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Supply Shocks and Fuel Price Fluctuations in Kenya

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ABSTRACT: Governments are on the edge to make the economy more conducive to both investors and its citizens in oil and petroleum businesses. Some challenges are however still hindering the provision of fuel at stable prices. The study's independent variables were: inflation rate shocks, world oil price shocks, pipeline cost shocks, and currency exchange rate shocks. The population of the study was identified to be Kenya's economy while the unit of analysis was the Energy and Petroleum Regulatory Authority (EPRA). The study adopted a time series data design for 8 years from 2015 to 2022 in monthly intervals to make 96 observations. Stata version 13 was used to assist in data analysis and presentation after the data went through a diagnostic test. VECM model was employed to analyse the relationship between the variables after which conclusions and recommendations were made. The study established that the rate of inflation rate shocks, world oil price shocks, and pipeline cost shocks have a significant effect on fuel price fluctuation while currency exchange rate shocks have a significant negative effect on fuel price fluctuation. The study recommends that the government should establish tax subsidies to control the impact of tax proportions on fuel prices and also that the government of Kenya needs to enter into a contractual agreement with the Organization of Petroleum Exporting Countries (OPEC) nations on oil deals for a steady supply of crude oil at a favourable price.

KEYWORDS: Inflation rate shocks, world oil price shocks, pipeline cost shocks, currency exchange rate shock

1. INTRODUCTION

The economic impact of oil price changes is a topic that has received a lot of attention recently, especially because oil prices have continued to rise globally. High oil prices had a direct impact on businesses, households, and governments, prompting the Kenyan government, through the ERC, to implement a capping guide for retail prices of diesel, gasoline, and kerosene in December 2010, citing the need to protect consumers from petroleum industry cartels. The capping guidance aimed to moderate gasoline prices and relieve consumer burdens, as high oil prices can contribute to greater transportation and production expenses and thus higher pricing for goods and services. Furthermore, governments are frequently pressed to address the economic effects of increased oil costs, which can contribute to inflationary pressures and impede economic progress.

Since the 1970s oil price shocks, there has been an extant literature identifying the relationship between oil prices and various macroeconomic variables such as real GDP growth rates, inflation, employment, exchange rates, current account and trade balances, and so on, using various econometric methodologies and oil price specifications (Kilian & Peersman, 2009). According to Cashin (2014), the macroeconomic consequences of a negative oil supply shock differ substantially between countries that import oil and export energy. In terms of actual output, following an oil supply shock, the Eurozone and the United States, two large energy-importing countries, experienced a long-term drop in economic activity, whereas China and Japan enjoyed a positive impact.

Recent developments in the crude oil market, such as the wide volatility of oil prices and rising demand for oil from emerging economies such as China and India, have led to an acknowledgment that the impact of oil price shocks may vary depending on their origin or source. In contrast to the implicit assumption in typical macroeconomic models that unexpected oil price increases were solely attributable to exogenous supply shocks in the crude oil market, researchers such as Hamilton (2009) and Kilian (2009) have demonstrated that oil prices can also be driven by demand. Thus, oil price shocks have been dissected by Kilian (2009) into shocks generated by demand (aggregate demand and oil-specific demand shocks) and supply (oil supply shocks), and their effects on macroeconomic variables were anticipated to differ. The analysis of stock markets for only developed oil-

importing and oil-exporting countries and emerging economies had been expanded to the impact of oil price shocks based on their origin (Wand et al., 2013).

In many developing countries like Kenya, governments have tried to manage oil product prices through measures like subsidies and promoting renewable energy sources. Budget pressures led to brief reform efforts, particularly after the 2008 price collapse, when rising fuel prices caught governments unprepared due to inadequate action on fuel subsidies. Global price increases prompted countries to implement strategies like wage rate hikes, oil reserve releases, tax cuts, and subsidies to mitigate the impact. However, the transmission of fuel price changes into domestic economies varies due to differing regulatory systems and authorities across countries (Vatansever, 2020). Various interconnected factors have also influenced the availability, costs, and prices of oil and petroleum products in many countries. Escalating prices strain the financial positions of oil companies in some states, leading to procurement difficulties and fuel shortages. Power shortages further exacerbated the situation in certain countries, driving up the demand for diesel and subsequently raising its price (Krane, 2017).

The repercussions of high fuel costs extend to reduced economic growth as businesses struggle to maintain profitability and consumers experience diminished disposable income. This can exacerbate income inequality and hinder poverty reduction efforts within the country. Additionally, escalated transportation expenses can have broader effects on various sectors, including tourism, as the increased travel costs discourage both domestic and international visitors.

Fuel price fluctuations, influenced by factors such as transportation costs, inflation, global oil prices, and currency exchange rates, have substantial implications for consumers and the economy. These fluctuations, intricately linked to all facets of production, contribute to inflationary pressures, posing a challenge for policymakers and industry stakeholders (Fogarassy, 2018).

