JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

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DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCES

THE IMPACT OF THE CHANGES IN PRICES OF PETROLEUM PRODUCTS ON INFLATION IN KENYA (A CASE STUDY OF NAIROBI COUNTY)

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DECLARATION

This research is our original work and has not been presented anywhere for degree award. I also declare that this dissertation contains no material written or published by other people except where due reference is made.

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LIST OF ABBREVIATIONS

VAR	-Vector Autoregression
KNBS	-Kenya National Bureau of Statistics
OTS	-Open Tender System
CPI	- Consumer Price Index
GDP	- Gross Domestic Product
EPRA	- Energy and Petroleum Regulatory Authority
AIC	- Akaike Information Criterion
ADF	– Augmented Dickey Fuller

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ABSTRACT

For almost half a century, global oil prices have witnessed a lot of volatility. In this study, the relationship between petroleum prices and inflation rate in Kenya is examined. The fluctuating international prices have led to unpredictable consumer prices thus resulting in an increase in the cost of living. The purpose of this study is to determine the overall impact of changes in prices of petroleum products on inflation in Kenya. This is a descriptive time series study with the monthly data of CPI and monthly prices of crude oil price per liter as the study variables. CPI was used as a a measure of inflation. The data will be collected from the Kenya National Bureau of Statistics and the Energy and Petroleum Regulatory Commission websites. The objectives of the study were achieved using a Vector Autoregressive model which assumes the series are stationary and not cointegrated. This study found that super petrol has a significant positive short run relationship with CPI while that of diesel and kerosene are insignificant. Further, the study used impulse response functions to determine the impact of petroleum prices shocks on CPI and these were in support of that obtained from VAR results. Based on the results from this study, further research should incorporate more time periods so as to get accurate and consistent results that show the impact of changes in prices of petroleum products in Kenya. **Keywords: Oil prices, inflation, CPI, Vector Autoregressive Model, Impulse Response Functions.**

CHAPTER 1: INTRODUCTION

1.1 Background Information

Petroleum, also known as crude oil is an essential commodity not only in Kenya but also worldwide. It is among one of our most important natural resources and has since been the largest major source of energy accounting for about 80% of the country's commercial energy requirements (Republic of Kenya 2004). Petroleum is used substantially in modern-day life by providing fuel to cook food at homes, run vehicles and machines, heat homes, manufacture fertilizers and pesticides as well as supplies and pharmaceuticals in the field of medicine.

Kerosene, gasoline, and diesel fuel are among the most widely used petroleum products in Kenya.

Kenya became the first East African nation to join the ranks of petroleum-exporting countries as of 26th August 2019. However, due to lack of the necessary equipment needed to unlock its full oil-producing potential, Kenya imports all its petroleum products from the Middle East (mainly Saudi Arabia) and thus the country is often affected by oil price fluctuations. From the KNBS statistical abstract, it is reported that there has been a tremendous increase in the price of petroleum over the past year and this has further contributed to a subsequent increase in prices of basic commodities. The relative increase in prices summed up with the global financial crisis, especially in developing countries like Kenya has led to inflationary pressure in the country as well as compelling its growth as an economy.

Inflation, by definition, is a sustained increase in the general price level in an economy or, equivalently, a fall in purchasing power. The annual inflation rate in Kenya was at 5.4% in

January 2022 from 5.7% in the previous month and is expected to rise by 3.6% in February 2022 (KNBS). The Consumer Price Index (CPI) is the most widely used measure of inflation and is a key indicator of the state of the economy. It is a measure of the average change over time in the prices paid by consumers for a market basket of consumer goods and services.

Kenya uses the Open Tender System (OTS) to import refined petroleum products, whereby petroleum products are purchased by a single company for the entire market based on a public tender and shared among all oil marketing companies in proportion to their respective shares in the market (Kojima et al. 2010). On data obtained from KNBS, it is noted that imports of petroleum products from Saudi Arabia increased last year (2021) by 61 percent to kshs132.6 billion, with the larger percentage being from the Murban Crude oil marketed by Abu Dhabi National Oil Company (ADNOC). Consequently, The Energy and Petroleum Regulatory Authority (EPRA) was forced to raise the prices of petroleum products by passing on these increased costs to consumers. The cost of importing a cubic meter of petrol increased by 4.8% to $520.04 from $461.95 during the same period (The Nation Nairobi, 2021).

Additionally, gasoline prices increased to $1.16 per liter in November from $1.15 per liter in October. Currently, 1 liter of petrol is retailing at kshs 129.72 in Nairobi, 1 liter of kerosene at kshs 103.54, and 1 liter of diesel at kshs 108.36 (Zindzy Gracia, 2022). This fuel- price increases are one of the top contributors to inflation in Kenya and this poses a cumulative effect on the cost of transport, food, electricity, and manufacturing. Manufacturers are forced to raise the prices of basic commodities such as maize flour, cooking oil, etc. to keep up with these new prices and a majority of Kenyans end up being affected by this as their purchasing power becomes markedly reduced. This in turn lowers their standard of living.

(KNBS, Economic Survey, 2017) In Kenya, the transportation sector accounts for the largest share of petroleum consumption by roughly 68.7%, while agriculture accounts for 1.05%, meaning when oil prices rise all goods which are transported will eventually be affected by higher transportation costs.

Petroleum products prices have been facing fluctuations and instability for quite some time and this pattern continues to date. This elicited the government to introduce oil price controls to ensure oil price stability by specifically forming one regulatory body for all the laws relating to energy policies known as The Energy and Petroleum Regulatory Authority (EPRA), established under the Energy Act 2019. This body publishes maximum wholesale price and retail pump prices of petroleum products usually monthly by setting the prices based on crude oil price, retailers' and wholesalers' margin, Cost, Insurance, and Freight (CIF) and transportation costs as well as government taxes. The prices are effective from the 15th day of every month and remain in force until the 14th day of the following month.

(Kojima, 2009) Before the reintroduction of price regulation, Kenya had tried using the National Oil Corporation of Kenya (NOCK)to stabilize prices of oil products but this was not successful in the long run. (Chen, 2009) A study in industrial countries has shown that oil has asymmetric pass through into inflation as it is observed that the subsequent increase in inflation by increased fuel prices remains solid and does not decline when oil price reduces, thus the need to investigate if the same applies to Kenya. Recent statistics have further shown that the cost of basic commodities increased by 8.89% in January 2022 (KNBS) and this has proven to be a major problem as the majority of Kenyans, especially low-income families cannot afford the basic retail commodities. The average retail prices of selected petroleum products as of 2020 are as shown (see appendix).

1.2 Problem Statement

Kenya imported $3.07B in refined petroleum as of 2019, making it become the 50th largest importer of refined petroleum in the world. However, it is with no doubt that the retail petroleum prices in Kenya do not reflect the true cost of product supply thus causing overall fluctuations in these prices. This has majorly been attributed to the failure of oil marketers to comply with the regulations set up by EPRA and Ministry of Energy, in that they are quick to raise the retail prices in the event of a price hike in international crude oil but fail to pass the satisfaction to consumers when the reverse happens (J.W Wepukhulu, 2011). The increased costs of production, therefore end up being passed to consumers who are the ones who are affected the most.

As a result, the CPI and inflation tend to also increase over time thereby reducing the purchasing power of Kenyans and leading to high living costs, thus lowering their standards of living. Many Kenyans are unable to afford basic items due to inflation; a larger portion of people's income is spent on basic daily requirements thus leaving little or no money for saving or investing. For example, when gasoline, a necessary product for most households' increases, a larger share of the household's budget will be spent on it leaving less to be spent on other necessities. For poorer households where food accounts for about 36% of total spending, the burden is even higher (KNBS).

The fact that inflation has diminished Kenya's purchasing power resulting in high living costs and has deteriorated its economy necessitates research into the relationship between changes in petroleum prices and inflation, both long and short term and thus applying effective models intended to stabilize oil prices in Kenya.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study is to determine the overall impact of changes in prices of petroleum products on inflation.

1.3.2 Specific Objectives

The specific objectives of this study will be;

1. To model the rate of change in prices of petroleum products in relation to inflation.
2. To measure the extent of the relation of inflation and the rate of change in prices of different petroleum products in Kenya.
3. To forecast the prices of major petroleum products and the annual rate of inflation.

1.4 Research Questions

This study carries out an empirical exploration of the following questions;

i)What is the rate of change in prices of petroleum products for one year?

ii)What is the relationship between the prices of different petroleum products and inflation in Kenya?

iii)What will be the prices of major petroleum products and the annual rate of inflation in Kenya in 12 months from the time of this study?

1.5 Significance of the Study

Despite the efforts made by the government through EPRA to stabilize oil prices, the country is still witnessing oil price shocks and their ensuing impact on inflation, thus making this research to be justifiable. The study will serve as an important tool to not only the government but also various stakeholders within the country. The information generated from this study is vital as it will enable the government through EPRA and the Ministry of Energy to come up with new measures and regulations such as lowering taxes or fees levied on petroleum products and thus lowering the end-user prices. The government may also use its influence by forcing oil companies to absorb losses from underpricing of fuels and thereby ensuring predictability of price movement of refined products to the final consumers.

