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The Nexus between the changes in Oil output in the United Arab Emirates and the Volatility of Petrol Prices in Kenya

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Abstract

The volatility of petroleum prices in Kenya compels an analysis into the fundamental causes of the recurrent fluctuations. Movements in oil production from important importing sources play a role in determining petroleum prices in importing countries. However, no clear model exists that explains how these changes in oil output affect the price of gasoline in Kenya. Additionally, there is no framework that explains how long these shocks last in the Kenyan market. The present situation has opened the door for a research project designed to comprehend the effects of changes in oil output from the United Arab Emirates on gasoline costs in Kenya. The two main goals of the study are to first determine how monthly oil output changes in the UAE affect Kenyan gasoline prices between 2017 and 2020, and then to determine how long the effects of oil production shocks from the UAE last in the Kenyan gasoline market. In order to determine whether monthly variations in oil output from the United Arab Emirates have an impact on Kenya's gasoline prices and whether oil production shocks from the United Arab Emirates have lasting effects on the Kenyan gasoline market, the research is set up as a hypothesis-driven investigation. The study made use of concepts from the Real Business Cycle theory and the conventional notion of market self-adjustments. The analysis relied on secondary data which were collected from various sources including OPEC, EIA, Central Bank of Kenya and World Bank's websites. The data were processed using the R programming language. After analysis, a model was constructed, enabling the derivation of conclusions and subsequent recommendations.
Keywords: Volatility, Petroleum prices, Oil production, Importing sources, Oil output, Monthly oil output changes, Oil production shocks, Real Business Cycle theory, Market self-adjustments

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1. Introduction

Energy has a critical role in fostering global economic growth, promoting sustainable development, and enhancing various facets of life, including businesses and households. Energy is one of the ten most important resources included in the Sustainable Development Goals (SDGs), and its importance is based on both its affordability and availability (Fan & Hao, 2020). Access to renewable energy sources that may be purchased without imposing excessive financial constraints on consumers is essential for achieving sustainable development (Economou, 2016). Both developed and developing countries struggle with the need for a consistent, reliable energy supply that is necessary for this pursuit of economic progress. In order to accelerate their growth trajectory, the latter in particular look for energy sources that are efficient, dependable, and economically viable.

While having access to energy is essential for economic development, its effective use is also essential for sustainability over time. In addition to protecting the environment, efficient energy use makes it easier to develop long-term, strategic energy policies. Governments can address economic needs using this strategy while also taking into account social and ecological factors (Matemilola et al., 2019). Affordability is strongly impacted by the interaction of demand and supply, with energy supply instability becoming a major worldwide concern. The instability of the crude oil supply and, by extension, the stability of the economy are seriously threatened by issues like energy security and price volatility.

Crude oil, being an important source of energy, has a significant impact on global consumption. It acts as a foundation for several types of energy, such as geothermal and hydroelectric power (Mohaddes & Pesaran, 2015). Due to the uneven distribution of crude oil production worldwide, geopolitical factors are a natural fit. The Middle East, particularly Kuwait, Iraq, Saudi Arabia, Iran, and the United Arab Emirates, has sizable crude oil deposits, whereas Qatar, Russia, and Saudi Arabia are the world leaders in liquefied petroleum. Data on global crude oil output from 2010 to 2020 show an overall increased trend while also highlighting variations and regional differences.

The United Arab Emirates (UAE) is the sixth-largest crude oil exporter globally making it a significant participant in the world's oil output. The oil production trajectory for the UAE from 2010 to 2020 shows expansion, which is impacted by global trends and regulatory initiatives (Mohaddes & Pesaran, 2015). Despite fluctuation, the UAE experienced periods of declining oil production, which were frequently related to international agreements like OPEC's production caps. The COVID-19 epidemic that characterized the turbulent year of 2020 underscored clearly the extent to which susceptible oil production is to outside shocks. The UAE is a large oil exporter, particularly to regions like Asia and Africa, which strengthens its influence over international energy markets.