The oil demand, according to Huntington (2019), is a critical element in influencing fuel costs. Fuel costs typically increase as worldwide demand for oil increases, such as during periods of economic development or increased industrial activity. A fall in demand, on the other hand, could result in cheaper pricing. Furthermore, the supply of oil, which was influenced by factors such as production levels and OPEC (Organization of Petroleum Exporting Countries) choices, had a substantial impact on fuel price changes. For example, if OPEC decides to raise oil output, it would result in a market surplus and as a result, lower fuel costs. On the other hand, if production levels went down or oil supply was disrupted due to geopolitical tensions or natural disasters, gasoline prices could go up owing to scarcity. As a result, when assessing fuel price variations, both demand and supply aspects must be considered.

According to Aloui (2015), industrial activity and economic growth were the main factors influencing oil demand. Oil demand went up as more energy was needed for manufacturing, transportation, and other economic activities during times of economic expansion and increased industrial production. On the other hand, as economic activity slowed down during economic downturns or recessions, oil demand typically declined. Ghalayini (2018) posited that the Organization of the Petroleum Exporting Countries (OPEC) decisions as well as the levels of production in major oil-producing nations had an impact on the supply of oil (OPEC). As a significant player in the world oil market, OPEC had the power to significantly affect the supply of oil and by extension, fuel prices through its decisions regarding production quotas.

Oil supply disruptions could have a big impact on fuel costs. Supply interruptions can occur as a result of political conflicts, wars, natural disasters, or unanticipated events in key oil-producing regions. Such disruptions might lower the overall oil supply, causing price increases owing to shortage. Political crises and wars in key oil-producing regions have the potential to impede oil production and delivery. Armed conflicts would cause the closure of oil fields, refineries, and pipelines, resulting in a significant decrease in oil supplies (Perez, 2019). Natural calamities like hurricanes and earthquakes had a big influence on oil production and transportation infrastructure. Severe storms, for example, might destroy offshore drilling platforms or interrupt shipping routes, aggravating the supply deficit and driving up fuel costs (Wang & Krupnick, 2018). According to Espinasa and Vera (2018), unplanned outages at oil facilities would result from equipment failures, technical challenges, and accidents, lowering oil production and disrupting supply. These unanticipated outages would have serious economic ramifications, such as higher oil prices and major disruptions in the global energy sector. To reduce the risk of equipment breakdowns and technical challenges, oil firms must emphasize regular maintenance and invest in innovative technology. Economic sanctions or trade embargoes imposed on nations that produce oil may restrict their capacity to export oil, which would disrupt the supply. The availability and prices of oil on a global scale would be significantly impacted by these disruptions. Additionally, they could deteriorate diplomatic ties between the parties involved and lead to geopolitical tensions (Nikkinen, 2017).

Recognizing fuel price instability as a significant issue impacting the economy, this study underscores the necessity for a comprehensive understanding of the intricate relationships between supply shocks and fuel price fluctuations. To the energy-exporting states, oil accounts provide a significant share of total export and material contribution to the national budget, thereby oil market prices became volatile. The volatility is because oil products supply and demand have a low-price elasticity, thus

resulting in wide price fluctuations and therefore there was a direct effect on countries' economies through oil exportation as there was dependence on export revenues, (Yoshino & Alekhina, 2016). This study determines the effect of supply shocks on fuel price fluctuations by focusing on four independent variables: pipeline transportation cost shocks, inflation rate shocks, world oil price shocks, and currency exchange rate shocks.

2. EMPIRICAL LITERATURE REVIEW

2.1 Pipeline Transportation Cost Shocks and Fuel Price Fluctuation

Various researchers have attempted to describe the effect of pipeline transportation cost shocks on fuel price fluctuation. For instance, Hernandez (2015) compares the cost of transportation truck transport to the pipeline cost of transport of wastewater sludge. The estimation for transportation cost per gallon of biodiesel was observed to be deviating in the costs based on the distance traveled and quantity shipped.

In another study from China, Wang (2015) researched on optimization of the oil transportation network by considering pipeline and shipping transport. Based on the least value of transportation cost and general risk, a model multi-objective programming was employed to optimize the transportation networks for crude oil importation, and a genetic algorithm and ant colony algorithm were established to help solve the problem. The final result showed that VLCC (a very large crude carrier) was better off over long-distance geographical sea transportation, while pipeline transportation was more secure than sea transport.

From the Nigerian perspective, Mohammed (2014) investigates the implications of price changes on oil and petroleum products distribution in Gwagwalada for the period of 12 years (2000-2012). Using primary data, the study establishes that there was a statistically significant impact of price changes on oil product distribution in Gwagwalada influenced by pipeline transportation cost shocks.

