we come up with the following models.

arima(gdp.diff,order = (1,1,1), (1,1,2), (1,1,3), (1,1,6), (1,1,10), (1,1,11), (4,1,2), (4,1,1), (4,1,3), (4,1,6), (4,1,10), (4,1,11), (13,1,1), (13,1,2), (13,1,3), (13,1,6), (13,1,10), (13,1,11)

The diesel ARIMA model for diesel gives the following;

arima(diesel.diff,order = (0,1,0),(0,1,1), (1,1,0), (1,1,1)

The model for petrols Arima is given with the following

arima(petrol.diff,order = (1,2,0), (1,2,2), (2,2,0), (2,2,1), (3,2,0), (3,2,1)

4.7 GDP ARIMA

Order	Log likelihood	AIC	Estimate
(1,1,1)	-308.21	622.41	1989
(1,1,2)	-308.21	624.41	1989
(1,1,3)	-304.14	618.28	1722
(1,1,6)	-299.63	615.25	1255
(1,1,10)	-297.44	618.88	1172
(1,1,11)	-297.69	617.39	983.7
(4,1,1)	-302.49	616.99	1622
(4,1,2)	-302.48	618.95	1622

Order	Log likelihood	AIC	Estimate
(4,1,6)	-296.59	615.19	1141
(4,1,10)	-291.98	613.96	892.7
(13,1,2)	-288.72	609.43	920.1
(13,1,3)	-288.59	611.17	913
(13,1,10)	-285.29	618.57	655.5
(13,1,11)	-285.19	620.38	653.7

4.8 Petrol ARIMA

Order	log likelihood	AIC	Estimate
(0,1,0)	-338.2	678.41	32.58
(0,1,1)	-309.8	623.59	18.34
(1,1,0)	-330.48	664.96	28.16
(1,1,1)	-309.04	624.08	18.12

4.9 Diesel ARIMA

Order	log likelihood	AIC	Estimate
(1,2,0)	-368.42	740.8472	60.94
(1,2,2)	-312.14	632.2855	19.36
(2,2,0)	-352.11	710.2296	44.54
(2,2,1)	-320.87	651.7392	23.38
(3,2,0)	-323.19	654.3705	24.54
(3,2,1)	-344.47	696.9429	38.4

4.10 Picking the Best Model

We pick the model with the highest log-likelihood as the best model for our analysis hence for :

1. GDP

WE PICK ARIMA(13,1,11) as the best model for our analysis.

2. DIESEL

we pick ARIMA(1,2,2)

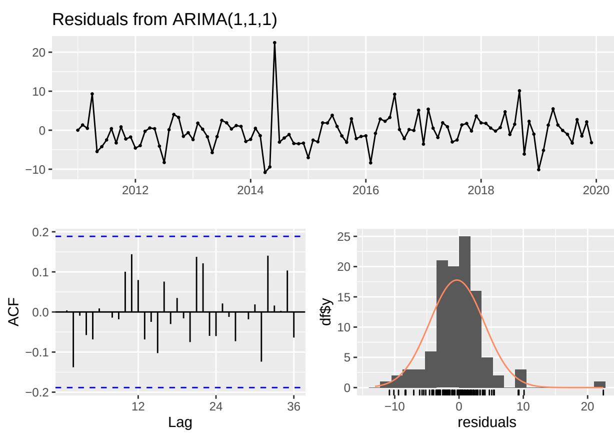
3. PETROL

We pick model ARIMA(1,1,1)

4.11 White Noise

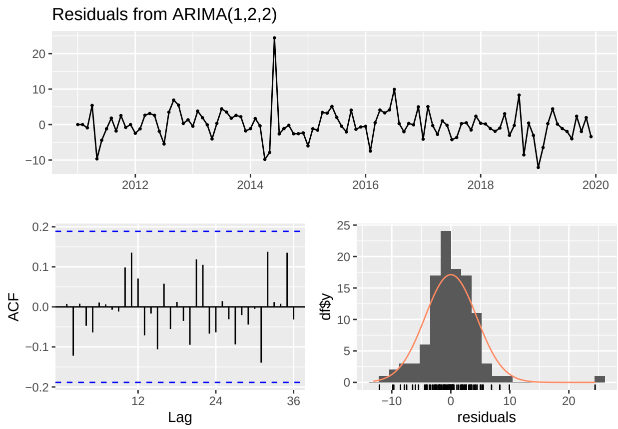
Are the residuals of the ARIMA following the WN process ? From the ACF and PACF plots, we do not observe any auto-regressive nature in our residuals. The Ljung Box test, further confirms our belief that the residuals from the best fit model is not auto-correlated as p-value significantly greater than 0.05.

