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Research Article

Modelling Liquefied Petroleum Gas Prices in Nigeria Using Time Series Machine Learning Models

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Abstract

Background: The usage of liquefied petroleum gas (LPG) in households has been increasing in recent years. The energy consumption by households is difficult to forecast due to the nature of the independent variables. Deep learning models has been broadly utilized in the machine learning area to model time series data, most notably in the area of forecasting.

Objective: This study was to determine the best model for LPG price prediction in Nigeria.

Methods: In this work, the neural network autoregressive (NNETAR) model, naive forecasting, and the autoregressive integrated moving average (ARIMA) models were used to model the price of LPG prices in 37 states (including the Federal Capital Territory) of Nigeria, with input variables in the form of the price of refilling LPG for 12.5kg from January 2016 to April 2019 covering a 1480 data points. The mean absolute percentage errors (MAPE) were used to evaluate the performance of the model.

Results: The present study suggested that Adamawa has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North East with a price of 2126.879 naira, FCT has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North Central with a price of 2003.056 naira, Kaduna has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North West with a price of 2006.436 naira, Edo has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South South with a price of 2092.955 naira, Ebonyi has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South East with a price of 2033.262 naira and Ekiti has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South West with a price of 2008.860 naira.

Conclusion: Naive produced lower MAPE for more states compared to NNETAR and ARIMA models.

Keywords: modelling, MAPE, artificial neural network, price, liquefied petroleum gas

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1 INTRODUCTION

Liquefied petroleum gas (LPG) is one of the main energy sources for the majority of households in Nigeria. Data have shown that only 5% of the LPG utilization potential has been achieved[1]. While LPG is only used as a fundamental fuel, it is utilized as a beginning up/start fuel to help subsequent liquid filling activities or as an optional fuel elective for fuel oil. Nonetheless, the capacity of fuel oil is less complicated and is more competitive than LPG as optional fuel.

The delivery of gas has been bolstered following the dramatic and subjective cost reduction of the special interest in LPG in Nigeria, which provides opportunities for the industry, among which is the development of LPG in Nigeria.

Afimia[1], in estimating natural gas demand elasticity in Nigeria, used the bound testing approach to co-integration within the framework of ARDL to estimate annual time series data over a 33-year period (1984-2016) so as to investigate the responsiveness of natural gas demand to changes in natural gas price, income, and prices of other energy products.

The findings indicate that domestic gas price, automotive gas oil (AGO) price, international liquefied natural gas (LNG) price, and electricity consumption per capital are major predictors of Nigeria's natural gas demand and that natural gas demand elasticity in Nigeria is relatively price inelastic.

As a result, a decrease in natural gas prices will result in an increase in natural gas demand by less than the percentage fall in price and vice versa, *ceteris paribus,* which concludes that natural gas price is a major determinant of the quantity demanded of natural gas in Nigeria.

Gould and Urpelain[2] explored the incorporation of a clean cooking fuel into rural families' energy mixes using the 2014 to 2015 access survey with over 8500 households from six energy-poor Indian states. The findings of a large survey of LPG consumption in rural India, conducted using a descriptive analysis approach, found that LPG cost is a major barrier to widespread adoption, and that both users and non-users of LPG show extremely favourable views of LPG as convenient and clean cooking fuel. The research also revealed that increasing LPG use in rural India has significant potential, but that affordability precludes a complete switch from conventional biomass to clean cooking fuels.