Further, from a Kenyan perspective, Mungai (2016) establishes that road infrastructure has an impact on the distribution of oil whereas 13% stated they did not think the road infrastructure did have an impact on the distribution of oil. Tanui (2019) also finds that there is a positive influence of infrastructure and ICT on the transport and distribution of oil and petroleum products at Kenya Pipeline Company.

2.2 Inflation Rate Shocks and Fuel Price Fluctuations

Inflation is a quantitative measure of the rate at which an economy's average price level of a basket of selected goods and services rises over time. Inflation, which is frequently stated as a percentage, denotes a decline in the purchasing power of a country's currency (Ozdemir & Akgul, 2015). Inflation can be damaging to both individuals and corporations. When prices rise, customers may find themselves unable to buy necessary products and services, resulting in a drop in their overall standard of living. Furthermore, as the cost of production rises, businesses may struggle to sustain profitability, potentially leading to layoffs or closures. As a result, it is critical for governments and central banks to closely monitor and regulate inflation to guarantee economic stability and citizens' well-being. Inflation can harm many sectors of an economy. It can, for example, diminish the value of savings and investments, making it more difficult for individuals to prepare for the future. High inflation rates can cause financial market uncertainty and instability, deterring investment and stifling economic progress (Ibrahim & Maram, 2019).

The Central Bank of the Republic of Turkey confirms that oil price unpredictability is a risk factor for Turkey, which follows an inflation-targeting regime (CBRT Monetary Policy Report, 2012). Furthermore, it has been suggested that the appearance of oil supply concerns could lead to an increase in energy prices, exacerbating the anticipation of inflation and finally necessitating action to avert it.

From the context of the United States, Huntington (1998) studies the relationship between oil prices and inflation from a different angle and discovers that consumer prices appear to respond asymptotically to energy price increases and drops. Kahn and Hampton (1990) also analyze whether increases in oil prices have an impact on the US economy and discover that, in the short run, higher oil prices can raise inflation and lower real GDP.

According to LeBlanc and Chinn (2004), increases in oil prices are anticipated to have only a minor impact on inflation in the United States, Japan, and Europe. However, increased oil prices might lead to lower consumption and investment in the long run as businesses and consumers confront higher costs. Furthermore, LeBlanc and Chinn (2004) argue that the impact of rising oil prices on inflation may differ among countries due to disparities in energy reliance and economic architecture.

Cunado and Perez de Gracia (2005) demonstrate that oil prices have persistent effects on inflation and asymmetric effects on GNP in European countries when a nonlinear relationship is taken into account. Medina and Soto (2007) also demonstrate, using a dynamic stochastic general equilibrium that a 13% increase in the real price of oil leads to a 0.4% increase in inflation in the Chilean economy. Farzanegan and Markwardt (2009) use a VAR to examine the dynamic link between oil price shocks and the main macroeconomic indicators in Iran and establish that negative oil price shocks significantly raise inflation.

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From a Kenyan perspective, KNBS (2023) posits that inflation is driven mostly by price increases in transportation, food and non-alcoholic beverages and housing, water, electricity, gas, and also other fuels. The impact of oil price fluctuations on the Consumer Price Index is significant, implying that changes in oil prices have a direct impact on the cost of products and services for Kenyan consumers. The rise in oil prices can exacerbate inflation, particularly in importing countries such as Kenya (Musyoka et al., 2012).

2.3 World Oil Price Shocks and Fuel Price Fluctuations

In an attempt to uncover the relationship between world oil price shocks and fuel price fluctuations, various studies have been undertaken. In the context of the United States, Chadi (2017) determines the dynamic impact of world crude prices on shocks in pump fuel prices using a monthly data set posting pump fuel prices for 162 countries over a period ranging between 2000 and 2014. The result shows that pump gasoline prices have a positive effect on price shocks of crude oil but vary depending on the level of income as per the economic status of the state. Also, the study revealed that a decline in world oil prices causes a smaller impact on pump prices of gasoline than increases in world oil prices.

In another vein, Maqbool (2019) assessed the volatility of oil spillovers in the leading oil trading states on returns from crude oil. By employing multivariate GARCH models with the inclusion of BEKK-GARCH, ABEKK-GARCH, DCC-GARCH, and ADCC-GARCH techniques of estimation using daily gathered data starting from September 2009 up to the end of August 2018 for specified three states exporting oil (Saudi Arabia, Iraq, and the United Arab Emirates) and four nations oil importers (China, India, Japan, and South Korea) for spot crude petroleum, the study establishes that oil exporting and importing states had a different significance level of correlation to oil but oil shock influences are more experienced by oil exporting states.

From Angola, Hassel (2015) determined the relationship between oil prices and domestic satisfaction development in the oil industry by focusing on the domestic variables. The notable external variable in the study was oil prices that reflected the worldwide demand and supply of oil and its profitability in the industry. It was determined that a reduction in oil prices had a greater impact on the macroeconomic environment that prohibits Angola from developing satisfaction in the petroleum industry.

