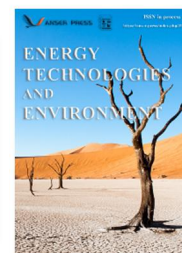




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## Macroeconomic Drivers of Electricity Prices in Nigeria

Mansur Bala <sup>a,\*</sup>, Nasir Ahmad Moyi <sup>a</sup>, Umar Muhammad Gummi <sup>a</sup>

<sup>a</sup> Department of Economics, Sokoto State University, Sokoto, Nigeria

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### ABSTRACT

Electricity price volatility in developing economies, particularly Nigeria, presents a significant challenge to sustainable development. In this paper, we examine the macroeconomic drivers of electricity prices (ELP) in Nigeria based on annual data spanning 1980-2022 and the autoregressive distributed lag (ARDL) procedure. Our model estimates the long-run and short-run impacts of population growth (PG), economic growth (GDP), crude oil price (COPR), and electricity consumption (ELC) on electricity prices (ELP). The empirical findings reveal a positive and long-run effect of PG on ELP, indicating that rising demand from a growing population increases electricity prices. In the short-run, ELC surprisingly co-moved with ELP, which may be attributable to price-sensitive demand within specific consumer segments or periods. Furthermore, GDP and COPR exert positive effects on ELP, indicating that economic growth drives energy consumption and prices, and the cost-driven impact of fossil fuel dependence in electricity generation. These findings shed light on the complex interplay of demographic, economic, and energy market-related forces driving electricity prices in Nigeria. Therefore, the paper proposes some policy suggestions based on the empirical findings.

### KEYWORDS

Electricity Price; Gross Domestic Product; Population Growth; Crude Oil Price; Electricity Consumption; Autoregressive Distributed Lag Model.

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\* Corresponding author: Mansur Bala  
E-mail address: [mansurbala1996@gmail.com](mailto:mansurbala1996@gmail.com)

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## 1. Introduction

Electricity markets have been increasingly liberalised in many nations over the past few decades, to the point where supply and demand largely decide electricity pricing. Given its unique qualities compared to other traded commodities, electricity exhibits unique pricing behaviour. Specifically, electricity is a flow commodity because it can hardly be stored (Knittel & Roberts, 2015). Therefore, the price of electricity fluctuates a lot more than the price of other energy products, posing a danger to market participants. According to Longstaff and Wang (2004), other unique characteristics of electricity include varying degrees of seasonality, price increases, mean reversion, and the likelihood of negative pricing. Therefore, there is no practical way to store electricity; however, maintaining a steady equilibrium between production and consumption is necessary to maintain the stability of the power system (Harris, 2006, Kirschen, & Strbac, 2004). Electricity prices are difficult to predict. In addition to volume risk, market participants face the risk of price change (Eydeland & Wolyniec, 2003; Weron & Misiorek, 2008). Thus, fluctuation in electricity pricing has increased the necessity for econometric models that can capture the varied nature of these prices. Practically speaking, electricity pricing models are essential for risk management, and forecasting. Several studies, including those by Zareipour (2012), Karakatsani and Bunn (2004), and Weron (2006), have investigated dynamic models for electricity pricing for forecasting purposes. Some researchers, nevertheless, concentrate on forecasting the sporadic sharp increases in electricity prices. The daily average price is the focus of most electricity price models and related forecasting studies.

Furthermore, most literature so far has been on wholesale electricity price forecasts because of the relatively inelastic demand and the inability of electricity to be stored efficiently enough to allow for inter-temporal load balancing and extremely substantial price variation results. Therefore, both academics and practitioners have focused on a great deal of interest on estimating the extent and probabilities associated with these dramatic price swings. Researchers are becoming more aware of the increasing price fluctuations in the electricity markets, and these so-called "extreme price swings" are seen as a symbolic aspect of these markets (Engle & Patton, 2007; Zareipour, Bhattacharya, & Canizares, 2007; Knittel et al., 2015; Xiao, Colwell, & Bhar, 2015; Hadsell, Marathe, & Shawky, 2004).