Box-Ljung	X-Squared	df	p-value
Diesel	9.6137	1	0.001931
Petrol	14.935	1	0.0001113
GDP	0.00023708	1	0.9877



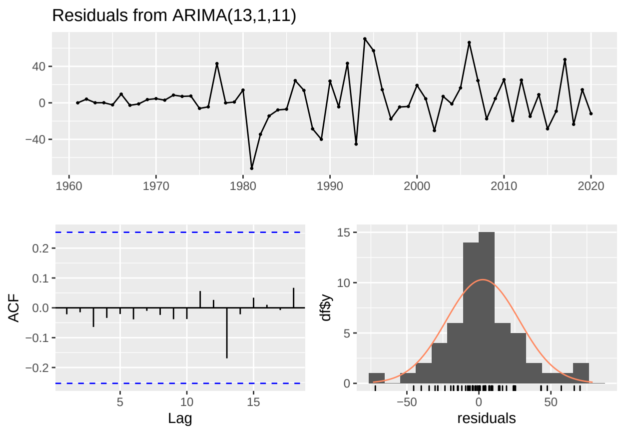

```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(1,1,1)
## Q* = 16.121, df = 20, p-value = 0.7091
##
## Model df: 2.   Total lags used: 22
```

From the petrol ACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.



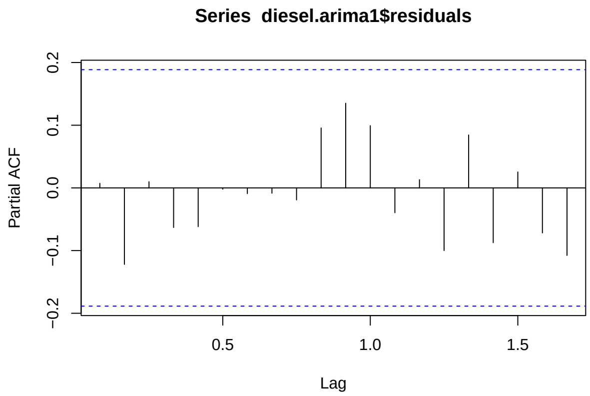

```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(1,2,2)
## Q* = 14.26, df = 19, p-value = 0.7683
##
## Model df: 3.   Total lags used: 22
```

From the diesel ACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.

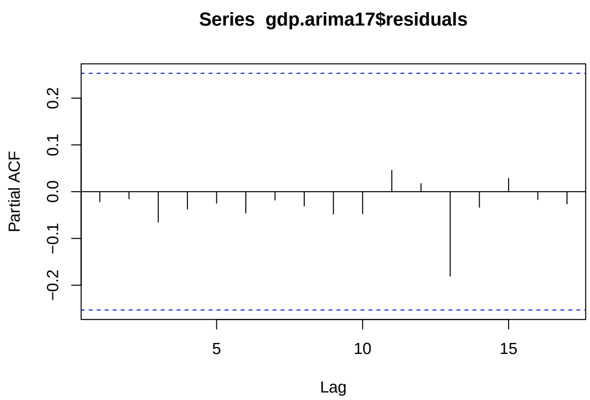



```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(13,1,11)
## Q* = 11.125, df = 3, p-value = 0.01107
##
## Model df: 24.   Total lags used: 27
```