A study by Keramidas (2016) argues that most Sub-Saharan and North African states are found to be at high risk as a result of high exposure and are easily affected. Macroeconomic impacts resulting from a fall in price by 60% were analyzed using the GEM-E3 model that represented world oil market fluctuation over the period previous two years. The study result showed that a drop-in oil prices had a different impact on export oil nations.

To explain the Kenyan perspective, a study by Mwangi (2015) was conducted to determine the effect of world oil prices on stock prices in the Kenyan economy by use of monthly data collected from 2003 to 2015. By deployment of Johansen's multivariate co-integration test and VECM-vector error correction model, it was determined that oil prices have a significant effect on oil prices in the short run and a negative impact on oil prices in the long run. Ang'u (2019) also in the same landscape evaluated the effect of world oil prices and their influence on the energy sector by employing correlation matrices for the information gathered between 1970 and 2016 from both global and local levels and established that there is a relationship between higher petroleum prices and civil war with the intervention of foreign states and low oil prices with domestic civil wars.

2.4 Currency Exchange Rates Shocks and Fuel Prices Fluctuations

Various studies have been undertaken to determine the effect of currency exchange rate shocks on fuel price fluctuations. For instance, a study done in Colombia and Ghana by Klutsem (2021) to determine the rate by which the US dollar exchange rates affect the prices of gasoline pump prices in Colombia and Ghana between 2012 and 2019 using a non-linear auto-regressive distributed lag model establishes that exchange rate has significance because of fluctuations of premium gasoline pump prices in both Ghana and Colombia.

In the context of Nigeria and South Africa, Daggash (2017) evaluates the impact of the rate of exchange on stock prices using the VAR Granger causality and establishes short-run rate fluctuation of naira to be the major significant factor influencing performance oil stock prices in Nigeria. In Johannesburg South Africa, results showed that short-run differences influence prices in rates of exchange.

In the Nigerian context, Musibau (2015) having investigated the relationship existing between the rate of exchange and oil prices in Nigeria for the period between 1997 and 2012 using time series establishes responses to both negative and positive shocks in oil prices. With positive price shocks rate of exchange was depreciating whereas with negative shocks in oil price exchange rates were appreciating.

From the Kenyan context, Omagwa (2017) on retail oil pricing and price regulations in the Kenyan oil sector establishes a lesser explanatory power on monthly oil prices during the time after the introduction of price controls compared to that time before the introduction of the oil products. The results further revealed that the is a positive correlation existing between monthly pump prices of diesel and super products for the period before price control whereas after price control the was a negative correlation for kerosene.

Also, Maina (2015) on the factors causing crude oil price shocks in Kenya using secondary data obtained from 1991 to 2014 for analysis using Structural VAR methodology establishes that there is bi-directional causality between inflation and real rate of exchange in Kenya and also unidirectional causality starting with inflation to GDP, then from GDP finally to real rate of exchange.

3. RESEARCH METHODOLOGY

To investigate the pathways through which supply shocks cause fuel price fluctuations in Kenya, a descriptive research design was employed. This design involved a quantitative collection method to provide a comprehensive understanding of the phenomenon. The quantitative aspect of the research involved analyzing historical data on fuel prices, supply shocks, and other relevant economic indicators.

The Energy and Petroleum Regulatory Authority (EPRA) database was used to gather daily information on fuel prices, import quantities, and consumption trends. A total of 96 observations were made during 8 years, from 2015 to 2022, using a time series data design. The study adopted a census approach since petroleum prices were under regulation by one state regulatory authority.

Secondary data was used to collect information from the respondents under study through published financial statements. Various authorities such as the Central Bank of Kenya (CBK) and the KPC, who have helped the EPRA when necessary, by providing more information and advice, were engaged in this study for more clarification and data collection. Since the CBK is the custodian of information on interest rates that operate inside the Kenyan economy, it was crucial for this study. KPC would offer details on oil pipeline transit from Kenya's coast to storage locations spread across the nation.

The secondary data collected was checked for completeness to ensure that relevant data for each of the years were available. The data obtained were recorded in an Excel sheet and later uploaded into the Stata version13 software for analysis. Diagnostic tests were done through a test of assumption for residual autocorrelation, multicollinearity, stationarity, differencing, test for co-integration, Granger causality test, and impulse response test. The effect of pipeline transportation cost shocks on fuel price fluctuations in Kenya, the effect of inflation rate shocks on fuel price fluctuations in Kenya, the effect of world oil price shocks on fuel price fluctuations in Kenya, and the effect of currency exchange rate shocks on fuel price fluctuations in Kenya were determined using time series data analysis.

