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VECTOR AUTOREGRESSIVE (VAR) MODEL FORECASTING OF THE PETROLEUM PRODUCTS PRICE RATE IN SOME NIGERIA STATE

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ABSTRACT: *This study, titled "Vector Autoregressive (VAR) Model Forecasting of Petroleum Products Price Rate in Some Nigerian States (Petrol, Diesel, and Kerosene)", examines the trend, interdependence, and future prediction of petroleum product prices across two Nigerian states. The research evaluates the stationarity and descriptive statistics of the products' price distributions. Petroleum remains Nigeria's major revenue source, contributing over 90% annually. However, the 2012 national debate on petroleum pricing exposed inconsistencies in cost determination across agencies, enabling corruption within the subsidy framework. Analysis revealed that prices of petrol, diesel, and kerosene have continued to rise due to inefficiencies and distortions in the distribution chain. The yearly and monthly mean plots (2017–2024) indicate upward trends. Yearly mean plots for Petrol, Diesel, and Kerosene show quadratic trends with coefficients of determination (R^2) of 97.2%, 96.1%, and 98.8%, respectively. Monthly mean plots for Petrol and Diesel also exhibit quadratic trends (R^2 = 90.8% and 92.8%), while Kerosene's monthly mean shows a linear trend (R^2 = 86.8%). Correlation analyses and cross-correlation functions show strong positive relationships among the three petroleum products. The series for all products were non-stationary and became stationary after first differencing. In the estimated VAR(2) models, when Petrol Prices served as the dependent variable, only Kerosene Prices were significant at the 5% level; a 1% change in Kerosene Prices caused about a 7.7% change in Petrol Prices. Similarly, when Diesel Prices were the dependent variable, Kerosene Prices remained the only significant predictor, where a 1% change in Kerosene Prices caused a 39.3% change in Diesel Prices. Conversely, when Kerosene Prices were the dependent variable, both Petrol and Diesel Prices were significant, with 1% changes in Petrol and Diesel Prices causing 85.0% and 18.3% changes in Kerosene Prices, respectively. Forecast results indicate that Petrol Prices will experience a slight upward and stable variation, Diesel Prices will trend upward, and Kerosene Prices will fluctuate gradually from 2025 to 2027. Predicted prices range from ₦183.19–₦225.93 for Petrol, ₦191.35–₦1121.25 for Diesel, and ₦451.76–₦1866.88 for Kerosene.*

KEYWORDS: Vector Autoregressive (VAR), Petroleum Products Price, Trend, Stationarity, Forecasting.

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INTRODUCTION

Forecasting in time series analysis is the process of making predictions or estimates about future data points based on historical observations. Time series forecasting is a critical component in various fields, including finance, economics, meteorology, and operations management, among others, that help to perform accurate forecasting. Several methods and techniques are available, depending on the characteristics of the time series data. The choice of forecasting method depends on the nature of the time series data, including its stationarity, seasonality, and the presence of exogenous variables. It's often recommended to experiment with different methods and evaluate their performance to select the most appropriate approach for a given dataset. Additionally, time series forecasting often requires continuous monitoring and re-evaluation as new data becomes available, allowing for model updates and improvement (Ali et al., 2019).

However, researchers can incorporate one or more time series in a model to predict the value of another series by using a Vector Autoregressive (VAR) model. Vector Autoregressive (VAR) can be used both to model and forecast the response series and to analyze the impact of a series on another time series.

Petroleum oil is Nigeria's next biggest source of energy after coal in the late sixty. It supplies heat and lighting power, machinery lubricants, and raw materials for a variety of manufacturing industries.

Production of petroleum is expected to reach peak oil before 2035 as global economies lower their dependencies on petroleum as part of climate change mitigation and a transition towards renewable energy and electrification. This is expected to have significant economic impacts that stakeholders argue need to be anticipated by a just transition and addressing the stranded assets of the petroleum industry.

Petroleum refineries for synthetic textiles, fertilizers, and numerous chemical industries act as a "nodal industry." Most of Nigeria's petroleum occurrences are associated with anticlines and fault traps in tertiary-age rock formations. It occurs in folding regions, anticlines, or domes, where oil is trapped in the unfolded crest.

Petroleum, also known as crude oil, or simply oil, is a naturally occurring yellowish-black liquid mixture of mainly hydrocarbons and is found in geological formations. The name petroleum covers both naturally occurring unprocessed crude oil and petroleum products that consist of refined crude oil. Petroleum has mostly been recovered by oil drilling. Drilling is carried out after studies of structural geology, sedimentary basin analysis, and reservoir characterization.

Recent developments in technologies have also led to the exploitation of other unconventional reserves such as oil sands and oil shale. Once extracted, oil is refined and separated —most easily by distillation —into numerous products for direct use or for manufacturing, such as gasoline (petrol), diesel, and kerosene, as well as asphalt and chemical reagents used to make plastics, pesticides, and pharmaceuticals. Petroleum is used in manufacturing a wide variety of materials, and it is estimated that the world consumes about 100 million barrels (16 million cubic meters) each day. Petroleum production can be extremely profitable and was important for economic development in the 20th century, with some countries, so-called "oil states", gaining significant economic and international power because of their control of oil production.

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Petroleum exploitation has significant negative environmental and social consequences. Most significantly, the extraction, refining, and burning of petroleum fuels all release large quantities of greenhouse gases, so petroleum is one of the major contributors to climate change. Furthermore, parts of the petroleum industry actively suppressed science and policy that aimed to prevent the climate crisis. Other negative environmental effects include the environmental impacts of the exploration and exploitation of petroleum reserves, such as oil spills, and air and water pollution at the sites of utilization.

Nigeria has 4 refineries (Port-Harcourt I & II, Kaduna & Warri) with a total installed capacity of 445,000 barrels per day, including 2 offshore jetties and 4 inland jetties, as well as over 90 tank farms with wide-ranging storage capacities being operated by different oil marketing companies to cater for domestic consumption of refined petroleum products (House of Representatives, 2012). In addition, there are networks of 5,120 kilometers of pipelines (consisting of multi-product pipelines and crude oil pipelines), 23 strategic depots, and 24 pump stations installed to facilitate petroleum products distribution across the country (Lasisi, 2021; Onu, 2020; Osi, 206).

Akpoghomeh and Odili (2000) note that the deregulation policy was expected to bring competition into the sector as well as increase sources of supply for petroleum products and thereby ameliorate the situation. However, price control and subsidy schemes are still in place and have negated the benefits of the partial deregulation policy.

Petroleum product pricing is a troubling issue in Nigeria and a major focus of numerous subsidy debates held and its removal in the country in the run up to the 2012 subsidy protests. The debates revealed that there was no common front/agreeable cost of refined petroleum, kerosene, and diesel per liter in Nigeria. As a result, various agencies quoted different figures. Corruption seemingly thrived under these conditions in the subsidy program.

Nigeria has been very active in the exploitation and exploration of petroleum products. It has been the major source of revenue, which has contributed over 90% on a yearly basis. There is no doubt that the Nigerian petroleum products is plagued with many impending problems, leading to fuel scarcity due to ineffective petroleum products supply in Nigeria.

The aim of this study is to model and forecast prices of petroleum products (petrol, diesel, and kerosene) in some Nigeria states, using the VAR model. The objectives are as follows

i. Estimate the descriptive statistics of products distribution in Nigerians petroleum sector and determine the stationary of the prices of petroleum products under study, (Petrol. Diesel and kerosene).

ii. Determine the trend and unit root effect on the prices of petroleum products.

iii. Fit suitable VAR Model by using each variable as the dependent variable that can be used to predict future time series of these sectors in Nigeria.

iv. Forecast figures of pricing of petroleum products in future- petrol, kerosene and diesel.

The study sought to review the various computations and figures of pricing of petroleum products- petrol, kerosene and diesel in some of the Niger delta states. It undertook a comparative analysis of pricing of petroleum products across the world and gives an indication of the actual cost of petroleum products in Nigeria whether through importation or local

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production. The report provides the answers to these questions and provides recommendations on how best the country can manage its petroleum product pricing regime.

REVIEW OF RELATED LITERATURES

Petroleum, in one form or another, has been used since ancient times, and is now important across society, including in economy, politics and technology. The rise in importance was due to the invention of the internal combustion engine, the rise in commercial aviation, and the importance of petroleum to industrial organic chemistry, particularly the synthesis of plastics, fertilizers, solvents, adhesives and pesticides. (Oil derrick in Okemah, Oklahoma, 1922 and Ikporukpo, 1995).

Today, about 90 percent of vehicular fuel needs are met by oil. Petroleum also makes up 40 percent of total energy consumption in the United States, but is responsible for only 1 percent of electricity generation. Petroleum's worth as a portable, dense energy source powering the vast majority of vehicles and as the base of many industrial chemicals makes it one of the world's most important commodities. The top three oil producing countries are Russia, Saudi Arabia and the United States. In 2018, due in part to developments in hydraulic fracturing and horizontal drilling, the United States became the world's largest producer. About 80 percent of the world's readily accessible reserves are located in the Middle East, with 62.5 percent coming from the Arab 5: Saudi Arabia, United Arab Emirates, Iraq, Qatar and Kuwait. A large portion of the world's total oil exists as unconventional sources, such as bitumen in Athabasca oil sands and extra heavy oil in the Orinoco Belt. While significant volumes of oil are extracted from oil sands, particularly in Canada, logistical and technical hurdles remain, as oil extraction requires large amounts of heat and water, making its net energy content quite low relative to conventional crude oil. Thus, Canada's oil sands are not expected to provide more than a few million barrels per day in the foreseeable future.

Petroleum includes not only crude oil, but all liquid, gaseous and solid hydrocarbons. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane exist as gases, while pentane and heavier hydrocarbons are in the form of liquids or solids. However, in an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions and on the phase diagram of the petroleum mixture.

An oil well produces predominantly crude oil, with some natural gas dissolved in it. Because the pressure is lower at the surface than underground, some of the gas will come out of solution and be recovered (or burned) as associated gas or solution gas. A gas well produces predominantly natural gas. However, because the underground temperature is higher than at the surface, the gas may contain heavier hydrocarbons such as pentane, hexane, and heptane in the gaseous state. At surface conditions these will condense out of the gas to form "natural-gas condensate", often shortened to condensate. Condensate resembles gasoline in appearance and is similar in composition to some volatile light crude oils. The proportion of light hydrocarbons in the petroleum mixture varies greatly among different oil fields, ranging from as much as 97 percent by weight in the lighter oils to as little as 50 percent in the heavier oils and bitumens.

Petroleum is a fossil fuel that is found in geological formations beneath the Earth's surface. The naturally occurring petroleum is a yellow-to-black liquid that is refined to produce various types of fuels. The term petroleum covers unprocessed crude oil and petroleum products that

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consist of refined crude oil. It includes crude oil, natural gas plant liquids, liquefied refinery gases, and refined petroleum products such as gasoline and diesel.

Since the drilling of first petroleum, the commodity has emerged as an important part of our life. It has been used as fuel for our transport, a fuel to generate electricity to light our homes, run factories and machines, a raw material to produce fertiliser to increase food production and produce plastic which is used in a wide range of things we use in daily life.

The countries having the largest petroleum reserves include Venezuela, Saudi Arabia, Canada, Iran, Iraq, Kuwait, Russia, the United Arab Emirates (UAE), Libya, and Nigeria. With an oil consumption of 19.6mbd in 2016, the US is the world's biggest oil consuming country. The introduction of new technologies for exploration and production activities in the oil and gas industry has helped many companies to witness a multi-fold increase in their petroleum output. However, the production of petroleum is concentrated in some of the Middle East countries to a large extent.

Transportation: Petroleum is a key source of energy for transportation. Nearly two-thirds of transportation fuels are obtained from petroleum. The transportation fuels that are derived from petroleum include gasoline/petrol, diesel, liquefied petroleum gas (LPG), jet fuel, and marine fuel. While gasoline/petrol is used in cars, motorcycles, light trucks, and boats, diesel is used as fuel by trucks, buses, trains, boats and ships. Jet airplanes and some types of helicopters use kerosene, a byproduct of petroleum refining. Gasoline is the dominant transportation fuel in the US, accounting for 55% of total transportation energy use in the country in 2016, according to the US Energy Information Department.

Power generation: Though petroleum is largely used in transportation, it is also used in electricity generation. A fossil fuel power station uses petroleum or natural gas to produce electricity. Power generation from oil still accounts for a significant share in energy mix of many countries, even though coal is the dominant source for electricity generation. However, oil-fired power plants cause significant environmental pollution. Oil-fired power plants also consume huge amounts of water. According to the Joint Organizations Data Initiative (JODI), Saudi Arabia is one of the few countries that use crude oil directly for power generation, due to lack of domestic coal production.

Lubricants: Derived from petroleum, lubricants are used in many types of machines in almost all the industries. Lubricants are used in all kinds of vehicles and industrial machines to reduce friction. Besides, they are used in cooking, bioapplications on humans, ultrasound examination, and medical examinations. Lubricants typically contain 90% of base oil, usually petroleum fractions.

Pharmaceuticals: Petroleum byproducts such as mineral oil and petrolatum are used in the manufacture of creams and topical pharmaceuticals. Though most of the pharmaceuticals consist of complex organic molecules, the basis, however, is linked to simple organic molecules, which are mostly petroleum byproducts.

Agriculture: Petroleum is used in the production of ammonia, which is used as a source of nitrogen in agricultural fertilizers. To achieve high crop yields, pesticides are widely in agricultural sector. Most of the pesticides are produced from petroleum. Besides, machinery for agricultural tasks also consume petroleum. In this way, agriculture is one of the major users of petroleum.