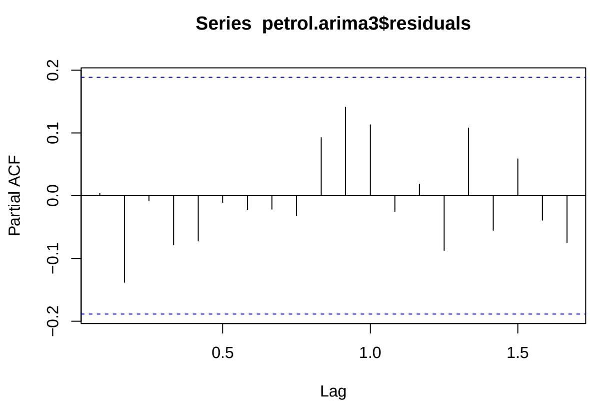
From the GDP ACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.



From the diesel PACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.



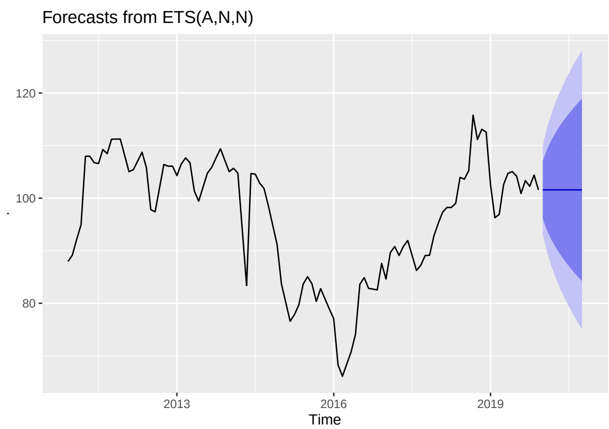
From the GDP PACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.



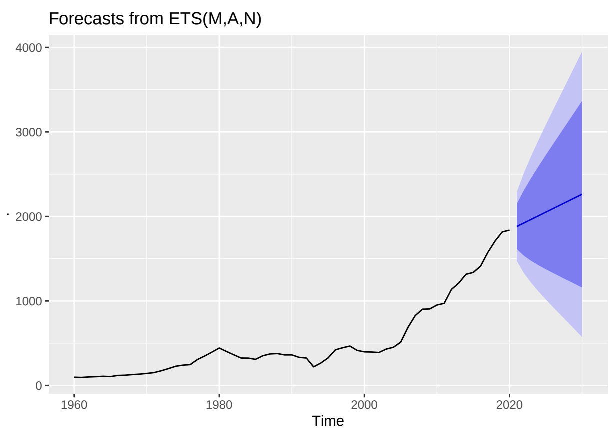
From the petrol PACF plot on the left of the graph above, we do not see any moving averages because there is no significant lag.

4.12 Forecasting

From our forecasted data we see that the prediction intervals will vary from 80 to 95 with each interval having their own highest and lowest values.

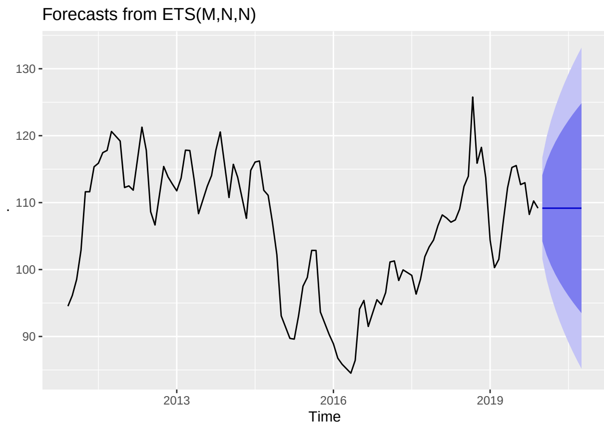


After fitting our ARIMA model, we were able to forecast the diesel prices for 10 months starting from January 2020 to October2020.