The deep learning models have been applied to address various managerial problems such as sales forecasting, price elasticity modeling, brand analysis, new product acceptance research, and market segmentation and more[3,4]. According to Mensah et al.[5], energy prices, income, urbanization, and economic structure are significant demand drivers of the different energy types in Ghana, with varying estimated elasticity, according to disaggregated analysis in estimating energy demand in Ghana, which used key disaggregated energy components such as gasoline, diesel, LPG, kerosene, biomass, residual fuel oil, and electricity. It also demonstrated a significant level of inter-fuel substitution in Ghana's energy demand, especially from gasoline, diesel, and kerosene to LPG. Ogundunmade and Adepoju[6] emphasized the importance of artificial neural network (ANN) models in predictions using heterogeneous transfer functions. Ogundunmade et al.[7], also considered the prediction performance of machine learning models under two cross validation approaches, namely K-fold and repeated K-fold CVs and when no cross validation technique is used. The models incorporated the simple linear regression model, random forest, classification and regression tree, artificial neural network and the support vector machine model. Standard strategic indicators such as root mean square error and mean absolute error were used to evaluate the models. The financial data including real gross domestic product, inflation rate, exchange rate, and interest rate are used as the input units in the model. Yaya et al.[8] studied the relationship between natural gas prices and consumer prices, and its potential to deliver better indicators to analyze economic activity. The analysis of natural gas spot prices using fractional integration techniques in the setting of non-linear deterministic trends is the subject of this research. The daily and monthly series, as well as their logarithmic conversions, show non-stationarity with mean reverting coefficients. Only the monthly series shows evidence of non-linearity, which might be attributable to the increased degree of volatility associated with this frequency. Ogundunmade et al.[9] analyzed models among the machine-learning time series models to predict crude oil prices in Nigeria. The alternative models were the auto-regressive integrated moving average model, naive Bayes, Holtwinter trend model, exponential smoothing model, and neural network autoregressive (NNETAR) model. The prediction criteria adopted for model screening were the root mean square error, mean absolute error, and mean absolute percentage error (MAPE). The NNETAR model was recommended for the prediction of crude oil prices in Nigeria. In the present study, time series machine learning models were used to model the LPG price for 12.5kg refilling gas in Nigeria. The purpose of this study is to model the price of 12.5kg of LPG refilling in Nigerian states using machine learning time series models.

2 MATERIALS AND METHODS

2.1 Study Area and Data

Nigeria, a country in West Africa, is the largest country in Africa. It has distinguished demographic characteristics in Sub-Saharan Africa and shares a border in the North with Niger, at North East Chad, at East Cameroon and also Benin in the west region. Nigeria at 9.0820º N latitude, 8.6753º E longitude is a tropical region at the extreme inner corner side of Guinea, which is on the west coast of Africa and covers an area of 923,768 square km and a coastline of 85km. The country is 1,045km long and 1,126km wide. Nigeria

comprises 36 states and the country capital Abuja which has the Federal Capital Territory (FCT). Nigeria is divided into six geopolitical zones and has various ethnic groups and different cultures across the states and geopolitical zones.

Figure 1 shows the map of the 36 states of Nigeria including the FCT. Monthly panel data of 12.5kg of LPG prices for 36 states and Abuja in Nigeria are considered. This series span from January 2016 to April 2019 covering 1558 data points. The data were sourced from the Nigeria Data Portal. The states were divided into:

North Central-include Benue, Niger, Kogi, Kwara, Plateau, Nassarawa, and FCT.

North West-include Jigawa, Kano, Katsina, Kaduna, Kebbi, Zamfara, and Sokoto states.

North East-include Gombe, Bauchi, Yobe, Benue, Adamawa, Taraba states.

South-South-include Akwa-Ibom, Cross Rivers, Bayelsa, Rivers, Delta and Edo states.

South East-include Abia, Imo, Ebonyi, and Anambra states.

South West-include Ekiti, Ondo, Osun, Oyo, Ogun and Lagos.

2.2 NNETAR Model

The "nnetar" function in the package "caret" (R environment) was used to identify NNAR models. The NNAR models were marked as NNAR (p,k) for non-seasonal data, where p represents the number of non-seasonal lags used as inputs and k denotes the number of nodes/neurons in the hidden layer. The NNAR (p,k) process was similar to the AR process but with nonlinear functions. The Akaike's information criterion (AICc) metric was used to determine the ideal number of non-seasonal delays, and the optimal number of neurons was determined by calculating (p+P+1)/2, where p is the nonseasonal AR order and P is the seasonal AR order (if any). Finally, the MAPE metric was used to assess the goodness of fit.