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Chemical industry: Petroleum by-products are used by many chemical companies as raw materials. They are used in the manufacture of chemical fertiliser, synthetic fiber, synthetic rubber, nylon, plastics, pesticides and insecticides, perfumes, and dyes, paints, among others. Refining of crude oil results in the production of several by-products, which are used in making different products for household and industrial purposes. Major by-products of petroleum include plastic, detergents, neptha, grease, vaseline, wax, and butadine, among others.

Domestic uses: Many household products such as detergents, vaseline, wax, and others are derived from petroleum. Kerosene, a byproduct of petroleum, still used in many countries for cooking, lighting and other domestic purposes.

The Nigerian government established a domestic liquefied petroleum gas penetration program (DLPGPP) in order to support Nigerian households who are still using traditional fuels, which are hazardous and inefficient for users as they constantly pollute and degrade the environment. Much is not known about the relationships that exist among liquefied petroleum gas (LPG) accessibility, LPG affordability, and LPG adoption to guide DLPGPP implementation. To addresses the gap among the aforementioned, a cross-sectional, correlational survey was employed to analyze responses to a structured questionnaire received from 544 participants selected through stratified random sampling across the rural, suburban, and urban areas of the Federal Capital City. The relationships were tested using Pearson's correlational analysis, and binomial logistic regression models were fitted to test whether LPG affordability and LPG accessibility predicted LPG adoption for cooking in Nigeria's households. It was made known that a significant relationship exists among LPG affordability, LPG accessibility, and LPG adoption. (Lasisi 2021).

A cross-sectional survey conducted in 519 households in Lagos, Nigeria used a structured questionnaire to obtain information regarding choice of household cooking fuel and the attitudes towards the use of LPG. Kerosene was the most frequently used cooking fuel (n = 475, 91.5%; primary use n = 364, 70.1%) followed by charcoal (n = 159, 30.6%; primary use n = 88, 17%) and LPG (n = 86, 16.6%; primary use n = 63, 12.1%). Higher level of education, higher income and younger age were associated with LPG vs. kerosene use. Fuel expenditure on LPG was significantly lower than for kerosene (N (Naira) 2169.0 ± 1507.0 vs. N 2581.6 ± 1407.5). Over 90% of non-LPG users were willing to switch to LPG but cited safety issues and high cost as potential barriers to switching. Our findings suggest that misinformation and beliefs regarding benefits, safety and cost of LPG are important barriers on the use of LPG. Kerosene was the most frequently used cooking fuel (n = 475, 91.5%; primary use n = 364, 70.1%) followed by charcoal (n = 159, 30.6%; primary use n = 88, 17%) and LPG (n = 86, 16.6%; primary use n = 63, 12.1%). Higher level of education, higher income and younger age were associated with LPG vs. kerosene use (Obianuju *et al* 2018; Ali et al., 2022).

Osi, A. (2006) focused on the impact of domestic pricing of petrol on economic growth of Nigeria, he looked at the effect of Gross Domestic Investment (GDI), Labor employment (LEMP), and leading interest rate (LIR) between 1970- 2013 on economic growth of Nigeria. The main focus was on the PMS pricing due to government foot dragging on the deregulation of PMS price in Nigeria. The error correlation mechanism method was applied, it revealed that rise in PMS price had a negative visible impact on the Nigerian economy which is the real GDP at 5% significant level. It means that 1% rise in PMS Price of one-year lag results to 0.7% decline in real GDP. GDI showed a positive and visible contribution on the real GDP at 0.5% significant level. LEMP of one-year lag showed a positive and visible contribution on real GDP

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and LIR of two and three-year lags indicated a negative and visible contribution on real GDP at 5% significant level. They concluded that PMS Price, GDI LIR and LEMP are drivers of RGDP in Nigeria. They recommended that government should reduce the price of PMS by deregulating the sector, hence encouraging private sector participation in the downstream sector to create competition in the system.

Eregha et al (2015), looked at the petroleum product prices and inflationary dynamics in Nigeria. They discovered that the price of premium motor spirit remained stable until the advent of the military administration in the country, when the then military heads of state randomly increased the prices of petroleum products. There was high positive relationship between the prices of PMS and AGO and inflation in Nigeria. They recommended that government should cancel the idea of the removal of subsidy on PMS for now and focus on deregulation of the downstream sector in order to attract private investment to encourage local refining of petroleum products instead of importation. This will consequently reduce the prices of petroleum products and inflation in Nigeria.

Pearl (2012), while studying petroleum product pricing and complementary policies; experience of 65 under-developed countries, discovered that since 2009, there have been policy reversals by governments in order to keep up with world oil price increases. The economic difficulties have been compounded by rising food prices. Between January 2004, when world oil prices began to increase and January 2013, energy and food prices on the world market rose and fell in tandem, with a correlation coefficient of 0.89 in countries with high experience of petroleum price rise, public protests were often against high fuel and food prices.

Biu et al., (2024), investigated the relationship between petroleum prices and inflation in Nigeria. It concentrated on the impact of petroleum product price increase on the Nigeria economy from 1990 to 2011, using empirical econometric approach with the variables such as inflation rate and petroleum prices in use, it also found that PMS apply higher effect on inflation than AGO, while negative relationship exists between inflation and DPK.

Peter (2010), explained that deregulation which brings about increase in fuel price have a multiplier effect on the economy, which means that the inflation that will be as a result of such deregulation would rubbish the workers' income such that higher percentage of their earning would be spent on consumption and thus reduces their ability to make savings. The multivariate linear regression model of Nigerian economy was built to investigate the impact of downstream oil deregulation policy on Nigerian economic performance.

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MATERIALS AND METHODS

Time series is a standard method of analysis whose aim is to describe the behavior of the data and to explain, control and to forecast the future behavior of the data. A time series as a stochastic process is an ordered sequence of observations ordered by a time parameter which may be measured continuously or discretely.

Types of Time Series: There are two types of time series: regular and irregular. A regular time series is one where the data is recorded in equal length time increments. An irregular time series occurs when the data is recorded in varying length time increments.

Consider a company that takes the temperature of their employees at the start of every day. These temperatures are taken every day at around the same time, so the time length between recording the temperatures is constant -- always around 24 hours. Now, consider a laboratory that can only be accessed with a key card. At the start of the day there would be a cluster of recordings taken while employees enter the room for their shift. Since the employees don't enter the room in any uniform length of time though, the data collected would form an irregular time series.

Graphical Presentation of Data

Graphical Representation is a way of analysing numerical data. It exhibits the relation between data, ideas, information and concepts in a diagram. It is easy to understand and it is one of the most important learning strategies. It always depends on the type of information in a particular domain. There are different types of graphical representation. Some of them are as follows:

- **Line Graphs** – Line graph or the linear graph is used to display the continuous data and it is useful for predicting future events over time.
- **Bar Graphs** – Bar Graph is used to display the category of data and it compares the data using solid bars to represent the quantities (i.e. Cross-correlation function).
- **Line Plot –** It shows the frequency of data on a given number line. ‘ x ‘ is placed above a number line each time when that data occurs again.
- **Table** – The table shows the number of pieces of data that falls within the given interval.

Sources of Data

The first step in every statistical investigation is the collection of data which forms the basis for statistical analysis. The method usually depends on the nature of the investigation of the research. Basically, there are two methods used in data collection which include: primary and secondary methods of data collection. However, secondary method of data collection was adopted for the purpose of this research work.

Vector Autoregressive (VAR) Model

The objective of univariate time series analysis is to find the dynamic dependence of Y_t that is the dependence of Y_t on its paste values $Y_{t-1,}Y_{t-2,}Y_{t-3\ldots}$. A linear model implies that Y_t depends on its past values. The Vector Autoregressive (VAR) model is an approach in modeling

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dynamics among a set of variables. The approach usually focuses on the dynamic of multiple time series. Vector Autoregressive (VAR) model is also an independent reduced form dynamic model which involves constructing an equation that makes each endogenous variable a function of their own past values and past values of all other endogenous variables. The formula of the p-lag Vector autoregressive VAR(p) model is given as.

$$Y_t = C + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + \varepsilon_t \quad t = 1, \ldots, T. \tag{3.1}$$

Where,

$Y_t = (y_{1t,} y_{2t,\ldots} y_{nt})$ is an $(n \times n)$ vector of time series variable

$\Pi = (n \times n)$ coefficient matrices

ε_t is an $(n \times 1)$ unobserved zero mean with white noise vector process (serially uncorrelated and independent) with invariant covariance matrix Σ.

The model can be expressed in the matrix form as

$(y_{1t}\ y_{2t} \ldots y_{nt}) = (c_1\ c_2 \ldots c_n) +$
$(\pi_{11}^1\ \pi_{21}^1 \ldots \pi_{n1}^1 \quad \pi_{12}^1\ \pi_{22}^1 \ldots \pi_{n2}^1 \quad \ldots\ldots \quad \ldots\ldots \quad \pi_{1n}^1\ \pi_{2n}^1 \ldots \pi_{nn}^1)(y_{1t-1}\ y_{2t-1} \ldots y_{nt-1})$

$(\pi_{11}^2\ \pi_{21}^2 \ldots \pi_{n1}^2 \quad \pi_{12}^2\ \pi_{22}^2 \ldots \pi_{n2}^2 \quad \ldots\ldots \quad \ldots\ldots \quad \pi_{1n}^2\ \pi_{2n}^2 \ldots \pi_{nn}^2)(y_{1t-2}\ y_{2t-2} \ldots y_{nt-2})$
$+ \cdots +$
$(\pi_{11}^p\ \pi_{21}^p \ldots \pi_{n1}^p \quad \pi_{12}^p\ \pi_{22}^p \ldots \pi_{n2}^p \quad \ldots\ldots \quad \ldots\ldots \quad \pi_{1n}^p\ \pi_{2n}^p \ldots \pi_{nn}^p)(y_{1t-1}\ y_{2t-1} \ldots y_{nt-1}) +$
$(\varepsilon_{1t}\ \varepsilon_{2t} \ldots \varepsilon_{nt})$ (3.2)

Stationary and non-stationary time series

A time series is described as stationary if the statistical property for example, the mean and variance have constant time all through. If we have n values of observations $x_{1,} x_{2,} x_{3,\ldots} x_n$ of a time series, we can plot these values against time to help us determine if the time series is stationary. If the n -values fluctuate with constant variation around a constant mean μ, then we can say that the time series is stationary and all processes which do not possess this property are called "non-stationary". A non-stationary time series can be made stationary by transforming the time series into series of stationary time series value (differencing).

Strict stationarity

The $\{X_t\}$ is said to be completely (or strictly) stationary if for any admissible $t_1,\ t_2, \ldots, t_n$ and any k, the joint probability distribution of $\{X_{t_1}, X_{t_2}, \ldots, X_{t_n}\}$ is identical with the joint probability distribution of $\{X_{t_{1+k}}, X_{t_{2+k}}, \ldots, X_{t_{n+k}}\}$ .That is

$$F(x_{t1,} x_{t2}, \ldots, x_{tn}) = F(x_{t1+k}, x_{t2+k}, \ldots, x_{tn+k}) \tag{3.3}$$

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Weak stationarity

The $\{X_t\}$ is said to be stationary up to order m, if for any admissible $t_1, t_2, \dots, t_n$ and any k, all the joint moments up to order m, of $\{X_{t_1}, X_{t_2}, \dots, X_{t_n}\}$ exist and equal to joint moments up to order m of $\{X_{t_{1+k}}, X_{t_{2+k}}, \dots, X_{t_{n+k}}\}$.This can be written as

$$E(X_{t1}^{m1}, X_{t2}^{m2}, \dots, X_{tn}^{mn}) = E(X_{t1+k}^{m1}, X_{t2+k}^{m2}, \dots, X_{tn+k}^{mn}) \quad (3.4)$$

Some simple operators

There are some operating techniques in time series analysis that we intend to describe, they are as follows:

Backshift (lag) Operator

The Backshift Operator B or the lag Operator L is defined by

$BX_t = X_{t-1}$ Hence

$$B^m Z_t = Z_{t-m} \quad (3.5)$$

The inverse operator

This is performed by the forward shift F and is defined by

$FX_t = X_{t+1}$ Hence

$$F^m X_t = Z_{t+m} \quad (3.6)$$

The backward difference operator

This backward difference operator,∇ , can be performed and expressed as

$\nabla X_t = X_t - X_{t-1}$. It can be written in terms of B as

$$\nabla X_t = X_t - X_{t-1} = (1 - B)X_t \quad (3.7)$$

Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test:

The KPSS test unlike the ADF test, tests the null hypothesis for the presence of stationarity around a deterministic trend in the null hypothesis against the backdrop of an alternate hypothesis that has presence of unit root or non-stationarity. The absence of unit root is not always the case of stationarity being present but can also be the case of trend stationarity.

The KPSS test statistic which is the Lagrange multiplier (LM) or score statistic for testing $\sigma_\varepsilon^2 = 0$ against the alternative that $\sigma_\varepsilon^2 > 0$ is given by

$$KPSS = \frac{\sum_{t=1}^{T} \hat{S}_t^2}{T^2 \hat{\lambda}^2} \quad (3.8)$$

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where $\hat{S}_t = \sum_{j=1}^{t} \hat{u}_j$; $\hat{u}_j$ is the residual of the regression of y_t on D_t T is time and $\hat{\lambda}^2$ is a consistent estimate of the long-run variance of u_t and $\hat{u}_t$.

The conditions to fail to reject the null hypothesis is: Test statistic < Critical value and p-value < 0.05, then fail to reject H_0.

Statistical software's use is Minitab 21, Gretl Statistical software and Micro-excel software.