The results obtained were presented on graphs, tables, and figures from the software to show the significance of a variable on fuel prices in Kenya. The tables provided other information that was relevant for further interpretation and to aid in conclusion and recommendations. VECM model was fitted in the form of:

$Y_{t-1}= \beta_0+ \beta_1X_{1t-1}+ \beta_2X_{2t-1}+ \beta_3X_{3t-1}+ \beta_3X_{3t-1}+ \beta_4x_{4t-1}+ e$……figure 4.1

Where: **Y** = Fuel price fluctuation; β_0 = Constant; β_1 = Change in fuel price per unit with change in Transport cost shocks holding other variables constant; X_1 = Transport cost shocks; β_2 = Change in fuel price per unit with change in the rate of inflation holding other variables constant; X_2 = Rate of inflation rate shocks; β_3 = Change in fuel price per unit with change world oil prices shocks holding other variables constant; X_3 = World oil prices shocks; β_4 = Change in fuel price per unit with change in exchange rates shocks holding other variables constant; X_4 = Exchange rates shocks; t-1 = The optimal lag; **e** = Error term. The analyzed data was presented using tables and figures.

4. FINDINGS AND DISCUSSION

4.1 Descriptive Analysis

This section summarizes and describes the main features of a dataset, such as its central tendency, variability, and distribution. Table 1 below, presents results of descriptive statistics findings:

Table 1: Descriptive Table

Variable	Obs	Mean	Std. Dev.	Min	Max
Fuel price fluctuation	96	0.82736	0.77713	0.03565	4.43916
Inflation rate	96	1.24573	0.81509	0.10000	3.90000
Transport cost	96	0.08321	0.02134	0.02172	0.20340
World oil price	96	0.01243	0.03795	0.00010	0.20340
Exchange rate	96	0.10915	0.29674	0.00021	0.99190

The analysis provided that the observation for all variables was 96 months the period of January 2015 to December 2022. The table above shows the statistics used to describe the characteristics of all variables. It showed that the fuel price fluctuation had

a mean ratio of 0.82736, a standard deviation of 0.77713 with a minimum ratio of 0.0.03565, and a maximum change of 4.43916. The inflation rate had a mean ratio change of 1.24573, an error of 0.81509 with a minimum inflation rate change of 0.10000, and a maximum change ratio of 3.90000. Also, it was found that the cost of transport had a mean ratio of 0.08321, std. deviation of 0.02134 minimum change ratio of 0.02172 and maximum change ratio of 0.20340. Further, the result revealed that world oil prices had a mean ratio of 0.01243, error ratio of 0.03795, minimum change ratio of 0.00010, and maximum change ratio of 0.20340. Lastly exchange rate had a mean ratio of 0.10915 standard deviation of .029674 with a minimum ratio change of 0.00021 and a maximum of 0.99190.

4.2 Test for stationarity

This was done by generating trend plots for the four independent variables to test how random variables would change over a period. It was found that the variables were non-stationary since there were no spikes from the trend plots. Stationarity could also be tested by carrying out unit root tests in the time series data. Non-stationary data refers to data that have variances, means, and covariance that would change over time as evidenced in Figure 1 below.

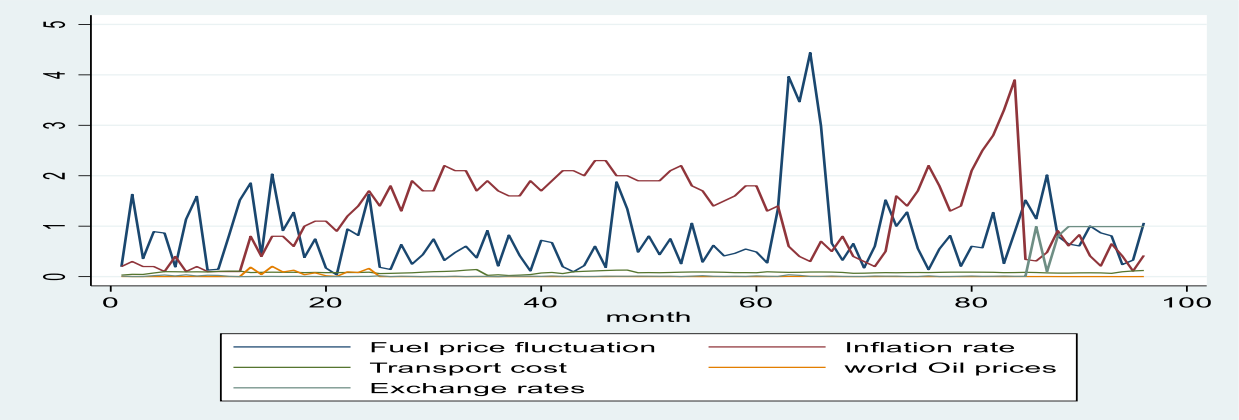

Figure 1: Trend Plot

After first differencing through dicky fuller test data was found to be stationarity as shown in figure 2 below. The trend plot generated for each variable showed deterministic trends for the four variables. This was of importance since statistical tests, analytical tools and models generated from the differenced data set could be relied on as the economic variables data set had stabilized mean variance between the factors under study.