Oil Marketing Companies (OMCs) have been disapproving of the regulation of prices set up by EPRA as they argue that it does not meet financing costs as well as the rising costs of doing business and thus opted for markets to be controlled by forces of demand and supply. This study will therefore enable the oil marketers to predict their sales revenue and hence reduce their total cost of operations. This will ensure that they comply with the regulatory body and set prices that are in line with the international crude oil prices thus guaranteeing an effective price control.

The study will also motivate planners and policymakers to dive more into the problem and suggest some policy options for coping with the oil price volatility in Kenya. This can be done by formulating policies that reduce the reliance on oil as a source of energy and suggesting other alternatives such as natural gas hence encouraging domestic oil production. Planners will be able to improve their skills in research and advice the government appropriately by making proper judgments on whether to raise or lower prices of petroleum products thus stabilizing the Kenyan economy in the long run.

By predicting the rate of inflation in the coming months, policymakers will be able to mitigate the impact of rising petroleum prices and inflation and in turn, this will benefit the consumers as well as businesses that rely on petroleum products. Inflation also brings with it a degree of unpredictability and as such investors are hesitant to invest in many industrial sectors of the economy. This study will look at petroleum prices as one of the major factors influencing the number of foreign and domestic investors willing to participate in various sectors of the economy, thus enabling policymakers to curb the increasing prices.

1.6 Scope of the Study

The study will concentrate on the oil sector in Kenya specifically majoring on three petroleum products; kerosene, gasoline, and diesel which account for a greater percentage of refined crude oil consumed by both households and various industrial sectors in Kenya. The study will focus on determining the overall impact of changes in prices of petroleum products on inflation by making use of the Consumer Price Index (CPI) which gives a general picture of the state of the economy with regard to inflation.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, we concentrate on previous research on topics that is strongly relevant to our research: the relationship between rates of change in the pricing of main petroleum products and inflation. There are three components in this chapter: theoretical review, empirical review, and summary.

2.2 Theoretical Review

Oil price fluctuations have a great influence on an economy's microeconomic and macroeconomic behavior. According to Lacheheb and Sirag (2019), because of the economic consequences of oil price fluctuations, both the government and educational institutions have performed substantial research on the subject. Lacheheb and Sirag (2019) also added that countries that export oil profit from higher prices, while countries that import petroleum products suffer from higher prices, and vice versa. Petroleum prices are affected by several factors. As cited by Hosseini and Shakouri (2016), these factors include; Supply and demand methods, proven oil reserves, oil substitution rate, storage strategies for oil and its products, energy intensity, economic growth outlook, futures, and options prices, geopolitical events among others.

Analyzing petroleum price behavior can be done in a variety of ways. The economics of finite resources, the supply-demand approach, and the informal approach are among them. Lidiema, (2020). The economics of finite resources explains that petroleum prices must exhibit an increasing trend while the supply-demand approach argues that petroleum prices are determined by the supply and demand forces of the economy. Within certain contexts and periods of oil market history, the informal technique is typically utilized to identify economic, geopolitical, and incidental elements that affect demand and supply, and hence oil price changes.

It is widely assumed that a drop in global crude oil prices has a direct and considerable impact on inflation in any country. However, in his article, Lidiema, (2020) states that the debate about trade openness and inflation remains unresolved. In further support of this, he points out that one arm discovered that trade openness has a favorable impact on inflation, while the other discovered the opposite, while others discovered mixed results or no significant association.

Petroleum is an important input for various industries; therefore, industries must come up with different strategies in response to its price fluctuation. According to Lacheheb and Sirag (2019) When faced with a high oil price, industries may choose to reduce production or convert it to a greater level of output for consumers. Similarly, lowering the price of oil would lower the cost of production and, as a result, the price level as cited by Lacheheb and Sirag (2019) in their article. How an industry would respond to these fluctuations would depend on several factors, but the majority respond by raising prices, for example, airlines would increase prices for transporting cargo as well as ticket prices.

2.3 Empirical Review

A significant amount of research has been done in an attempt to understand the relationship between the fluctuation of petroleum products price and economic variables (e.g., Inflation, Economic Growth, and Unemployment). For instance, as stated by Nyangarika, (2018), In 2004, American scientists evaluated the impact of oil prices on important macroeconomic indicators, including GDP growth rates, through using the Interlink program developed by the Organization for Economic Cooperation and Development. In his article, Nyangarika, (2018), also stated that unemployment is affected by changes in oil prices, with a 0.1 percent movement resulting in the loss of nearly 400,000 jobs across the Organization for Economic Development and Cooperation member countries. As cited in his article, Nyangarika, (2018), countries that import oil are the ones who are most affected by oil price fluctuations, e.g., Japan. On the other hand, countries like the United States suffer the least because it fulfills 40% of their oil needs with domestic production.

As a result of the above, an increase in oil prices will surely result in a decrease in a country's GDP. According to Nyangarika, (2018), countries that import oil are logically the most reliant on oil prices, whereas exporting countries will benefit from higher prices in the short term. Nyangarika, (2018), employed the Fractionally integrated generalized autoregressive conditional heteroscedasticity (FIGARCH) model to determine the link between oil and GDP in his article. His findings revealed that there is interdependence between oil prices and GDP in all countries, however to varying degrees. Saudi Arabia and Russia's economies for example are strongly reliant on energy exports, therefore variations in oil prices have a detrimental influence on their GDP.

When it comes to responding to exogenous oil price shocks, policymakers play a critical role. According to Hakro and Omezzine (2016), there is a clear correlation between short-term fluctuations in oil prices and their impact on the domestic economy. Hakro and Omezzine (2016), also added that oil price fluctuations have a direct impact on exchange rates, and these fluctuations, in turn, indirectly demand management policies. Developing countries respond to exogenous shocks in diverse ways. For example, when oil prices rise, some countries adopt deflationary policies, resulting in increased long-term economic development. On the other hand, Countries that rely on external funding yet do not have adequate output-increasing policies face slower economic growth.

Inflation is a major problem in many developing countries. In Kenya, for instance, as cited by Lidiema, (2020) inflation soared to as high as 20% in 2012, owing to rising political tensions and uncertainties. Lidiema, (2020) mentions that, apart from changes in macroeconomic policy, various factors contribute to inflation, including increases in income and money supply; domestic and global oil prices; increasing demand for domestic goods; and a fast rise in foreign commodities. In the computation of inflation, both food and non-food components are used. According to Lidiema, (2020) food inflation is higher and more variable than non-food inflation, particularly in emerging and low-income countries, with food inflation being 36% of total inflation for the case of Kenya. Lidiema, (2020) employed monthly data from January 2009 to December 2019 in his mathematical model, with his variables being the Food Consumer Price Index (CPIF), Crude Oil prices, Trade Openness as measured by Volume of Trade (% GDP),

Broad Money Supply, and foreign currency rates. In his results, Lidiema, (2020) pointed out that overall, trade openness has a negative impact on food inflation in Kenya. According to the findings, a 1% increase in trade openness will result in a 0.55 % reduction in food inflation in Kenya. As for the case of oil prices, crude oil prices have a long-run positive and considerable effect on food inflation, according to the long-run equation. The coefficient of Crude Oil Prices implies that a 1% increase in crude oil prices per barrel raises inflation by 0.12% as cited by Lidiema, (2020). This is because oil is a crucial component of every economy. As a result, activities related to food production, such as transportation costs and the creation of food packaging items, are immediately affected, as are all the shock spillover effects on food prices.

Changes in the price of oil have an impact on exchange rates both directly and indirectly. In

Baek & Kim (2020), the exchange rate of a country is equally affected by the price of crude oil. Baek & Kim (2020), used the nonlinear autoregressive distributed lag (NARDL) model to see if crude oil price changes are asymmetrically passed on to real exchange rates in oil-exporting and importing poor nations, particularly in sub-Saharan Africa. In their results, Baek & Kim (2020), pointed out that, In the long run, oil prices appear to have an unbalanced effect on real exchange rates in SSA nations including Kenya, Mozambique, Nigeria, and Zambia. That is to say, currency rates react more to rising oil prices than falling oil prices.

2.4 Summary

Oil price changes have a significant impact on the microeconomic and macroeconomic behavior of an economy. While countries that export oil benefit from rising prices, countries that import petroleum products face greater costs. A decline in global crude oil prices is usually considered to have a significant impact on inflation. However, the debate about trade openness and inflation is still ongoing. Some research has discovered the contrary, while others have discovered mixed results or no substantial link.

A rise in oil costs will almost certainly result in a drop in a country's GDP. Additionally, exogenous shocks affect developing countries in a variety of ways. In return, countries respond in a variety of ways, for instance, some governments implement deflationary policies as oil prices rise. Countries that rely on external funding, on the other hand, see weaker economic growth. In Kenya, due to escalating political tensions and uncertainty, inflation surged to as high as 20% in 2012.

Crude oil prices have a long-term and significant positive impact on food inflation. Oil prices appear to have an imbalanced effect on real exchange rates in the long run.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter will describe specific procedures or strategies, as well as the statistical model, for analyzing secondary source data on oil prices and inflation. The monthly average prices of diesel, petrol, and kerosene in Kenya Shillings from January 2017 to June 2022 period will be obtained from the Energy and Petroleum Regulatory Authority (EPRA) while statistics on monthly CPI will be obtained from the Kenya National Bureau of Statistics (KNBS) website. Monthly data will be used because EPRA usually reviews oil prices monthly.