2.3 Naive Forecasting Model

One of the most basic predicting approaches is the Naive Forecasting Model. The one-step-ahead forecast is equal to the most recent actual value, according to each:

$$y = f(x) + e_i = \sum x_i w_i + e_i \qquad (1)$$

The "Random Walk" statistical model that underpins Naive is written as:

$$\text{Output} = \text{sum}(\text{weights} * \text{inputs}) + \text{bias} \qquad (2)$$

is the price of the refilling LPG of the current year while representing the prices of the 12.5kg refilling LPG for the previous year and represents random error which is assumed to be stochastic.

2.4 Autoregressive Integrated Moving Average (ARIMA) Model

ARIMA models were recognized using the "auto. arima" function, which was developed by Hyndman and Khandakar (2008) and was included in the package "forecast" (in R environment). The number of p parameters of the autoregressive (AR) process, the order I of differencing (I), and the number of q parameters of the moving average process were all used in this function to find the best ARIMA models (MA). It incorporated unit root tests, as well as the reduction of the bias, corrected AICc and maximum likelihood estimation (MLE) methods. The unit root tests were available to determine the order of differencing, while the AICc and MLE methods could be used to determine the AR and MA processes' optimal parameters.

2.5 Model Performance Measures

To assess the ANN performance of these models, conventional measurements such as MAPE were employed. In the present study, the goodness of fit measure, namely, MAPE was utilized to assess the performances of all models.

MAPE is a measure of how accurate a forecast is. It measures accuracy as a percentage.

$$\text{MAPE} = \left|\frac{1}{y_T}\sum_{i=1}^{n}(y_T - y_P)\right| \qquad (3)$$

3 RESULTS AND DISCUSSION

This presents the analysis of the modelling of the price of 12.5kg refilling LPG in Nigeria. The data obtained from the Nigeria data portal spanned from January 2016 to April 2019. The zones in Nigeria included for analysis were North East North Central, North West, South South, South East and South West.

3.1 Descriptive Statistics

The summary of the data is displayed below in terms of the minimum (min), maximum (max), mean, standard deviation (SD) and median (med) values of the 12.5kg refilling prices of LPG in Nigerian states. Tables 1-6 show the descriptive statistics of the price of 12.5kg of refilling LPG for North East, North Central, North West, South South, South East and South West respectively.

Table 1 shows the descriptive statistics for North East. It shows that Gombe has a mean and standard deviation of 2145.293 and 2854078, Bauchi has 2253.650 and 238.1346, Yobe has 2243.021 and 246.2442, Adamawa has 2126.879 and 267.6890, Taraba has 2163.504 and 201.5800 and Borno has 2287.875 and 252.6571 respectively. On average, Adamawa has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019

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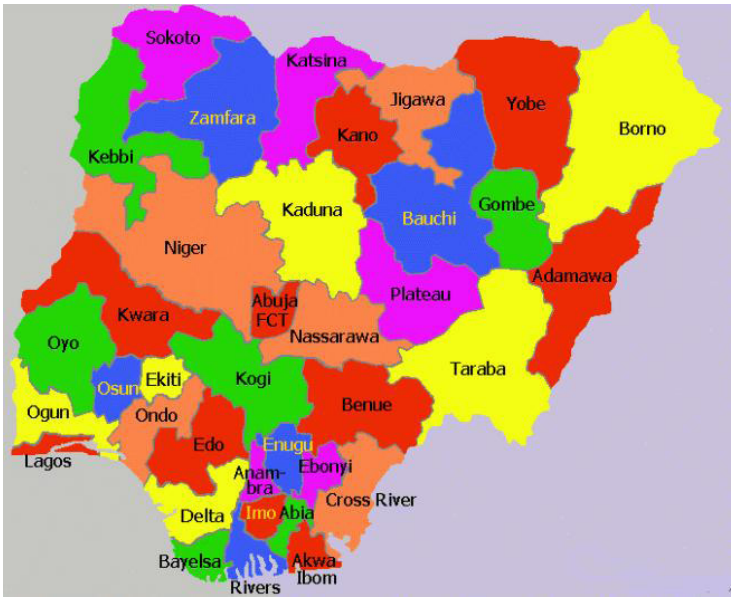

Figure 1. Map of Nigeria showing the states. Source: Nigeria Data Portal.