However, there is a dearth of literature on the dynamics of the electricity market and price fluctuations in Nigeria. The rising electricity prices in Nigeria may be both advantageous and disastrous depending on the prevailing market situation and the driving force behind price fluctuations. According to Ralf, Stan, and Vlad (2007), electricity prices can spike sharply during times of market stress to the point where retailers are unable to pass these high charges on to customers due to retail price regulation. Therefore, the current study empirically examined the macroeconomic drivers responsible for electricity price fluctuations in Nigeria using the ARDL approach and annual data spanning from 1980 to 2022. Consequently, the study seeks to address the following research questions:

- What is the long-run effect of population growth on electricity prices in Nigeria?
- How does the Gross Domestic Product (GDP) influence electricity prices in Nigeria?
- What impact does electricity consumption have on electricity prices in Nigeria?
- How does crude oil price influence electricity prices in Nigeria?

In addressing these critical questions, this study achieves the following objectives:

- Determine the long-run effect of population growth on electricity prices in Nigeria
- Determine the influence of Gross Domestic Product (GDP) on electricity prices in Nigeria
- Evaluate the impact of electricity consumption on electricity prices in Nigeria
- Assess the influence of crude oil prices on electricity prices in Nigeria.

This research contributes significantly to understanding electricity price dynamics in Nigeria. By quantifying the long-term effects of key variables, policymakers and stakeholders gain valuable insights to predict and manage future price fluctuations. Moreover, this study identifies opportunities for short-term adjustments and sheds light

on the complex relationship between economic growth and electricity costs. Finally, unexpected findings serve as springboards for further research, fostering a deeper understanding of electricity pricing mechanisms in Nigeria.

## 2. Literature Review

This section is designed to provide an in-depth review of the relevant and related literature to the current study. Thus, this section is segmented into three parts: Conceptual review, theoretical framework, and empirical review.

### 2.1. Clarification of Concepts

#### 2.1.1. Concept of Electricity

Electricity is a controllable energy source that may be used for power, heat, and light. (Umar, Mathias, & Praisad, 2022). Another definition of electricity is a collection of events brought about by the presence, interaction, and mobility of electric charges that are produced from kinetic or potential energy (Oiol, 2019). Economically speaking, electricity is a non-storable good; therefore, maintaining a balance between its supply and demand is extremely difficult and constantly precarious. (Girish & Vijayalakshmi, 2013).

#### 2.1.2. Concept of the Electricity Price

Electricity prices typically reflect the cost of developing, financing, operating, and maintaining power plants and electricity grids [EIA], (2022). The price of electricity varies significantly between countries and between cities within countries. A few factors that affect the price of electricity are the cost of producing the energy, government taxes or subsidies, CO2 charges, local weather patterns, infrastructure for transmission and distribution, and multi-tiered industry regulation (Girish et al., 2013). Depending on the client base, which comprises domestic/residential, commercial, and industrial use, the pricing or tariffs may also vary. Electricity prices are dynamic; in competitive power markets, even slight variations in the quantity of electricity generated or in demand can result in significant fluctuations in pricing within a few hours (Girish et al., 2013).

### 2.2. Theoretical Framework

Understanding electricity prices in Nigeria requires consideration of two key economic theories: price theory and cost theory

#### 2.2.1. Theory of Price

Price theory proposes that market forces of supply and demand ultimately determine the equilibrium price of any good or service. It is a microeconomic idea that asserts that the market's forces of supply and demand determine the fair price point for a particular good or service at any given moment (Caroline, 2022). This theory has been largely attributed to the father of classical economics Adam Smith (1776), who first distinguished price into natural and market price (Sule, 2005). While customers prefer to pay as little as possible for products and services, producers charge as much as they can fairly for them. These opposing forces find balance at a point where the quantity supplied meets the quantity demanded. This concept allows for price adjustments as market conditions evolve.

Market forces, as described by price theory, directly influence electricity price fluctuations in Nigeria. The equilibrium price point continuously adjusts to balance supply and demand. Increased demand, driven by factors such as population growth or economic activity, leads to upward pressure on prices. Conversely, low demand

during off-peak seasons or economic downturns creates downward pressure. These fluctuations align with the classical economic model, highlighting the dynamic interplay between consumer preferences and resource allocation.

### 2.2.2. Theory of Cost

Determining the cost of a good or service is a difficult task. It is governed by several additional things.

Cost theory highlights the factors influencing the cost of producing a good or service. These factors include raw materials, labour, overhead, and production methods. Cost theory emphasises how production costs ultimately impact a firm's pricing decisions. Cost theory derives its origin from the classical views of David Ricardo in the 1970s, when he introduced the relative cost of a commodity as a determinant factor of its price (Sule et al., 2005).

