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VISUALIZATION BASED APPROACH FOR FUEL (PMS) PRICE FORECAST

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Abstract: Prediction in time-series data deals with predicting future trends and movements of data from the previous analysis of the data. Analysis of past events or tends usually influences future events or trends. This is achieved through the use of effective visualization tools/methods. Fuel (PMS) pump price is a time-series data that changes due to government policies and programmes, economic factors and market dynamics. To address this challenge, a visualization based approach is adopted in this work to forecast fuel (PMS) prices for selected states in Nigeria: Kogi, Lagos, Bauchi, Borno, Anambra, Rivers and Abuja - FCT. The dataset used is obtained from monthly fuel (PMS) pump price gathered and monitored by Petroleum Products Pricing Regulatory Agency (PPPRA) and National Bureau of Statistics (NBS) over the period of six years (that is, January 2016 – December, 2021). The result of the time-series graphs showed that there are continuous fuel (PMS) price fluctuation across geo-political regions of Nigeria especially North East region. This is influence by large disparity and consistency in the fuel (PMS) pump price, product availability and enforcement of regulatory policies and programmes during the period of study.

Keywords: Fuel (PMS) Price, Forecasting, Machine Learning, Time-series Analysis, Visualization

Introduction

Nigeria is blessed with abundant natural resources with crude oil products playing significant role in our economy. At present, Nigeria is the ninth world producer and sixth world exporter of crude oil. On the domestic economy, the petroleum sector generates over 90% of the country's economic earnings, and provides employment in various forms to Nigerians (Central Bank of Nigeria, 2020). In addition, the tremendous growth in crude oil earnings has significantly influenced Nigeria's economic, political and international relations.

Fuel (PMS) is a by-product of crude oil; it has contributed greatly to the Nigerian economy, contributing significantly to the country's foreign exchange earnings and total revenue needed for both socio-economic and infrastructural development of Nigeria. As a result, Fuel (PMS) price has a direct effect on the Nigerian society, our economy and other activities. From records, instability of fuel prices both in the country and global market has adversely affected Nigeria's socio-economic and infrastructural performance owing to the fact that the country is heavily dependent on crude oil earnings. This has been found to significantly affect production cost of firms since Nigeria is import dependent; thus, an increase in fuel prices makes imported goods to be very expensive which is in turn transmitted to domestic prices by raising the general price level.

Various regimes in Nigeria increased fuel prices more than 20 times between 1978 to 2021. This large fluctuation in fuel (PMS) price has brought great cost management pressure to downstream related consumer industries, enterprises and individuals. As a result, there is need to adopt modern technology to visualize the trend of fuel (PMS) price and generate the corresponding time-series graph. This is to enhance the development of fuel (PMS) price forecasting model which has become the need of the hour, since it is of great importance to many large and small industries, individuals, and the government. To this end, this research work seeks to visualize the trends of fuel (PMS) prices in Nigeria over a given period, and recommend for a forecasting model to be develop for accurate prediction of fuel (PMS) price in Nigeria using a combination of statistical tools and machine learning algorithms to assist industries, businesses, individuals and government decision-making processes.

There are related research work on time series analysis and prediction of crude oil products and associated commodities. Al-Fattah (2020) in his work developed a predictive model to analyze and forecast energy markets, and tests it for gasoline demand of Saudi Arabia using Genetic Algorithm (GA), Artificial Neural Network (ANN), and Data Mining (DM) approach for Time-Series (TS) analysis, referred to as GANNATS. The result showed that, the model yields accurate predictions with robust key performance indicators. The model forecasts that Saudi gasoline demand will maintain a mild growth over the short-term outlook. Variables impact and screening analysis was performed to identify the influencing factors driving the gasoline demand. These results put the proposed model over the traditional econometric models by improving the predictability and accuracy of gasoline price forecasting. Though, there is need to increase the prediction performance.

In a related study, Olayiwola and Seeletse (2020) used time series techniques: autocorrelation analysis and spectral analysis to determine the trends and patterns of the prices of petrol in South Africa. Data collected from the Department of Energy, South Africa covers a period of 14 years monthly-based retail fuel prices of unleaded 95 petrol. The study results show that, there is upward trend variation which continue into the future petrol price in a quadratic rate while there are also some indications of seasonality of petrol price. Furthermore, Berrisch and Ziel (2021) examined the problem of modeling and forecasting European Day-Ahead and Month-Ahead natural gas prices. The authors proposed two distinct probabilistic models for the forecast.