Table 1. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for North East

North East				
State	**Min**	**Max**	**Mean±SD**	**Med**
Gombe	1700	2650	2145.293±854078	2136.76
Bauchi	1850	2550	2253.650±238.1346	2308.175
Yobe	1843.8	2700	2243.021±246.2442	2300.997
Adamawa	1720	2700	2126.879±267.6890	2108.333
Taraba	1850	2580	2163.504±201.5800	2151.5
Borno	1800	2825	2287.875±252.6571	2362.5

Table 2. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for North Central

North Central				
State	**Min**	**Max**	**Mean±SD**	**Med**
Benue	1800	2740	2183.289±238.1493	2200
Niger	1800	2800	2102.836±228.0681	2007.143
Kogi	1803.13	2650	2071.667±226.8594	2000
Kwara	1816.67	2800	2090.430±246.1266	2000
Plateau	1800	2820	2110.039±229.2054	2084.444
Nassarawa	1814.88	2860	2105.772±241.8497	2077.451
Fct	1730	2800	2003.056±271.2168	1900

Table 3. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for North West

North West				
State	**Min**	**Max**	**Mean±SD**	**Med**
Jigawa	1775	2500	2060.193±206.8024	1977.017
Kano	1750	2750	2097.443±229.4912	2070.833
Katsina	1757.143	2572.222	2089.130±219.8488	2023.185
Kaduna	1687.5	2566.667	2006.436±248.6832	1933.333
Kebbi	1850	3000	2130.074±237.3954	2050.165
Zamfara	1700	3000	2113.924±268.4952	2038.75
Sokoto	1800	2575	2058.047±195.5089	2000.447

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Table 4. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for South-South

South-South				
State	**Min**	**Max**	**Mean±SD**	**Med**
Akwa-Ibom	1705.65	3000	2167.797±253.1529	2181.335
Cross Rivers	1800	3000	2156.812±260.7478	2122.917
Bayelsa	1800	3000	2131.340±250.5978	2061.111
Rivers	1800	3000	2157.388±260.9368	2121.023
Delta	1771.429	2984.615	2121.364±277.2808	2094.712
Edo	1700	3030.769	2092.955±285.1201	2072.5

Table 5. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for North Central

South East				
State	**Min**	**Max**	**Mean±SD**	**Med**
Abia	1657.14	3000	2089.043±276.9539	2112.5
Imo	1750	2700	2084.864±246.2536	1998.875
Ebonyi	1690	2880.34	2033.262±292.4602	1913.333
Anambra	1666.67	2800	2218.837±250.7015	2245.113
Enugu	1672.222	2944.444	2047.211±302.4435	2000

Table 6. Descriptive Statistics of the 12.5kg Refilling Prices of LPG for South West

South West				
State	**Min**	**Max**	**Mean±SD**	**Med**
Ekiti	1745.455	2580	2008.860±221.1862	1956.667
Ondo	1731.25	2600	2091.869±192.0355	2093.18
Osun	1703.571	2616.66	2091.675±220.5871	2045.536
Oyo	1753.684	2700	2067.757±254.3063	2000
Ogun	1700	2555.556	2063.711±231.9369	2058.723
Lagos	1813.89	2650	2066.9430±224.896	1977.273