Electricity market prices are also intricately linked to cost theory. Production costs, which encompass fuel, maintenance, and infrastructure, significantly impact pricing decisions. Fluctuations in global fuel prices, particularly for gas and coal, have a direct impact on Nigerian electricity generation costs. Additionally, inefficiencies in transmission and distribution infrastructure can escalate costs, further influencing price variations. Understanding these cost dynamics and their sensitivity to external factors is crucial for predicting and managing price fluctuations.

Although both theories are applicable to the Nigerian electricity market, price theory has the most significant influence. Market forces of demand and supply, driven by private sector actors; largely dictate the price of electricity. Consumer demand fluctuates seasonally and is influenced by economic factors. On the supply side, generation capacity, fuel costs, and operational expenses determine the overall cost of electricity production. These competing forces of demand and cost, both pushing and pulling, influence the market price of electricity, ultimately guiding it towards its equilibrium point.

## 2.3. Empirical Review

The following are some empirical studies that investigated the important factors that influence the electricity prices in Nigeria and other countries:

Goutam and Krishnendranath (2017) reviewed the literature on a range of subjects related to dynamic electricity pricing and made a list of potential areas for future study in the areas of market segmentation, pricing strategies, and customer willingness to pay. The study found that in dynamic electricity pricing situations, demand and price forecasting are crucial for setting prices and allocating load. They also discovered that to set limits on prices based on customer demand and the demand response curve, consumers' willingness to pay for power services is also essential. Additionally, it is proposed that optimizing electrical load scheduling improves customer responsiveness to dynamic tariffs.

During a period of profound sector upheaval, Patrícia and Cerqueira (2017) evaluated the primary factors influencing the electricity prices of households in the European Union (EU). They compared the long-term trends in prices of households' electricity across the EU with the EU energy policy course and offered empirical evidence on the factors influencing these trends, all based on Eurostat data. They used the General Method of Moments (GMM) proposed by Blundell and Bond (1998) with the Windermeyer (2005) correction, utilising a first-hand approach based on a dynamic model with panel data. The study provides evidence that the liberalisation of the industry is accompanied by a downward trend in prices, which aligns with the liberalisation goals of the European Commission.

Nagayama (2007) investigated how each policy tool of the reform measures affected electricity prices for countries in Latin America, the former Soviet Union, and Eastern Europe using panel data for 83 countries covering the years 1985–2002. The study's findings indicated that lower electricity prices are not always the outcome of

unbundling and the development of a wholesale pool market. Nonetheless, he contended that unbundling might help lower electricity prices if it occurs in tandem with an independent regulator.

Erkan (2011) investigated how the power industry's reforms affected the price-cost margins for both residential and commercial electricity, as well as how much cross-subsidy was provided to different consumer categories. Based on panel data spanning 63 developed and developing nations between 1982 and 2009, the study's conclusions imply that the overall influence of the reform process on price-cost margins and cross-subsidy levels does not follow a consistent pattern. For every consumer and country group, the effects of each reform step vary in terms of price-cost margins and cross-subsidy levels. Therefore, the study concludes that transferring the formal and structural elements of a successful power market from a developed nation to a developing nation is insufficient to ensure that the electricity industry in developing nations functions profitably. Additionally, the study indicates that other significant factors influencing electricity price-cost margins and cross-subsidy levels include power consumption, income level, and nation-specific characteristics.

Steiner (2001) investigated the effects of energy market reform on final electricity prices using panel data for 19 OECD countries spanning 1986–1996. Factors in her analysis, included reserve margin, capacity utilisation rate, industrial-to-residential electricity price ratio, and electricity price. The analysis shows that the former group benefits more from the reform than the latter because changes to the energy market usually result in a fall in the industrial price and an increase in the price differential between residential and industrial consumers. Additionally, she discovered that unbundling is linked to lower reserve margins, better capacity utilisation rates, and a lower industrial-to-residential pricing ratio rather than cheaper prices.

In a 2013 study, Girish and Vijayalakshmi examined the variables influencing the electricity prices in markets with intense competition. The paper discusses stylised facts about electricity markets as well as the problem of pre-processing approaches for electricity spot prices that are employed in the literature. The study encourages and motivates business owners to think about the power trading sector, which was once a haven for technical expertise but now includes consumers from every sphere of life. This is particularly true given the rise in the number of financial professionals drawn in by deregulation, the opening of the electricity market to the public, and the introduction of international power/energy exchanges.