Research Design

A research design refers to the overall strategy used to incorporate the different components of the study in an accordant way by clearly highlighting how the research problem will be addressed. The study will use a descriptive design to answer the research questions with the values of petroleum price per barrel and rates of inflation as its variables. In descriptive design, a researcher has no control of the variables and it is the only research design that provides a continuous record of fluctuations in the study variables over a given period in which the variables are being studied. This explains the use of time series analysis for this study since the general objective is to determine the impact of fluctuation in oil prices on inflation across time.

3.2 The Model

The vector autoregression (VAR) model tends to be more useful in the analysis of the impact of oil price changes on inflation. It offers a variety of advantages, including the fact that it is simple because there are no dependent and independent variables to complicate things. VAR models are useful forecasting tools. They are created in such a way that the present value of a variable is influenced by its previous values as well as the past values of other variables involved in a particular study.

Illustration

Assuming we use a ***p*** time period into the past ***VAR (p)*** we will have the model as;

$$\mathbf{Y}_{1t} = \boldsymbol{\beta}_{10} + \boldsymbol{\beta}_{11}\mathbf{Y}_{1t-1} + \ldots + \boldsymbol{\beta}_{1p}\mathbf{Y}_{1t-p} + \boldsymbol{\lambda}_{11}\mathbf{Y}_{2t-1} + \ldots + \boldsymbol{\lambda}_{1p}\mathbf{Y}_{2t-p} + \boldsymbol{\Phi}_{11}\mathbf{Y}_{3t-1} + \ldots + \boldsymbol{\Phi}_{1p}\mathbf{Y}_{3t-p} + \boldsymbol{\Pi}_{11}\mathbf{X}_{t-1} + \ldots + \boldsymbol{\Pi}_{1p}\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_{1t} \quad \ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$\mathbf{Y}_{2t} = \boldsymbol{\beta}_{20} + \boldsymbol{\beta}_{21}\mathbf{Y}_{1t-1} + \ldots + \boldsymbol{\beta}_{2p}\mathbf{Y}_{1t-p} + \boldsymbol{\lambda}_{21}\mathbf{Y}_{2t-1} + \ldots + \boldsymbol{\lambda}_{2p}\mathbf{Y}_{2t-p} + \boldsymbol{\Phi}_{21}\mathbf{Y}_{3t-1} + \ldots + \boldsymbol{\Phi}_{2p}\mathbf{Y}_{3t-p} + \boldsymbol{\Pi}_{21}\mathbf{X}_{t-1} + \ldots + \boldsymbol{\Pi}_{2p}\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_{2t} \quad \ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$\mathbf{Y}_{3t} = \boldsymbol{\beta}_{30} + \boldsymbol{\beta}_{31}\mathbf{Y}_{1t-1} + \ldots + \boldsymbol{\beta}_{3p}\mathbf{Y}_{1t-p} + \boldsymbol{\lambda}_{31}\mathbf{Y}_{2t-1} + \ldots + \boldsymbol{\lambda}_{3p}\mathbf{Y}_{2t-p} + \boldsymbol{\Phi}_{31}\mathbf{Y}_{3t-1} + \ldots + \boldsymbol{\Phi}_{3p}\mathbf{Y}_{3t-p} + \boldsymbol{\Pi}_{31}\mathbf{X}_{t-1} + \ldots + \boldsymbol{\Pi}_{3p}\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_{3t} \quad \ldots\ldots\ldots\ldots\ldots \text{(3)}$$

$$\mathbf{X}_{t} = \boldsymbol{\beta}_{40} + \boldsymbol{\beta}_{41}\mathbf{Y}_{1t-1} + \ldots + \boldsymbol{\beta}_{4p}\mathbf{Y}_{1t-p} + \boldsymbol{\lambda}_{41}\mathbf{Y}_{2t-1} + \ldots + \boldsymbol{\lambda}_{4p}\mathbf{Y}_{2t-p} + \boldsymbol{\Phi}_{41}\mathbf{Y}_{3t-1} + \ldots + \boldsymbol{\Phi}_{4p}\mathbf{Y}_{3t-p} + \boldsymbol{\Pi}_{41}\mathbf{X}_{t-1} + \ldots + \boldsymbol{\Pi}_{4p}\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_{4t} \quad \ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$\mathbf{Y_{1t}}$ is the super petrol price, $\mathbf{Y_{2t}}$ is the diesel price and $\mathbf{Y_{3t}}$ is the kerosene price at time t.

$\mathbf{X_t}$ the CPI at time t.

Φ's, Π's, β's and **λ's** are unknown coefficients and $\boldsymbol{\varepsilon_{t's}}$ are the error terms. Coefficients of the model are estimated by estimating each equation by Ordinary Least Square Method (OLS).

We will assume the price of oil at time ***t*** is dependent on its prices ***p*** periods into the past and that the CPI is dependent on its previous values ***p*** periods into the past. Additionally, we will assume that the past values of oil prices influence the present values of CPI and vice versa.

Assumptions of the model

1. The variables in the model are stationary.
2. The error term has a conditional mean of zero
3. Large outliers are unlikely
4. No perfect multicollinearity
5. No serial correlation
6. Variables are homoscedastic.

3.3 Time Series Diagnostic Tests

Diagnostic testing on data series provides information on how its data can be modelled (Chung-Ming Kuan,2008).

Unit Root Test.

Here the study will use ADF to test for stationarity of the variables to avoid getting inconsistent results. This will be determined by testing the null and alternative hypothesis and coming up with a relevant conclusion based on the p-value using R functions.

Johansen Cointegration Test.

Cointegration is a statistical property used to model the long-run relationships in time series data. It occurs when two or more nonstationary time series have a long-run equilibrium and share an underlying common stochastic trend. Cointegration aspect is equally important in time series as it avoids spurious regression problems. Absence of a long run relationship between equilibrium relationships among the variables corresponds to zero coefficients for the variables.

Lag selection.

This test uses the lag length criterion in determining the autoregressive lag length. In this study we have made use of the AIC, where we choose the specification which has the smallest value of AIC.

Granger Causality Test.

This determines whether one-time series is useful in forecasting another. They are F statistics that test if the coefficients of all lags of a variable are jointly equal to zero in the equation for another variable. The study used this test to determine whether CPI, super petrol, diesel and kerosene have causality among them by testing the null and alternative hypothesis at 5% significance level.

Impulse response functions.

These were used to trace the dynamic impact to a system of a "shock" or change to an input. The resulting regime-dependent impulse response functions show how the reaction of variables in the mode to fundamental disturbances differs across regimes (Michael Ehramann,2003).

Forecasting using VAR

A VAR model has an extensive application in econometric forecasting model. It is useful when one is interested in predicting multiple time series using a single model. Since a VAR models all variables using lags of the respective other variables, we need to forecast for all variables.

CHAPTER 4: ANALYSIS AND DISCUSSION OF RESULTS

4.1 Data Description

To examine the impact of changes in prices of petroleum products on inflation in Kenya, secondary data was adopted. The study used monthly time series data from January 2017 to June 2022.The description of all the variables employed in the study are shown in table 1.

Table 4.1: Definition and sources of variables

Variable	**Definition**	**Source**
Consumer Price Index	Change in consumer prices	KNBS
Super petrol	Kenya shillings per liter	EPRA website
Diesel	Kenya shillings per liter	EPRA website
Kerosene	Kenya shillings per liter	EPRA website

4.2 Descriptive Analysis

Table 4.2 : Descriptive statistics results

Sample: 2017M01 2022M06

	LCPI	LSUPER_P...	LDIESEL	LKEROSENE
Mean	5.029469	4.713702	4.607474	4.483109
Median	5.208064	4.692764	4.624335	4.576489
Maximum	5.327391	5.069659	4.941642	4.844187
Minimum	4.666547	4.422809	4.311738	4.134526
Std. Dev.	0.265904	0.121831	0.112150	0.193619
Skewness	-0.235039	0.549475	0.126281	-0.433128
Kurtosis	1.162036	3.467041	3.745520	1.915923
Jarque-Bera	9.897483	3.921005	1.703866	5.295463
Probability	0.007092	0.140788	0.426590	0.070812
Sum	331.9450	311.1043	304.0933	295.8852
Sum Sq. Dev.	4.595824	0.964786	0.817552	2.436750
Observations	66	66	66	66

There are four variables from the table 2 above each with a total of 66 observations based on the months of the study. LCPI denotes the log of CPI, LSuper petrol the log of super petrol, LDiesel the log of diesel and LKerosene the log of kerosene. The log of variables was applied in this study as it boosts the validity of the statistical analysis.

Standard deviation is a measure of how dispersed the data is in relation to the mean. Kerosene prices has the highest standard deviation, meaning that its prices are spread out over a wide range while CPI deviate the least from the mean.

Skewness measures the degree of asymmetry of a given series. From the table above, all the variables mirror a fairly symmetrical distribution except super petrol which is moderately skewed. Kurtosis on the other hand, measures the extent to which a given series contains outliers. Super petrol and diesel are both leptokurtic since their kurtosis is more than 3, hence they have distributions with longer tails.CPI and kerosene are platykurtic (values are less than 3) and therefore they have shorter tails in their distribution.