Kenya's energy system, which depends on fuels like electricity, gasoline, and wood fuel, demonstrates the crucial role that energy plays in the country's economy. The nation's growing industries and population have increased energy consumption, underscoring the importance of energy security. However, concerns with regulation and subpar goods have plagued Kenya's petroleum sector (Takase et al., 2021). The oil industry was liberalized in an effort to resolve these problems and guarantee quality. In order to stop market manipulation, the Energy Regulatory Commission (ERC) assumed responsibility for regulating petroleum prices.

Kenyan imports of crude oil from the UAE offer a clear picture of the difficulties in energy supply and pricing. Because of The Kenyan economy's sensitivity to changes in oil prices, managing potential economic shocks requires a predictive framework. The nation's rising energy needs, which are driven by different economic factors, are reflected in the increase in petroleum imports in terms of both quantity and value.

Statement of the Problem

Petroleum output in the United Arab Emirates (UAE) saw considerable changes between January 2010 and December 2020, according to data from the United States Energy Information Administration (EIA). There were variations in Kenya's imports of petroleum fuels as well. The volume of imports went up by 17% between 2015 and 2019, and prices increased by 41% during the same period. Kenya's purchases from the UAE were significant, indicating an increase in the country's petroleum imports. Previous research has examined how variables like currency rates and global crude oil prices affect Kenyan retail oil prices (Economou, 2016; Fan & Hao, 2020). These analyses, however, depended on retail pricing that were not determined by the market and ignored the impact of supply fluctuations on oil product prices (Caldara et al., 2016). Given the gaps in the literature, this study aims to determine how fluctuations in UAE oil production, Kenya's primary oil importer, affect the prices of landed oil products on the country's petroleum market. The study aimed at answering the following research questions.

How have the changes in the monthly oil output in the UAE affected the monthly petrol prices in Kenya during the period 2017 to 2020?

How have the previous month's petrol prices affected the subsequent month's petrol prices in Kenya during the period 2017 to 2020?

How have the monthly exchange rates affected petrol prices in Kenya during the period from 2017 to 2020?

2. Methodology

This study's research design is quantitative in nature and relies on secondary data collection and analysis. The study used secondary data on landed petrol prices from the KNBS and EPRA and on monthly oil output in the UAE from OPEC and EIA websites. The exchange rate, inflation rate, and lending rate are obtained from the websites of Central Bank of Kenya and World Bank. The study dealt with lags in the effect of changes in oil output in the United Arab Emirates on petrol prices in Kenya by incorporating historical data on global oil prices and petrol prices in Kenya. This is useful in identifying the optimal time lag between changes in global oil prices and changes in petrol prices in Kenya. Time series data on oil production and petroleum prices was analyzed using R software at a VAR lag of 1. In order to accept or reject the null and alternative hypotheses, the study's main objective was to ascertain how dependent and independent variables interacted by calculating coefficients from the data. A thorough understanding of the results and the creation of a succinct conclusion were made possible by the visual presentation of the insights that resulted in tables and charts.

3. Theoretical Framework

This logical relationship between petroleum prices and the independent variables is derived from the theory of demand and supply which states that an increase in supply reduces the prices of products while a reduction in production leads to a rise in the price of the product. The current study depends on the Real Business Cycle theory which holds that prices serve to clear markets. Adjustments in prices would, therefore, be required to absorb changes in production. Therefore, the market demand function and market supply function is given in the following form.

$$Q = QD(P) \quad \ldots \quad (1)$$

$$Q = QS(P) \quad \ldots \quad (2)$$

To find the equilibrium price — that is, a price that clears the market, quantity demanded is equated to quantity supplied (equation 3).

$$QD(P) = QS(P) \quad \ldots \quad (3)$$

In standard cases QS is an increasing function and QD is a decreasing function, implying that there is at most one equilibrium price.