After fitting our ARIMA model, we were able to forecast the growth and decrease in the Kenyan GDP for 10 months starting from January 2020 to October 2020.

```
petrol.ts %>%
  forecast(h = 10) %>%
  autoplot()
```



After fitting our ARIMA model, we were able to forecast the petrol prices for 10 months starting from January 2020 to October 2020.

```
gdp.ts %>%
  forecast(h = 10)
```

```
##      Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 2021       1880.635 1613.954 2147.316 1472.7812 2288.488
## 2022       1923.057 1533.740 2312.374 1327.6477 2518.467
## 2023       1965.480 1473.506 2457.454 1213.0704 2717.889
## 2024       2007.902 1422.035 2593.770 1111.8953 2903.909
## 2025       2050.325 1375.106 2725.543 1017.6670 3082.982
## 2026       2092.747 1330.606 2854.888  927.1535 3258.341
## 2027       2135.170 1287.304 2983.035  838.4716 3431.868
## 2028       2177.592 1244.409 3110.776  750.4115 3604.773
## 2029       2220.015 1201.375 3238.654  662.1401 3777.890
## 2030       2262.437 1157.808 3367.067  573.0524 3951.822
```

Above are the values on GDP obtained after forecasting using our model for a period of 10 months.

```
petrol.ts %>%
  forecast(h = 10)
```

```
##          Point Forecast     Lo 80    Hi 80     Lo 95    Hi 95
## Jan 2020       109.1701 104.22374 114.1165 101.60529 116.7349
## Feb 2020       109.1701 102.17306 116.1672  98.46904 119.8712
## Mar 2020       109.1701 100.59797 117.7422  96.06015 122.2801
## Apr 2020       109.1701  99.26884 119.0714  94.02743 124.3128
## May 2020       109.1701  98.09675 120.2435  92.23487 126.1053
## Jun 2020       109.1701  97.03610 121.3041  90.61275 127.7275
## Jul 2020       109.1701  96.05982 122.2804  89.11965 129.2206
## Aug 2020       109.1701  95.15026 123.1900  87.72860 130.6116
## Sep 2020       109.1701  94.29518 124.0450  86.42087 131.9193
## Oct 2020       109.1701  93.48567 124.8545  85.18283 133.1574
```

Above are the values on the Kenyan petrol prices obtained after forecasting using our model for a period of 10 months.

```
diesel.ts %>%
  forecast(h = 10)
```