Sonal, Deepankar, and Hiranmoy (2020) examined the factors influencing electricity from India's perspective. From August 2008 to June 2017, a descriptive study was carried out to determine the main causes of spikes and jumps in the day-ahead market (DAM) prices for all five zones (north, south, east, west, and northeast) of the Indian energy exchange. The study revealed that the primary determinants of DAM pricing are regulatory frameworks, meteorological conditions, fuel availability, transmission bottlenecks, power plant outages or new plant startup frequency, and reservoir levels. The study challenges the interested parties to develop pricing models and forecasts and to use strategies for profit maximisation.

In their 2019 study, Kun Li, Yunchuan, and Zizheng examined how extreme prices influence price changes in the electricity market. As part of a two-stage analysis, they constructed a principal component analysis (PCA) and a nonlinear autoregressive distributed lag model (NARDL). They find that PCA asserts that spike prices are the components with the most explanatory capacity to explain price variance in individual transmission lines, whereas NARDL maintains that negative prices have a greater likelihood of having an impact on the forward and real-time markets. Managers and operators in the electricity markets might considerably benefit from these discoveries in making policy decisions.

A time-varying-probability Markov-switching model of Queensland power prices was developed by Ralf et al. (2007) to better predict price spikes. The study utilised variables that capture weather changes and demand patterns. Unlike standard Markov-switching models that assume the normality of the prices in each state, their

model uses a generalised beta distribution to account for the skewness in the distribution of electricity prices during high-price episodes.

An empirical examination of the factors influencing power costs was carried out by Blanca, AnaJ, and María Teresa (2012). They created econometric panel models to investigate the correlation between variables about renewable energy sources, the competitiveness in the electricity generation sector, and household power prices. More precisely, they used of a panel data collection that was made available by Eurostat and included data from 27 EU member states between 1998 and 2009.

The results indicate that, given the existence of a CO<sub>2</sub> emission trading mechanism within the European Union, the deployment of renewable energy sources and the growth of greenhouse gas emissions from the energy industry both result in higher power prices. The findings also show that the features of a nation can influence the cost of residential electricity.

With an emphasis on the German power markets, Stephanía and Anjali (2019) evaluated the factors influencing electricity pricing in the spot and futures markets. The study used threshold regressions and structural breaks to account for nonlinearities in electricity price fluctuations. The study discovered that more significantly, pricing drivers fluctuate over time and that they are different in the short-, medium-, and long-term. Whereas natural gas, coal, and carbon pricing are the primary drivers in the futures market, renewable energy sources, and power demand are the factors that determine prices in the spot market. The findings provide useful information to market players looking to maximise their spot market procurement and selling tactics and use futures to protect themselves from the increasing volatility of spot prices caused by a rise in renewable energy generation.

Ologbenla (2021) used the price of premium motor spirits (PMS) in Nigeria from 1980 to 2020 to investigate the factors influencing domestic petroleum pricing. The autoregressive distributed lag model was used to analyse the data. The data used in the study spans the years between 1980 and 2020. The study's findings, which are statistically significant at the 5% level of significance, indicate a positive association between inflation and the gas pump prices. The study also found that the main factors influencing Nigeria's domestic energy prices are the country's oil imports and output. The study indicated that Nigeria should maintain its refineries to avoid the high cost of selling the product in Nigeria by refining it abroad instead of having to export it. Additionally, the study indicated diversifying the economy to focus more on the actual sectors, which will increase the amount of commodities available for export and improve the balance of payments.

### 3. Materials And the Method

#### 3.1. Data Description

Data for this study were obtained from a secondary source. The data for electricity price (ELP), population growth (PG), gross domestic product (GDP), and electricity consumption (ELC) were obtained from the Energy Information Administration [EIA], (2022). The data for crude oil price (COPR) was obtained from the Central Bank of Nigeria [CBN], (2022). The analysis covers the period spanning 1980 to 2022. The choice of the period is intended due to fluctuations seen in electricity prices in Nigeria in the period, which makes it very interesting to examine the driving factors responsible for dynamic trends in the electricity prices in the country. This is evident from the fluctuation in the prices of electricity metres on a timely basis. It has been documented that the Nigerian government has been raising the price of electricity metres, both single-phase and three-phase. In 2021, for example, the price of a single-phase metre was revised from N44,896.17 to N58,661.69, and the price of a three-phase metre was revised from N82,855.19 to N109,684.36 (NERC, 2021). Additionally, the share of the population with access to electricity in Nigeria is not stable. From 2018 to 2021, the share of the population with access to

electricity in Nigeria was 56.5%, 55.4%, 55.4%, and 59.5%, respectively (Doris, 2023). This was how the fluctuation was even before this period.