To estimate the impact of changes in oil output in the UAE on petrol prices in Kenya addressing OPEC production quotas and world oil production, this study supposes the petrol prices are a function of the oil prices of the previous month, oil output and exchange rate, then;

$$P_t = f(P_{(t-1)}, S, X) \quad \ldots \quad (4)$$

Where;

P_t – Prices at the time of t

$P_{(t-1)}$ – Lag 1 values of oil prices

S – Oil output

X – Exchange rate

There is no advice currently available on the nature and shape of the functional relationship between these variables in theory. Hence, a multiplicative form of equation (4) can be written as;

$$P_t = (P_{(t-1)}^{b1}, S^{b2}, X^{b3}) \quad \ldots \quad (5)$$

Error Correction Model

Pump prices can have tendency to rise relative to crude oil output in the long-run, which would be of greatest relevance to policymakers and other stakeholders. Thus, in the case that these variables (pump prices (Pt), and oil output (S)) have stochastic trend and have long-run link, they should be co-integrated. Co-integrating Pt and S results in the following ECM representation:

$$\Delta Pt = \alpha 0 + \beta 1 \Delta S - \Pi \hat{u}t\text{-}1 + \omega \quad \ldots \quad (6)$$

Where:

ΔP – change in petrol prices in Kenya at time t

ΔS – change in oil output in the UAE at time t

ût-1 – error correction term at time t-1, and measures the adjustment rate towards the equilibrium in the relationship between petrol prices and oil output in the long-run

α, β, and Π – coefficients to be estimated

ω – error term

This will have an advantage of including data for both the short-term and the long-term. The short-run effect (β1) in this model estimates the immediate influence that a change in S will have on a change in Pt. The adjustment effect, or feedback effect (π), measure the disequilibrium addressed, or how much any disequilibrium from the prior period has an impact on any adjustment in S.

$$\hat{u}t\text{-}1 = \ln(Pt/Pt\text{-}1) - \hat{\beta}2\ln(St/St\text{-}1) \quad \ldots \quad (7)$$

Where:

Pt and Pt-1 – petrol prices in Kenya at time t and t-1, respectively

St and St-1 – oil output in the UAE at time t and t-1, respectively

ln – natural logarithm

From equation 7 ˆβ2 is also the long-run reaction. In Equation (6), everything is stationary. The spurious regression problem arises when non-stationary data is used. However, equation (6) fully satisfies our set of expectations for the performance of the traditional linear regression model and OLS. Studies show that causation must flow in at least one direction in a co-integration system of two series expressed by an ECM representation (Granger 1969, 1988). To determine the impact of crude oil prices on petroleum prices, the current study considered the time-series properties of the data and then discern between short-run and long-run reactions as a result. The rate of adjustment toward long-term values can then be explicitly measured.

ECM has been used to estimate the petroleum demand at three different stages. The first thing is to study if the time series data has a unit root. That is whether it is of first-difference, second-difference, or n-difference stationarity series. The process is said to be stationary if the mean and variance of a time series process remain stable throughout time and the autocorrelation between the process' values at two times depends only on the space between the time points rather than the actual length of time. The long-run elasticities can be estimated if the variables being studied are co-integrated, or if they have a long-term relationship from the co-integrated regression in the second stage based on the first stage's results. In the third stage, the results from the first and second phases can be used to decide whether or not to estimate the short-run elasticities and the rate at which the ECM is adjusting.

It is imperative to recognize short-term fluctuations when dealing with cointegrated variables. However, the fluctuations are transitory and will ultimately return to the long-run equilibrium relationship. Therefore, to analyze the impact of changes in oil output in the United Arab Emirates on petrol prices in Kenya, it is necessary to use vector error correction models (VECM) that can capture the short-term dynamics while still accounting for the long-run relationship. VECM can help identify the direction and extent of the impact of changes in oil output on petrol prices in Kenya, and can also be used to forecast future petrol prices based on expected changes in oil output.