Dataset utilized is daily pricing data from 2011 to 2020. The data analysis revealed that there is difference both in time series feature heavy tails, conditional heteroscedasticity, and asymmetric behaviour. Therefore, state-space time series models under skewed, heavy-tailed distributions was proposed to capture the impact of autocorrelation, seasonality, risk premia, temperature, storage levels, the price of European Emission Allowances, and related fuel prices of oil, coal, and electricity. However, the role of risk premia for natural gas markets provides a research gap.

Based on Variational Mode Decomposition (VMD), Particle Swarm Optimization (PSO) and Deep Belief Network (DBN) as proposed by Li *et al.* (2021) in their work, developed a hybrid forecasting model of monthly Henry Hub natural gas prices. Investigated and considered are the factors that influence long-term variation on the natural gas price forecasting. The result showed a number of factors which contribute to long-term Henry Hub natural gas spot prices forecasting to varying degrees to include natural gas consumption, natural gas gross withdrawals, monthly West Texas Intermediate (WTI) crude oil spot prices, the proportion of extreme high temperature weather, and the proportion of extreme low temperature weather. It is also revealed that the proposed hybrid forecasting model has better forecasting performance than the traditional models by comparing the accuracy of the model with different combinations of influencing factors for natural gas prices. The outcomes can be better in the future works.

A hybrid model based on nonlinear and non-stationary characteristics of carbon price was proposed by Yang et al. (2020) to predict the carbon prices of Beijing, Fujian, and Shanghai. The model combines Modified Ensemble Empirical Mode Decomposition (MEEMD) and Long Short-Term Memory (LSTM) optimized by the Improved Whale Optimization Algorithm (IWOA). The results reveal that the hybrid model provide better prediction performance than other benchmark models. Also, it showed that the improved LSTM model is more suitable for time series prediction. However, it is expected that future works should consider both historical carbon price sequence and external factors to obtain more accurate forecasting results.

Using Artificial Neural Network (ANN), Gupta and Nigam (2020) proposed a model for predicting crude oil prices. The model captures the unstable pattern of the crude oil prices by finding out the variation of optimal lag in a period of time and number of the delay effect that controls the prices of crude oil. Their result was validated by evaluating for the most optimum and close results using the root mean square error. The results obtained by the proposed model having significantly outperformed. Similarly, Aji and Surjandari (2020) proposed a novel model to forecast the jet fuel transaction price based on predictive analytics tool. It considered the global and local jet fuel prices and other economic variables. The hybrid model is a combination of traditional multivariate time series forecasting method, Vector Autoregression (VAR) with two Recurrent Neural Networks (RNN) algorithm, Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU). VAR was first used as an optimization method for parameter and input, then the LSTM and GRU was applied in order to minimizing their weakness. The accuracy of the predicted results were evaluated using Mean Absolute Deviation (MAD), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) in assessing the performance of each algorithm. The combined methods produced forecasting results with a high degree of accuracy. VAR-LSTM produces forecasting performance with an accuracy of 98.98%, while VAR-GRU produces forecasting performance with an accuracy of 99.40% respectively to show that the model have significantly outperformed.

Materials Methods

Data collection

The data for historical pump price of PMS was collected from Petroleum Products Pricing Regulatory Agency (PPPRA) and National Bureau of Statistics (NBS) in Nigeria. This study collected the Premium Motor Spirit (PMS) average price per litre sold in Nigeria over the period of six years (that is, January 2016 – December, 2021). The dataset covered one (1) state each from the six (6) geopolitical zones of Nigeria including North Central, North-East, North-West, South-West, South-East and South-South as reported on National Bureau of Statistics. The states include Kogi, Lagos, Bauchi, Borno, Anambra, and Rivers. Also, Abuja - FCT was selected due to its neutrality to the geopolitical zones being the Nation's capital.