Based on findings of this study: In order to achieve the central aim of the research, the following research questions will be answered:

- ✓ Will the research come out with the suitable solutions to high rise in prices of petrol, kerosene and diesel in the petroleum sector?
- ✓ What actually is the cause of high rise in prices of this sector and how does the analysis describe the data?

The results of this study will deal with the analysis and interpretations of results. This section will be divided into four parts: the series plots and trend analysis; correlation and cross correlation; stationary of the series using unit root test and each variable as the dependent variable were modelled and forecasts to determine the fluctuation of the series in future using VAR model.

Series Plots and Trend Analysis: The series were plotted using Microsoft Excel and Gretl Statistical software. Then, each individual series fluctuation was examined to determine the trend component in the series monthly and yearly mean plots. Examples

Scopes/Limitations: This research work titled "prices of petroleum products in two states in Nigeria" could have cover many fuel stations, but due to strength and time constrain, it is limited to Nigeria National Petroleum Company (NNPC) Yenagoa and Rivers states only.

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RESULTS AND INTERPRETATIONS

This section deals with the VAR model establishment, analysis and interpretations of results, which is the Vector Autoregressive (VAR) Model formation and forecasting of petroleum products price rate in two Nigeria states. This section is divided into three parts: the series plots and cross correlation, stationary of the series using unit root test and each variable was used as the dependent variable to construct suitable VAR model for forecasting of the series in future.

Table 4.1: **Descriptive statistics of the three Petroleum Products for Both States**

State	Statistics	'Petrol Prices'	'Diesel Prices'	'Kerosene Prices'
Bayelsa	Mean	272.97	508.34	597.19
	Median	162.00	375.00	450.00
	Minimum	140.00	185.00	250.00
	Maximum	1214.00	1170.98	1363.00
	Standard deviation	251.98	365.79	382.05
	C.V.	0.92	0.72	0.64
	Skewness	2.21	0.85	1.03
	Kurtosis	4.06	-0.88	-0.44
Rivers	Mean	273.14	479.08	588.79
	Median	165.30	400.00	450.00
	Minimum	99.76	184.00	250.00
	Maximum	1214.00	1130.69	2400.00
	Standard deviation	252.53	336.37	422.96
	C.V.	0.92	0.70	0.72
	Skewness	2.19	1.02	1.96
	Kurtosis	3.99	-0.36	4.52

Footnote: C.V. = Coefficient of Variation

Table 4.1 showed that the three pump prices (Petrol, Diesel and Kerosene per month) in both states are similar basic of average pump prices and coefficient of variation in each petroleum products. Cross-correlation function between the three Petroleum Products in both states were done in the Appendix.

Table 4.2: **Cross-Correlation Coefficients between the three Petroleum Products, using the observations 2016:01 - 2024:12**

Bayelsa State Petrol Prices	Bayelsa State Diesel Prices	Bayelsa State Kerosene Prices	
1	0.8148	0.8626	Bayelsa State Petrol Prices
	1	0.9708	Bayelsa State Diesel Prices
		1	Bayelsa State Kerosene Prices
Rivers State Petrol Prices	**Rivers State Diesel Prices**	**Rivers State Kerosene Prices**	
1	0.8643	0.9069	Rivers State Petrol Prices
	1	0.9012	Rivers State Diesel Prices
		1	Rivers State Kerosene Prices

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Footnote: Level of Reliability of the Cross Correlation Coefficient: 0.00 is not related, 0.01-0.20 is slightly (very low), 0.21-0.40 is Fair (low), 0.41-0.60 is Moderate, 0.61-0.80 is Substantial (high) and 0.81-0.99 is almost Perfect (very high), 1.00 is Perfect.

The cross-correlation coefficients results in Table 4.2 showed almost prefect relationship between the petroleum products, which lies between the coefficient of 81% to 97% relationship.

Series Plots and KPSS Unit Root Test for Bayelsa State Petroleum Products Price (Petrol, Diesel and Kerosene pump price) Per Litre

The series were plotted constructed using Gretl Statistical software. Each individual series in Appendix fluctuation were examined monthly to determine the trend component in the series plots. The three pump prices of petroleum products (Petrol, Diesel and Kerosene) per month plots in the Appendix (Fig. 1a and 1b) showed an appreciation from January, 2016 to December 2024.

Figures 2a and 2b showed the individual series, where Petrol, Diesel and Kerosene prices with all series showed an upward trend that is a linear or quadratic trend in the series. These behaviour's suggested non-stationary series for all series that is a non-stationary series with linear or quadrate trend. Thus, the three prices of petroleum products series needed first or second order difference to obtain stationarity, since the suggested trend is either linear or quadratic. The first order difference series are in Figure 3a and 3b in the Appendix.

Table 4.3: KPSS Unit Root Test of the three Petroleum Products for Both States

Data	Variable	Bayelsa State KPSS Unit Root Test	P-value	Remark	Rivers State KPSS Unit Root Test	P-value	Remark
Actual Series	Petrol Prices	**0.604**	**0.029 ****	Non-Stationary	**0.600**	**0.030****	Non-Stationary
	Diesel Prices	**0.822**	**0.001 ****	Non-Stationary	**0.805**	**0.002****	Non-Stationary
	Kerosene Prices	**0.809**	**0.002 ****	Non-Stationary	**0.810**	**0.002****	Non-Stationary
First Order Difference	Petrol Prices	**0.597**	**0.031 ****	Non-Stationary	**0.566**	**0.035****	Not Stationary
	Diesel Prices	0.280	1.000	Stationary I(1)	0.239	1.000	Stationary I(1)
	Kerosene Prices	0.377	0.088	Stationary I(1)	**0.503**	**0.044****	Non-Stationary
Second Order Difference	Petrol Prices	0.085	1.000	Stationary I(2)	0.087	1.000	Stationary I(2)
	Diesel Prices	-	-	-	-	-	-
	Kerosene Prices	-	-	-	0.062	1.000	Stationary I(2)

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Footnote: **= Sig. at 5% (or KPSS Unit root greater than 0.466, implies Sig.)

Table 4.3 confirm that the three prices of petroleum products series are not stationary, it implies the series needed first/second order difference for stationary. Bayelsa State KPSS unit root test showed that the petrol pump prices per month was stationary after second order differencing, while diesel and kerosene pump prices were stationary after first order difference. Rivers State KPSS unit root test showed that the petrol and kerosene pump prices per month was stationary after second order differencing, while diesel pump prices was stationary after first difference. These results confirm that the three prices of petroleum products series in both states pump prices per month needed first or second order difference(s).

VAR Model

VAR Model Building for Bayelsa State

VAR system, maximum lag order 2. The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

Table 4.4: **Identification of VAR Model Order using Model Information Criteria for Bayelsa State**

lags	loglik	p(LR)	AIC	BIC	HQC
1	-1637.78035		31.184535	31.561437	31.337295
2	-1624.58064	0.00176	31.105295*	31.708338*	31.349712*

Table 4.4 suggested VAR (2) model is the best model that can explain the fluctuation among these variables and then used to predict future time series of these variables. Since, AIC and HQC information criteria indicated the minimized at lag 2.

Suitable VAR Models was identified using each variable as the dependent variable, which were used to predict future values of these variables pump prices in Bayelsa State, Nigeria.

Table 4.5: **VAR (2) model when the each variable as Dependent variable and Its Information Criteria for Bayelsa State**

Dependent Variable	Statistics	Coefficient	std. error	t-ratio	p-value	R^2	Adjusted R^2	AIC	BIC	HQC
Petrol pump prices per month	Constant	-10.165	7.293	-1.394	0.167	0.981	0.980	31.082	31.609	31.295
	Bayelsa_S_PET_1	1.210	0.100	12.059	**0.001****					
	Bayelsa_S_PET_2	-0.238	0.111	-2.145	**0.034****					
	Bayelsa_S_DIE_1	-0.036	0.093	-0.387	0.700					
	Bayelsa_S_DIE_2	0.071	0.090	0.791	0.431					
	Bayelsa_S_KER_1	-0.033	0.063	-0.530	0.597					
	Bayelsa_S_KER_2	0.047	0.067	0.708	0.481					
Diesel pump prices per month	Constant	-14.349	7.635	-1.880	0.063	0.990	0.989			
	Bayelsa_S_PET_1	0.013	0.105	0.126	0.900					
	Bayelsa_S_PET_2	-0.165	0.116	-1.423	0.158					
	Bayelsa_S_DIE_1	0.765	0.097	7.849	**0.001****					

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	Bayelsa_S_DIE_2	0.047	0.094	0.502	0.617		
	Bayelsa_S_KER_1	0.086	0.065	1.321	0.190		
	Bayelsa_S_KER_2	0.183	0.070	2.611	**0.010****		
Kerosene pump prices per month	Constant	25.271	11.112	2.274	**0.025****	0.981	0.979
	Bayelsa_S_PET_1	0.532	0.153	3.480	**0.001****		
	Bayelsa_S_PET_2	-0.564	0.169	-3.344	**0.001****		
	Bayelsa_S_DIE_1	0.074	0.142	0.521	0.604		
	Bayelsa_S_DIE_2	0.128	0.137	0.935	0.352		
	Bayelsa_S_KER_1	0.822	0.095	8.634	**0.001****		
	Bayelsa_S_KER_2	-0.012	0.102	-0.122	0.903		

Footnote: **= Sig. at 5%.

Hence, the Identified VAR (2) Model when the dependent variable is Petrol Prices (Y_t), Diesel Prices (X_t) and Kerosene Prices (Z_t);

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 X_t + \beta_4 X_{t-1} + \beta_5 Z_t + \beta_6 Z_{t-1} \quad (4.1)$$

$$X_t = \beta_0 + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 Y_t + \beta_4 Y_{t-1} + \beta_5 Z_t + \beta_6 Z_{t-1} \quad (4.2)$$

$$Z_t = \beta_0 + \beta_1 Z_{t-1} + \beta_2 Z_{t-2} + \beta_3 Y_t + \beta_4 Y_{t-1} + \beta_5 X_t + \beta_6 X_{t-1} \quad (4.3)$$

where $\beta_0, \beta_1, \ldots, \beta_6$ are the estimated coefficients, Y_t is Petrol Prices, X_t is Diesel Prices and Z_t is Kerosene Prices.

By substituting the estimated coefficients into the identified model:

$$\hat{Y}_t = -1`0.165 + 1.21 Y_{t-1} - 0.238 Y_{t-2} - 0.036 X_t + 0.071 X_{t-1} - 0.033 Z_t + 0.047 Z_{t-1} \quad (4.4)$$

$$\hat{X}_t = -14.35 + 0.765 X_{t-1} + 0.047 X_{t-2} + 0.013 Y_t - 0.165 Y_{t-1} + 0.086 Z_t + 0.183 Z_{t-1} \quad (4.5)$$

$$\hat{Z}_t = 25.271 + 0.822 Z_{t-1} - 0.0128 Z_{t-2} + 0.532 Y_t - 0.564 Y_{t-1} + 0.074 X_t + 0.128 X_{t-1} \quad (4.6)$$

The estimated VAR (2) model is given in Table 4.5 and it revealed that only the petrol pump prices lags 1 and 2 are significant at 5% when the dependent variable is petrol pump prices. Furthermore, when the dependent variable is diesel prices, it's revealed that the independent variables (kerosene prices lag 2 and diesel lag 1) have a significant effect on diesel prices at 5% level. It implies that 1% change in diesel prices causes about 76.5% change in kerosene price at 5% with its lag 1. The model further revealed that 1% change in diesel prices causes about 18.3% change in kerosene prices. In addition, when the dependent variable is kerosene prices, it's had significant effect on petrol price lag 1 and 2 with its lag 1. Suggesting a1% change in kerosene price will cause a 53.2% change in petrol price and about 82.2% change in

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diesel price at lag 1.

The R^2 and adjusted R^2 in Table 4.5 showed that the VAR (2) model explained suitable significant effect of independent variables of the dependent variable, which is 98% (or 99%) of the variation. The identified VAR (2) model was used to predicted the three petroleum products pump prices for three years (i.e. forecast values) in Table 4.6 and **Figure 6a** in the Appendix.

$$\hat{Y}(t+1) = -1`0.17 + 1.21Y(t-1) - 0.24Y(t-2) - 0.04X(t) + 0.07X(t-1) - 0.03Z(t) + 0.05Z(t-1) \quad (4.7)$$

$$\hat{X}(t+1) = -14.35 + 0.76X(t-1) + 0.05X(t-2) + 0.01Y(t) - 0.16Y(t-1) + 0.09Z(t) + 0.18Z(t-1) \quad (4.8)$$

$$\hat{Z}(t+1) = 25.27 + 0.82Z(t-1) - 0.013Z(t-2) + 0.53Y(t) - 0.56Y(t-1) + 0.07X(t) + 0.13X(t-1) \quad (4.9)$$

where t is the lead (or last observation index); i.e. t = 108.

