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Predicting access to electricity in Nigeria: Autoregressive integrated moving average approach

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Abstract
Having Access to affordable, reliable and sustainable electricity is a vital instrument of energy security that will develop the private businesses, industries and good livelihood of well-meaning Nigerians.
The sole objective of this paper is to adopt the autoregressive integrated moving average (ARIMA) model to predict Access to Electricity in Nigeria.
The unit root test was carried out and the result revealed that Access to Electricity becomes stationary after the first difference this suggests that further time series analysis like the ARIMA model can be performed.
The ARIMA approach was adopted and different tentative ARIMA models were obtained. The ARIMA (1, 1, 6) is the best selected ARIMA model among the other tentative models because it has the highest no of significant coefficients, highest adjusted R-squared, lowest volatility, and lowest AIC and SBIC. The forecasted values from 2021 to 2030 by the fitted ARIMA (1, 1, 6) model provided a future view of the possibility of having better Access to Electricity in Nigeria and this is also a significant contribution to the existing body of knowledge as there is no previous study that has applied ARIMA model to Access to Electricity in Nigeria which is one of the major challenges confronting the country. As a result of this, the Nigeria government need to develop an efficient energy policy to meet up with the united nation development goal target that will ensure that all the developing nations including Nigeria will have access to affordable, reliable and sustainable energy security in terms of access to sustainable electricity that will drive the economic growth and development in Nigeria.

Keywords: Access to electricity, unit root test, ARIMA model

1. Introduction

Access to affordable, reliable, modern and sustainable electricity is the most important tool of energy security that will bring about economic growth and development (United nation, 2022) [9]. Nigeria is currently suffering a severe setback due to the availability of epileptic power supply that has jeopardized many businesses and even made many foreign investors relocate their businesses to other west African countries with good access to affordable and reliable electricity. The cost of electricity suddenly rose in 2020 as a result of the untold emergence of a covid-19 pandemic that has made the government of all the countries decide on a lockdown or sit-at-home policy that crippled economic activities and still having a cruel effect on the global economy till now (World health organization, 2020) [11].

However, developed countries like the united states of America, Europe, Australia etc. have a better system that enables them to still survive the effect of covid-19 pandemic and still good energy security for better livelihood of their citizens and also maintain good industrialization within their region (World bank, 2022) [10].

Meanwhile, other African countries like Egypt have adopted renewable energy options like wind energy as an alternative to a conventional source of electricity have access to reliable and affordable electricity and thereby making their country improve their industry's capacity and also attract meaningful foreign investors (IEA, 2021; Dudley, 2018) [5, 4].

It is very noteworthy that for Nigeria to have better industrial growth and attract foreign investors, access to reliable and affordable electricity as key energy security should be achieved and this can be done by examining the current trend or pattern of access to electricity as well as forecasting for the future trend in subsequent years in Nigeria and this will help the

government to have a future view and then develop a policy that will improve energy security in the country.
Therefore, the core objective of this study is to predict the Access to electricity in Nigeria using the autoregressive integrated moving average (ARIMA) model and this will also contribute to the existing body of knowledge as this research is a new study that will adopt ARIMA model to forecast the future trend of Access to Electricity in Nigeria.