Description of the Proposed Model

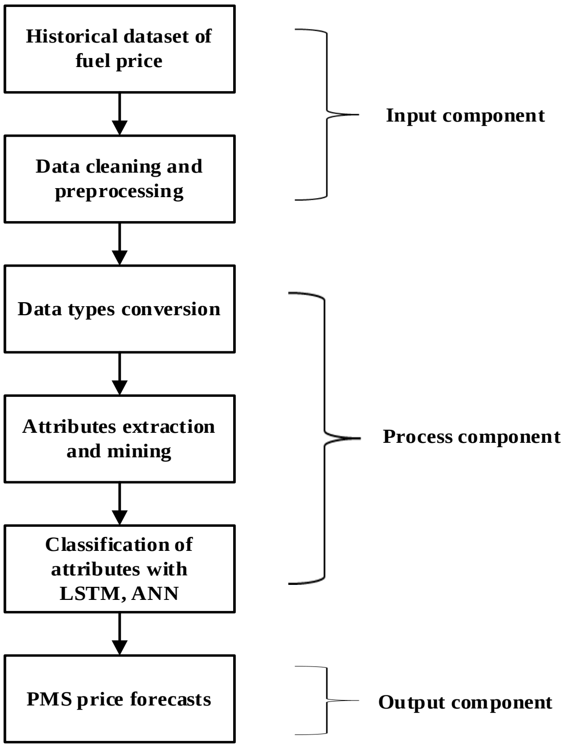

Figure 1: The conceptual diagram of proposed fuel (PMS) price forecasting model.

Results and Discussion

Data Visualization

The times series values of different fuel (PMS) prices visualization against the months monitored from the selected states understudied are presented below.

Fuel (PMS) price visualization for Kogi State revealed that the price of PMS over the periods covered were unstable and unpredictable as shown in Figure 2.

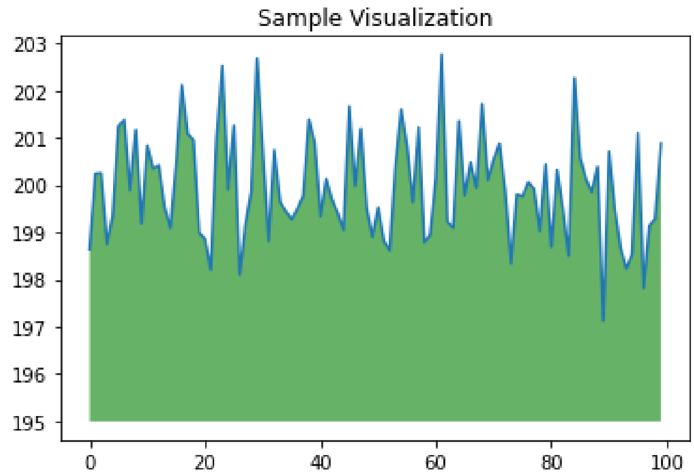

Figure 2: Kogi State PMS prices visualised.

Also, the trend in the data points for the PMS prices in Kogi State increased steadily at the start of the period, and relatively stable at N142 per litre afterwards towards the end of the period. The PMS pricing regime is relatively under control due to proximity to the Nation's capital and activities of regulatory agents as depicted in Figure 3.

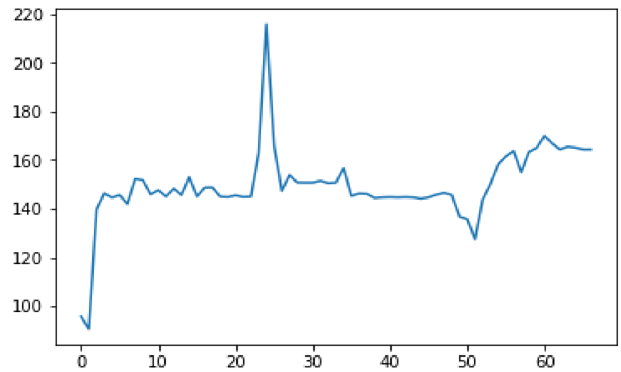

Figure 3: Kogi State PMS Price time's series curve.

PMS price visualization for Lagos State revealed that the price of PMS over the periods covered were highly uncontrollable and unpredictable with rising cases as shown in Figure 4.

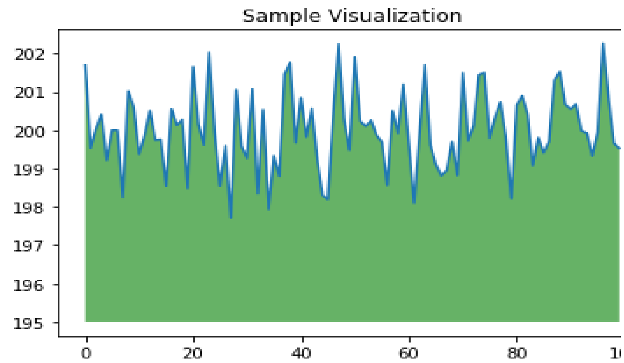

Figure 4: Lagos State PMS prices visualised.