Table 4.6: The VAR (2) Model Forecast values for the three Petroleum Products for Bayelsa State

Year	Month	Petrol Prices ($\hat{Y}_t$)	Diesel Prices ($\ddot{X}_t$)	Kerosene Prices ($\hat{Z}_t$)
2025	Jan	1236.81	1119.81	1309.74
	Feb	1203.19	1119.49	1345.49
	Mar	1259.74	1066.24	1250.56
	Apr	1214.33	1067.28	1325.59
	May	1280.05	1006.96	1184.70
	Jun	1222.01	1013.83	1303.63
	Jul	1297.31	942.29	1112.20
	Aug	1226.34	958.71	1279.85
	Sep	1311.12	872.56	1033.40
	Oct	1227.54	901.66	1254.15
	Nov	1321.02	798.11	948.94
	Dec	1225.92	842.50	1226.04
2026	Jan	1326.49	719.34	859.79
	Feb	1221.86	781.04	1194.68
	Mar	1326.92	636.74	767.30
	Apr	1215.84	717.08	1158.87
	May	1321.65	550.89	673.22
	Jun	1208.44	650.33	1116.95
	Jul	1309.92	462.50	579.73
	Aug	1200.33	580.42	1066.87
	Sep	1290.95	872.56	489.50
	Oct	1192.23	901.66	1006.12
	Nov	1263.89	798.11	405.64
	Dec	1184.95	842.50	931.75
2027	Jan	1227.90	719.34	331.72

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Feb	1179.28	781.04	840.42
Mar	1182.14	636.74	271.70
Apr	1176.02	717.08	728.46
May	1125.88	550.89	521.32
Jun	1175.88	650.33	490.77
Jul	1058.50	665.98	460.23
Aug	1179.43	661.11	429.69
Sep	979.58	656.24	399.15
Oct	1187.02	651.37	368.61
Nov	889.00	646.50	338.06
Dec	1198.71	641.63	307.52

Table 4.7: The VAR (2) Model Forecast values Statistics Summarized between 2023 to 2025 for Bayelsa State

Statistics	*Petrol Prices*	*Diesel Prices*	*Kerosene Prices*
Average	1212.45	783.36	842.01
Minimum	889.00	462.50	271.70
Maximum	1326.92	1119.81	1345.49

Table 4.7 showed that the prices of Petrol will be sold at the average price of 1212.45 naira and its will lie between 1212.45 naira to 1326.92 naira, Diesel price will be sold at the average price of 783.36 naira and its will lie between 462.50 naira to 1119.81 naira, while Kerosene will be sold at the average price of 842.01 naira and its will lie between 271.70 naira to 1345.49 naira from January 2025 to December 2027.

VAR Model Building for Rivers State

VAR system, maximum lag order 2. The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC = Akaike criterion, BIC = Schwarz Bayesian criterion and HQC = Hannan-Quinn criterion.

Table 4.8: **Identification of VAR Model Order using Model Information Criteria for Rivers state**

lags	loglik	p(LR)	AIC	BIC	HQC
1	-1732.52337		32.915535	33.217057	33.037744
2	-1709.66129	0.00000	32.653987*	33.181649*	32.867851*

Table 4.8 suggested VAR (2) model is the best model that can explain the fluctuation among these variables and then used to predict future time series of these variables. Since, AIC and HQC information criteria indicated the minimized at lag 2.

Suitable VAR Models was identified using each variable as the dependent variable, which were used to predict future values of these variables pump prices in Rivers State, Nigeria.

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Table 4.9: **VAR (2) model when each variable as Dependent variable and Its Information Criteria for Rivers state**

Dependent Variable	Statistics	Coefficient	Std. error	t-ratio	p-value	R^2	Adjusted R^2	AIC	BIC	HQC
Petrol pump prices per month	Constant	-20.519	8.521	-2.408	**0.018****	0.974	0.973	32.654	33.182	32.867
	Rivers_S_Petr_1	0.979	0.104	9.410	**0.000****					
	Rivers_S_Petr_2	-0.026	0.114	-0.227	0.821					
	Rivers_S_Dies_1	-0.155	0.103	-1.503	0.136					
	Rivers_S_Dies_2	0.117	0.102	1.142	0.256					
	Rivers_S_Kero_1	-0.007	0.040	-0.168	0.867					
	Rivers_S_Kero_2	0.119	0.060	1.982	0.050					
Diesel pump prices per month	Constant	-4.671	7.111	-0.657	0.513	0.990	0.989			
	Rivers_S_Petr_1	0.351	0.087	4.047	**0.000****					
	Rivers_S_Petr_2	-0.501	0.095	-5.277	**0.000****					
	Rivers_S_Dies_1	0.793	0.086	9.188	**0.000****					
	Rivers_S_Dies_2	0.129	0.085	1.510	0.134					
	Rivers_S_Kero_1	0.039	0.033	1.171	0.244					
	Rivers_S_Kero_2	0.116	0.050	2.297	**0.024****					
Kerosene pump prices per month	Constant	5.168	21.566	0.240	0.811	0.940	0.937			
	Rivers_S_Petr_1	0.544	0.263	2.067	**0.041****					
	Rivers_S_Petr_2	-0.149	0.288	-0.520	0.604					
	Rivers_S_Dies_1	-0.002	0.262	-0.006	0.995					
	Rivers_S_Dies_2	-0.021	0.259	-0.081	0.936					
	Rivers_S_Kero_1	0.786	0.101	7.760	**0.000****					
	Rivers_S_Kero_2	0.076	0.153	0.497	0.620					

Footnote: **= Sig. at 5%.

Hence, the Identified VAR (2) Model when the dependent variable is Petrol Prices (Y_t), Diesel Prices (X_t) and Kerosene Prices (Z_t).

By substituting the estimated coefficients into the identified model into Equations 4.1, 4.2 and 4.3

$$\hat{Y}_t = -20.52 + 0.98Y_{t-1} - 0.03Y_{t-2} - 0.16X_t + 0.12X_{t-1} - 0.007Z_t + 0.12Z_{t-1} \quad (4.10)$$

$$\hat{X}_t = -4.67 + 0.79X_{t-1} + 0.13X_{t-2} + 0.35Y_t - 0..50Y_{t-1} + 0.04Z_t + 0.12Z_{t-1} \quad (4.11)$$

$$\hat{Z}_t = 5.17 + 0.79Z_{t-1} + 0.08Z_{t-2} + 0.54Y_t - 0.51Y_{t-1} - 0.002X_t - 0.021X_{t-1} \quad (4.12)$$

The estimated VAR (2) model is given in Table 4.5 and it revealed that only the petrol pump prices lags 1 and 2 are significant at 5% when the dependent variable is petrol pump prices. Furthermore, when the dependent variable is diesel prices, it's revealed that the independent variables (kerosene prices lag 2 and diesel lag 1) have a significant effect on diesel prices at 5% level. It implies that 1% change in diesel prices causes about 76.5% change in kerosene

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price at 5% with its lag 1. The model further revealed that 1% change in diesel prices causes about 18.3% change in kerosene prices. In addition, when the dependent variable is kerosene prices, it's had significant effect on petrol price lag 1 and 2 with its lag 1. Suggesting a1% change in kerosene price will cause a 53.2% change in petrol price and about 82.2% change in diesel price at lag 1.

The R^2 and adjusted R^2 in Table 4.5 showed that the VAR (2) model explained suitable significant effect of independent variables of the dependent variable, which is 98% (or 99%) of the variation. The identified VAR (2) model was used to predicted the three petroleum products pump prices for three years (i.e. forecast values) in Table 4.6 and **Figure 6b** in the Appendix.

$$\hat{Y}_t(t+1) = -20.52 + 0.98Y(t-1) - 0.03Y(t-2) - 0.16X(t) + 0.12X(t-1) - 0.007Z(t) + 0.12Z(t-1) \quad (4.13)$$

$$\hat{X}(t+1) = -4.67 + 0.79X(t-1) + 0.13X(t-2) + 0.35Y(t) - 0..50Y(t-1) + 0.04Z(t) + 0.12Z(t-1) \quad (4.14)$$

$$\hat{Z}(t+1) = 5.17 + 0.79Z(t-1) + 0.08Z(t-2) + 0.54Y(t) - 0.51Y(t-1) - 0.002X(t) - 0.021X(t-1) \quad (4.15)$$

where t is the lead (or last observation index); i.e. t = 108.

Table 4.10: The VAR (2) Model Forecast values for the three Petroleum Products for Rivers state

Year	Month	Petrol Prices ($\hat{Y}_t$)	Diesel Prices ($\ddot{X}_t$)	Kerosene Prices ($\hat{Z}_t$)
2025	Jan	1235.07	1104.15	2007.04
	Feb	1338.50	1257.34	2127.76
	Mar	1359.45	1233.82	1849.94
	Apr	1433.58	1264.68	1869.27
	May	1459.68	1284.86	1689.21
	Jun	1498.69	1245.69	1657.86
	Jul	1534.32	1261.36	1524.57
	Aug	1543.17	1203.14	1485.53
	Sep	1585.28	1186.62	1364.13
	Oct	1572.83	1135.42	1342.10
	Nov	1616.21	1079.85	1215.32
	Dec	1591.07	1043.21	1219.17
2026	Jan	1631.39	954.45	1082.79
	Feb	1600.02	929.90	1111.23
	Mar	1634.98	818.89	968.20
	Apr	1601.28	800.65	1015.37
	May	1630.49	678.17	871.00
	Jun	1596.33	661.13	930.42

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	Jul	1620.67	954.45	789.40
	Aug	1586.66	929.90	855.96
	Sep	1607.56	818.89	721.21
	Oct	1573.73	800.65	791.78
	Nov	1592.63	678.17	664.38
	Dec	1558.90	661.13	737.49
2027	Jan	1576.99	705.38	617.20
	Feb	1543.34	689.71	692.45
	Mar	1561.45	674.05	578.35
	Apr	1528.04	658.38	655.81
	May	1546.68	642.72	546.79
	Jun	1513.73	627.06	626.62
	Jul	1533.19	611.39	521.67
	Aug	1500.99	595.73	603.93
	Sep	1521.41	580.06	502.29
	Oct	1490.21	564.40	586.84
	Nov	1511.65	548.73	487.99
	Dec	1481.65	533.07	574.57

Table 4.11: The VAR (2) Model Forecast values Statistics Summarized between 2023 to 2025 for Rivers state

Statistics	*Petrol Prices*	*Diesel Prices*	*Kerosene Prices*
Average	1536.44	872.70	1024.60
Minimum	1235.07	533.07	487.99
Maximum	1634.98	1284.86	2127.76

Table 4.11 showed that the prices of Petrol will be selling at the average price of 1536.44 naira and its will lie between 1235.07 naira to 1634.98 naira, Diesel price will be marketing at the average price of 872.70 naira and its will lie between 533.07 naira to 1284.86 naira, while Kerosene will be trade at the average price of 1024.60 naira and its will lie between 487.99 naira to 2127.76 naira from January 2025 to December 2027.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

Summary

This research work titled "Vector autoregressive (VAR) model forecasting of petroleum products price rate in some Nigeria state (petrol, diesel and kerosene)" is aimed at determining the trend and seasonal effect on prices of petroleum products, its stationarity and estimating the descriptive statistics of products distribution in the Nigeria petroleum sector. However, Nigeria has been very active in the exploitation and exploration of petroleum products. Research shows that petroleum has been the major source of revenue which has contributed over 90% on yearly basis. The debates held in the country in 2012 reveals that there was no common front/agreeable cost of refined petroleum, kerosene and diesel per liter in Nigeria. As a result, various agencies quoted different figures. Corruption seemingly thrived under these

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conditions in the subsidy program. From the analysis, the prices of this product is going higher and higher due to factors that are entangled with the distribution chain in the petroleum sector. The problems among others include volatility of oil prices, obsolete laws and regulation, pipeline vandalism, corruption and lack of government funding and natural disasters.

CONCLUSION

The three Prices of Petroleum Products (Petrol, Diesel and Kerosene) yearly and monthly mean plots showed an appreciation from January to December and 2017 to 2022 yearly and monthly mean estimated respectively in Figures 1a to 3f. The yearly mean plot for Petrol prices shows a quadratic trend with R^2 of 97.2%; yearly mean plot for Diesel prices also identified a quadratic trend with R^2 of 96.1% and the yearly mean trend analyses for Kerosene prices identified a quadratic trend with R^2 of 98.8%.

Similarly, the monthly mean trend analyses plot for Petrol and Diesel prices shows a quadratic trend with R^2 of 90.8% and 92.8% respectively; while only the monthly mean trend analyses for Kerosene prices identified a linear trend with R^2 of 86.8%.

The correlation coefficients' results between the petroleum products are the same as the cross-correlation function results between them. The three prices of petroleum products series are not stationary required first order difference to obtained stationarity.

The estimated VAR (2) model when the dependent variable is Petrol Prices revealed that only the independent variable (Kerosene Prices) is positively related (or significant) to Petrol Prices at 5% with its lags 1 and 2. The model further revealed that 1% change in Kerosene Prices causes about 7.7% change in Petrol Prices.

The estimated VAR (2) model when the dependent variable is Diesel Prices shown that only the independent variable (Kerosene Prices) is positively related (or significant) to Diesel Prices at 5% with its lags 1 and 2. The model further revealed that 1% change in Kerosene Prices causes about 39.3% change in Diesel Prices.

The estimated VAR (2) model when the dependent variable is Kerosene Prices revealed that the independent variables (Petrol and Diesel Prices) is positively related (or significant) to Kerosene Prices. Then 1% change in Petrol Prices causes about 85.0% change in Kerosene Prices at 5% with its lags 1 and 2. The model further revealed that 1% change in Diesel Prices causes about 18.3% change in Kerosene Prices.

Then, suitable VAR Model was identified using each variable as the dependent variable which was used to predict future time series of these variable prices in Yenagoa, Bayelsa State, Nigeria.

The forecast values show a slight upward and constant variation for Petrol Prices, while the forecast values for Diesel Prices shows an upward trend which appreciating for the year 2025 to 2027. Then the forecasts for Kerosene Prices show a gradual upward variation with appreciating and depreciating prices movement (from 2025 -2027).

The prices of Petrol will lie between 183.19 Naira to 225.93 Naira. Diesel will lie between 191.35 naira to 1121.25 naira and Kerosene will lie between 451.76 naira to 1866.88 naira from

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2025 to 2027.