Model Specification

The study will evaluate the effect of the explanatory variables on dependent variable by transforming equation 5 into a log-linear specification. The advantages of log-linearlized equation 8 is that it provide precise estimations of elasticities, easy to use and fulfil the homoscedasticity requirements that underlie the use of least squares estimates. Our deterministic equation, equation 5, can then be represented in its log-linear form as;

y= b_1 〖ln X〗_1+b_2 〖ln X〗_2+b_3 ln X_3+ ω…………………………..… (8)

y – Prices at time t

X1 – Lag 1 values of oil prices

X2 – Oil output

X3 – Exchange rate

b_1 − b_3 It is the change that each independent variable introduces in Y.

ε-is the disturbance term that is a representative of variables not captured in the model but do determine oil prices in Kenya.

4. Empirical Results and Discussion

The current study analyzed four variables: Landed Petrol Prices, Lag-1 Landed Petrol Prices, Oil Output, and Exchange Rate. The dependent variable was Landed Petrol Prices while independent variables were Lag-1 Landed Petrol Prices, Oil Output, and Exchange Rate. The period under analysis was March 2017 to December 2020, which make a total of 46 data points.

Descriptive Statistics

Table 1: Descriptive Statistics

The sample size for the analyzed variables was 46 months. Mean values for Landed Petrol Prices, Lag-1 Landed Petrol prices, Oil output, and Exchange Rate were 3.81, 3.81, 1.18, and 4.64 respectively, with respective standard deviations of 0.22, 0.22, 0.09, and 0.03. Medians closely reflected the means. Trimmed means were 3.84, 3.84, 1.18, and 4.63. Median absolute deviations for the variables were 0.16, 0.15, 0.11, and 0.02. Variable ranges were Landed Petrol Prices (1.05), Lag-1 Landed Petrol prices (1.05), Oil output (0.43), and Exchange Rate (0.10). Skewness ranged from -1.69 to 1.57, while kurtosis ranged from 0.22 to 3.17. The variable's skewness and kurtosis aligned with normal distribution criteria (skewness -2 to +2; kurtosis -10 to +10 per Mishra et al. (2019) and Kline (2016).

Graphical Data Analysis

Trend analysis was carried out to provide information on the general movement of prices of petrol, oil output and oil production in UAE over the period under analysis as well as provide useful information for the unit root test model. The following figure 1, 2, and 3 shows the trends for landed petrol prices, oil output, and exchange rate respectively.

Figure 1: Trends in Landed Petrol Prices (March 2017 – December 2020)

Figure 2: Trends in Oil Output in UAE (March 2017 – December 2020)

Figure 3: Trends in Exchange Rate (March 2017 – December 2020)

Figure 1 show that the landed petrol prices remained averagely constant until 2020 when it sharply fell. However, it has shown a rising trend. Oil output showed a fairly consistent rising trend from 2017 to 2020 when it also sharply fell. It has also show a rising trend. A similar trend was observed for exchange rate. However, exchange rate is rising exponentially especially after the covid-19 pandemic.

Correlation Analysis

Table 2: Correlation Matrix

The correlation results shows that there is a very strong positive correlation between landed petrol prices and lag-1 of itself (r = 0.86). There exist a strong negative correlation between landed petrol prices and exchange rate (r = -0.74). There is also a strong negative correlation between lag-1 landed petrol prices and exchange rate (r = -0.71). A strong positive correlation also exist between oil output and lag-1 landed petrol prices (r = 0.64). Finally, there is a moderate positive correlation between oil output and landed petrol prices (r = 0.48) and a moderate negative correlation between oil output and exchange rate (r = -0.51).

Empirical Results

This section discusses the empirical findings of this study based on four important issues: testing the stationarity of the data, identifying co-integration in the model under study, fitting the error correction model, and conducting regression analysis.

Unit Root Test

Augmented Dickey Fuller (ADF) was used to test for unit root and the stationarity feature of the data. The results for the unit root test are presented in the table 4 below.

Table 3: ADF Unit Root Test Results

The results above shows that the variables under analysis are stationary since the p-values of all the variables are greater than 0.05. Therefore, null hypothesis was rejected and alternative hypothesis accepted that all the variables are stationary at log levels.