2. Literature review

Access to affordable, reliable and sustainable electricity is the most essential component of energy security as this will drive better livelihood for the citizen and the country's economic growth (United Nations, 2022) [9].
Asumadu-Sarkodie (2017) [1] applied Autoregressive (AR), Autoregressive moving average (ARMA) and Autoregressive integrated moving average (ARIMA) in forecasting Ghana's electricity consumption to examine the future pattern of the country's electricity consumption by 2030 and he discovered that ARIMA model provided the best forecast.
Castrillejo, Cugliari, Massa and Ramirez (2018) [2] adopted the ARIMA model to forecast electricity demand in Germany and the result of the analysis shows that ARIMA (1,1,1) provided the best forecast among the other tentative ARIMA models.
Chujai, Kerdprasop and Kerdprasop (2013) [3] employed ARIMA and ARMA models to predict household electricity consumption in Hong Kong. The result of the analysis reveals that the ARIMA model outperformed the ARMA model.
Nichiforov, Stamatescu and Fagarasan (2017) [6] adopted ARIMA and Neural network models for the forecast of energy consumption in Romania. The findings show that both models provided an accurate forecast of energy consumption patterns.
Ramakrishna and Kumari (2018) [7] applied the ARIMA model for forecasting rice production in India and the findings show that ARIMA (6,1,1) provided the best forecast among the other estimated ARIMA models.
Sen, Roy and Pal (2016) [8] adopted the ARIMA model for predicting energy consumption in India and the findings of the research study show that ARIMA (1,1,5) provided the most accurate forecast compared with the other tentative ARIMA models.
However, several other studies have been carried out using univariate time series models like ARIMA and even ARCH and GARCH for volatility examination but this study will contribute greatly to the existing knowledge because it is the first study to adopt the best fitted ARIMA model among the other tentative ARIMA models that has the highest numbers of coefficients that are significant, the highest Adjusted R-squared, lowest volatility, lowest AIC and SBIC which form the basis for selecting the best ARIMA model for prediction of Access to Electricity in Nigeria.

3.Data and methodology

This particular section will present data description and methodology adopted for this study.

3.1 Data

Secondary data was collected for this study from the period 1990 to 2020 from the world bank development Indicators (data.worldbank.org) and it is a univariate variable which was selected purposively based on its relevance in driving the production capacity of a country and contribution to the gross domestic product growth.

3.2 Methodology

The method of analysis applied for this study are summary statistics (by estimating the mean and standard deviation of the variable) and time series analysis using the unit root test and ARIMA model. EViews software version 11 was applied for the analysis of this study.

3.3 Variable measurement

The variable used for this research study is the Access to Electricity in Nigeria and it is measured in percentage (%).

3.4 Unit root test

The unit root test also called the stationarity and it implies that there should be absence of unit root for the variable or series to be stationary so as to prevent bottleneck of spurious results. The well-established hypothesis for unit root test can be stated as:
H_0: there is a presence of a unit root (series is not stationary) vs H_a: there is no unit root (the series is stationary). The ADF test can be presented mathematically as:

$$\Delta Y_t = \theta + \gamma Y_{t-1} + \sum_{i=1}^{p} \delta_i Y_{t-i} + u_t$$

Where, θ is a constant, γ is the coefficient of process root, δ_i coefficient in time tendency, p is the lag order and u_t is the disturbance (error) term. The Access to Electricity in Nigeria was considered for this study and when it is stationary, then further time series model like ARIMA will be applied.

3.5 Model specification

ARIMA model can be written in the form (p, d, q) which was developed from the combination of three building blocks, namely; p for Autoregressive (AR), d for Integration order term (I) and q for Moving Average (MA) for modeling the serial correlation in the disturbance. This means that ARIMA considers both the past values (AR) and the mean residuals of the error term (MA).
The general Autoregressive (AR (p)) of order p can be expressed below as:

$$y_t = p_1\mu_{t-1} + p_2\mu_{t-2} + \ldots\ldots + p_p\mu_{t-p} + \delta + \varepsilon_t \quad (1)$$

While MA (q) is specified as:

$$y_t = \mu_t + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \ldots\ldots - \theta_q\varepsilon_{t-q} \quad (2)$$

Therefore, ARMA (p, q) is given as:

$$y_t = p_1 y_{t-1} + p_2 y_{t-2} + p_p y_{t-p} + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \ldots\ \theta_q\varepsilon_{t-q} \quad (3)$$

Hence, ARIMA process of order (p, d, q) can be specify using backward shift operator as:

$$\Phi(B)\Delta^d y_t = \delta + \theta(B)\varepsilon_t \quad (4)$$

$$\Phi(B) = 1 - \varphi_1 B - \varphi_2 B^2 - \ldots\ldots - \varphi_p B^p \quad (5)$$

$$\text{And } \theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \ldots\ldots - \theta_q B^q \quad (6)$$

Where $\Phi(B)$ is the autoregressive operator while θ (B) is the moving average operator
However, ARIMA (p, d, q) can also be expressed as:

$$y_t = \sum^{p}_{i=1}\varphi_i y_{t-I} + \sum^{q}_{i=1}\theta_i e_{t-I} + e_t \quad (7)$$