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APPENDIX

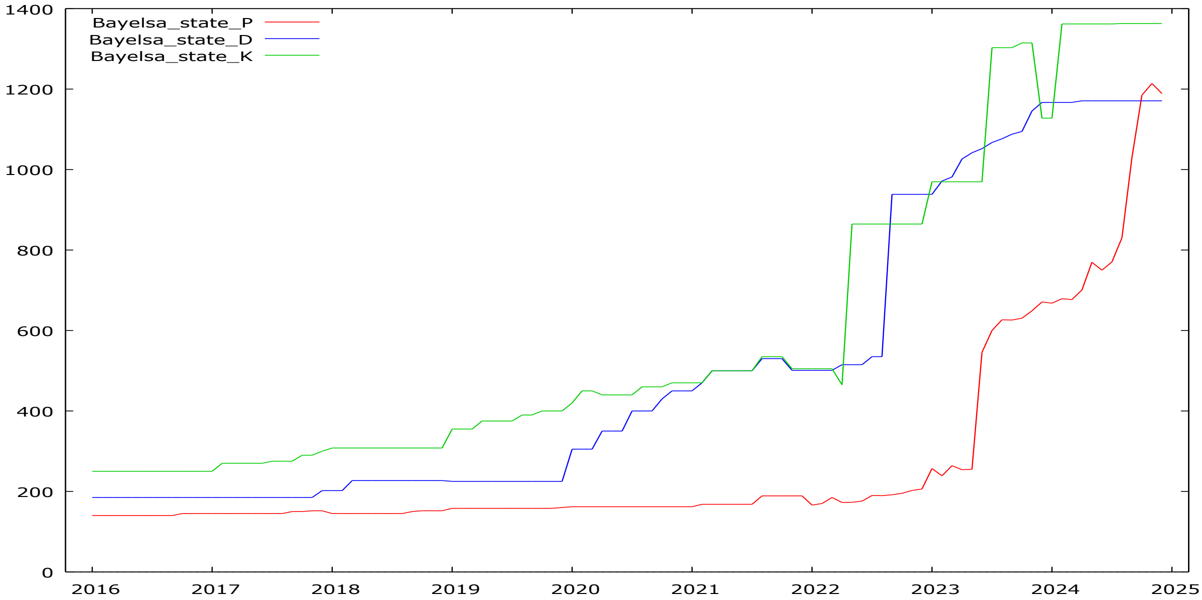

Figure 1a: Plots of the three Series Prices of Petroleum Products (Petrol, Diesel and Kerosene) Bayelsa State

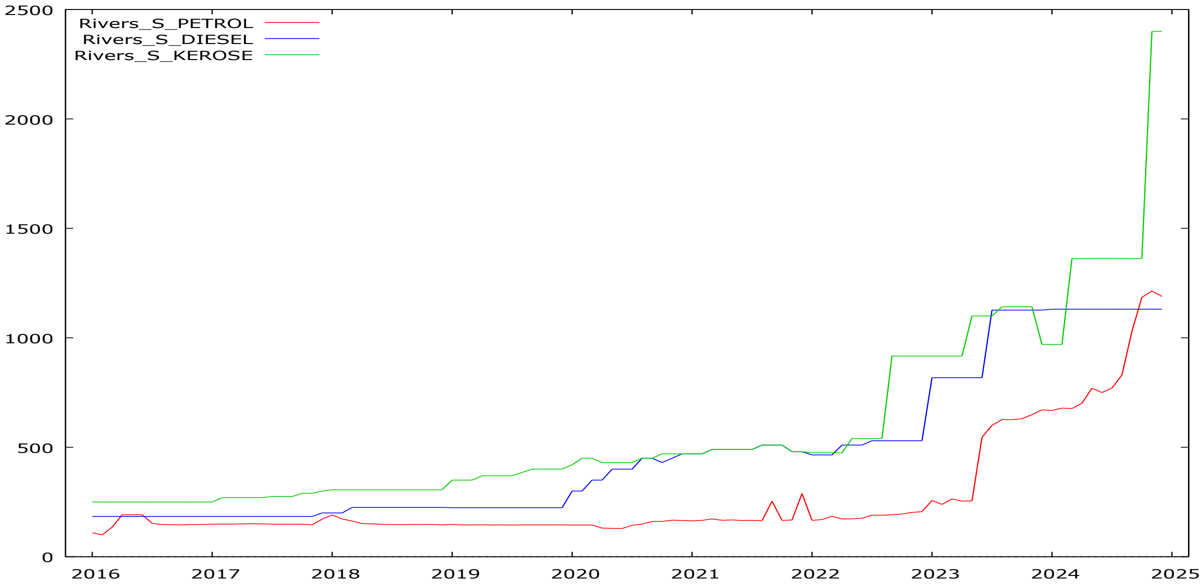

Figure 1b: Plots of the three Series Prices of Petroleum Products (Petrol, Diesel and Kerosene) Rivers State

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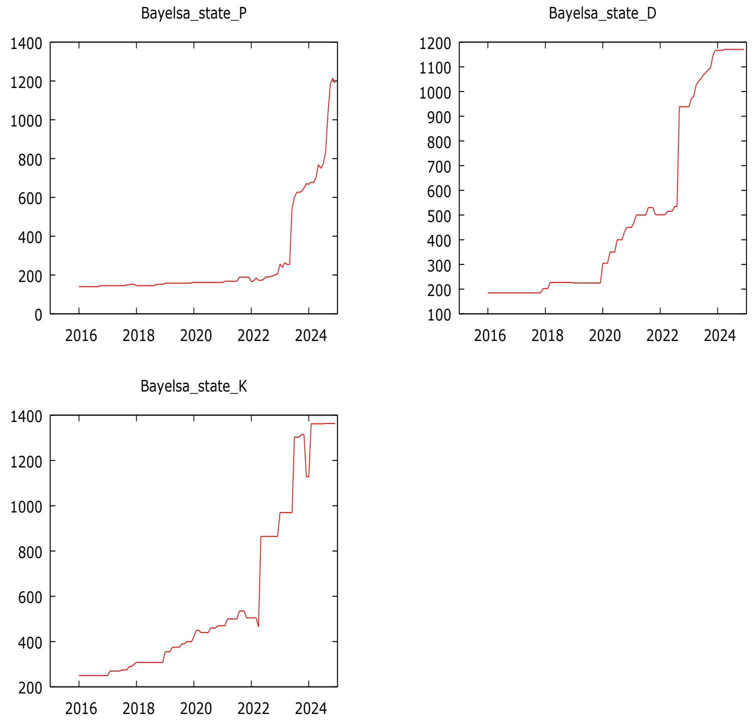

Figure 2a: The individual series of the three Prices of Petroleum Products (Petrol, Diesel and Kerosene) for Bayelsa State.

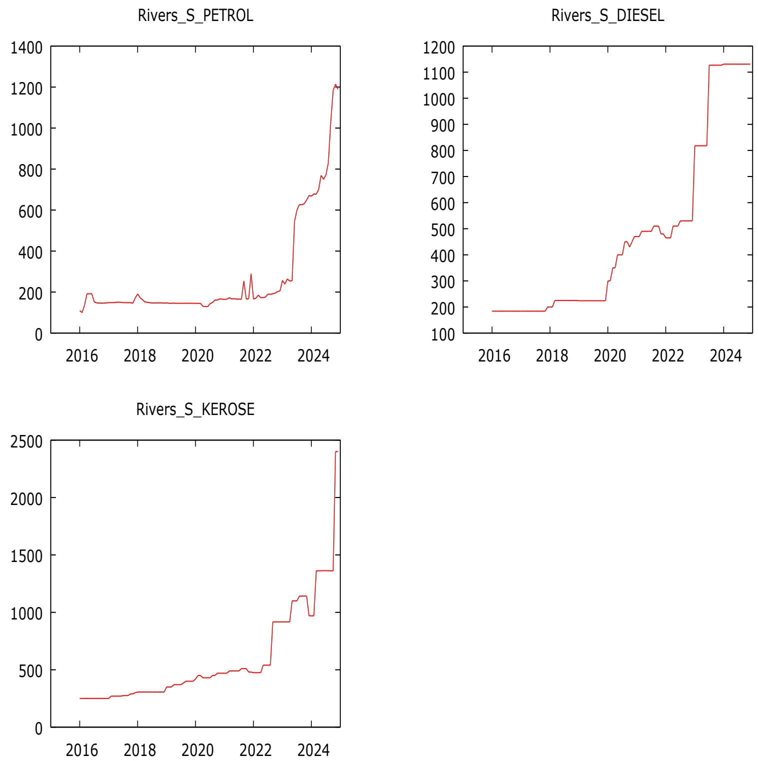

Figure 2b: The individual series of the three Prices of Petroleum Products (Petrol, Diesel and Kerosene) Rivers State

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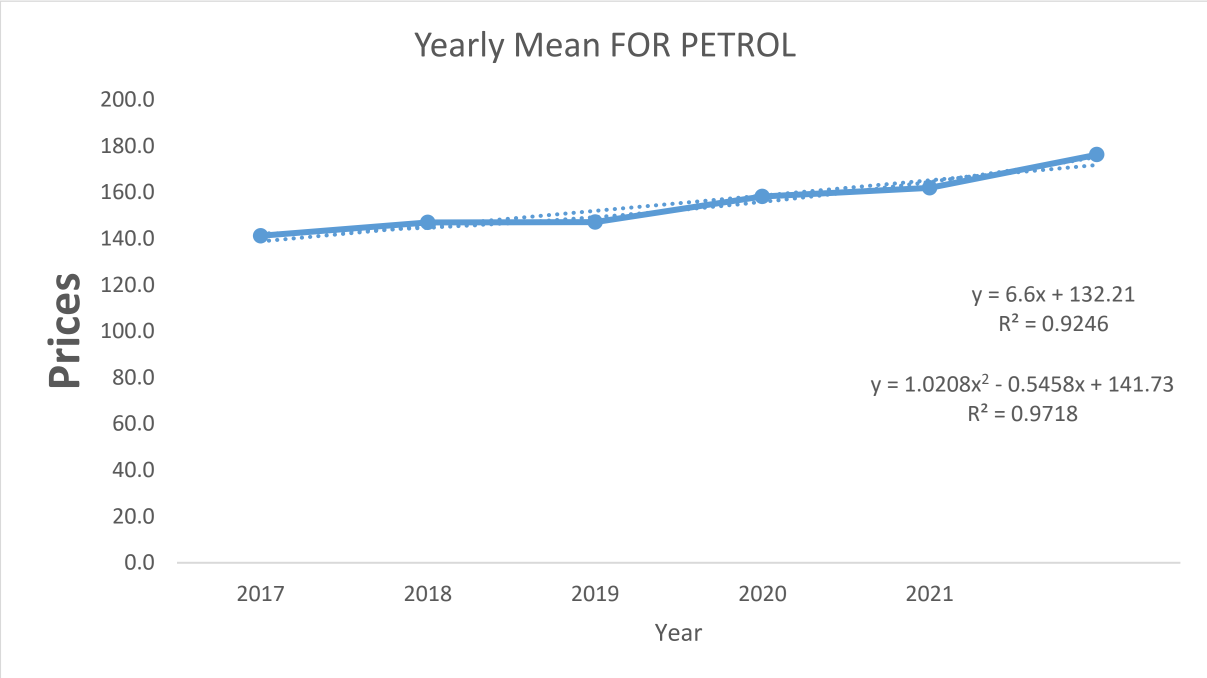

Figure 3a: Trend Analysis of the Yearly Mean Plots of the Petrol Prices, Bayelsa State

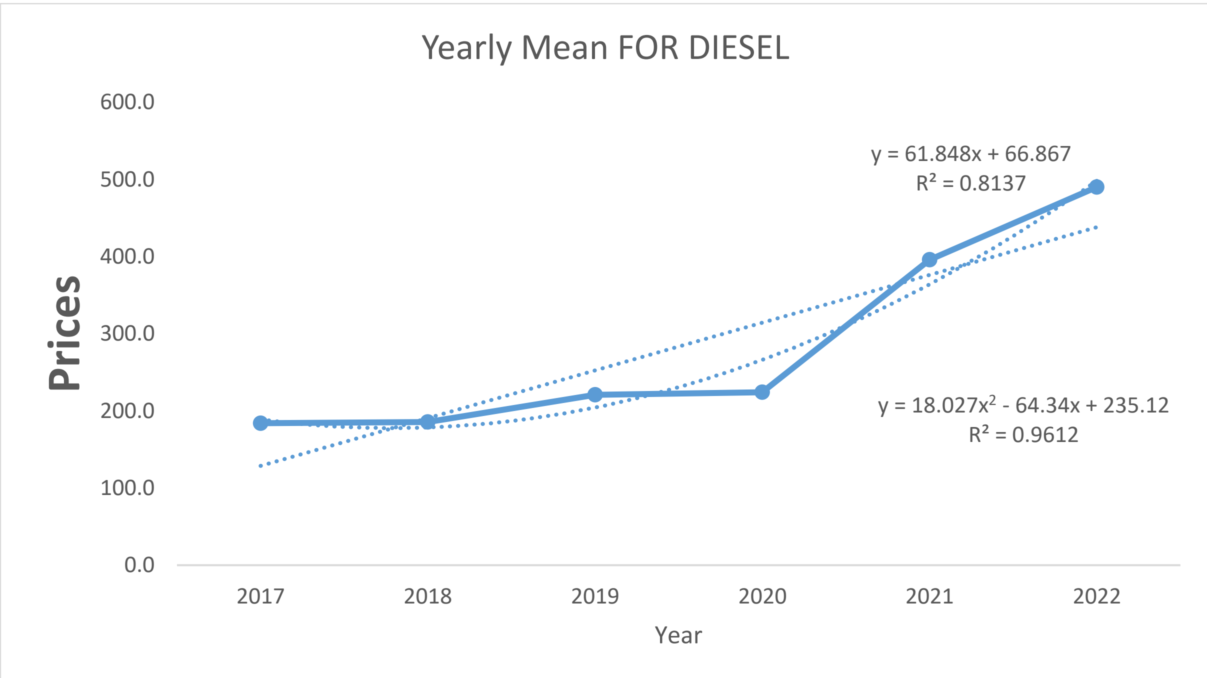

Figure 3b: Trend Analysis of the Yearly Mean Plots of the Diesel Prices, Bayelsa State