Likewise, the trend in the data points for the PMS prices in Lagos state increased steadily at the start of the period, and relatively stable shortly throughout the period at N145.00 per litre. However, there are occasional price increases in the period of study. The PMS pricing trend can be attributed to poor regulation and ineffective price control as depicted in Figure 5.

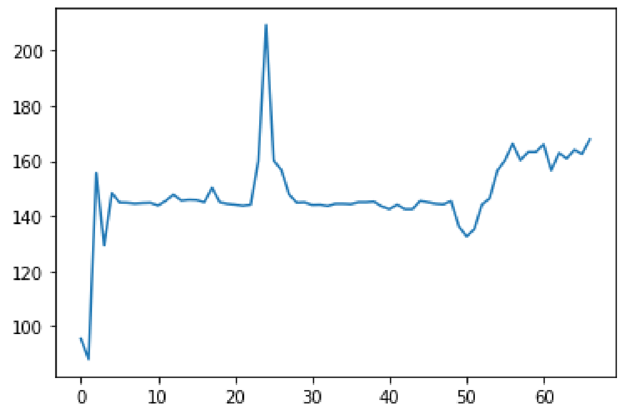

Figure 5: Lagos State PMS Price time's series curve.

PMS Price visualization for Abuja-FCT showed that, the price of PMS in the city over the periods covered were mixed with highs and lows as in Figure 6.

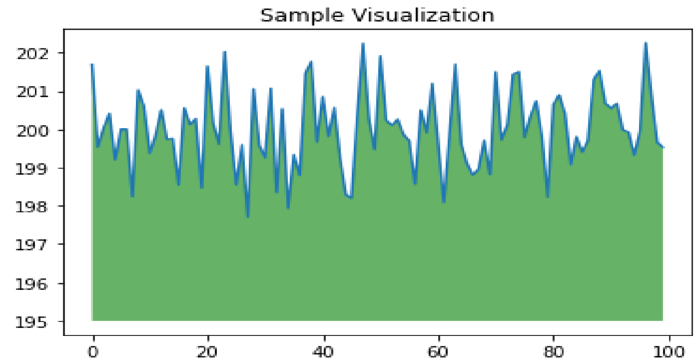

Figure 6: Abuja-FCT PMS prices visualised.

But, the running trend in the data points for the PMS prices in Abuja-FCT was generally stable with little fluctuation at the start and the end. The relative PMS Price of N145 per litre was observed. However, these run of trend can be attributed to the strong and viable product control and prices regulation being the Nation's capital as illustrated in Figure 7.

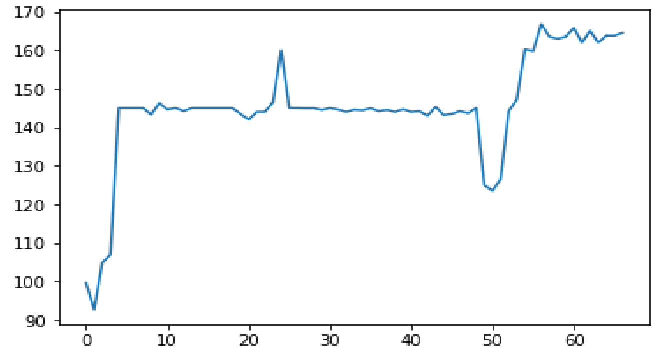

Figure 7: Abuja-FCT PMS price times series curve.

PMS Price visualization for Bauchi State showed that, the prices of PMS were relatively higher when compared to the Western and Central states of Nigeria with data points densely populated around N199 per litre as indicated in Figure 8.

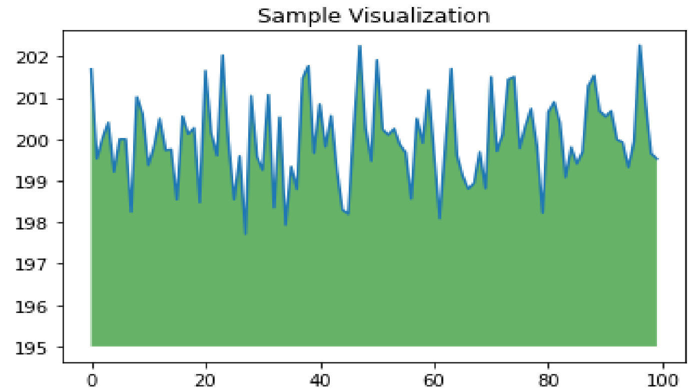

Figure 8: Bauchi State PMS prices visualised.