4.Results and Discussion

This section is partitioned into two namely results of the analysis and the discussion of findings

4.1 Results

Table 1: Summary statistics

Access	
Mean	46.87845
Std. Dev.	7.817477
Skewness	-0.469590
Kurtosis	2.495697
Jarque-Bera	1.467827
Probability	0.480027
Observations	31

Source: Author's computation using EViews software

Table 1 shows that the average access to electricity in Nigeria grow by about 47% during the period under review with variability of about 8%. The kurtosis approximately 3 while the skewness approaches zero which indicate that the data is normally distributed. The Jarque-Bera probability also indicated that the data is normally distributed which satisfy the normality condition.

Table 2: Unit root test (Augmented Dickey Fuller)

Differenced Variables	Test statistic	P-value	Order
Access to Electricity	-4.856	0.0006	I (1)

Source: Author's computation using EViews software

Table 2 shows that Access to Electricity is statistically significant at 1% level at order one and that implies that it becomes stationary after the first difference of the series. This suggest that further time series analysis can be carried out.

Table 3: Results of estimated tentative ARIMA models of Access to Electricity in Nigeria

Model	No of significant Coefficients	Adjusted R-squared	Volatility (SIGMASQ)	Akaike Info Criterion (AIC)	Schwarz Criterion (SBIC)
ARIMA (1,1,1)	2	0.318	6.538	5.01	5.20
ARIMA (1,1,2)	2	0.308	6.633	5.03	5.21
ARIMA (1,1,3)	2	0.201	7.657	5.16	5.34
ARIMA (1,1,6)	3	0.348	6.24	5.00	5.20

Source: Author's computation using EViews software

Table 3 shows that ARIMA (1,1,6) has the highest no of significant coefficients, highest adjusted R-squared, lowest volatility, as well as lowest AIC and SBIC compared to the other tentative ARIMA models of ARIMA (1,1,10, ARIMA (1,1,2), and ARIMA (1,1,3). This suggest that ARIMA (1,1,6) is the bested fitted ARIMA model to predict the future trend of Access to Electricity in Nigeria.

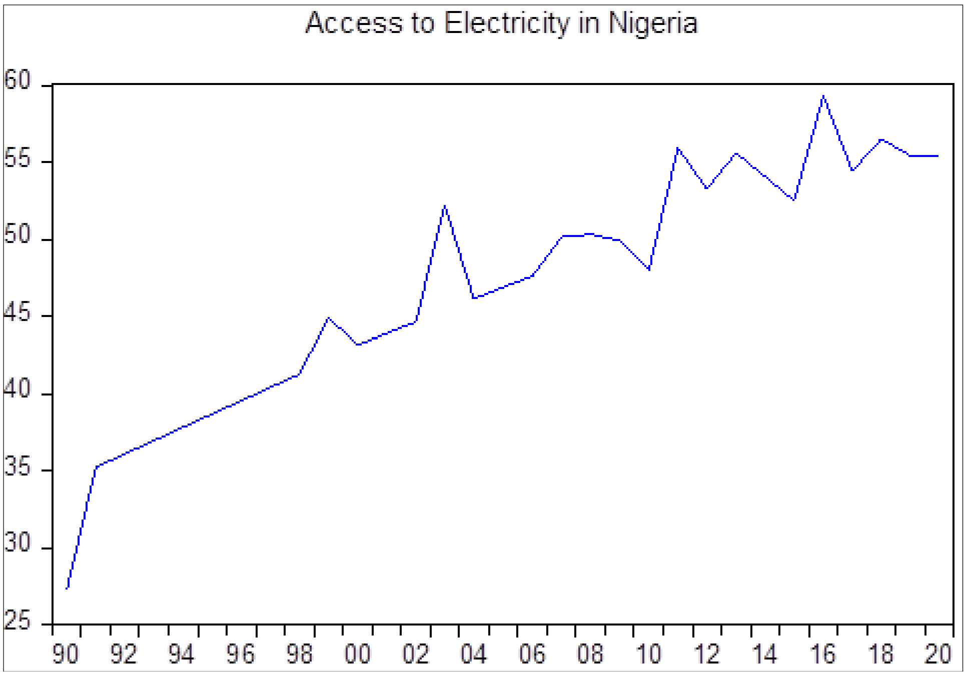

Fig 1: Graphical representation of Access to Electricity in Nigeria

Figure 1 shows the graphical representation of Access to Electricity pattern in Nigeria from period of 1990 to 2020 and we can see that there is irregular and sluggish growth in access to electricity while the country experienced highest Access to Electricity growth in 2002.