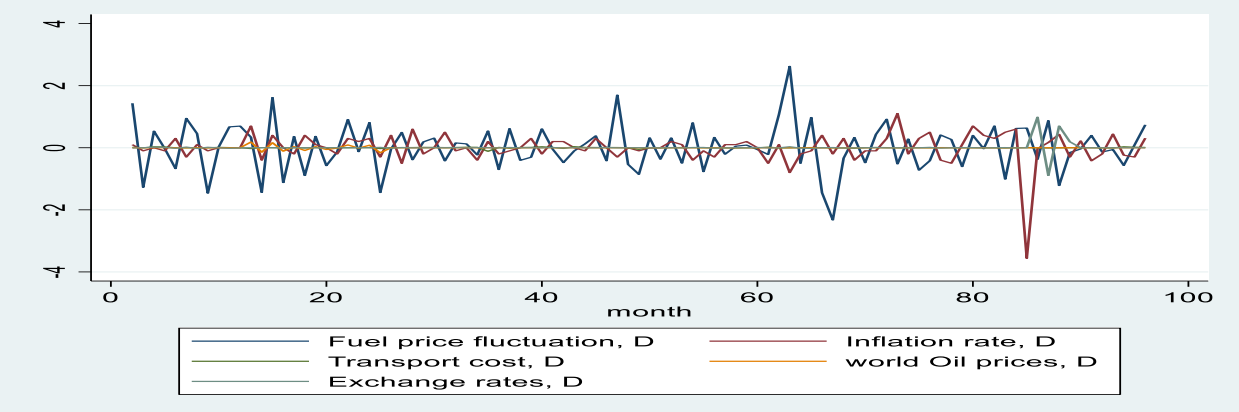

Figure 2: Trend Plot

4.3 Optimal Lag Selection

The figure below presented the results of the number of lags to be included in the model as provided by the various information criteria techniques. From the table, it was concluded that the optimal lag was lag 1 since it had a higher number of steric and also a low number of AIC values (-7.42566). The implication of lag selection was to reduce the residual correlation between the study variables.

TABLE 2: Lag Selection

Selection-order criteria
Sample: 5 - 96 Number of obs = 92

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	299.149			1.1e-09	-6.39453	-6.33922	-6.25748	
1	371.58	144.86*	25	0.000	4.1e-10*	-7.42566*	-7.09377*	-6.60334*
2	385.186	27.21	25	0.345	5.3e-10	-7.17795	-6.56947	-5.67036
3	397.023	23.674	25	0.538	7.1e-10	-6.8918	-6.00674	4.69894

4.4 Co-integration Test

Time series data were assumed to be co-integrated if they co-move towards long-run equilibrium. The determination of stationary of the series was the first step before co-integration then Johansen methodology was adopted to test for co-integration thereafter appropriate model could be fitted for this case, the VEC model was considered since there was co-integration. As per the table below, it was confirmed that there was co-integration as it was evidenced by the lack of a steric at lag zero.

Table 3: Co-integration test

Trend: constant Number of obs = 94
Sample: 3 - 96 Lags = 1

rank	parms	LL	eigenvalue	SBIC	HQIC	AIC
0	5	82.921389		-1.52262	-1.603258	-1.657902
1	14	183.94093	0.88344	-3.236976	-3.462762	-3.615764
2	21	266.09992	0.82589	-4.646709	-4.985388	-5.214892
3	26	312.80449	0.62980	-5.398759	-5.818075	-6.102223
4	29	349.27929	0.53978	-6.029819*	-6.497518*	-6.814453
5	30	381.00843	0.49089	-6.656575	-7.140401	-7.468264

4.5 Fitting VECM model

4.5.1 Model fitness statistic

The tables below provided an analysis of whether the model was safe to be used for reliance and prediction purposes. It provided an overall p-value of 0.0000 ($p<0.05$) which implied the model was statistically significant for economic shocks and variables analysis as shown in Table 4:

Table 4: Model fitness

Cointegrating equations

Equation	Parms	chi2	P>chi2
ce1	4	736.4356	0.0000

4.5.2 Model Coefficients

Table 5 provides the fuel prices estimator for the various independent variables shocks which were considered to be the major fuel fluctuation determinants in the Kenyan economy. The world oil prices and transportation shocks were found to be having a positive effect while inflation rates and exchange rates shocks were found to be hurting fuel prices where a unit increase or decrease of an independent value of the variable would lead to an increase or decrease in value of the dependent variable. The findings are shown in the table 5:

Table 2: VECM Coefficients

Johansen normalization restriction imposed						
beta	Coef.	Std. Err.	z	P>|z|	[95%Conf.	Interval]
_ce1						
Fuel price fluctuation						
D1.	1					
Inflation rate						
D1.	5.536788	.4926804	11.24	0.000	4.571152	6.502424
Transport cost						
D1.	-1.315837	13.93195	-0.09	0.925	-28.62195	25.99028
World oil prices						
D1.	-20.32437	5.978216	-3.40	0.001	-32.04146	-8.607284
Exchange rates						
D1.	36.86426	1.501153	24.56	0.000	33.92205	39.80646
cons	-.4595614					

The individual variables provided a significance level about fuel price fluctuation i.e., inflation rate shocks (0.0000), world oil price shocks (0.0.001), and exchange rate shocks (0.000) which were statistically significant ($p < 0.05$)., Transportation cost shocks (0.925) had been statistically significant since the impacts are not hour-to-hour or monthly like the other variables but the effect is transmitted to fuel price changes as shown in Table 5. Since data established that the equation p-value was 0.000 ($p<0.05$) therefore it was concluded that the variable shocks were statistically significant in fuel price fluctuations as provided by Table 5.
It was also determined that there was a constant fuel price fluctuation ratio of 0.4595614 (45%) affecting fuel prices whenever the prices of other economies like transportation cost, inflation rates, world oil prices, and foreign exchange rates were kept constant. The cost was to be incurred irrespective of any shocks experienced from the other variables. The VECM model was fitted as shown below.

$$Y_{t-1} = -0.459614 - 1.315837X_1t_1 + 5.536788X_{2t1} - 20.32437X_{3t1} + 36.86426X_{4t1}$$

4.6 Test for normal distribution

The result provided that the time series data set for the variables was normally distributed across the period i.e., p-value 0.0000 ($p<0.05$) as shown in Table 6. Therefore, any economic decision made from data and the result were reliable for economic importance.

Table 6: Test for Normal Distribution

vecnorm

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D2_fuelpricefluctuation	5.678	2	0.05848
D2_inflationrate	1581.839	2	0.00000
D2_transportcost	1527.477	2	0.00000
D2_worldoilprices	433.460	2	0.00000
D2_exchangerates	47.252	2	0.00000
ALL	3595.707	10	0.00000

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
D2_fuelpricefluctuation	-.26502	1.077	1	0.29937
D2_inflationrate	-2.8758	126.811	1	0.00000
D2_transportcost	-3.1442	151.589	1	0.00000
D2_worldoilprices	0.94382	13.659	1	0.00022
D2_exchangerates	1.0386	16.540	1	0.00005
ALL	309.676	5	0.00000	

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
D2_fuelpricefluctuation	4.0956	4.601	1	0.03195
D2_inflationrate	22.483	1455.028	1	0.00000
D2_transportcost	21.945	1375.888	1	0.00000
D2_worldoilprices	13.465	419.801	1	0.00000
D2_exchangerates	5.8306	30.713	1	0.00000
ALL	3286.031	5	0.00000	

4.7 Test for Residual autocorrelation

The analysis carried out provided that there was no residual correlation between the variables. This was established since the p-values (p>0.05) as provided in the table 7:

Table 7: Test for residual autocorrelation.

veclmar

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	26.5746	25	0.37746
2	30.8097	25	0.19540

5. SUMMARY, DISCUSSION AND RECOMMENDATIONS

5.1 Summary of Findings

It was determined that there was a constant ratio of 0.4595614 (46%) having a major impact on fuel prices whenever the prices of other economic factors like pipeline cost, taxes, world oil prices, and foreign exchange rates remained unchanged. The cost was to be incurred irrespective of any favorable or adverse change experienced from the other variables.

5.1.1 Pipeline Transport Cost Shocks and Fuel Price Fluctuation

The study revealed a slight correlation between transportation disruptions and fuel price fluctuations in response to economic conditions, with a positive relationship between pipeline costs and fuel price increases. It further established that transportation costs charged on transportation of fuel products should be catered for when determining the sales value of the fuel products as it's a major contributing factor to fuel price instability. The transport charges were found to be ever-varying in response to the economic condition. Fuel price fluctuation was found to have a negative relationship with pipeline cost such a change in a unit change of pipeline cost leads to a change in fuel price by a ratio of 1.32.

5.1.2 Inflation Rate Shocks and Fuel Price Fluctuation

The study established that there were constant price changes in goods and services across the world. This affected the prices of both exports and imports therefore it recorded that crude oil being one of the imported items such shocks like inflation contributed to higher charges recorded on imported oil. The study found that the inflation rate had a negative relationship with fuel prices such that a unit change in the inflation rate would result in a change in the fuel price by a ratio of 5.54 depending on the upward or downward movement of rates.

5.1.3 World Oil Prices Shocks and Fuel Price Fluctuation

It was established that there was a positive relationship between world oil prices and fuel price fluctuation. The study determined that a unit change in the value of world oil prices would impact the fuel prices value by a ratio of 20.32 depending on the increase or decrease of world oil prices. This was reached since fuel products were refined mostly from imported crude oil, therefore, the alteration of world oil prices cut across into the domestic economy with the impact felt on fuel charges after refinery. On that note, when the prices went up, the domestic fuel prices went up and inversely felt when the prices decreased as observed from this study.