Lag Selection

Optimal lag selection is the process of choosing the appropriate number of lags to be included in a time series model. The main reason for selecting a lag is to balance between having enough lags to capture the relevant dynamics of the data and avoiding overfitting the model with too many lags. The table below show four different criteria for evaluating different number of lags: AIC (Akaike Information Criterion), HQ (Hannan-Quinn Criterion), SC (Schwarz Criterion), and FPE (Final Prediction Error). Each of these criteria measures the trade-off between model complexity and goodness of fit. Lower values indicate a better model fit.

Table 4: Lag Order Selection

The table 5 above shows the results of lag selection using the different criteria earlier mentioned. The criteria suggest different numbers of lags (1, 2, 3, 4, or 5), where each criterion has a minimum value for a specific number of lags. To determine the optimal number of lags, the criteria were combined and lag order with minimum AIC and FPE values chosen. It should also be within one standard error of the minimum SC and HQ values. Even as all four criteria suggest a different number of lags, the minimum AIC and FPE values are achieved at lag 1. Therefore, the optimal number of lags for the current study's data was concluded to be lag 1.

Co-integration

After analyzing the unit root test which is important in determining the order of integration, the next step is to find out if the variables are co-integrated. The current study used Johansen-Procedure to test for co-integration. Co-integration allows for the analysis of the long-term relationship of data and enables accurate forecast of future values by considering the long-term relationship between the variables under analysis. The co-integration test for the current study are shown in the table below.

Table 5: Results of Co-integration Test

The Johansen procedure test verifies co-integration between variables. Trace statistic test with linear trend was used which indicated one co-integrating relationship among four eigenvalues. The test's significance level of 1% rejects null hypothesis for r=0, that there is no co-integrating vectors. However, it cannot reject for r=1 (one co-integrating vector) at 5% level of significance. Eigenvectors denote normalized co-integration. Eigenvalues suggest three co-integrating vectors. Loading matrix includes Landed_Petrol_Prices, Lag1_Landed_Petrol_Prices, Oil_Output_Millions, and Exchange_Rate. Results support long-term relationship between variables, suitable for a co-integrated vector autoregression (VAR) model.

Error Correction Model

The error correction model for the current study is reported in Table 7 below. The model was in a log-linear form hence the estimated coefficients of the results are interpreted as partial elasticities.

Table 6: Error Correction Model Coefficients

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The elasticity of landed petrol prices with respect to lag-1 landed petrol prices is inelastic as evidenced by its coefficient being statistically insignificant at all levels of significance. On the other hand, the elasticity of landed petrol prices in relation to exchange rate is elastic meaning that a 1 percent increase in exchange rate would result in a 2.65 percent decrease in in the landed petrol price. The coefficient is statistically significant at 0.01. The elasticity of landed petrol prices with respect to oil output is also elastic. A 1 percent increase in oil output would result in 0.39 percent decrease in landed petrol prices. This relationship is statistically significant at 0.05. The lag (residuals, 1) shows the coefficient of the ECM term. The results shows that about 1.25 percent of the errors are corrected each month and this coefficient is statistically significant at all levels of significance.

Regression Analysis

Residuals

The residuals provide information about the error term, which is the difference between the observed value and the predicted value. The results are presented in the table below.

Table 7: Descriptive Statistics of Residuals

The table of residuals shows the minimum and maximum residuals of -14.0351 and 4.5967, respectively. This indicate that some observations have a large difference between the observed and predicted values. The median residual is 0.4939, which means that the model is approximately unbiased. The interquartile range (IQR) was found to be 1.9582 - (-1.2794) = 3.2376. IQR is the difference between the 75th percentile and the 25th percentile giving a measure of the spread of the residuals.