### 3.2. Variables Description

**Electricity price (ELP):** This variable is measured based on the annual electricity price. The data specifically for Nigeria are not available. Hence, the average value of international electricity prices is used for Nigeria.

**Population Growth (PG):** It measures the percentage of annual population growth of the residents of Nigeria.

**Gross Domestic Product (GDP):** This is measured on the basis of total monetary value of all final goods and services produced annually in Nigeria.

**Crude Oil Price (COPR):** This is simply measured on the basis of the total sum of annual prices of crude oil sold by Nigeria.

**Electricity Consumption (ELC):** This measures the amount of electricity consumed annually during the transmission and distribution process. It is measured in kilowatt quantities.

Several studies such as Patrícia et al., (2017); Nagayama et al., (2007); Goutam et al., (2017); Steiner et al., (2001); Sonal et al., (2020); and Blanca et al., (2012) attempted to identify the variables that determine the electricity prices such as electricity sector liberalisation, electricity policy instruments, electricity demand, consumers' willingness to pay for electricity, electricity industry reforms, renewable energy sources, and greenhouse gas emissions. However, this study considered variables such as population growth, GDP, crude oil price, and electricity consumption.

The selection of these variables is justified by their theoretical relevance and supporting empirical evidence from previous studies within and outside the Nigerian context.

First, understanding the impact of population growth on electricity prices requires acknowledging its influence on demand. As Nigeria's population expands, electricity demand naturally increases. This increased demand can put pressure on existing generation capacity, leading to potential price hikes to incentivize reduced consumption or encourage investments in expanding capacity. This theoretical association aligns with findings from Patrícia et al., (2017), who observed a positive correlation between population density and electricity prices in the European Union. While studies directly examining the Nigerian context are scarce, the theoretical foundation and international evidence make population growth a crucial variable in understanding price dynamics.

Second, the relationship between economic growth and electricity prices is multifaceted. On the one hand, GDP growth can signify increased industrial activity and higher electricity consumption, potentially leading to price increases. However, economic prosperity may enable investments in efficient generation technologies and infrastructure upgrades, potentially moderating price hikes. Additionally, government policies implemented during economic growth phases can further influence pricing mechanisms. Steiner et al., (2001) found that energy market reforms often result in an industrial price reduction and an increased residential-industrial price differential. However, the specific impact of GDP on electricity prices in Nigeria requires further investigation, considering its unique economic structure and policy landscape.

Third, the relationship between electricity consumption and price is complex and can vary depending on several factors. High consumption can strain the generation capacity, leading to price increases to manage demand. Conversely, low consumption might result in underutilized capacity and potential price hikes to recover fixed costs. Additionally, the pattern of consumption (e.g., peak vs. off-peak) can significantly impact pricing strategies. Sonal et al., (2020) identified demand patterns as a key determinant of DAM pricing in India. Analysing electricity consumption in Nigeria will help understand its specific influence on price fluctuations, considering factors such as generation mix, grid capacity, and pricing structures.

Finally, Nigeria's heavy reliance on oil-fired power plants makes crude oil prices a critical cost factor directly impacting electricity generation costs. Fluctuations in oil prices can translate into changes in generation costs, ultimately affecting electricity prices for consumers. This theoretical link is further supported by Ologbenla et al, (2021), who found a positive relationship between crude oil prices and domestic energy prices in Nigeria. Understanding the dynamics of this relationship is crucial for predicting and managing electricity price variations in a nation heavily dependent on oil-based generation.

This study acknowledges that the selected variables interact and their influence on electricity prices can be non-linear. Moreover, the limitations of existing research in the Nigerian context necessitate further investigation. Despite these considerations, the chosen variables provide a robust foundation for analysing electricity price fluctuations in Nigeria, paving the way for a more comprehensive understanding of this complex phenomenon.

The choice of these is informed by their historic influence on Nigerian electricity as explained in module 3.1 of this section.

### 3.3. Model Specification

The ARDL model was used for this study because it is a reliable econometric method for estimating the level of relationship between a set of independent and dependent variables, even if they are not integrated in the same order. The advantage of ARDL bound testing is that it does not require pretesting, unlike the unit root test. However, unit root testing will still be required to ensure that none of the variables are 1(2) because the combination of the series order cannot exceed 1(1) for the estimation to be considered valid.