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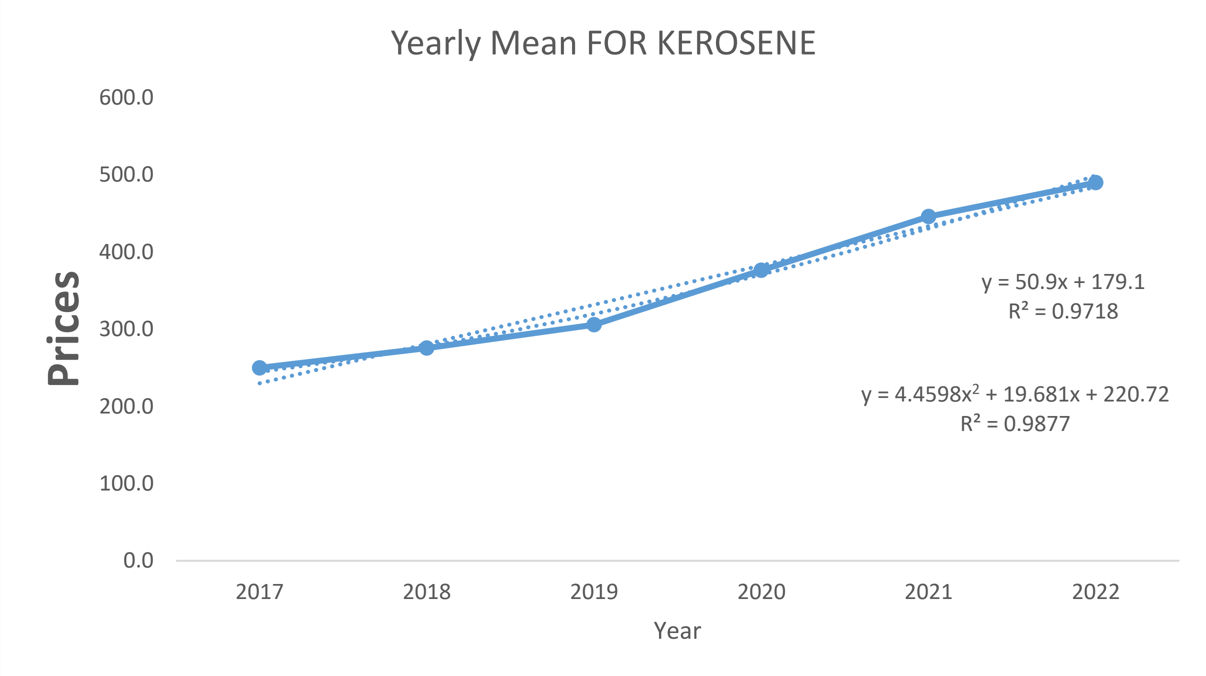

Figure 3c: Trend Analysis of the Yearly Mean Plots of the Kerosene Prices, Bayelsa State

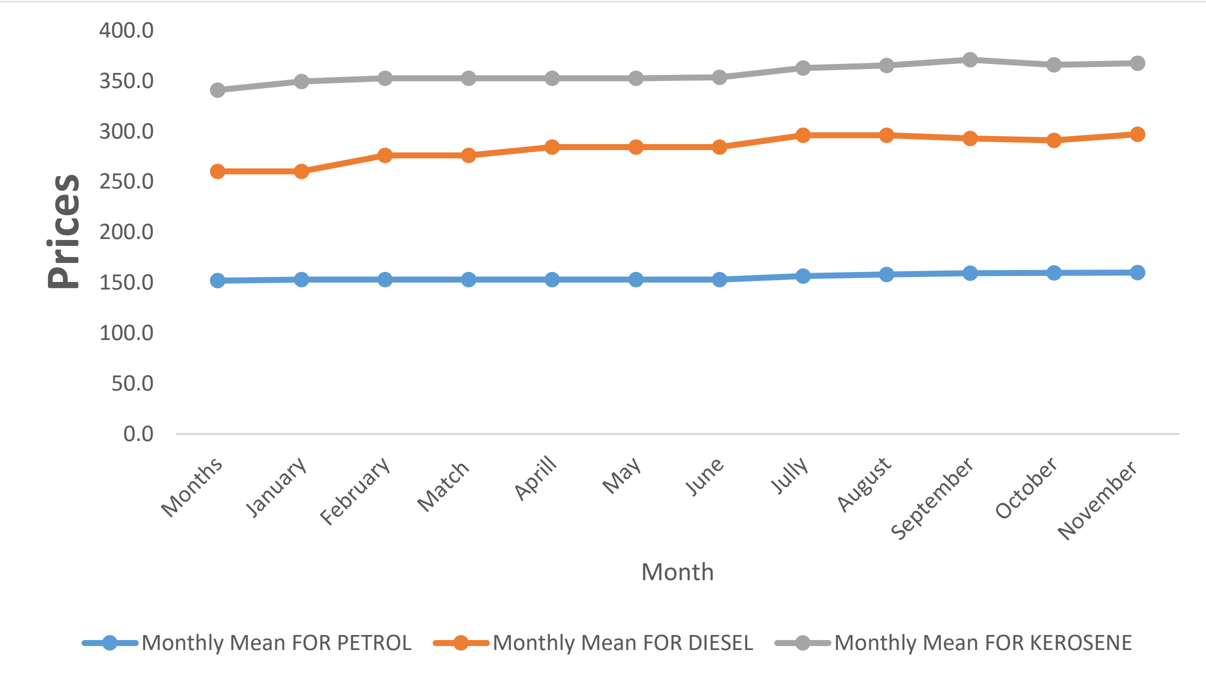

Figure 3d: Monthly Mean Plots of the three Prices of Petroleum Products

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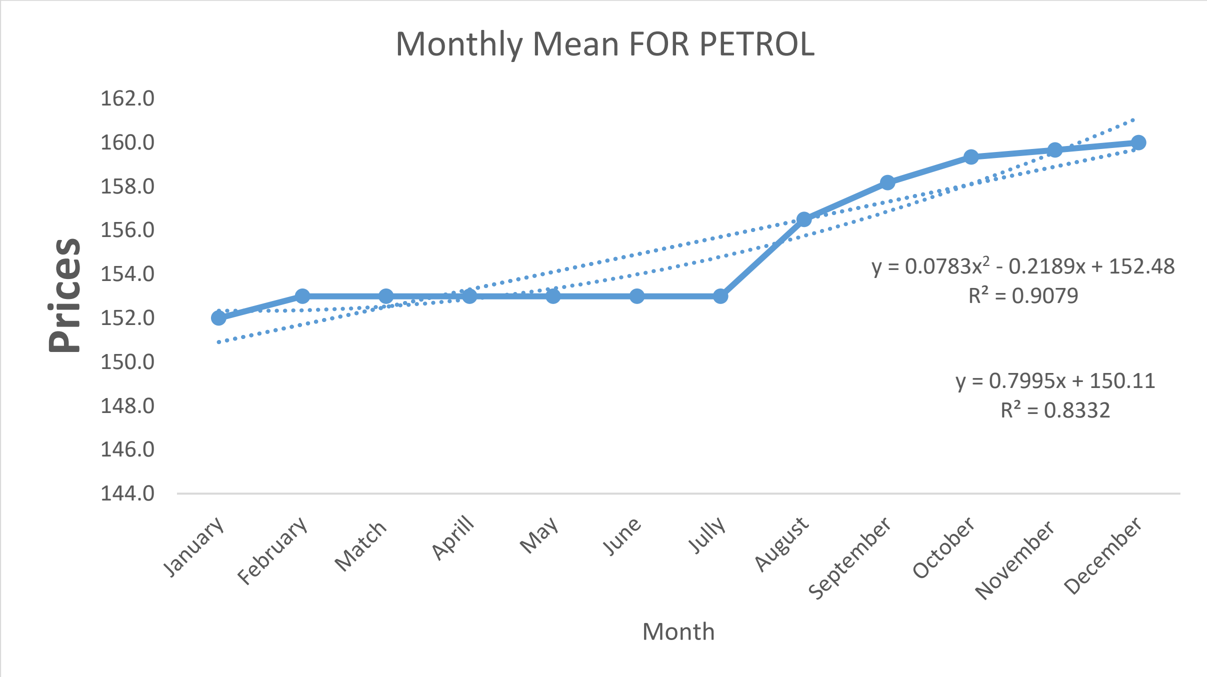

Figure 3e: Trend Analysis of the Monthly Mean Plots of the Petrol Prices, Rivers State

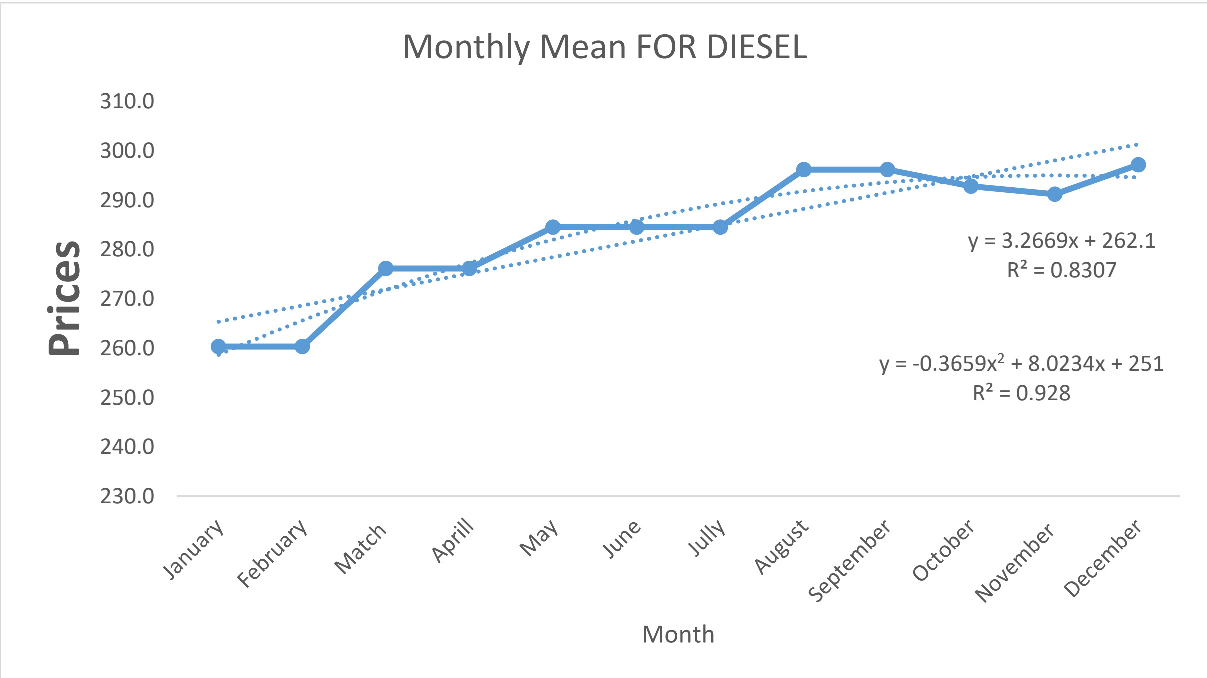

Figure 3f: Trend Analysis of the Monthly Mean Plots of the Diesel Prices, Rivers State