Figure 4.1: **Trend of the Variables**

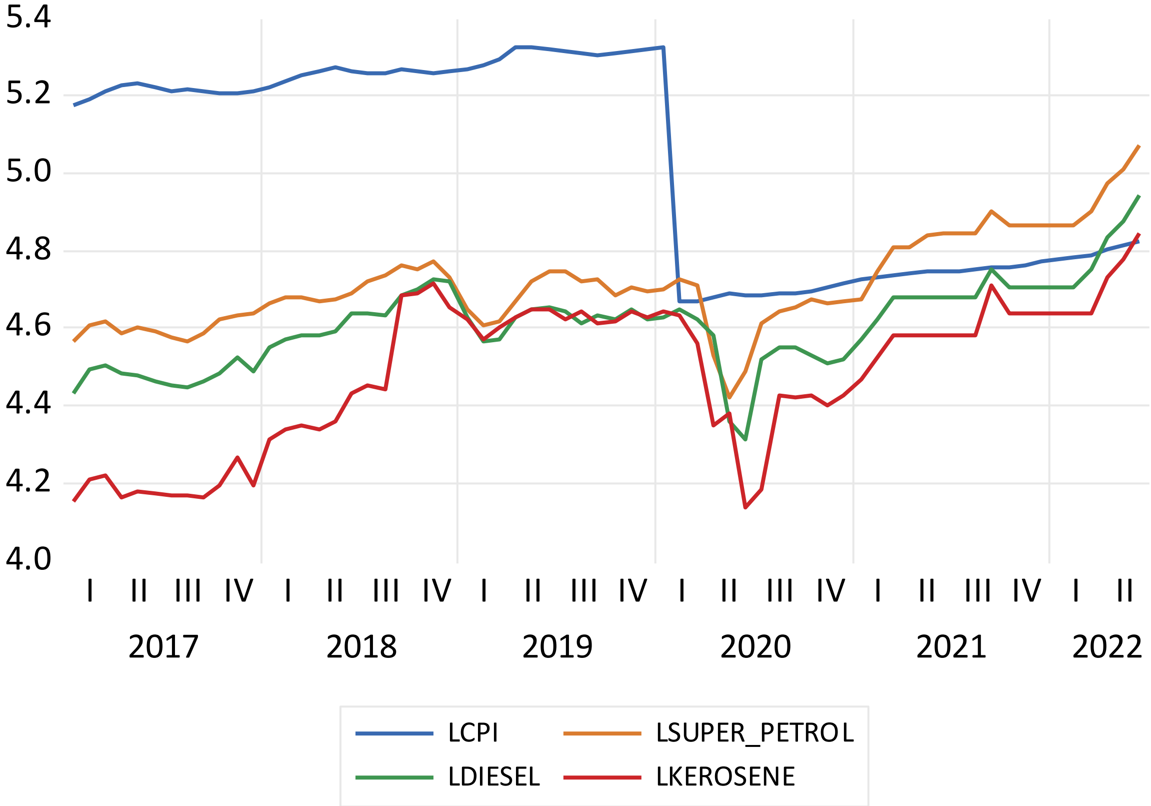


Figure 1 above displays the trend of all the four variables in the study from January 2017 to June 2022. From the graph, it is rather noticeable that the values of the all the four variables have been fluctuating over time.

CPI for instance, was relatively high at the start of 2020 but witnessed a significant drop afterwards. At the end of the study period, its value was at 120 points. Super petrol prices had a slight decline in 2019 and it dropped again in 2020.

Diesel and kerosene prices also witnessed the same trend as their prices fell at the start of 2020 but immediately rose again. The prices have been increasing gradually since then.

4.3 Stationarity Test

As a first step of time series analysis, stationarity tests were carried out for all the four variables. A stationary time series is one whose properties do not rely on the time at which the time series is observed. That is to say that a time series with trends or seasonality is not stationary since the trend and seasonality affects the value of the time series at separate times. The Augmented Dickey Fuller (ADF)unit root test was used to check for stationarity of the variables by computing the null and alternative hypotheses for the series and using the p-value to make inference.

H_o : the series has a unit root (non-stationary)

vs H_a: the series has no unit root (stationary)

Table 4.3: CPI ADF Test Results

Null Hypothesis: LCPI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.181099	0.6778
Test critical values:	1% level	-3.534868	
	5% level	-2.906923	
	10% level	-2.591006	

*MacKinnon (1996) one-sided p-values.

From table 3 above, the null hypothesis is that CPI has a unit root, meaning that it is non stationary while the alternative hypothesis is that it is stationary. Since the p-value in this case is greater than 5% significance level, we fail to reject the null hypothesis. This signifies that CPI series is not stationary at 0.05 significance level.

Table 4.4 : Super petrol ADF Test Results

Null Hypothesis: LSUPER_PETROL has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.192334	0.9334
Test critical values:	1% level	-3.538362	
	5% level	-2.908420	
	10% level	-2.591799	

*MacKinnon (1996) one-sided p-values.

The p-value for the given series (0.9334) is greater than 5% significance level. As a result, we fail to reject the null hypothesis and infer that super petrol series is not stationary.

Table 4.5 : Diesel ADF Test Results

Null Hypothesis: LDIESEL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.958516	0.7630
Test critical values:	1% level	-3.534868	
	5% level	-2.906923	
	10% level	-2.591006	

*MacKinnon (1996) one-sided p-values.

From the ADF test disclosed by the table above, the p-value (0.7630) is greater than 0.05 significance level and hence we fail to reject the null hypothesis. Diesel series is not stationary.

Table 4.6 : Kerosene ADF Test Results

Null Hypothesis: LKEROSENE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.416963	0.5687
Test critical values:	1% level	-3.534868	
	5% level	-2.906923	
	10% level	-2.591006	

*MacKinnon (1996) one-sided p-values.

Kerosene series is also not stationary as its p-value is greater than 5% significance level.

4.4 Differencing

The series of all the three variables were found not be stationary and therefore differencing them to make them stationary was also a crucial step in the analysis in order to avoid inconsistent results. Differencing converts a non-stationary time series to a stationary time series by computing the between successive observations and otherwise eliminating trend and seasonality. The results of ADF test after differencing the four variables are shown in the figures below;

Table 4.7: CPI ADF Test After Difference Results

Null Hypothesis: D(DLCPI) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.411714	0.0000
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

Table 4.8 : Super petrol ADF Test After First Differencing Results

Null Hypothesis: D(DLSUPER_PETROL) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.527874	0.0000
Test critical values:	1% level	-3.546099	
	5% level	-2.911730	
	10% level	-2.593551	

*MacKinnon (1996) one-sided p-values.

Table 4.9 : Diesel ADF Test After First Difference Results

Null Hypothesis: D(DLDIESEL) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.737614	0.0000
Test critical values:	1% level	-3.544063	
	5% level	-2.910860	
	10% level	-2.593090	

*MacKinnon (1996) one-sided p-values.

Table 4.10 : Kerosene ADF Test After Difference Results

Null Hypothesis: D(DLKEROSENE) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

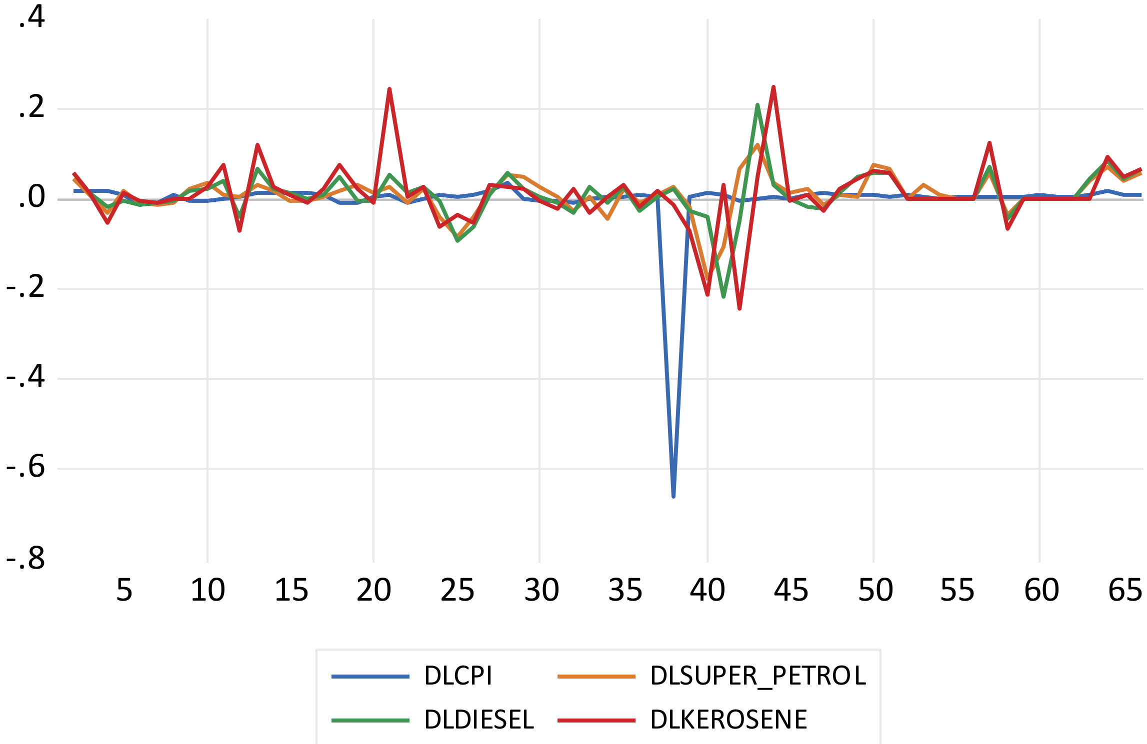
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.716340	0.0000
Test critical values:	1% level	-3.540198	
	5% level	-2.909206	
	10% level	-2.592215	

*MacKinnon (1996) one-sided p-values.