in the North East with a price of 2126.879 naira. Table 2 shows the descriptive statistics for North Central. It shows that Benue has a mean and standard deviation of 2183.289 and 238.1493, Niger has 2102.836 and 228.0681, Kogi has 2071.667 and 226.8594, Kwara has 2090.430 and 246.1266, Plateau has 2110.039 and 229.2054, Nasarawa has 2105.772 and 241.8497 and FCT has 2003.056 and 271.2168 respectively. On average, FCT has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North Central with a price of 2003.056 naira. Table 3 shows the descriptive statistics for North West. It shows that Jigawa has a mean and standard deviation of 2060.193 and 206.8024, Kano has 2097.443 and 229.4912, Kastina has 2089.130 and 219.8488, Kaduna has 2006.436 and 248.6832, Kebbi has 2130.074 and 237.3954, Zamfara has 2113.924 and 268.4952 and Sokoto has 2058.047 and 195.5089 respectively. On average, Kaduna has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North West with a price of 2006.436 naira. Table 4 shows the descriptive statistics for the South South. It shows that Akwa-Ibom has a mean and standard deviation of 2167.797 and 253.1529, Cross Rivers has 2156.812 and 260.7478, Bayelsa has 2131.340 and 250.5978, Rivers has 2157.388 and 260.9368, Delta has 2121.364 and 277.2808 and Edo has 2092.955 and 285.1201 respectively. On average, Edo has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South South with a price of 2092.955 naira. Table 5 shows the descriptive statistics for the South East. It shows that Abia has a mean and standard deviation of 2089.043 and 276.9539, Imo has 2084.864 and 246.2536, Ebonyi has 2033.262 and 292.4602, Anambra has 2218.837 and 250.7015 and Enugu has 2047.211 and 302.4435 respectively. On the average, Ebonyi has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South East with a price of 2033.262 naira. Table 6 shows the descriptive statistics for the South West. It shows that Ekiti has a mean and standard deviation of 2008.860 and 221.1862, Ondo has 2091.869 and 192.0355, Osun has 2091.675 and 220.5871, Oyo has 2067.757 and 254.3063, Ogun has 2063.711 and 231.9369 and Lagos has 2066.9430 and 224.896 respectively. On average, Ekiti has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South west with a price of 2008.860 naira.

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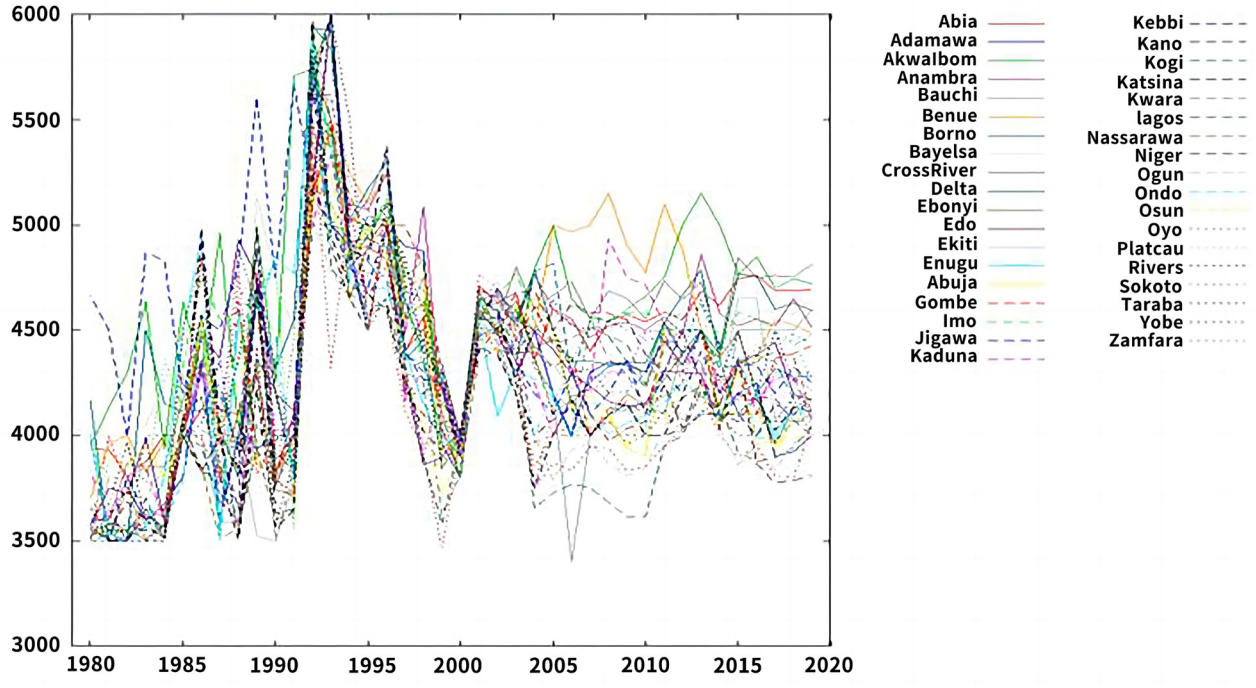

Figure 2. Line plot of 12.5kg refilling price of LPG in 37 states in Nigeria.