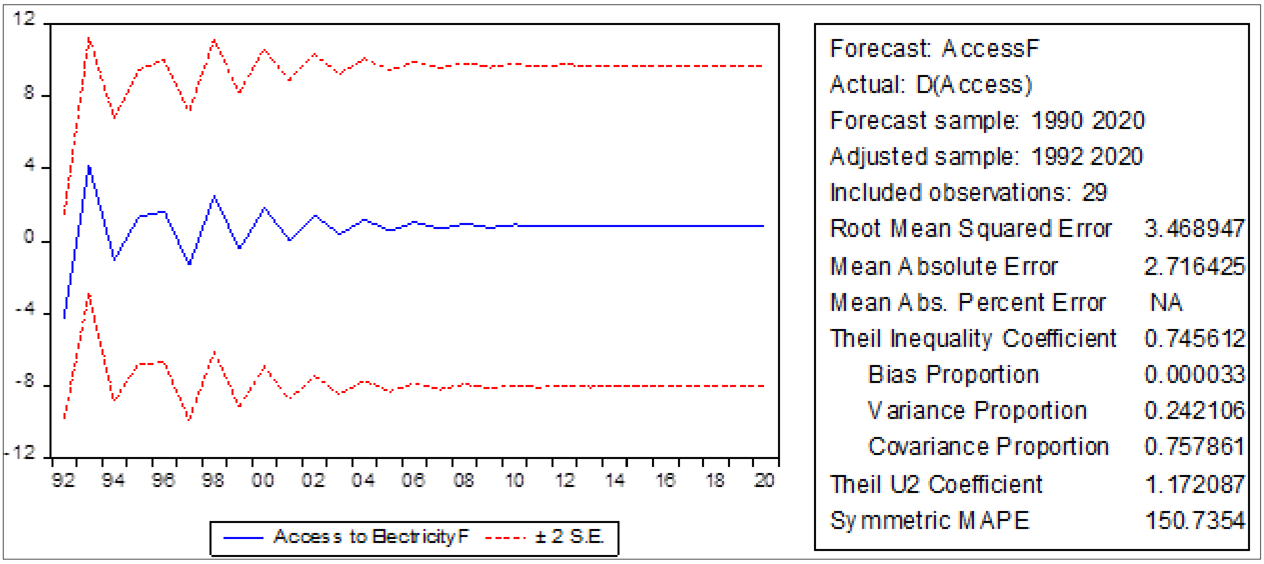

Fig 2: Predicting Access to Electricity with Best ARIMA (1,1,6) within the given period

Figure 2 shows the forecasting of the fitted ARIMA (1,1,6) model within the given period and we can see that the forecasted value fall between the two 95% confidence interval and this implies that the forecast is stable, reliable and good. Hence, the need for future forecast.

Table 4: Predicting Access to Electricity in Nigeria from 2021 to 2030

Year	Access to Electricity Forecast
2021	59.8935
2022	60.707
2023	61.5204
2024	62.3339
2025	63.1473
2026	63.9608
2027	64.7742
2028	65.5876
2029	66.4011
2030	67.2145

Table 4 shows the table of future forecast of Access to Electricity in Nigeria from 2021 to 2030 and we can see that there is a gradual and positive increase in the forecasted value within the 10 years forecast.