Though, the trend in the data points for the PMS prices in Bauchi State was generally unstable and highly volatile throughout the period of the study. The average price of PMS Price is N200 per litre due to non-availability of product and ineffective price control by designated agents as illustrated in Figure 9

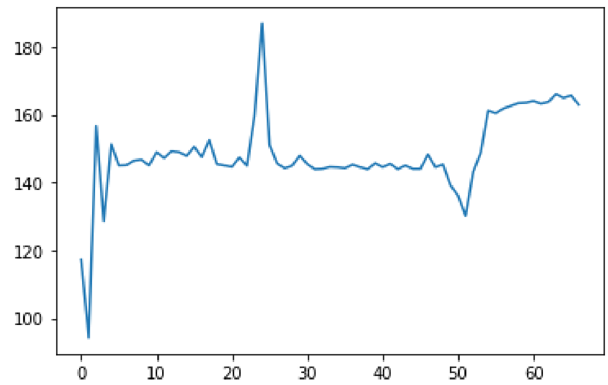

Figure 9: Bauchi State PMS Price time's series curve.

PMS Price data point's visualization for Borno State showed that, there were high saturation along N200 per litre for PMS with occasional ups and downs throughout the period of study when compared to the Western and Central and Southern states of Nigeria as indicated in Figure 10.

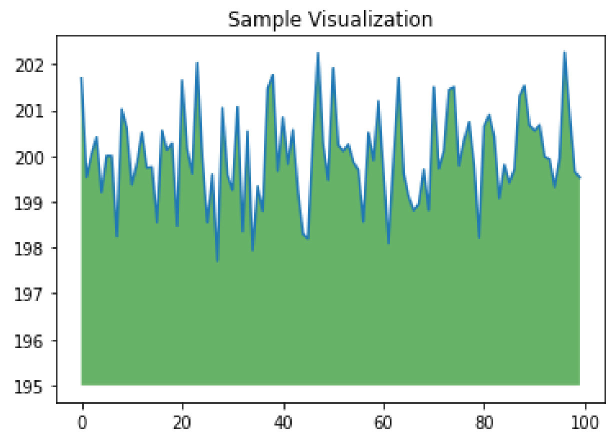

Figure 10: Borno State PMS prices visualised.

Though, the trend in the data points for the PMS prices in Borno State was largely unstable and highly volatile with considerable price range of N157 per litre throughout the period understudied. Borno is a North-Eastern state with lesser vehicle activities caused by insurgency and availability of product as shown in Figure 11.

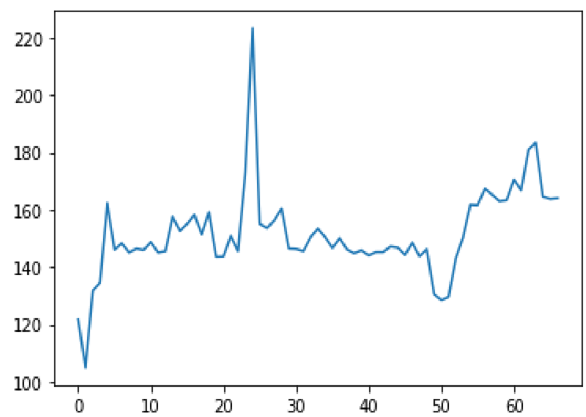

Figure 11: Borno State PMS price times series curve.

The PMS Price data point's visualization for Anambra State showed unpredictable and unsteady pricing with highest concentration under N199 per litre caused by high economic and vehicular activities christened "the Commercial City of Nigeria" located in South-east. There were ups and downs in the PMS price within the region of N195 - N202 per litre for the period of review as indicated in Figure 12.

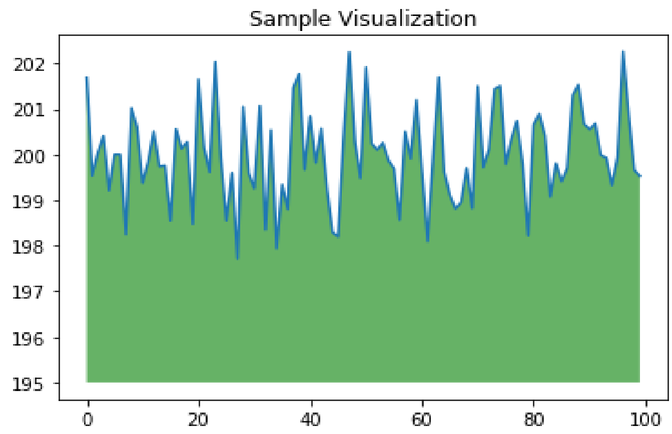

Figure 12: Anambra State PMS prices visualised.