Table 7. Model Estimation

State	ARIMA Model AIC	Naive (Residual s.d)	NNETAR
Abia	ARIMA (0,1,1) 454.37	361.9403	NNAR (1,1) 1-1-1
Abuja	ARIMA (1,0,0) 463.8	368.9542	NNAR (1,1) 1-1-1
Adamawa	ARIMA (1,0,0) 483.07	469.6651	NNAR (1,1) 1-1-1
Akwa Ibom	ARIMA (1,0,0) 483.44	493.4473	NNAR (1,1) 1-1-1
Anambra	ARIMA (0,1,0) 460.23	469.1738	NNAR (1,1) 1-1-1
Bauchi	ARIMA (0,0,1) 468.98	465.6608	NNAR (1,1) 1-1-1
Bayelsa	ARIMA (1,0,0) 463.52	346.2418	NNAR (1,1) 1-1-1
Benue	ARIMA (0,1,0) 472.01	419.9018	NNAR (1,1) 1-1-1
Borno	ARIMA (0,0,1) 481.25	533.8451	NNAR (1,1) 1-1-1
Cross River	ARIMA (1,0,0) 484.47	522.6915	NNAR (1,1) 1-1-1
Delta	ARIMA (1,0,0) 481.94	520.946	NNAR (1,1) 1-1-1
Ebonyi	ARIMA (0,0,1) 479.66	499.6535	NNAR (1,1) 1-1-1
Edo	ARIMA (1,0,0) 481.35	390.7121	NNAR (1,1) 1-1-1
Ekiti	ARIMA (0,0,1) 471.94	415.274	NNAR (2,2) 2-2-1
Enugu	ARIMA (1,0,0) 472.35	366.3566	NNAR (1,1) 1-1-1
Gombe	ARIMA (0,1,0) 471.25	602.5744	NNAR (2,2) 2-2-1

Imo	ARIMA (1,0,0) 478.06	424.2197	NNAR (1,1) 1-1-1
Jigawa	ARIMA (1,1,0) 454.54	472.5319	NNAR (5,3) 5-3-1
Kaduna	ARIMA (1,0,0) 472.11	379.8261	NNAR (1,1) 1-1-1
Kano	ARIMA (2,0,0) 469.98	371.3084	NNAR (2,2) 2-2-1
Katsina	ARIMA (0,1,1) 450.17	516.4989	NNAR (1,1) 1-1-1
Kebbi	ARIMA (1,0,0) 493.1	591.1371	NNAR (1,1) 1-1-1
Kogi	ARIMA (1,0,0) 461.74	315.4195	NNAR (1,1) 1-1-1
Kwara	ARIMA (1,0,0) 483.83	554.797	NNAR (1,1) 1-1-1
Lagos	ARIMA (0,0,1) 484.9	442.1647	NNAR (1,1) 1-1-1
Nasarawa	ARIMA (0,1,0) 462.42	432.8119	NNAR (1,1) 1-1-1
Niger	ARIMA (0,0,1) 486.03	522.2372	NNAR (3,2) 3-2-1
Ogun	ARIMA (1,0,0) 457.45	313.9312	NNAR (1,1) 1-1-1
Ondo	ARIMA (1,0,0) 492.35	399.5036	NNAR (1,1) 1-1-1
Osun	ARIMA (1,0,0) 461.63	362.9345	NNAR (1,1) 1-1-1
Oyo	ARIMA (1,0,0) 484.97	533.4016	NNAR (1,1) 1-1-1
Plateau	ARIMA (0,1,1) 450.77	553.5682	NNAR (1,1) 1-1-1
Rivers	ARIMA (1,0,0) 471.95	462.582	NNAR (1,1) 1-1-1
Sokoto	ARIMA (1,0,0) 487.45	514.229	NNAR (1,1) 1-1-1
Taraba	ARIMA (0,0,1) 488.61	541.1193	NNAR (1,1) 1-1-1
Yobe	ARIMA (0,0,1) 478.57	546.9955	NNAR (1,1) 1-1-1
Zamfara	ARIMA (1,0,0) 478.87	416.2259	NNAR (1,1) 1-1-1