5.1.4 Exchange rates shocks and fuel price fluctuations

This study determined that exchange rate shocks had a negative relationship with fuel price fluctuations in the Kenyan economy. This was established in the sense that a unit change of exchange rates would result in a change in fuel prices by the ratio of 36.86 which could be either favorable or adverse depending on the change of the rates. Kenyan currency was measured against US dollars which was found to be more preferred unit of trade in the international market. The study therefore found out that, when the value of US currency appreciated against Kenya shillings, the crude oil prices would go up thus, importation becomes very expensive as the value of crude would increase as well. In the case that the value of a dollar depreciates, importation becomes less expensive and this would be reflected in low fuel prices in the domestic market.

5.2 Discussion of Findings

5.2.1 Pipeline Transport Cost Shocks and Fuel Price Fluctuation

The study found that transportation shocks had a slight impact on fuel price fluctuation in response to the economic condition. This was observed since transport changes were not felt daily or monthly unlike the other factors that had daily or average monthly effects. Fuel price fluctuation was found to have a negative relationship with transportation shocks such that whenever there is a

unit change in pipeline cost, fuel price would change by 1.315837 to shocks experienced from the transport sector, which is a positive increment in fuel prices.

The change was a result that the dealers needed to maximize their trading profits with changes in economic factors. This study agrees with Dagmar (2010) who also established that pipeline cost i.e., transport cost, maintenance, and oil spillage a major factors of fuel price instability

5.2.2 Inflation Rate Shocks and Fuel Price Fluctuation

It was established that the inflation rate was a major factor affecting the cost of domestic and imported goods and services in the economy. Crude oil being one of the imported goods was found to be highly affected by changes in exchange rate thus affecting the prices of goods and services including fuel prices. Inflation rate shocks will affect all oil products more in an open economy like Kenya where prices of commodities are determined by demand and supply. The study determined that inflation rate shocks had a negative relationship with fuel prices such that a percentage change in the rate of inflation would lead to a 5.536788 change in the value of the fuel price either upward or downwards depending on the inflation rate.

The study agrees with Mwangi (2013) that inflation rate shocks affect food items and disagrees with Jaewoo (2022) who had established that an increase in inflation goes hand in hand with the increase in wages and salaries and also that the oil price shocks' effect on inflation expectations is consistent with the effects on wage rates.

5.2.3 World Oil Prices Shocks and Fuel Price Fluctuation

The study established that there is a positive relationship between world oil price shocks and fuel price fluctuation in the Kenyan economy. It was determined that a unit change in the world oil prices would lead to a 20.32437 change in the fuel prices in Kenya depending on either an increase or a decrease in world oil prices. Because fuel and petroleum products were refined mostly from imported crude oil this was affected by economic shocks that were found to be having a greater impact on the fuel prices.

The study establishes that when the world oil prices went up, the domestic fuel prices were up as well since the purchase price was higher it was also realized inversely when the world oil prices decreased, the domestic fuel prices decreased as well and this was felt as a trend in the oil and fuel products industry. This study's findings therefore disagree with Ntoiti (2016) who had established that petroleum prices do not move in the same direction as world oil prices.

5.2.4 Exchange Rates Shocks and Fuel Price Fluctuations

The study established that in a real economic condition, currency exchange rate shocks had a negative relationship with fuel price fluctuations in Kenya. This was evident in the sense that a unit percentage change of exchange rates would lead to a ratio change of 36.86426 in fuel prices which could be either favorable or adverse depending on the decrease or increase in foreign currency rates.

The Kenyan shilling was measured against US dollars which was more preferable mode of exchange in the international market. It was established that when the value of US currency appreciated against shillings, the crude oil prices went up thereby making importation of crude oil very expensive. In the case that the value of a dollar depreciated, importation became cheaper for Kenya and this was reflected in fuel prices in the domestic market as well. The study findings agree with Omagwa, (2017) who also established that exchange rates have a major influence on fuel price fluctuation in the Kenyan economy.

5.4 Recommendations

The study recommends that the government should establish tax subsidies to control the impact of tax proportions on fuel prices and also that the government of Kenya needs to enter into a contractual agreement with OPEC nations on oil deals for a steady supply of crude oil at a favorable price. Such contracts would forward contracts that lock the future oil purchase prices.

Further research is recommended on the resilience of global supply chains in the face of supply shocks in the energy sector and also the analysis of how disruptions in the supply of fuel impact different industries and economies worldwide. Further research can also be conducted to evaluate the macroeconomic consequences of supply shocks and fuel price fluctuations and how that impacts inflation, employment, and overall economic stability, considering both short-term and long-term effects.

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