The p-values of all the series above are less than 0.05significance level, therefore all the series are stationary at first difference.

Figure 4.2 : Plots of First Differencing of the Variables

All the plots of the three series below indicate that the variables are now stationary (no unit root).



4.5 Cointegration Test

After checking for stationarity among the variables, the next step is to test for cointegration. Presence of cointegration among the variables implies that the series will be connected through an Error Correction Model (ECM) but if there is no cointegration then The VAR model can be implemented. The Johansen Test for Cointegration was particularly used in this study.

Johansen Test for Cointegration

Johansen's test is used to determine if three or more-time series are cointegrated. There are two \types of Johansen's test; trace and maximum Eigen value. The two hypotheses when conducting this test are;

H_o: No cointegrating equations vs

H_a: At least one cointegrating relationships

When the trace statistic or maximum Eigen value is greater than the critical value, the null hypothesis is rejected and when the trace statistic or maximum Eigen value is less than the critical value, we fail to reject the null hypothesis.

Johansen's Test of Cointegration Results

The results presented in figure below indicate that there is no cointegrating equations among the variables since both the trace statistic and maximum Eigen value are less than their critical values. This implies that the variables have no long-term relationship and therefore VAR model is the most appropriate model to use.

Table 4.11 Cointegration test results

Series: DLCPI DLSUPER_PETROL DLDIESEL DLKEROSENE
Lags interval (in first differences): 1 to 6

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.312798	42.83634	47.85613	0.1366
At most 1	0.185549	21.07894	29.79707	0.3527
At most 2	0.102344	9.174969	15.49471	0.3495
At most 3	0.048981	2.912809	3.841465	0.0879

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

4.6 Lag Order Selection

Table 4.12 : Lag Selection Criteria Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	209.8685	NA	1.23e-08	-6.862285	-6.722662	-6.807670
1	395.4882	340.3027	4.32e-11	-12.51627	-11.81816	-12.24320
2	420.4296	42.40032	3.23e-11	-12.81432	-11.55771	-12.32279
3	465.6544	70.85230	1.24e-11	-13.78848	-11.97338*	-13.07850*
4	478.0600	17.78132	1.45e-11	-13.66867	-11.29508	-12.74023
5	496.1902	23.56925	1.43e-11	-13.73967	-10.80759	-12.59277
6	523.2363	31.55377*	1.09e-11*	-14.10788*	-10.61730	-12.74252

The table above specifies the optimal lag length to be used in the model. The number of lags recommended by AIC is 6 and therefore this is the best lag to use in the model.

4.7 Vector Autoregressive Model

The first step in implementing the VAR model was to determine the correct number of lags to include in the model and from figure, the appropriate lag length chosen was lag 6. In this model, all the four variables are treated as endogenous variables hence there are four different equations for each variable, which describe the dynamics of each variable as a linear function of the previous 6 lags of every variable in the system including its own lag.

The variables were found not to be cointegrated and therefore the study will basically focus on the short run association among them. Short run is a term often used in the field of economics to describe a future period during which one input is fixed while others are variable.

VAR Estimation Results

One of the specific objectives of this study was to measure the extent of correlation between changes in prices of petroleum products and inflation. This was achieved by analyzing the coefficient values of each variable from the CPI equation, which was the main point of inference in this case. There is no long-term association of the variables and therefore the results only reveal the short run effect among them.

Table 4.13: VAR estimation results

Sample (adjusted): 2017M08 2022M06
Included observations: 59 after adjustments
DLCPI = C(1)*DLCPI(-1) + C(2)*DLCPI(-2) + C(3)*DLCPI(-3) + C(4)*DLCPI(-4) + C(5)*DLCPI(-5) + C(6)*DLCPI(-6) + C(7)*DLSUPER_PETROL(-1) + C(8)*DLSUPER_PETROL(-2) + C(9)*DLSUPER_PETROL(-3) + C(10)*DLSUPER_PETROL(-4) + C(11)*DLSUPER_PETROL(-5) + C(12)*DLSUPER_PETROL(-6) + C(13)*DLDIESEL(-1) + C(14)*DLDIESEL(-2) + C(15)*DLDIESEL(-3) + C(16)*DLDIESEL(-4) + C(17)*DLDIESEL(-5) + C(18)*DLDIESEL(-6) + C(19)*DLKEROSENE(-1) + C(20)*DLKEROSENE(-2) + C(21)*DLKEROSENE(-3) + C(22)*DLKEROSENE(-4) + C(23)*DLKEROSENE(-5) + C(24)*DLKEROSENE(-6) + C(25)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.052493	0.177081	0.296434	0.7687
C(2)	-0.108923	0.183036	-0.595093	0.5557
C(3)	-0.161249	0.334322	-0.482315	0.6327
C(4)	0.114235	0.334153	0.341864	0.7346
C(5)	-0.065461	0.330393	-0.198130	0.8441
C(6)	-0.182190	0.386362	-0.471552	0.6403
C(7)	0.431734	1.039477	0.415338	0.6805
C(8)	-0.036128	0.956776	-0.037760	0.9701
C(9)	-0.598350	0.875511	-0.683430	0.4990
C(10)	1.841086	0.804897	2.287357	0.0285
C(11)	0.027285	0.930504	0.029323	0.9768
C(12)	0.845974	0.906664	0.933063	0.3574
C(13)	-0.313954	1.108223	-0.283295	0.7787
C(14)	0.568303	0.939623	0.604820	0.5493
C(15)	-0.455733	0.855772	-0.532540	0.5978
C(16)	-0.681511	0.854108	-0.797921	0.4305
C(17)	-0.658414	0.813805	-0.809056	0.4241
C(18)	-0.301829	0.745360	-0.404943	0.6881
C(19)	0.100689	0.430543	0.233865	0.8165
C(20)	-0.137968	0.401507	-0.343625	0.7332
C(21)	0.105219	0.371605	0.283148	0.7788
C(22)	-0.052739	0.400590	-0.131652	0.8960
C(23)	0.295394	0.379163	0.779070	0.4413
C(24)	-0.129901	0.293102	-0.443195	0.6604
C(25)	-0.015327	0.018110	-0.846350	0.4033

R-squared	0.229197	Mean dependent var	-0.006622
Adjusted R-squared	-0.314899	S.D. dependent var	0.086645
S.E. of regression	0.099355	Akaike info criterion	-1.483958
Sum squared resid	0.335627	Schwarz criterion	-0.603646
Log likelihood	68.77677	Hannan-Quinn criter.	-1.140320
F-statistic	0.421244	Durbin-Watson stat	1.916906
Prob(F-statistic)	0.984865		

The fourth lag of inflation has a positive short run relationship with the current level of inflation with 11% of the previous inflation feeding through the current inflation. However, this relationship is not significant as the p-value is greater than 0.05 significance level and therefore the results cannot be validated.

The first month lags of super petrol also do not reveal any significant relationship with CPI. However, it is worth mentioning that at the fourth month lag, super petrol presents a strong positive short run relationship with the current CPI (coefficient is 1.8%). This means that a 1 unit rise in petrol prices was accompanied by a change of 1.8 units in CPI. Since the p-value is less than 5% significance level, the association between the two variables is significant and therefore petrol price and CPI have some directional changes.

The results above suggest that diesel has a negligible impact on CPI in the short run as all the p-values of its lagged coefficients are greater than 5% significance level. The second lag of diesel indicates a positive relationship though this is rendered a minor effect while the third lag implies a negative relationship. Practically, diesel is a dominantly consumed fuel and therefore a major channel through which changes in oil price directly affects an economy (Siddhartha Pradeep). It has a large impact on the economy as it is the main transportation fuel in road transport and thus it is expected that an increase in diesel prices would cause a symbolic change in CPI in the short run. However, this appeared not to be the case during the study period.

Kerosene prices indicate a negative short run relationship with CPI as seen in the second month lag. This implies that a unit increase in kerosene is associated by a decline in CPI by 0.13 units but this also is not significant at 5% significance level.

Furthermore, it is clear from the results above that the lagged responses of CPI to changes in prices of super petrol in particular, are a bit larger than the current responses; the coefficient of super petrol at the fourth month lag, 1.8%%, is greater than that of the first month lag (0.43%). This further suggests that in as much as super petrol has a significant positive relationship with inflation, a definite and positive change in its prices may not be soaked up immediately by inflation but may take some time before it causes a significant effect on it, ideally at a lagged timespan of 4 months.