Figure 2 shows the plot of the prices of 12.5kg refilling LPG in the 37 states in Nigeria, and possible co-movement is observed, with longer spikes on many occasions implying points of high prices.

3.2 Model Estimation

In this section, the data were modeled using the considered time series machine learning models, i.e. ARIMA, naive Bayes and the neural network auto-regressive models. The result for each model is given in Table 7.

Table 7 shows the results of the model estimation for ARIMA, naive Bayes and the NNETAR models. The result for ARIMA is in the first column showing the value for p, d and q respectively. The ARIMA result for Abia state shows ARIMA (0,1,1) with the min AIC value of 454.37. ARIMA (0,1,1) implies that the data of LPG price of 12.5kg refilling follows the moving average of order 1 with a difference of 1. The same implies to the other 36 states considered. Column 2 in Table 7 produced the residual SD for the data of each state. Column 3 shows the neural network model order of the LPG price for each state. 32 out of 37 states follow NNAR (1,1) which implies one input and one output. States like Ekiti, Gombe and Kano follow NNAR (2,2) each. While Jigawa and Niger follow NNAR (5,3) and NNAR (3,2) respectively.

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Table 8. Forecast Measures for the Models Using MAPE

State	ARIMA	Naive	NNETAR
Abia	0.3984873	0.3984873	0.01242292
Abuja	0.03152774	0.19276	0.06222852
Adamawa	0.3244903	0.5741522	0.07843926
Akwa Ibom	0.3229858	0.2305255	0.2296724
Anambra	0.2659146	0.4064739	0.6248645
Bauchi	1.354522	1.854664	1.522133
Bayelsa	0.3770372	0.5410757	0.4711242
Benue	0.4946475	0.3919953	0.6060867
Borno	0.2224315	0.04651095	0.05739366
Cross River	0.4342346	0.8379205	0.4317453
Delta	0.07834129	0.3710712	0.1998949
Ebonyi	0.2359589	0.001648152	0.1553445
Edo	0.3989752	0.1298232	0.3851524
Ekiti	0.2927878	0.07778386	0.3971776
Enugu	0.3138865	0.04509449	0.1952926
Gombe	0.3227813	0.5397284	0.04946849
Imo	0.1506556	0.2236358	0.4041998
Jigawa	0.2972069	0.4076087	0.3352684
Kaduna	0.5438156	0.5438156	0.3424322
Kano	0.01648947	0.4983143	0.2404467
Katsina	0.1323356	0.1504144	0.00542202
Kebbi	0.1680548	0.1173754	0.1493791
Kogi	0.1878467	0.134234	0.4363876
Kwara	0.5020068	0.2578385	0.7497674
Lagos	0.1273739	0.02536944	0.4018972
Nasarawa	0.2845860	0.2845861	0.04729451
Niger	0.05939995	0.4034468	0.4690108
Ogun	0.1354385	0.2713824	0.001506067
Ondo	0.4401882	0.3995298	0.1362453
Osun	0.1412026	0.2214668	0.08729425
Oyo	0.2024877	0.1955366	0.7445525
Plateau	0.03584741	0.2297746	0.005409473
Rivers	0.09964443	0.07063571	0.1906414
Sokoto	0.3687059	0.2089954	0.4322136
Taraba	0.1562326	0.07520401	0.2184252
Yobe	0.3877903	0.3638269	0.5743241
Zamfara	0.7021517	0.8626734	0.8146726

3.3 Forecast Measures for the Models

Table 8 shows the MAPE results for the models used for the price of 12.5kg of refilling LPG in 37 states of Nigeria. The coloured values marked in the tables are the least MAPE values produced for each state. NNETAR and ARIMA best predict the price of 12.5kg refilling LGP for 12 and 11 states respectively while naive predicts for 14 states.