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
```

```
## Jan 2020       101.5743 96.08388 107.0647 93.17743 109.9711
## Feb 2020       101.5743 93.81006 109.3385 89.69994 113.4486
## Mar 2020       101.5743 92.06526 111.0833 87.03148 116.1171
## Apr 2020       101.5743 90.59430 112.5543 84.78184 118.3667
## May 2020       101.5743 89.29835 113.8502 82.79986 120.3487
## Jun 2020       101.5743 88.12671 115.0219 81.00800 122.1406
## Jul 2020       101.5743 87.04928 116.0993 79.36021 123.7884
## Aug 2020       101.5743 86.04643 117.1021 77.82648 125.3221
## Sep 2020       101.5743 85.10453 118.0440 76.38597 126.7626
## Oct 2020       101.5743 84.21366 118.9349 75.02350 128.1251
```

Above are the values on the Kenyan diesel prices obtained after forecasting using our model for a period of 10 months.

CHAPTER 5: CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

According to our findings the study indicates that petrol and diesel prices are not constant as they keep on fluctuating as the GDP rapidly increases in the recent years. This implies that their prices are non-stationary which suggests utilization of a non-linear model, thus incorporating the ARIMA model for this study. This also implies that petrol and diesel prices are not stable and keep on fluctuating. This research project concludes that the best Auto regressive Integrated Moving Average for the petrol was (ARIMA, 1,1,1), diesel was (ARIMA, 1,2,1) and that for the GDP was (ARIMA, 13,1,11). These models were the best to be used for predicting the volatility and forecasting the prices of petrol and diesel in Kenya. The forecasts obtained indicate a rising trend of the petrol and diesel prices for the months after December 2019 (forecasts).

5.2 Recommendation

From our findings and conclusions, we recommend that EPRA should adopt a stable form of petrol and diesel price indexing and taxations that are favorable. Petrol and diesel prices in Kenya are characterized by non-stationary prices that fluctuate unexpectedly which makes it difficult for petrol and diesel fuel users to think critically when buying or selling these fuels. As a result, this causes uncertainty in the petroleum energy market.

Petrol and diesel being inputs used in many sectors, e.g production, transport and agriculture etc. are so essential in the growth of the country's GDP. Therefore, an increase in their prices may lead to high cost of production among other variables, thus resulting to a cost push inflation in the country.

Inflation lowers the value of the currency in relation to other currencies such that country's exports become expensive while its imports get to be cheaper. The country will thus experience more imports compared to exports. If the government can maintain low/moderate prices, inflation will be eliminated and the economy will be in a position to have significant economic growth and development/GDP.

From the findings of our study, there is need for more data collection on Petrol and Diesel prices so as to come up with better and significant forecasts on petrol and diesel prices for the time periods ahead.

References

[1] Mutua, John, et al. “Consumers satisfaction in the energy sector in Kenya.” Energy policy 48 (2012): 702-710.

[2] Ngeno, K., & Kinoti, D. J. (2017). EFFECT OF E-PROCUREMENT ON EFFECTIVE SUPPLY CHAIN MANAGEMENT PROCESS IN ENERGY SECTOR IN KENYA. International Journal of Supply Chain Management, 2(3), 18–37.

[3] Nyongesa (2016). International Journal of Academic Research in Economics and Management Sciences, Maseno University

[4] Kotut,C.C.,Menjo,K.I.,Jepkwony,J.(2012) An Econometric Impact of Petroleum Oil Price Fluctuation in Kenya.Journal of Economics and Sustainable Development. Vol.3,No.7,2012

[5] EPRA, (2019) Energy and Petroleum Regulatory Authority (EPRA) Energy Policy, Kenya

[6] EPRA, (2019) Operationalization of the Energy Act 2019, Kenya

[7] EPRA, (2019) Energy and Petroleum Regulatory Authority (EPRA) monthly Petroleum Prices, Kenya

[8] Kumar,M.Dinesh,OP Singh and Sivamohan.M.V.K.(2001).Diesel Price Hikes and Farmers Distress:The Myth and the Reality. New Dephi Sage Publication 8(1).pp.483.

[9] Kumar,M.Dinesh(2005).Impacts of Electricity Prices and Volumetric Water Allocation on Groundwater Demand Management: Analysis from Western India. Energy Policy,33(1).pp.39-51.

[10] Kumar, M. D., Singh, O. P., & Sivamohan, M. V. K. (2008). Diesel price hikes and farmer distress: the myth and the reality. Proceedings of the 7th annual meet of IWMI-Tata Water Policy Program, 498-512.

[11] Lipsey, R. G., & Chrystal, K. A. (2007). Economics Oxford University Press.

[12] Makridakis, S. and Hibon,M.(1995). ARMA Models and the Box Jenkins Methodology.Journal of Forecasting, Vol.(1).No.2 pp111-153 [13] Moses, K. (2009). Oil Prices Pass- Through into Inflation in Kenya.Kenya Monetary School Research Centre.

[14] Prerna,M. (2012).Forecasting Natural Gas Price-Time Series and Nonparametric Approach.Proceedings of the World Congress on Engineering. VOL.(1).pp.5.

[15] Kumar,M.Dinesh,OP Singh and Sivamohan.M.V.K.(2001).Diesel Price Hikes and Farmers Distress:The Myth and the Reality. New Dephi Sage Publication 8(1).pp.483.

[16] Dinesh, et al, (2005).Impacts of Electricity Prices and Volumetric Water Allocation on Groundwater Demand Management Energy Policy,33(1).pp.39-51.

[17] Sivamohan, et al (2008). Diesel price hikes and farmer distress: the myth and the reality. Water Policy Program, 498-512.

[18] Chrystal, K. et al, (2008). Economics Oxford University Press.

[19] Makridaskis, et al,(1995). ARMA Models and the Box Jenkins Methodology. Journal of Forecasting, Vol.(2).No.2 pp111-153

[20] Moses, K. (2009). Oil Prices Pass- Through into Inflation in Kenya. Kenya Monetary School Research Centre.