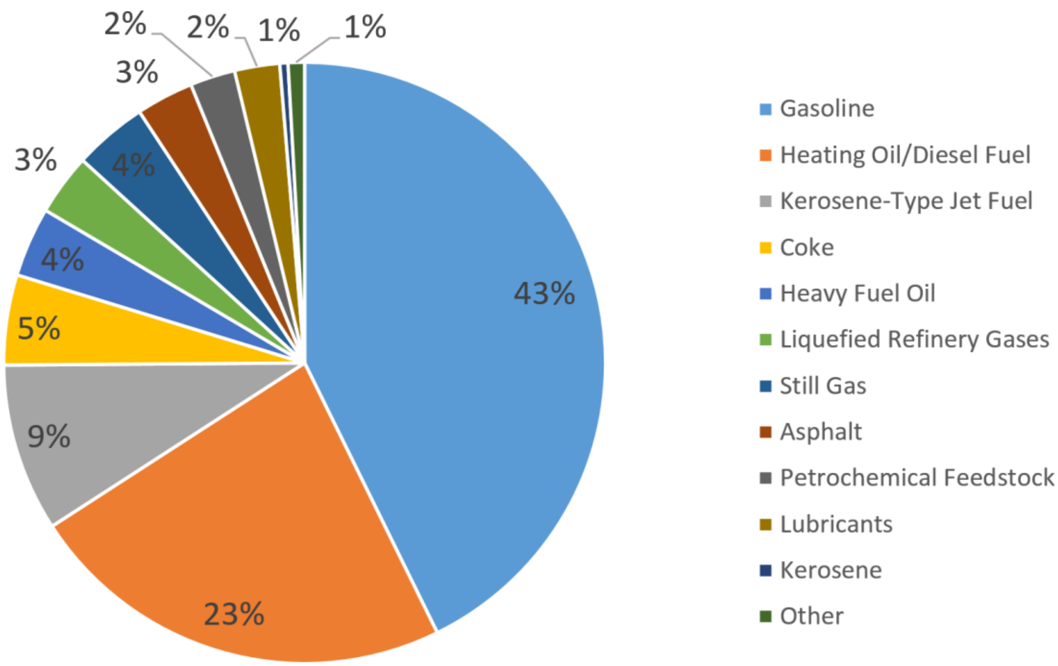


Figure 4.3: Consumption of petroleum products

4.8 Granger Causality Test

A prerequisite for performing the Granger Causality test is that the time series data need to be stationary. Since all the series are confirmed to be stationary after the first difference, the Granger Causality test can be performed to check if one variable acts as a determining factor for another variable (Granger,1980). This is achieved by testing the hypothesis;

H_o: The independent variable does not Granger-cause the dependent variable

H_a: The independent variable Granger-causes the dependent variable

Table 4.14 : Granger Causality Results

Sample: 2017M01 2022M06
Lags: 6

Null Hypothesis:	Obs	F-Statistic	Prob.
DLSUPER_PETROL does not Granger Cause DLCPI	59	1.08243	0.3870
DLCPI does not Granger Cause DLSUPER_PETROL		8.17787	5.E-06
DLDIESEL does not Granger Cause DLCPI	59	0.50236	0.8033
DLCPI does not Granger Cause DLDIESEL		11.8451	5.E-08
DLKEROSENE does not Granger Cause DLCPI	59	0.50236	0.8033
DLCPI does not Granger Cause DLKEROSENE		11.8451	5.E-08
DLDIESEL does not Granger Cause DLSUPER_PETROL	59	0.54086	0.7743
DLSUPER_PETROL does not Granger Cause DLDIESEL		10.6320	2.E-07
DLKEROSENE does not Granger Cause DLSUPER_PETROL	59	0.54086	0.7743
DLSUPER_PETROL does not Granger Cause DLKEROSENE		10.6320	2.E-07
DLKEROSENE does not Granger Cause DLDIESEL	59	NA	NA
DLDIESEL does not Granger Cause DLKEROSENE		NA	NA

From table above, there is no short run causality between super petrol, diesel, kerosene and CPI. The respective p-values of the petroleum series are greater than 0.05 significance level, implying that both super, diesel and kerosene do not Granger cause CPI in the short run. CPI on the other hand Granger-causes the prices of super petrol, diesel and kerosene.

4.9 : Diagnostic Tests

In this section, various diagnostic tests were performed to check for possible discrepancy of the fitted VAR model. Diagnostic tests are also applied to evaluate model residuals, which also serves as a test for model adequacy.

4.9.1 : Autocorrelation Test**:**

H_o: No autocorrelation

H_a: Presence of autocorrelation

Table 4.15: Autocorrelation test results

VAR Residual Serial Correlation LM Tests
Date: 07/17/22 Time: 21:55
Sample: 2017M01 2022M06
Included observations: 59

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	11.18359	16	0.7980	0.686391	(16, 83.1)	0.7995
2	21.54519	16	0.1585	1.403013	(16, 83.1)	0.1606
3	13.35482	16	0.6467	0.829810	(16, 83.1)	0.6489
4	24.67364	16	0.0758	1.636078	(16, 83.1)	0.0772
5	23.69909	16	0.0963	1.562606	(16, 83.1)	0.0979
6	12.43246	16	0.7137	0.768462	(16, 83.1)	0.7156
7	13.33723	16	0.6480	0.828634	(16, 83.1)	0.6502

From table results, there is no autocorrelation among the variables since the p-value (0.7156) is greater than 5% significance level.

4.9.2 Test of ARCH Effects**:**

Null hypothesis: No ARCH effects

Alternative hypothesis: ARCH effects

Table 4.16: ARCH Effects Results

Sample: 2017M01 2022M06
Included observations: 59

Joint test:

Chi-sq	df	Prob.
469.2334	480	0.6288

Individual components:

Dependent	R-squared	F(48,10)	Prob.	Chi-sq(48)	Prob.
res1*res1	0.707120	0.502993	0.9443	41.72008	0.7265
res2*res2	0.888099	1.653439	0.1981	52.39787	0.3073
res3*res3	0.700475	0.487211	0.9521	41.32800	0.7410
res4*res4	0.706401	0.501252	0.9451	41.67769	0.7281
res2*res1	0.853128	1.210132	0.3945	50.33453	0.3812
res3*res1	0.764625	0.676780	0.8229	45.11290	0.5919
res3*res2	0.821686	0.960015	0.5756	48.47945	0.4535
res4*res1	0.806419	0.867877	0.6545	47.57875	0.4900
res4*res2	0.659166	0.402912	0.9826	38.89077	0.8230
res4*res3	0.643958	0.376803	0.9884	37.99351	0.8492

The p-values are greater than 0.05 significance level thus we fail to reject the null hypothesis. This shows that there are no ARCH effects among the variables under study. This implies that there is some conditional homoscedasticity among the variables, that is to say, the error term between the variables is the same across all the values of the variables.

4.9.3 : Normality Test:

H_o: No normality of residuals

H_a: Normality is present

Table 4.17 : Normality Test Results

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 07/17/22 Time: 21:57
Sample: 2017M01 2022M06
Included observations: 59

Component	Skewness	Chi-sq	df	Prob.*
1	-4.802444	226.7908	1	0.0000
2	-0.041668	0.017073	1	0.8960
3	0.156560	0.241024	1	0.6235
4	1.650741	26.79530	1	0.0000
Joint		253.8442	4	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	32.72467	2172.075	1	0.0000
2	4.110979	3.034256	1	0.0815
3	3.079778	0.015646	1	0.9005
4	12.28404	211.8922	1	0.0000
Joint		2387.017	4	0.0000

Component	Jarque-Bera	df	Prob.
1	2398.866	2	0.0000
2	3.051329	2	0.2175
3	0.256671	2	0.8796
4	238.6875	2	0.0000
Joint	2640.861	8	0.0000

*Approximate p-values do not account for coefficient estimation

The Jarque-Bera Normality test implies that the residuals are normally distributed since the p-value is less than 5% significance level.

4.9.4 : Stability Test**:**

Once we have estimated the VAR model, there are a number of tests that can be used to help us determine if we have a good model. Model stability plays an important role in assessing whether the algorithm produces an optimal model. This was done in R software.

Stability Test Results

Roots of the characteristic polynomial:

```
0.9173 0.9173 0.8992 0.8992 0.8616 0.8616 0.8479 0.8479 0.8384 0.8384 0.8217
0.8217 0.819 0.7585 0.7585 0.7547 0.7547 0.7541 0.7541 0.68 0.678 0.678
0.5512 0.2375
```

All the values above lie inside a unit circle therefore the fitted VAR model is stable.

4.10 : Impulse Response Function

The VAR model passed all the diagnostic checks and consequently it is statistically fit to forecast the data and make reasonable conclusions based on the results. Before forecasting the values of the variables, it is necessary to determine the effect of a shock on one variable to another. After assessing the correlation between the variables, it is rather customary to ask yourself when, for how long and how much does the shock to say, prices of super petrol impact inflation rates?