4 CONCLUSION

The present study modeled the price of 12.5kg of refilling LPG for 37 states in Nigeria for the data spanning from January 2016 to April 2019. The artificial neural network model was employed given its ability to capture both the linearity and the non-linearity part of the data. The results suggested that Adamawa has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North East with a price of 2126.879 naira, FCT has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the North Central with a price of 2003.056 naira, Kaduna has the lowest price of 12.5kg refilling LPG from January 2016

to April 2019 in the North West with a price of 2006.436 naira, Edo has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South South with a price of 2092.955 naira, Ebonyi has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South East with a price of 2033.262 naira and Ekiti has the lowest price of 12.5kg refilling LPG from January 2016 to April 2019 in the South west with a price of 2008.860 naira.

With reference to the result of the MAPE, the naive models produced lower MAPE values for most states compared to the NNETAR and ARIMA models, implying that the naive model produces valuable predictions of the price of 12.5kg refilling LPG for most states in Nigeria.

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Not applicable.

Conflicts of Interest
The authors declared no conflict of interest.

Author Contribution
Ogundunmade TP designed the study and wrote the article. Adepoju AA revised the paper for intellectual contribution. Both authors approved the final version.

Abbreviation List
AGO, Automotive gas oil
AICc, Akaike's information criterion
ANN, Artificial neural network
AR, Autoregressive
ARIMA, Autoregressive integrated moving average
FCT, Federal Capital Territory
LNG, Liquefied natural gas
LPG, Liquefied petroleum gas
MAPE, mean absolute percentage error
max, Maximum
Med, Median
min, Minimum
MLE, Maximum likelihood estimation
NNETAR, Neural network autoregressive
SD, Standard deviation

References

[1] Afimia EO. Estimating natural gas demand elasticities in Nigeria. *J Energy Research Rev*, 2019; 2: 1-12. DOI: 10.9734/JENRR/2019/v2i430084

[2] Gould CF, Urpelainen J. LPG as a clean cooking fuel: Adoption, use, and impact in rural India. *Energ Policy*, 2018; 122: 395-408. DOI: 10.1016/j.enpol.2018.07.042

[3] Hakimpoor H, Tat HH, Khani N et al. Marketing networking dimensions (Mnds) and SMEs performance, A new conceptual model. *Aust J Basic Applied Sciences*, 2011; 5: 1528-1533.

[4] Ogundunmade TP, Adepoju AA. On heterogenous transfer functions in bayesian neural network: Paper presented at the Virtual Paper Session-16th Brazilian Meeting of Bayesian Statistics and VI Latin American Conference on Statistical Computing, March, 2022.

[5] Mensah JT, Marbuah G, Amoah A. Energy demand in Ghana: A disaggregated analysis. *Renew Sust Energ Rev*, 2016; 53: 924-935. DOI: 10.1016/j.rser.2015.09.035

[6] Ogundunmade TP, Adepoju AA. The performance of artificial neural network using heterogeneous transfer functions. *Int J Data Sci Anal*, 2021; 2: 92-103. DOI: 10.18517/ijods.2.2.92-103.2021

[7] Ogundunmade TP, Adepoju AA, Allam A. Stock price forecasting: Machine learning models with K-fold and repeated cross validation approaches. *Mod Econ Manag*, 2022; 1: 1. DOI: 10.53964/mem.2022001

[8] Yaya OOS, Abu N, Ogundunmade TP. Economic policy uncertainty in G7 countries: Evidence of long-range dependence and cointegration. *Econ Chang Restruct*, 2021; 54: 541-556. DOI: 10.1007/s10644-020-09288-3

[9] Ogundunmade TP, Adepoju AA, Allam A. Predicting crude oil price in Nigeria with machine learning models. *Mod Econ Manag*, 2022; 1: 4. DOI: 10.53964/mem.2022004