To measure the unit properties of the series, this study adopts both the Augmented Dickey Fuller (ADF) unit root test and the Phillips Perron Test to confirm the unit properties of the series. These tests are used to check the problem of non-stationary or unit roots in the series variables. The ADF is given as:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum \alpha_i \Delta y_{t-1} + \mu_i \quad (1)$$

Where  $\Delta y_t$  is the variation in  $y$  at period  $t$ ,  $\alpha_0$  represents constant,  $y_{t-1}$  is the past value of  $y$ ,  $\alpha_1$  is the estimated lag coefficients and  $\mu_t$  is the error term.

On the other hand, Phillips and Perron (1988) established the Phillips-Perron test. When there is a serially correlated error, the PP test adjusts the test statistics so that no further lags of the dependent variable are required. One of the best things about the PP test, as mentioned by Mahadeva and Robinson (2004), is that it is a non-parametric test, meaning it may be used for a very broad range of situations because it presupposes no efficient form for the variable's error process. The Phillips and Perron's (1988) model is specified as follows:

$$\Delta y_t = \beta D_t + \lambda y_{t-1} + \mu_t \quad (2)$$

Where  $y_t$  is the series variable,  $\beta$ , and  $\lambda$  are the parameters,  $D_t$  is the vector of the deterministic terms (constant and trend),  $\Delta$  is the difference operator,  $y_{t-1}$  is the previous value of a series,  $\mu_t$  is the error term while  $t$  time trend within the study period.

In addition, the study started the analysis by running an ARDL-bound co-integration test to determine whether long-run relationships existed. The calculated F-statistics are compared with the tabulated critical value. If the F-statistics is higher than the upper critical value, the null hypothesis—that there is no long-term relationship—will be rejected; if it is lower than the lower critical value, the null hypothesis cannot be rejected; and if it is in between these two critical bounds, the outcome is inconclusive (Pesaran, Smith, and Shin, 2001).

Thus, the functional specification of the model following Ologbenla et al., (2021) and Girish et al, (2013) with some modifications is expressed as follows:

$$ELP = f(PG, GDP, COPr, ELC) \quad (3)$$

This equation can be transformed into an econometric equation as follows:

$$ELP_t = \beta_0 + \beta_1 PG_t + \beta_2 GDP_t + \beta_3 COPr_t + \beta_4 ELC_t + \mu_t \quad (4)$$



Where: ELP=Electricity Price, PG=Population Growth, GDP=Growth Domestic Product, COPR=Crude Oil Price, ELC=Electricity Consumption,  $\beta_0$ =Constant,  $\beta_{(1-4)}$ =Estimation parameters,  $\mu$ =Stochastic variable,  $\beta_0>0, \beta_1>0, \beta_2>0, \beta_3>0, \beta_4>0$ .

Thus, the autoregressive distributed lag form of the model based on the notations of the variables in equation (3.3) is specified as follows:

$$ELP_t = \beta_0 + \sum_{i=1}^k \beta_1 \Delta ELP_{t-i} + \sum_{i=1}^k \beta_2 \Delta PG_{t-i} + \sum_{i=1}^k \beta_3 \Delta GDP_{t-i} + \sum_{i=1}^k \beta_4 \Delta COPR_{t-i} + \sum_{i=1}^k \beta_5 \Delta ELC_{t-i} + \alpha_1 ELP_{t-1} + \alpha_2 PG_{t-1} + \alpha_3 GDP_{t-1} + \alpha_4 COPR_{t-1} + \alpha_5 ELC_{t-1} + u_{1t} \tag{5}$$

Where  $(\beta_1 - \beta_5)$  and  $(\alpha_1 - \alpha_5)$  are the long run and short run multipliers respectfully,  $\beta_0$  is the drift and  $u_{it}$  = is the stochastic error term.

Pesaran et al., (2001) identified that the ARDL model is divided into two parts; the first part of the model with  $\beta_1$  to  $\beta_5$  represents the short-run, while the parameters  $\alpha_1$  to  $\alpha_5$  are the long-run part of the model. In an attempt to test the hypotheses, the null hypothesis of the ARDL model is expressed as  $H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$  which means that there is no long-run relationship among the variables. On the other hand, the alternative hypothesis is stated as  $H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5$  which indicates the existence of a long-run relationship among the variables.