Impulse response functions help to answer this question as it primarily describes the response over time of each variable in the VAR model to a one-time shock in any variable while all others remain constant

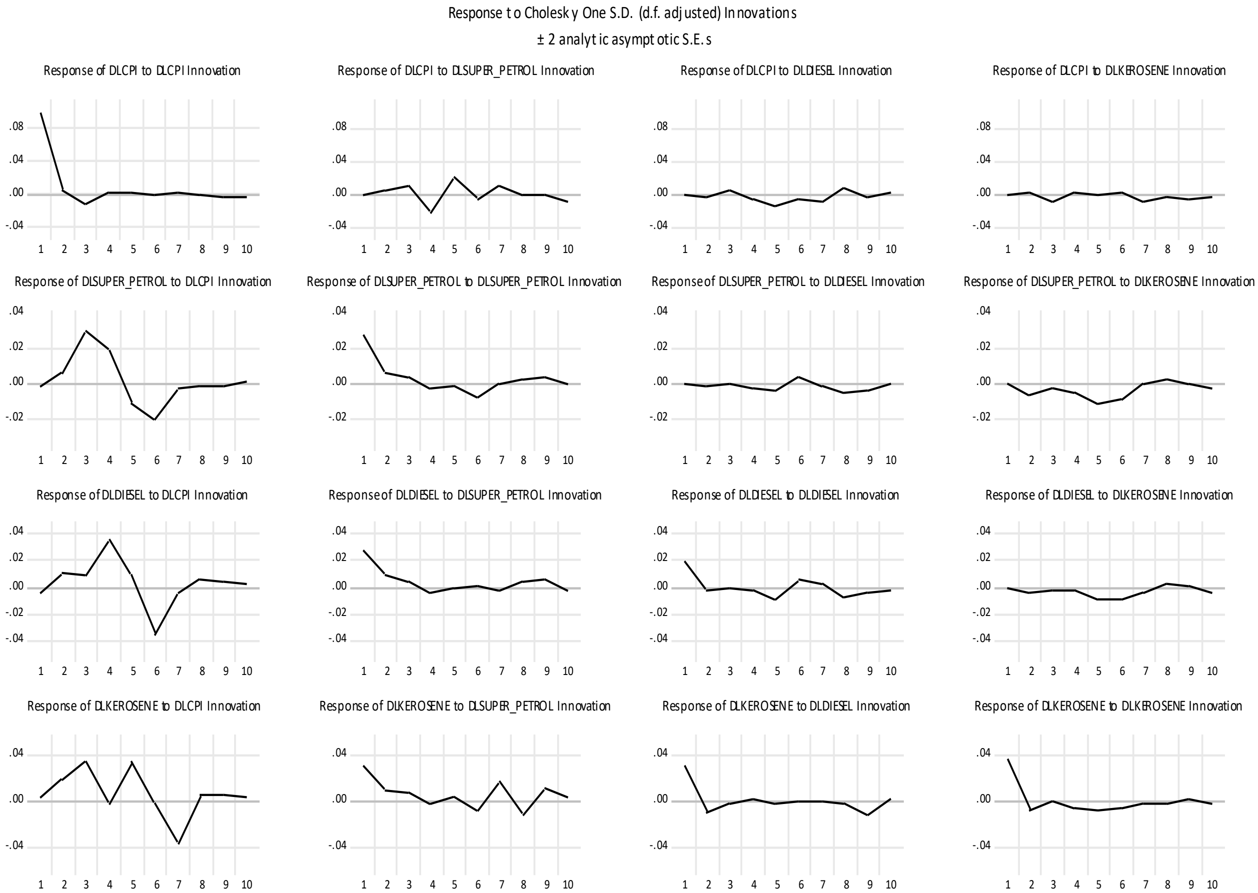
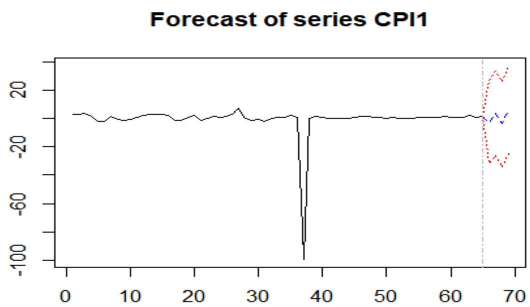


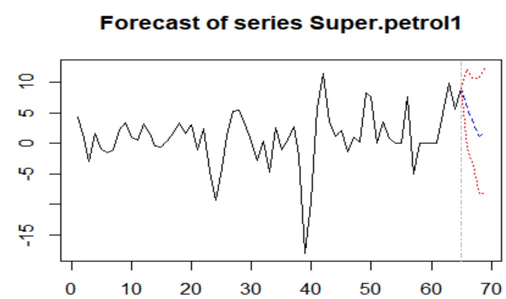
Figure 4.4: Impulse Response Functions

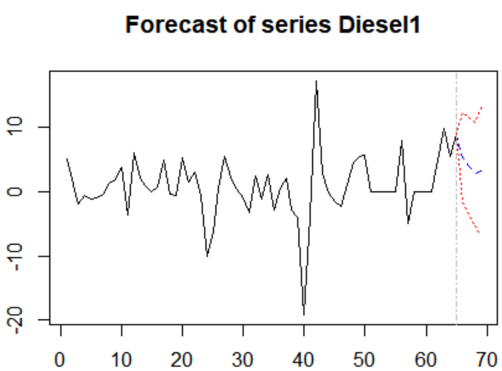
From figure above, super petrol shocks immediately cause a positive response to CPI in the short run in that an increase in its prices will ultimately cause a significant response on CPI. However, this stabilizes after some time. Diesel price shocks also cause a positive and negative response to CPI during the first two months then it later stabilizes. Kerosene prices shocks standard deviation immediately cause a negative response to CPI in the short run and after a while, it causes a positive response and shifts during the period causing negative and positive responses but later. The impact of prices of super petrol, diesel and kerosene on CPI is the same as they all cause a positive response on CPI but eventually stabilizes with time.

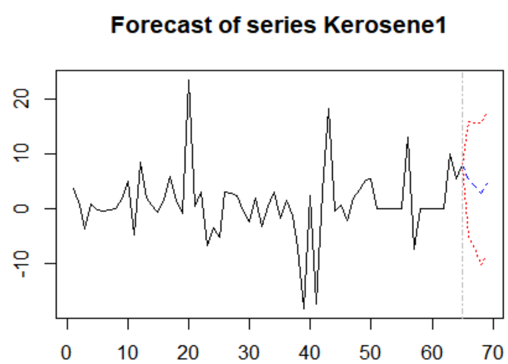
4.11 : Forecasting

Forecasting was one of the specific objectives of the study. The VAR model has proven to be useful for describing the dynamic behavior of time series data and thus it can be used in forecasting. Forecasts from VAR models are flexible since they can be made conditional on the potential future paths of specified variables in the model.









From the curves displayed above, it is rather evident that for the next 12 months, there is expected increase in the value of CPI, though its units are fluctuating over time. Forecasts of super petrol on the other hand demonstrate a decrease in prices. However, the prices are decreasing at a relatively slower rate. Diesel prices falls of and rises again after some time at a much faster rate.

The forecasted curve of kerosene series shows a slight decrease in the prices but it immediately increases again thus displaying an upsurge in its prices. (See appendix 2)

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

This chapter presents a continuation of the analysis part as it entails the summary of findings, limitations of the study and possible recommendations. The purpose of this study is to fill the research gap between January 2017 and June 2022 since hardly any explorations have been done on the same

5.1 Findings of the research

- There is a strong positive relationship between super petrol and inflation which is significant in the short run. This result is in line with the theoretical expectation and it follows the cost push theory of inflation. This can be ascribed to the idea that petrol drives the prices of most product and services in the country and therefore an increase in its prices would have significant knock-on-effect on inflation.

  The productive sector relies on super petrol to fuel their power generators and as a consequence, production costs increases and this in turn increases the prices of goods and services. Granger-causality results as well as the impulse response function graph further ascertains that a shock in super petrol will bring about an immediate positive response on inflation.

- It was observed that diesel prices have a negative short run effect on inflation but all the same, this is not significant. Practically, diesel is a dominantly consumed fuel and therefore a major channel through which changes in oil price directly affects an economy (Siddhartha Pradeep). It has a large impact on the economy as it is the main transportation fuel in road transport and thus it is expected that an increase in diesel prices would cause a symbolic change in CPI in the short run. However, this appeared not to be the case during the study period.

The findings of diesel relationship with inflation are similar to that of Kulathunga et.al (2013), where they propose that kerosene is a common adulterant utilized for mixing with diesel hence leading to degradation of engine performances and fugitive emissions. The consecutive rise in diesel prices may have prompted users to turn to kerosene which is much cheaper. producers of goods and services in the economy also tend to use less diesel compared to petrol.

However, these findings are not in congruence with that of EA Odera (2015), who found a significant definite relationship between diesel and inflation.

The Granger Causality results also allude that there is no short run causality between diesel and inflation, insinuating that the two variables do not determine changes in the behavior of the other.

- The insignificance of kerosene on inflation in the short run could be justified by the certitude that kerosene only accounts for about a third of the total production in Kenya as it is mostly used at homes for lighting and heating purposes. This assertion is corroborated with literature since according to KNBS, kerosene in households has not gone past the 20,000 metric tonnes mark since August 2018 after the introduction of the adulteration levy by EPRA during the same period.