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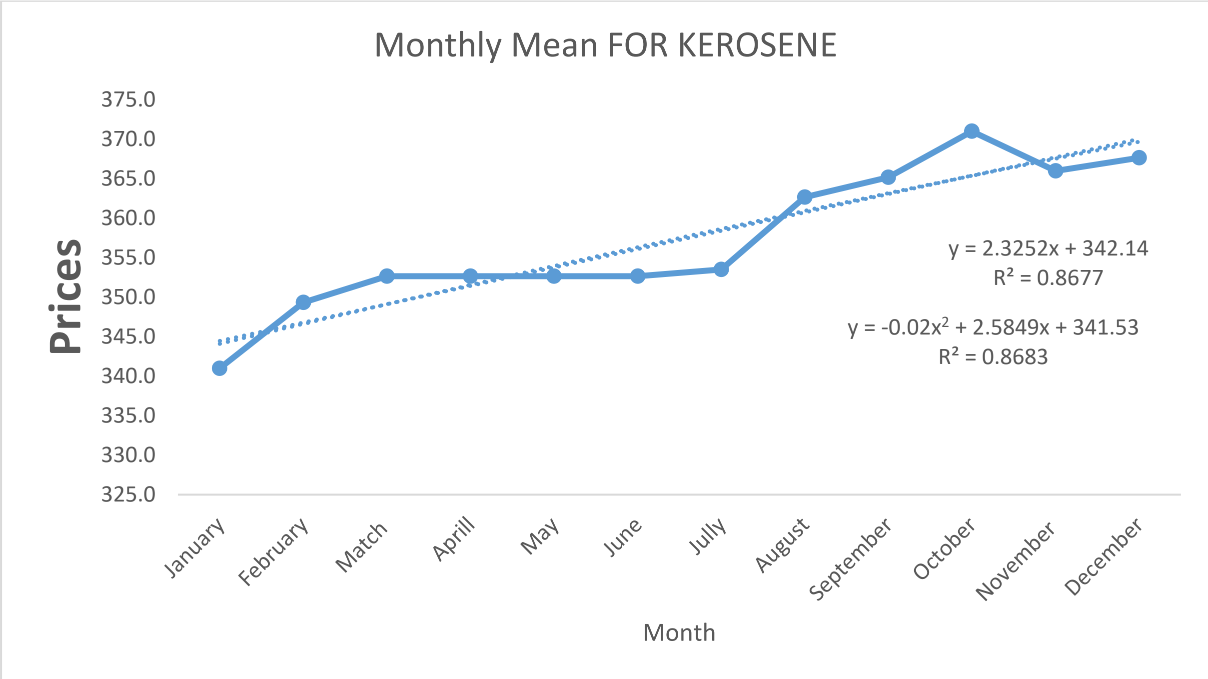
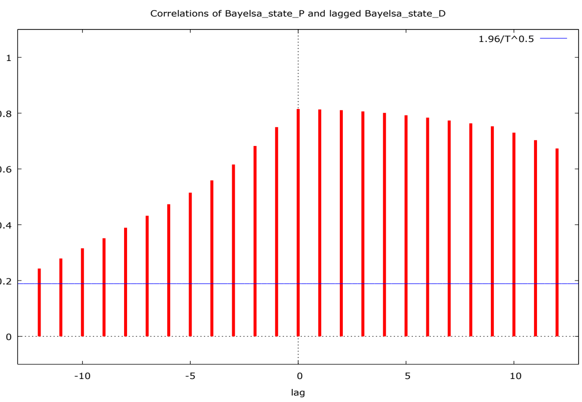
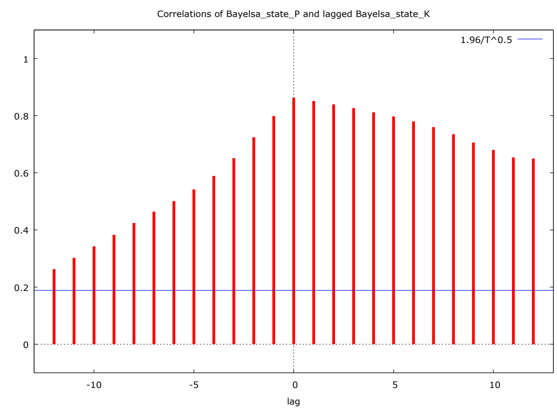


Figure 3f: Trend Analysis of the Monthly Mean Plots of the Kerosene Prices, Rivers State





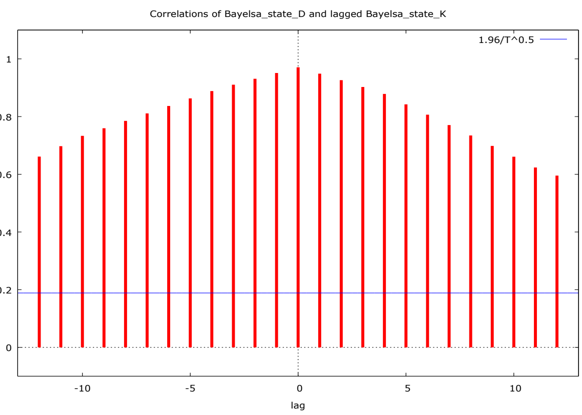


Figure 4a: Cross-correlation function for Bayelsa_state_P and Bayelsa_state_D
Figure 4b: Cross-correlation function for Bayelsa_state_P and Bayelsa_state_K
Figure 4c: Cross-correlation function for Bayelsa_state_D and Bayelsa_state_K

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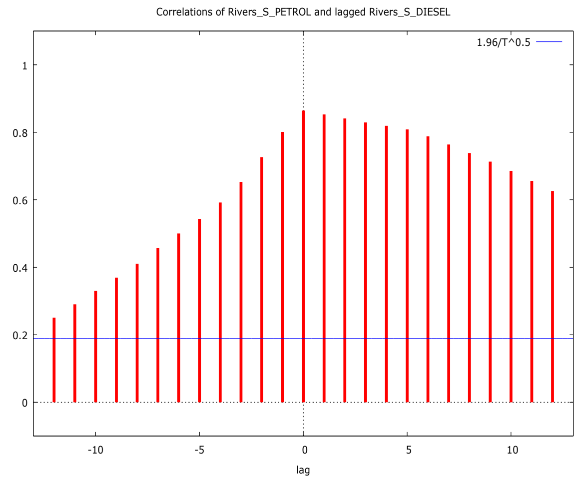

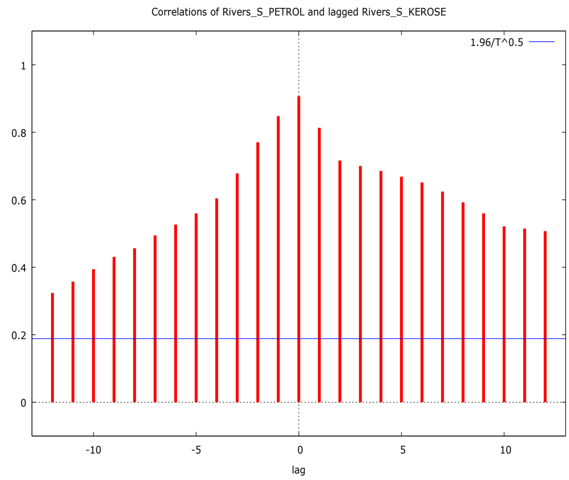

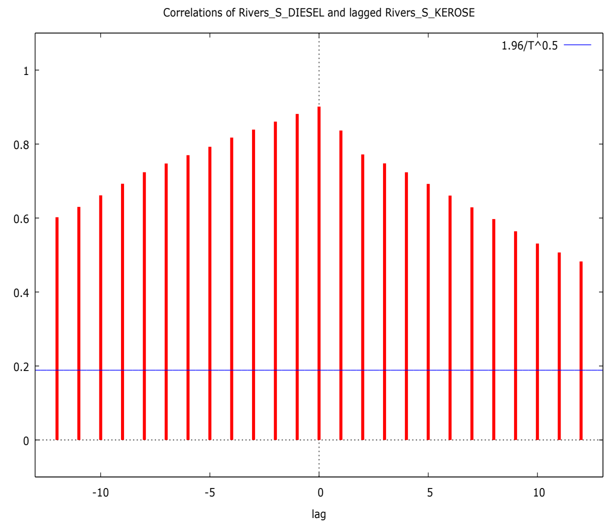

Figure 4d: CCF for Rivers_S_PETROL and Rivers_S_DIESEL
Figure 4e: CCF for Rivers_S_PETROL and Rivers_S_KEROSENE
Figure 4f: CCF for Rivers_S_DIESEL and Rivers_S_KEROSENE

Cross Correlation Function (CCF)

LAG	Bayelsa_state_P and Bayelsa_state_D (XCF)	Bayelsa_state_P and Bayelsa_state_K (XCF)	Bayelsa_state_D and Bayelsa_state_K (XCF)	LAG	Rivers_S_PETROL and Rivers_S_DIESEL (XCF)	Rivers_S_PETROL and Rivers_S_KEROSENE	Rivers_S_DIESEL and Rivers_S_KEROSENE
-12	0.2430 **	0.2629 ***	0.6613 ***	-12	0.2509 ***	0.3240 ***	.6022 ***
-11	0.2791 ***	0.3023 ***	0.6974 ***	-11	0.2902 ***	0.3573 ***	0.6301 ***
-10	0.3157 ***	0.3429 ***	0.7332 ***	-10	0.3302 ***	0.3944 ***	0.6614 ***
-9	0.3517 ***	0.3830 ***	0.7595 ***	-9	0.3693 ***	0.4307 ***	0.6927 ***
-8	0.3893 ***	0.4245 ***	0.7851 ***	-8	0.4106 ***	0.4563 ***	0.7239 ***
-7	0.4322 ***	0.4641 ***	0.8110 ***	-7	0.4566 ***	0.4945 ***	0.7474 ***
-6	0.4735 ***	0.5009 ***	0.8367 ***	-6	0.5002 ***	0.5266 ***	0.7700 ***
-5	0.5149 ***	0.5420 ***	0.8630 ***	-5	0.5436 ***	0.5596 ***	0.7927 ***

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-4	0.5591 ***	0.5892 ***	0.8884 ***
-3	0.6159 ***	0.6513 ***	0.9105 ***
-2	0.6824 ***	0.7245 ***	0.9311 ***
-1	0.7499 ***	0.7987 ***	0.9511 ***
0	**0.8148** ***	**0.8626** ***	**0.9708** ***
1	0.8132 ***	0.8515 ***	0.9487 ***
2	0.8106 ***	0.8396 ***	0.9262 ***
3	0.8062 ***	0.8265 ***	0.9026 ***
4	0.8010 ***	0.8119 ***	0.8785 ***
5	0.7924 ***	0.7974 ***	0.8424 ***
6	0.7838 ***	0.7800 ***	0.8066 ***
7	0.7736 ***	0.7601 ***	0.7706 ***
8	0.7635 ***	0.7352 ***	0.7345 ***
9	0.7529 ***	0.7060 ***	0.6983 ***
10	0.7300 ***	0.6800 ***	0.6609 ***
11	0.7031 ***	0.6539 ***	0.6236 ***
12	0.6734 ***	0.6498 ***	0.5954 ***

-4	0.5919 ***	0.6041 ***	0.8176 ***
-3	0.6532 ***	0.6781 ***	0.8391 ***
-2	0.7262 ***	0.7706 ***	0.8606 ***
-1	0.8012 ***	0.8479 ***	0.8815 ***
0	**0.8643** ***	**0.9069** ***	**0.9012** ***
1	0.8528 ***	0.8134 ***	0.8366 ***
2	0.8409 ***	0.7163 ***	0.7720 ***
3	0.8291 ***	0.7000 ***	0.7479 ***
4	0.8193 ***	0.6853 ***	0.7237 ***
5	0.8084 ***	0.6685 ***	0.6923 ***
6	0.7879 ***	0.6512 ***	0.6607 ***
7	0.7638 ***	0.6242 ***	0.6290 ***
8	0.7385 ***	0.5922 ***	0.5972 ***
9	0.7131 ***	0.5598 ***	0.5642 ***
10	0.6859 ***	0.5212 ***	0.5310 ***
11	0.6561 ***	0.5146 ***	0.5069 ***
12	0.6259 ***	0.5070 ***	0.4826 ***

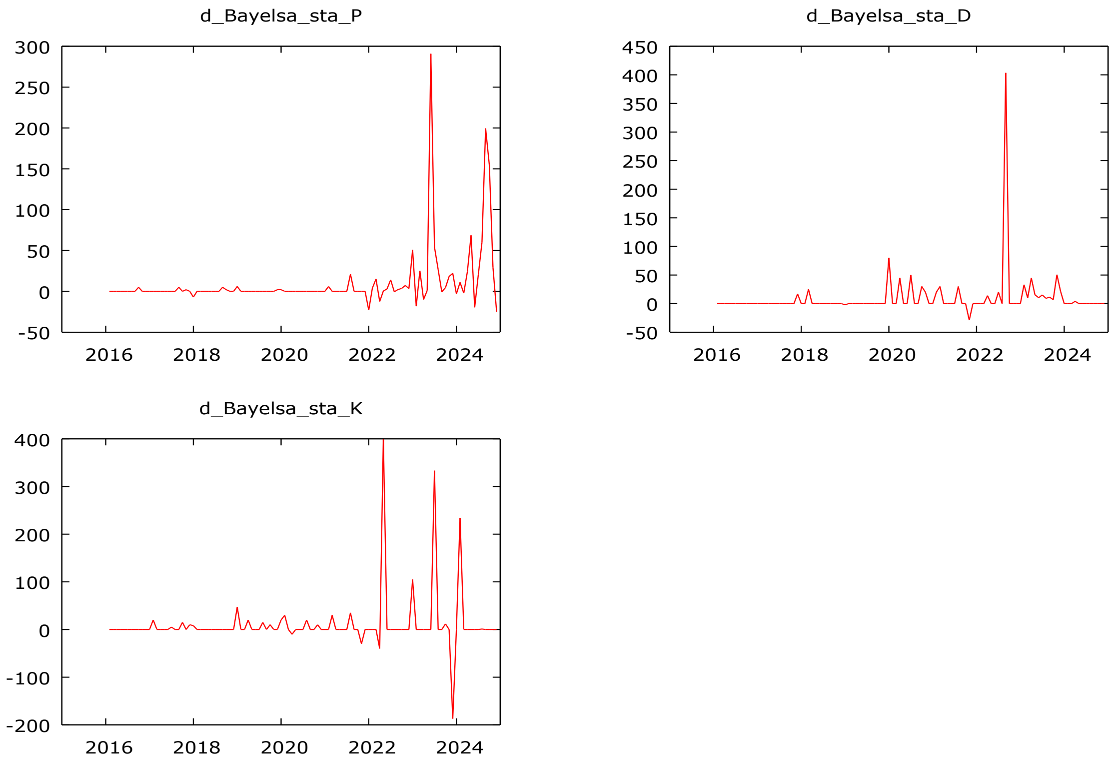

Figure 5a: First Difference of the three Prices of Petroleum Products (Petrol, Diesel and Kerosene) Bayelsa State