Coefficients

Table 8: Model of Coefficients

The dependent variable was Landed Petrol Prices as the dependent variable while independent variables were: Log Exchange Rate, log Oil Output (Millions), and log Lag1

Landed Petrol Prices. The coefficients table provides the estimates of the regression coefficients, their standard errors, t-values, and p-values. The intercept of the model was 12.6107. This means that the expected value of the dependent variable when all the independent variables are zero is 12.6107. The results show that Exchange Rate had a negative coefficient of -2.4296. This means that an increase in the exchange rate leads to a decrease in landed petrol prices by 242.96%. Oil Output also had a negative coefficient of -0.3962, indicating that an increase in oil output results in a decrease in landed petrol prices by 39.62%. The Lag1 Landed Petrol Prices variable had a positive coefficient of 0.7682. this indicate that an increase in the previous period's landed petrol prices results in an increase in the current period's landed petrol prices by 76.82%. All the variables under analysis had significant p-values. Therefore, all the independent variables were all significant predictors of the dependent variable.

The R-squared value measures the proportion of the total variation in the dependent variable that is explained by the changes in the independent variables. The R-squared value in this case was found to be 0.7853, which means that 78.53% of all the variation in the dependent variable is explained by the changes in the independent variables. The F-statistic measures the overall significance of the model. It was found that the F-statistic is 51.19, with its p-value being 4.382e-14. Since the p-value is less than 0.05, the model is concluded to be significant and provides a better fit.

5. Discussion of the Results

The findings of the current study show that all the independent variables under analysis are significant predictors of the dependent variable, landed petrol prices. The findings have shown that an increase in the exchange rate and oil output lead to a decrease in landed petrol prices. However, an increase in the previous period's landed petrol prices results in an increase in the current period's landed petrol prices. The results of this study are consistent with the existing literature on the determinants of petrol prices. An increase in oil output would result in an excess supply of petroleum products, which would lead to a reduction in petrol prices. An increase in exchange rate, that is, a depreciation in the Kenyan currency results in the decrease in landed petrol prices because a depreciated Kenya Currency would mean an appreciating United Arab Emirates Dirham. An appreciated United Arab Emirates Dirham means reduction in production costs in the UAE which directly results in reduced prices of petrol landing in Kenya from the UAE. Additionally, factors such as increased demand, supply disruptions, and geopolitical tensions could be attributed to increase in landed petrol prices in the previous period (Al-Fattah, 2019). These factors can result in a spillover effect on the petrol prices of the current period.

6. Conclusion

The study provides valuable insights on the factors that influence landed petrol prices in Kenya. The results showed a significant positive relationship between the landed petrol prices of the previous period and of the current period. Therefore, the study concludes that landed petrol prices of the previous period positively influence the current period’s landed petrol prices. Additionally, the result showed a significant negative relationship between oil output and landed petrol prices. The study concludes that oil output in UAE have an inverse relationship with landed petrol prices in Kenya. Finally, the study found a significant negative relationship between exchange rate and landed petrol prices. This study concludes that exchange rate appreciation negatively affect the landed petrol prices in Kenya.

It can therefore be concluded that the current study’s objective which was to determine the effect of nexus in oil output in UAE and the selected macroeconomic variables on landed petrol prices in Kenya has been met. This study had conceptualized that changes in oil output in UAE, lag-1 landed petrol prices, and exchange rate influence the landed petrol prices. The study has proven that oil output in UAE is a significant factor that affect the fluctuation of petrol prices in Kenya. Since oil is an important resource that drive the production of goods and services in any country. Therefore, fluctuation in its price could lead to high inflation and slow economic growth. This is because consumers are left with little income for non-oil products.

Policy Implication

The current study has established that there is a long-term negative relationship between oil output and landed petrol prices in Kenya. Based on the findings, it is imperative for the government of Kenya to focus on promoting oil production and exchange rate stability to mitigate fluctuations in landed petrol prices. Since oil was discovered in Turkana, Kenya should revamp its oil refinery at Changamwe to reduce fluctuation of imported oil. This would increase the stability of petrol prices in Kenya.

Areas of Further Research

The study could be extended by including other factors such as political instability, supply chain disruptions, and changes in demand for petrol in the analysis to provide a more comprehensive understanding of the factors that affect landed petrol prices.