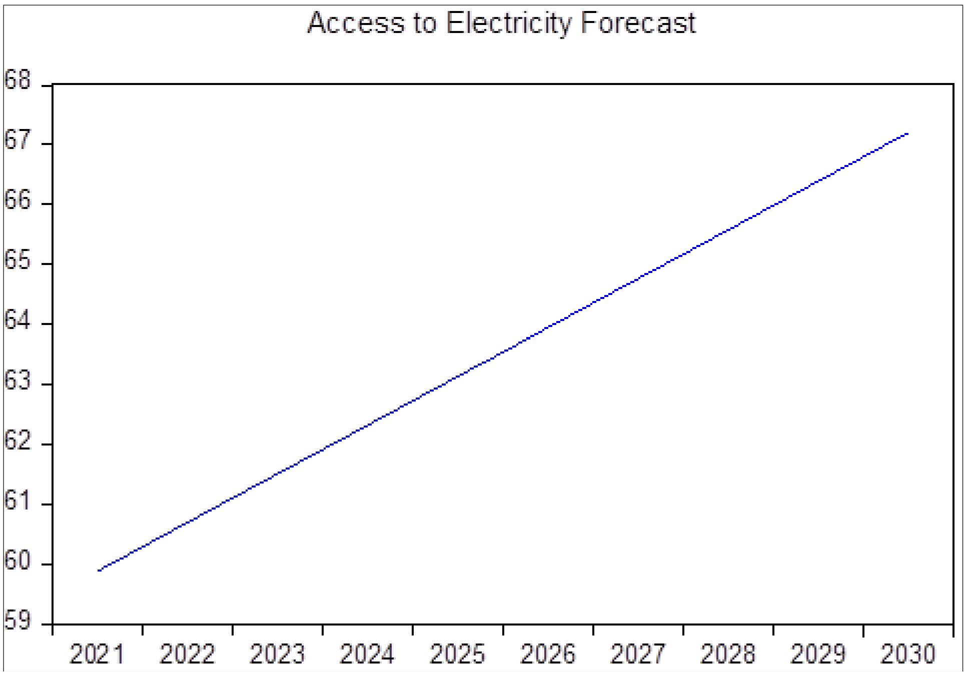

Fig 3: Graph of Access to Electricity prediction from 2021 to 2030 in Nigeria

Figure 3 shows that graph of Access to electricity prediction for 10 years spanning from 2021 to 2030 indicated an upward trend pattern towards the year 2030 which is the targeted period of united nations sustainable development goal. This suggest that there is very better likelihood for Nigeria to meet up the sustainable development goal if the government of Nigeria can adopt an alternative option to Access to Electricity.

4.2 Discussion of findings

As a result of the analysis of this study, the notable findings are discussed below.

The unit root test was applied and it shows that Access to Electricity becomes stationary after the first difference and this makes it qualify for further time series analysis.

The autoregressive integrated moving average (ARIMA) model shows that ARIMA (1,1,6) is the best selected ARIMA model among the other tentative ARIMA models because it has the highest no of significant coefficients, highest adjusted R-squared, lowest volatility, as well as lowest AIC and SBIC.

Meanwhile, the 10 years graphical forecast of the Access to Electricity in Nigeria from 2021 to 2030 indicated an upward trend pattern towards the year 2030 which is the targeted period of the united nations sustainable development goal. This suggests that there is a very better likelihood for Nigeria to meet up the sustainable development goal if the government of Nigeria can adopt an alternative option to Access Electricity.

5. Conclusion and Policy implication

Access to electricity is a key element of energy security and it has the potential ability to ensure the smooth running of any industries, businesses, and private companies as well as attract foreign investors which will increase the production capacity of the country and deliver better economic growth.

The sole objective of this study is to predict Access to Electricity in Nigeria using the most suitable ARIMA model. The ARIMA (1,1,6) is the best selected ARIMA model among the other tentative models because it has the highest no of significant coefficients, highest adjusted R-squared, lowest volatility, and lowest AIC and SBIC. The future forecast upward trend pattern towards the year 2030 shows that Nigeria can improve its Access to Electricity in the future based on the future trend forecast result by the fitted ARIMA (1,1,6) model.

Consequently, the Nigeria government need to develop an efficient energy policy to meet up with the united nation development goal target that will ensure that all the developing nations including Nigeria will have access to affordable, reliable and sustainable energy security in terms of access to sustainable electricity that will drive the economic growth and development in Nigeria.

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Appendix

Null Hypothesis: D(ACCESS to Electricity) has a unit root			
Exogenous: Constant			
Lag Length: 3 (Automatic - based on SIC, maxlag=7)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.856404	0.0006
Test critical values:	1% level	-3.711457	
	5% level	-2.981038	
	10% level	-2.629906	