In addition, the error correction model of the ARDL is specified to determine the speed of adjustment from the short-run to the long-run equilibrium. The ECM model of ARDL is given as:

$$\Delta ELP_t = \beta_1 + \sum_{i=1}^m \beta_1 \Delta ELP_{t-i} + \sum_{i=1}^m \beta_2 \Delta PG_{t-i} + \sum_{i=1}^m \beta_3 \Delta GDP_{t-i} + \sum_{i=1}^m \beta_4 \Delta COPR_{t-i} + \sum_{i=1}^m \beta_5 \Delta ELC_{t-i} + \beta_0 ECM_{t-1} + \mu_t \tag{6}$$

Where:  $ECT_{t-1}$  is the error correction term which is the lagged value of the residuals obtained from a cointegrating regression of the dependent variable on the regressors.  $u_{it}$  is the stochastic error term.

As the establishment of co-integration among the variables is simply a required but not sufficient condition, we tested for the stability of the model after obtaining the short-run parameters. Therefore, we used the cumulative sum and cumulative sum of squares (CUSUM and CUSUMQ), a stability test developed by Brown et al. (1975).

Lastly, diagnostic tests such as heteroskedasticity (Breusch-Pagan Godfrey), serial autocorrelation (Breusch-Godfrey LM) test, and normality (Jarque-Bera) test were examined to assess the robustness of our findings.

## 4. Results and Discussion

### 4.1. Descriptive Statistics

**Table 1.** Descriptive statistics of variables.

|             | ELP      | PG       | GDP      | COPRI    | ELC      |
|-------------|----------|----------|----------|----------|----------|
| Mean        | 7.959070 | 133642.9 | 543.2721 | 79.92180 | 14.74994 |
| Median      | 6.890000 | 126153.0 | 379.8000 | 74.96250 | 11.72700 |
| Maximum     | 12.49000 | 218541.0 | 1067.300 | 121.8700 | 27.95516 |
| Minimum     | 4.700000 | 72951.00 | 8.6000   | 41.89000 | 4.685000 |
| Std. Dev.   | 2.012661 | 43561.91 | 297.0251 | 25.00118 | 7.972408 |
| Skewness    | 0.361456 | 0.385177 | 0.563045 | 0.196003 | 0.386805 |
| Kurtosis    | 1.902422 | 1.931435 | 1.677030 | 1.593354 | 1.577810 |
| Jarque-Bera | 3.094708 | 3.109034 | 5.407840 | 3.820411 | 4.696130 |

|              |          |          |          |          |          |
|--------------|----------|----------|----------|----------|----------|
| Probability  | 0.212810 | 0.211291 | 0.066943 | 0.148050 | 0.095554 |
| Sum          | 342.2400 | 5746645. | 23360.70 | 3436.638 | 634.2475 |
| Sum Sq. Dev. | 170.1338 | 7.97E+10 | 3705403. | 26252.48 | 2669.490 |
| Observations | 43       | 43       | 43       | 43       | 43       |

Source: Authors' computation using EViews 10.

A descriptive statistics summary of all our variables is shown in Table 1. The table showed that "Electricity Price," "Population Growth," "Growth Domestic Product," "Crude Oil Price," and "Electricity Consumption" have average means that are positive. This demonstrates that during the study period, all variables increased. The three variables with the highest standard deviation are as follows: Population Growth (PG), Growth Domestic Product (GDP), and Crude Oil Price (COPR). This implies that these variables have higher levels of variability than any other variable in the distribution. Electricity price, on the other hand, was found to have the lowest standard deviation (2.012661), closely followed by electricity consumption (7.972408), which explains why its variation was so negligibly small during the study period. The skewness of zero indicates a perfect normal distribution. The skewness of above or below zero indicates the thick tail abnormal distribution of the variables. The table, therefore, shows that all the variables: "Electricity Price", "Population Growth," "Growth Domestic Product," "Crude Oil Price," and "Electricity Consumption" are almost perfectly distributed. This gives the idea that the data used in this study does not suffer from abnormality problems in the distribution of the variables across the study period. The value of Jarque-Bera, as indicated in the table, also confirms the normality distribution of our variables. This is because the values of the Jarque-Bera are greater than 0.05. The table shows that the probability values are low for all variables, and the means are nearly equal to the medians, hence we conclude that the residuals for the distribution are normally distributed.