Disclosure Statement

I wish to confirm that there is no known conflict of interest concerning the publication of this document

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Table 1: Descriptive Statistics

Measures	Landed Petrol Prices	Lag-1 Landed Petrol prices	Oil output	Exchange Rate
Vars	1	2	3	4
n	46	46	46	46
Mean	3.81	3.81	1.18	4.64
Sd	0.22	0.21	0.09	0.03
Median	3.86	3.86	1.16	4.63
Trimmed	3.84	3.84	1.18	4.63
Mad	0.16	0.15	0.11	0.02
Minimum	3.00	3.00	0.98	4.61
Maximum	4.05	4.05	1.42	4.71
Range	1.05	1.05	0.43	0.10
Skewness	-1.57	-1.69	0.01	1.04
Kurtosis	2.71	3.17	0.22	0.14

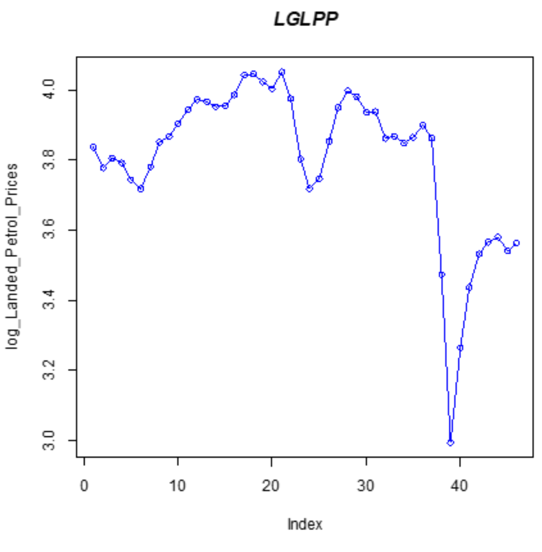

Figure 1: Trends in Landed Petrol Prices (March 2017 – December 2020)

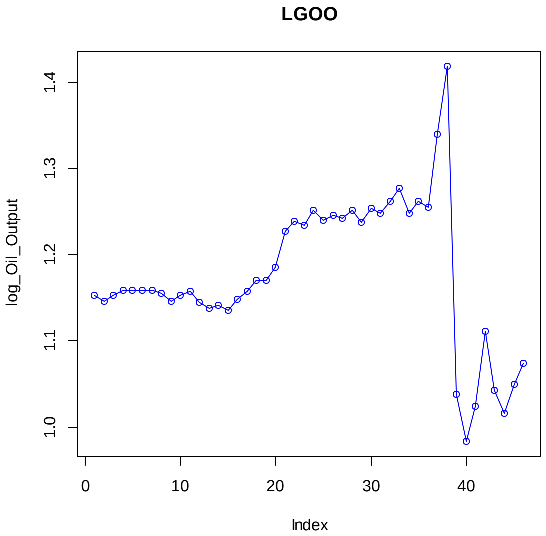

Figure 2: Trends in Oil Output in UAE (March 2017 – December 2020)

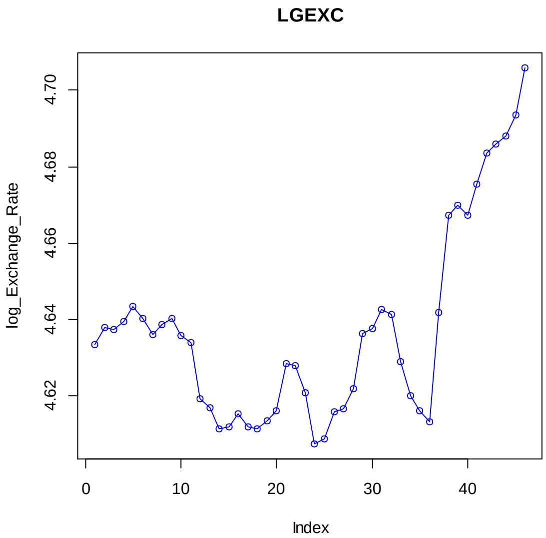

Figure 3: Trends in Exchange Rate (March 2017 – December 2020)