  (OR Masera, BD Saatkamp, 2000) There is a high demand for and consumption of firewood, through a massive fuel switch towards kerosene and therefore this illustrates that there is a low demand and supply of kerosene in the country.

  The impulse response function graph further suggest that kerosene has a slight positive shock on inflation which stabilizes over time.

In summary, treating inflation as the dependent variable, super petrol is the only variable with a significant positive relationship with inflation in the short run. This can be backed up by the supposition that during the period of the study, other factors like increase in money supply, exchange rates and interest rates may have had a greater impact on inflation and thus causing the effect of oil prices to be insignificant.

5.2 Recommendations

Based on the research findings and conclusion, the study recommends the following on macroeconomic policy;

i) EPRA should come up with an effective and accurate model that will productively assess the changes in prices of petroleum products and thus stabilize them.

ii) The government should implement and promote switching to alternative sources of energy in the country to reduce dependence on oil.

iii) The government should open access and remove mandates and subsidies on oil prices so as to respond adequately to oil price volatility.

iv) The controls taken to reduce the effect of oil prices on CPI can be enforced on the other factors that contribute to inflation. This will further help in curbing the cost push inflation as policymakers will be able to alleviate the effects of such factors on CPI upon noticing a significant relationship

Limitation of the study

Inflation is affected by other factors which this study does not account for , for instance exchange rates.

Suggestions for further research

Future researches done on the same topic should incorporate more time periods in their study so as to get a comprehensible insight on the impact of changes in prices of petroleum products on inflation. The findings can be improved if the study is adjusted to cover a period of time as long as possible compared to the 5-year period that was used in this study, thus ensuring higher levels of validity in your research.

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APPENDICES

Appendix 1: Original data of CPI and prices of petroleum products

Month	CPI	Super petrol	Diesel	Kerosene
Jan-17	176.93	96.01	84.23	63.44
Feb-17	179.98	100.27	89.26	67.19
Mar-17	182.98	101.05	90.44	67.96
Apr-17	186.24	98.04	88.62	64.38
May-17	187.64	99.59	88.05	65.28
Jun-17	185.39	98.73	86.89	65.05
Jul-17	183.6	97.16	85.94	64.56
Aug-17	184.72	96.08	85.56	64.42
Sep-17	183.66	98.3	86.86	64.36
Oct-17	182.5	101.67	88.71	66.18
Nov-17	182.08	102.7	92.41	71.23
Dec-17	183.05	103.14	88.74	66.37
Jan-18	185.47	106.3	94.82	74.78
Feb-18	188	107.92	96.85	76.75
Mar-18	190.62	107.46	97.86	77.45
Apr-18	193.18	106.83	97.86	76.72
May-18	195.05	107.17	98.64	78.22
Jun-18	193.31	108.81	103.6	84.1
Jul-18	191.59	112.2	103.25	85.73
Aug-18	192.18	113.73	102.74	84.95
Sep-18	194.14	116.79	108.12	108.41
Oct-18	192.6	115.73	109.72	108.84
Nov-18	192.25	118.11	112.83	111.83
Dec-18	193.51	113.54	112.28	105.22
Jan-19	194.18	104.21	102.24	101.7
Feb-19	195.78	100.09	95.96	96.5
Mar-19	198.91	101.35	96.61	99.46
Apr-19	205.9	106.6	102.13	102.22
May-19	205.77	112.03	104.37	104.62
Jun-19	204.34	115.1	104.76	104.28
Jul-19	203.61	115.39	103.88	101.97
Aug-19	201.78	112.53	100.6	103.95
Sep-19	201.57	112.81	103.04	100.64
Oct-19	202.12	108.05	101.96	101.08

Nov-19	202.94	110.59	104.61	104.06
Dec-19	204.77	109.5	101.78	102.31
Jan-20	205.4	110.2	102.32	103.95
Feb-20	106.33	112.87	104.45	102.69
Mar-20	106.53	110.87	101.65	95.46
Apr-20	107.92	92.87	97.56	77.28
May-20	108.6	83.33	78.37	79.77
Jun-20	108.27	89.1	74.57	62.46
Jul-20	108.35	100.48	91.87	65.45
Aug-20	108.57	103.95	94.63	83.65
Sep-20	108.57	105.15	94.51	83.15
Oct-20	109.6	107.27	92.91	83.73
Nov-20	110.78	105.85	90.7	81.63
Dec-20	111.87	106.82	91.82	83.56
Jan-21	112.58	106.99	96.4	87.12
Feb-21	113.47	115.18	101.91	92.44
Mar-21	113.81	122.81	107.66	97.85
Apr-21	114.75	122.81	107.66	97.85
May-21	114.98	126.37	107.66	97.85
Jun-21	115.11	127.14	107.66	97.85
Jul-21	115.34	127.14	107.66	97.85
Aug-21	115.71	127.14	107.66	97.85
Sep-21	116.08	134.72	115.6	110.82
Oct-21	116.67	129.72	110.6	103.54
Nov-21	117.2	129.72	110.6	103.54
Dec-21	118.27	129.72	110.6	103.54
Jan-22	118.642	129.72	110.6	103.54
Feb-22	119.129	129.72	110.6	103.54
Mar-22	120.139	134.72	115.6	103.54
Apr-22	122.17	144.62	125.5	113.44
May-22	123.12	150.12	131	118.94
Jun-22	124.22	159.12	140	127

Appendix 2: Forecasted values of CPI and prices petroleum products

```
## $CPI1
##             fcst     lower    upper       CI
##  [1,] -2.6873600 -32.17807 26.80335 29.49071
##  [2,]  3.6420798 -26.00554 33.28970 29.64762
##  [3,] -3.5637332 -33.64581 26.51834 30.08207
##  [4,]  6.1253058 -24.64209 36.89270 30.76740
##  [5,]  0.4009869 -31.34995 32.15192 31.75093
##  [6,]  2.4915848 -29.36034 34.34351 31.85193
##  [7,] -2.0565767 -34.36648 30.25333 32.30991
##  [8,] -2.7889994 -35.17156 29.59356 32.38256
##  [9,] -4.2218022 -36.69416 28.25055 32.47235
## [10,] -3.8232979 -36.36437 28.71777 32.54107
## [11,] -1.8624800 -34.52823 30.80327 32.66575
## [12,] -0.6516260 -33.74032 32.43707 33.08869
##
## $Super.petrol1
##            fcst       lower    upper        CI
##  [1,] 5.5584219  -0.9834055 12.10025  6.541827
##  [2,] 3.3877062  -3.7526117 10.52802  7.140318
##  [3,] 1.1710276  -8.3712579 10.71331  9.542286
##  [4,] 2.1231722  -8.1254762 12.37182 10.248648
##  [5,] 1.8463779  -9.0399777 12.73273 10.886356
##  [6,] 3.1662017  -8.6171338 14.94954 11.783335
##  [7,] 2.9087575  -8.8943939 14.71191 11.803151
##  [8,] 2.8990046  -8.9552507 14.75326 11.854255
##  [9,] 1.8897867 -10.0287482 13.80832 11.918535
## [10,] 1.2670524 -10.6804974 13.21460 11.947550
## [11,] 0.5526133 -11.4521902 12.55742 12.004803
## [12,] 0.6247231 -11.4335728 12.68302 12.058296
##
## $Diesel1
##            fcst      lower    upper        CI
##  [1,] 5.4060171  -1.612843 12.42488  7.018860
##  [2,] 3.9869915  -3.690020 11.66400  7.677012
##  [3,] 2.7812156  -5.253481 10.81591  8.034697
##  [4,] 3.1346496  -6.866835 13.13613 10.001484
##  [5,] 3.5031474  -7.066068 14.07236 10.569215
##  [6,] 3.5434576  -8.715947 15.80286 12.259405
##  [7,] 3.1787589  -9.144811 15.50233 12.323570
##  [8,] 3.2789962  -9.182012 15.74000 12.461008
##  [9,] 2.0106853 -10.550885 14.57226 12.561570
## [10,] 1.9087533 -10.693923 14.51143 12.602676
## [11,] 0.9631769 -11.738982 13.66534 12.702159
## [12,] 1.1473896 -11.636381 13.93116 12.783771
##
## $Kerosene1
##            fcst      lower    upper       CI
```

```
##  [1,] 5.3524699  -5.058204 15.76314 10.41067
##  [2,] 4.2442492  -7.114783 15.60328 11.35903
##  [3,] 2.7415051 -10.097295 15.58030 12.83880
##  [4,] 4.4897714  -8.542522 17.52206 13.03229
##  [5,] 1.5325569 -12.596212 15.66133 14.12877
##  [6,] 5.2394342  -9.079532 19.55840 14.31897
##  [7,] 2.8397472 -12.642253 18.32175 15.48200
##  [8,] 3.6547748 -11.951609 19.26116 15.60638
##  [9,] 3.0474533 -12.785061 18.87997 15.83251
## [10,] 1.1848849 -14.710257 17.08003 15.89514
## [11,] 1.3225909 -14.648217 17.29340 15.97081
## [12,] 0.1425762 -15.923484 16.20864 16.06606
```