But, the trend in the data points for the PMS prices in Anambra State was driven by economic activities and official pricing regime. There are relatively stable and uniform movements in price of PMS within the region of N142 per litre as observed. Anambra PMS Price movements are represented in Figure 13.

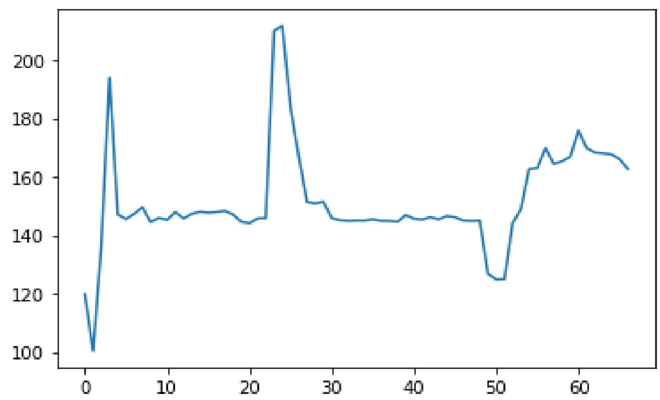

Figure 13: Anambra State PMS price times series curve.

The PMS Price data point's visualization for Rivers State showed predictable and steady concentration of prices towards N200 per litre caused by high economic and vehicular activities as a major oil producer in South-South region of Nigeria. The data points for the PMS Price are illustrated in Figure 14.

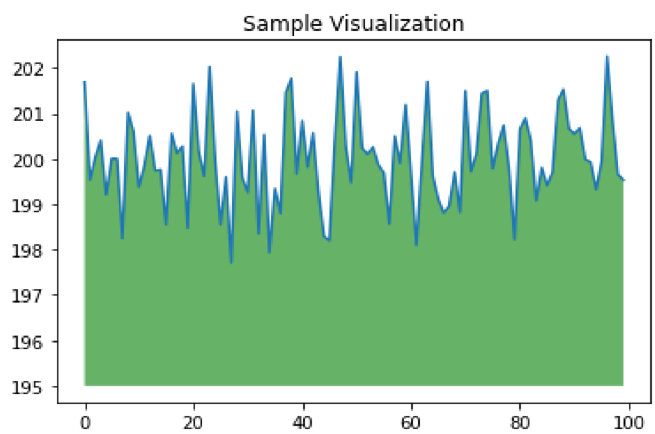

Figure 14: Rivers State PMS prices visualised.

Similarly, the trend in the data points for the PMS prices in Rivers State was driven by economic activities and availability of product. There are relatively stable and uniform movements in price of PMS within the region of N150 per litre as observed. Rivers State PMS price movements rally are shown in Figure 15.

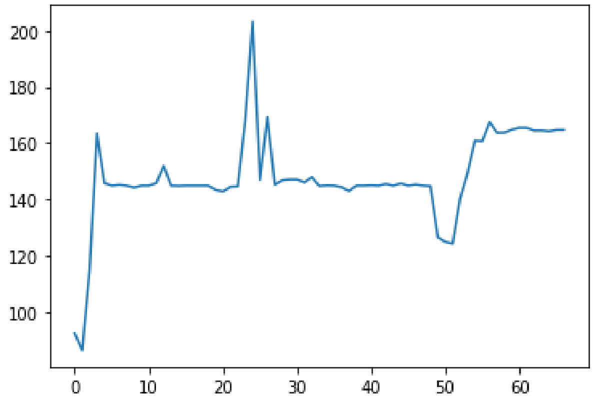

Figure 15: Rivers State PMS Price time's series curve.

Conclusion

The outcomes of the visualised fuel (PMS) price in the geo-political zones are influence by large disparity and consistency in the datasets collected, product availability and enforcement of regulatory policies in the selected states and geo-political regions of Nigeria. The dynamism in fuel (PMS) price cycles have further reinforced the calls to evolve forecasting models capable of providing valuable information to assist decision-making and planning. Thus, due to the significant economic impact of fuel (PMS) price prediction, development of efficient forecasting models using time series data is proposed in this study.

Conflict of Interest

The authors declare no conflict of interest, financial or otherwise.

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