Table 2: Correlation Matrix

	Landed Petrol Prices	Lag1 Landed Petrol Prices	Oil Output	Exchange Rate
Landed Petrol Prices	1.0000000			
Lag1 Landed Petrol Prices	0.8578220	1.000000		
Oil Output	0.4764636	0.644923	1.0000000	
Exchange Rate	-0.7422174	-0.711986	-0.5128941	1.0000000

Table 3: ADF Unit Root Test Results

Variable	Dickey-Fuller	Lag order	p-value	Hypothesis
Landed Petrol Prices	-2.2723	3	0.4657	alternative hypothesis: stationary
Lag1 Landed Petrol Prices	-2.0475	3	0.5551	alternative hypothesis: stationary
Oil Output	-1.0034	3	0.9273	alternative hypothesis: stationary
Exchange Rate	-0.66599	3	0.9663	alternative hypothesis: stationary

Table 4: Lag Order Selection

Selection					
AIC(n)	HQ(n)	SC(n)	FPE(n)		
1	1	1	1		
Criteria					
	1	2	3	4	5
AIC(n)	-9.016207e+01	-9.011062e+01	-8.981607e+01	-8.967068e+01	-8.940911e+01
HQ(n)	-8.985769e+01	-8.956273e+01	-8.902467e+01	-8.863577e+01	-8.813070e+01
SC(n)	-8.932618e+01	-8.860603e+01	-8.764276e+01	-8.682866e+01	-8.589838e+01
FPE(n)	7.002121e-40	7.552130e-40	1.078188e-39	1.408638e-39	2.269937e-39

Table 5: Results of Co-integration Test

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######################
# Johansen-Procedure #
######################

Test type: trace statistic , with linear trend

Eigenvalues (lambda):
[1] 1.418308e+02 1.426171e-01 4.393943e-02 1.815871e-05

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 3 | 0.00  6.50  8.18 11.65
r <= 2 | 1.98 15.66 17.95 23.52
r <= 1 | 8.75 28.71 31.52 37.22
r = 0  |  NaN 45.23 48.28 55.43

Eigenvectors, normalised to first column:
(These are the cointegration relations)
```

	Landed Petrol Prices (l2)	Lag1 Landed Petrol Prices (l2)	Oil Output (l2)	Exchange Rate (l2)
Landed_Petrol_Prices.d	-9.222921e+10	1.592553e+09	4.399220e+10	4.664445e+10
Lag1_Landed_Petrol_Prices.d	4.780152e-03	3.237460e-04	-7.803676e-04	-4.323531e-03
Oil_Output_Millions.d	2.437165e+10	-2.196877e+10	-6.250365e+09	3.847480e+09
Exchange_Rate.d	-5.304672e+09	8.831722e+08	-4.224890e+08	4.843989e+09

Table 6: Error Correction Model Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.002886	0.006866	-0.420	0.67652
diff(log_Exchange_Rate)	-2.651340	0.846800	-3.131	0.00325 **
diff(log_Oil_Output)	-0.394647	0.158082	-2.496	0.01676 *
diff(Log_Lag1_Landed_Petrol_Prices)	-0.104717	0.072860	-1.437	0.15843
lag(residuals, 1)	1.250921	0.095004	13.167	3.98e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 7: Descriptive Statistics of Residuals

Min	1Q	Median	3Q	Max
-14.0351	-1.2794	0.4939	1.9582	4.5967

Table 8: Model of Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	12.6107	4.3583	2.893	0.00602 **
Exchange Rate	-2.4296	0.8762	-2.773	0.00825 **
Oil Output	-0.3962	0.2365	-1.675	0.01367 *
Lag1 Landed Petrol Prices	0.7682	0.1166	6.588	5.66e-08 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error	0.1042 on 42 degrees of freedom			
Multiple R-squared	0.7853			
Adjusted R-squared	0.7699			
F-statistic	51.19 on 3 and 42 DF			
p-value	4.382e-14			