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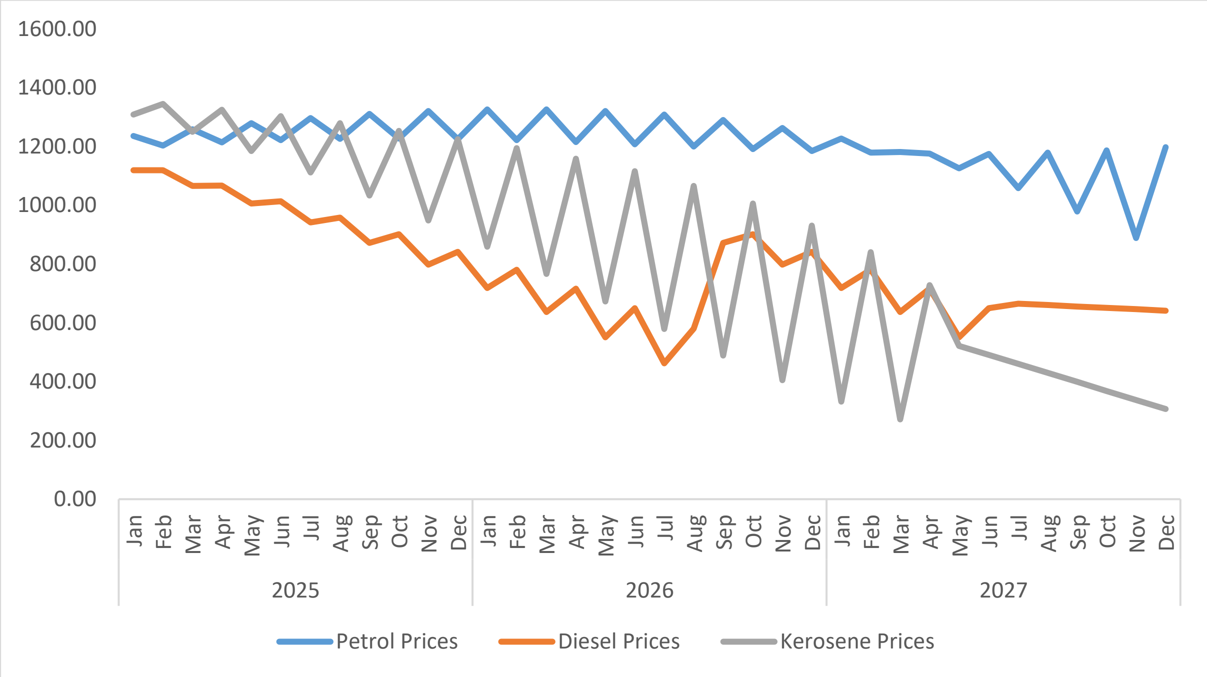

Figure 6a: Forecast Values of the three Prices of Petroleum Products (Petrol, Diesel and Kerosene), Bayelsa State

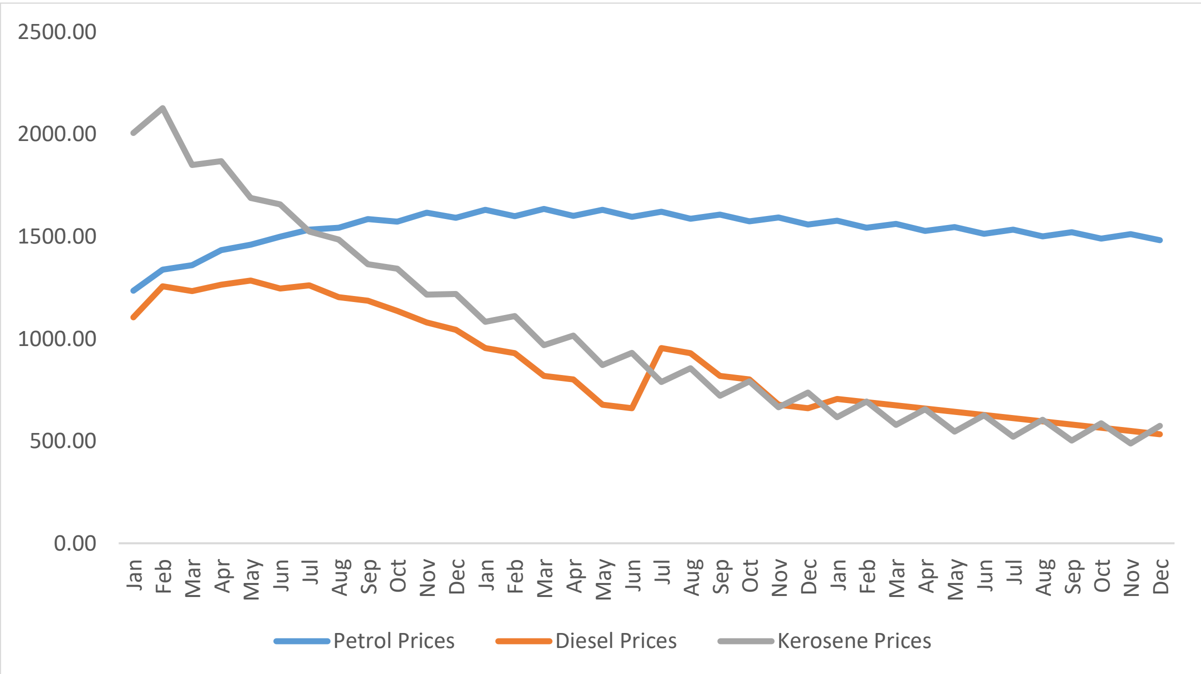

Figure 6b: Forecast Values of the three Prices of Petroleum Products (Petrol, Diesel and Kerosene), Rivers State

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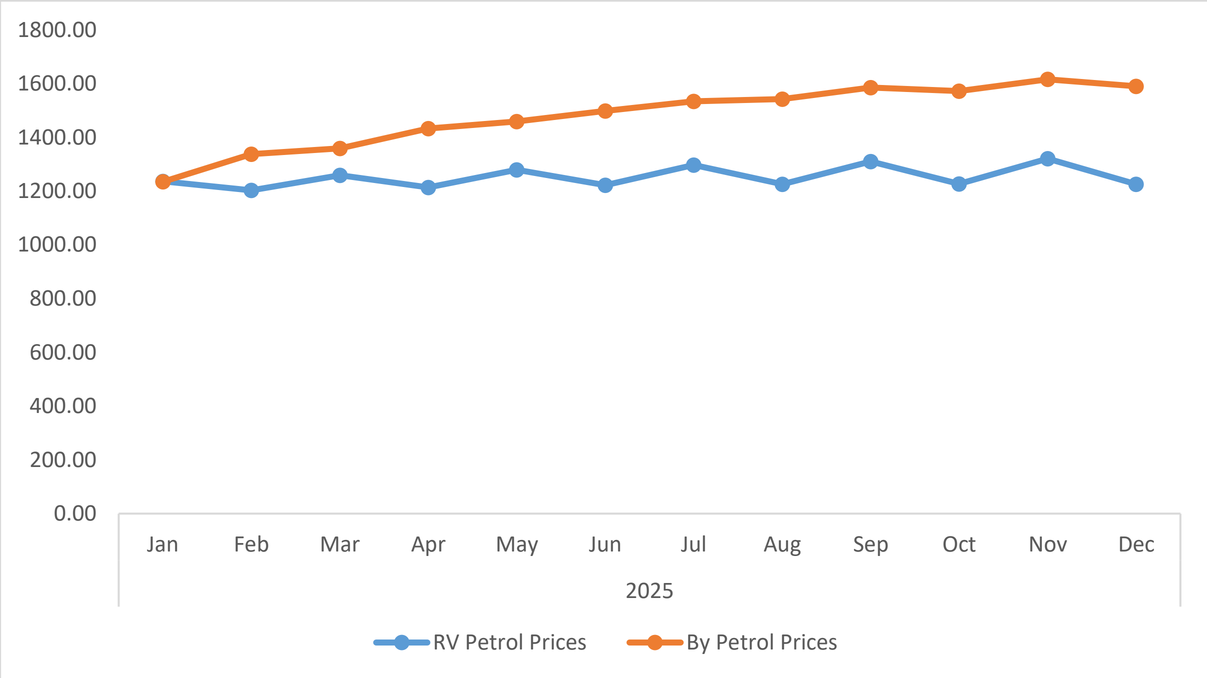

Figure 6C: Forecast Values of the Prices of Petrol in Bayelsa and Rivers State

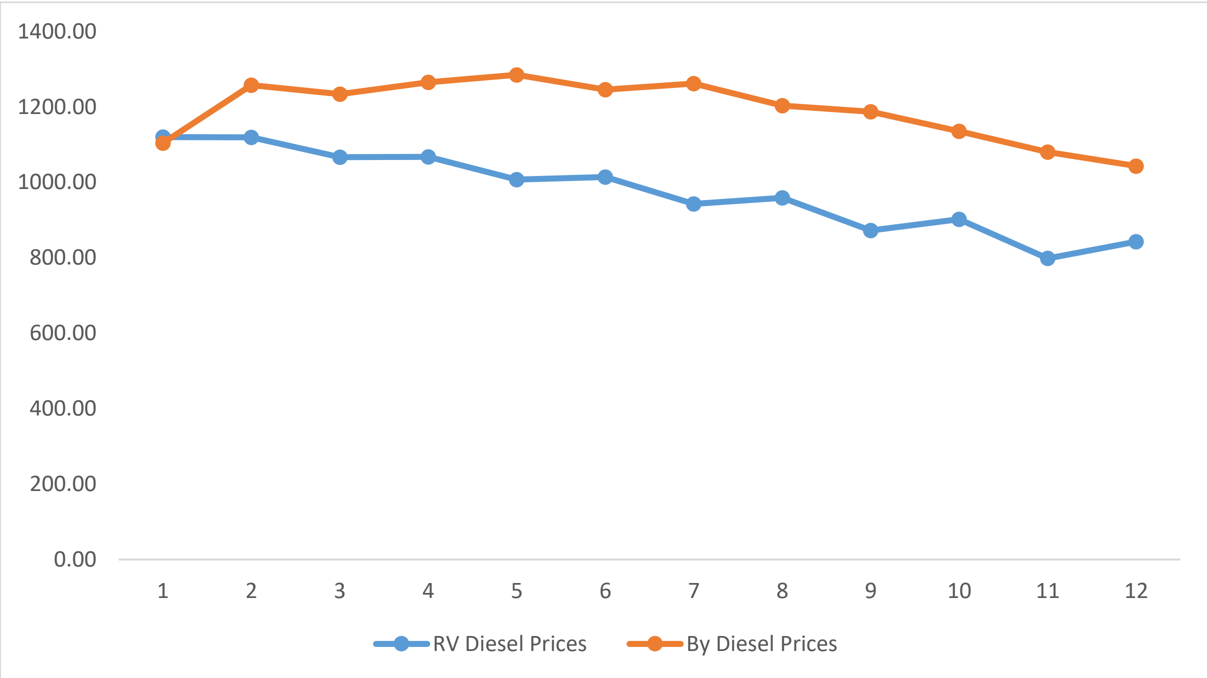

Figure 6d: Forecast Values of the Prices of Diesel in Bayelsa and Rivers State

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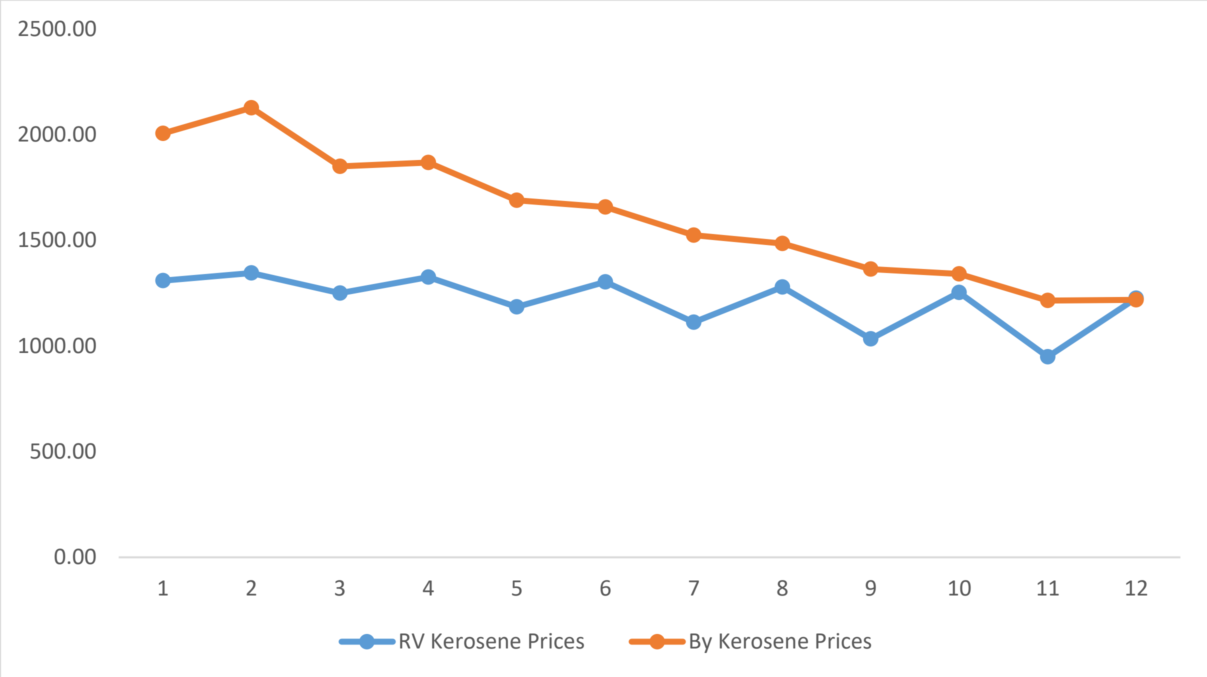

Figure 6e: Forecast Values of the Prices of Kerosene in Bayelsa and Rivers State

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