#### 4.2. Stationary Test

**Table 2.** Unit Root Test Results.

| Variables   | Augmented Dickey-Fuller |                |          | Phillips-perron test |                |          | Order |
|-------------|-------------------------|----------------|----------|----------------------|----------------|----------|-------|
|             | Test statistic          | Critical value | P-values | Test statistic       | Critical value | P-values |       |
| <i>ELP</i>  | -3.24233                | -2.93500       | 0.0245   | -3.2775              | -2.935001      | 0.0225   | 1(1)  |
| <i>PG</i>   | -1.66862                | -3.54032       | 0.7444   | -3.3450              | -3.523623      | 0.0733   | 1(1)  |
| <i>GDP</i>  | -3.74713                | -3.52362       | 0.0301   | -3.7471              | -3.523623      | 0.0301   | 1(1)  |
| <i>COPr</i> | -3.13294                | -2.93315       | 0.0316   | -3.2086              | -2.933158      | 0.0264   | 1(0)  |
| <i>ELC</i>  | -8.00714                | -3.52362       | 0.0000   | -7.9075              | -3.523623      | 0.0000   | 1(1)  |

Source: Authors' computation using EViews 10.

The stationarity of the variables is a necessary condition to be met before a time series analysis can be conducted. This is to avoid spurious regression, which gives invalid and biased results. To ensure that all variables are stationary, the techniques of the Augmented Dickey-Fuller and Phillips-Perron tests were conducted and are presented in Table 2. It is clearly shown in the table that all four variables ("Electricity Price," "Population Growth," "Growth Domestic Product," and "Electricity Consumption") are stationary at first difference 1(1). Only "Crude Oil Price," is found to be stationary at level 1(0). This indicates that the variables are integrated in a different order. Therefore, the ARDL technique is found to be a suitable model for this analysis.

#### 4.3. Bound Test for Co-integration Analysis

Having conducted the unit root test, we need to conduct a bound test for integration to determine the existence of a long-run equilibrium relationship among our variables. This has been carried out and is presented in Table 3.

**Table 3.** Bound Test Results.

| F-Bounds Test<br>Test Statistic | Value    | Sign. | Null Hypothesis: No levels of relationship |      |
|---------------------------------|----------|-------|--|------|
|                                 |          |       | I(0)                                       | I(1) |
| F-statistic                     | 12.28732 | 10%   | 2.45                                       | 3.52 |
| k                               | 4        | 5%    | 2.86                                       | 4.01 |
|                                 |          | 2.5%  | 3.25                                       | 4.49 |
|                                 |          | 1%    | 3.74                                       | 5.06 |

Source: Authors' computation using EViews 10.

The bound test results in Table (3) reveal evidence of co-integration among the variables. The F-calculated from Table 3 (i.e. 12.28732) reveals that the null hypothesis of no co-integration is rejected at 10%, 5%, and 1% significance levels respectively. This is because the F-statistic is greater than the lower bound critical values of 2.45, 2.86, and 3.74, respectively. After all, variables are co-integrated when the F-statistic value is greater than the lower bound critical values at some level of significance. Second, the F-statistic is also higher than the upper bound critical values of 3.52, 4.01, and 5.06 respectively. This also implies the rejection of the null hypothesis. Therefore, from the bound test result, it is clearly shown that with the presence of co-integration, we can establish both the short-run and long-run equilibrium relationship in the ARDL model for this analysis.

#### 4.4. Analysis of the ARDL Results.

Based on the outcome of the Bound test above, the short-run ARDL equilibrium relationship was estimated among our study variables as presented in this section as follows

##### 4.4.1. Estimated Long Run Co-efficient

The long-run estimates of the variables (dependent and independent), after the cointegration test become necessary to identify the long-run coefficient of the variables in the study using the ARDL approach. See Table (4)

**Table 4.** Result of Estimated Long Run Co-efficient of the: ARDL.

| Dependent variable: ELP |              |            |              |        |
|-------------------------|--------------|------------|--------------|--------|
| Variables               | Coefficients | Std. Error | t-statistics | Prob.  |
| PG                      | 0.479E-05    | 1.16E-05   | 4.145492     | 0.0009 |
| GDP                     | 0.009815     | 0.000921   | 10.65161     | 0.0000 |
| COPR                    | 0.008315     | 0.002401   | 3.462591     | 0.0035 |
| ELC                     | -0.209304    | 0.042794   | -0.684768    | 0.5039 |
| C                       | 7.988365     | 1.363884   | 5.857071     | 0.0000 |

Source: Authors' computation using EViews 10.

The estimated long-run coefficients show a statistically significant positive relationship between population growth and electricity prices in Nigeria. An increase in population growth will also increase electricity prices in Nigeria. A 1% rise in population growth will lead to a 4.7% increase in electricity prices in Nigeria throughout the period under review. It is also demonstrated that GDP has a positive and statistically significant effect on electricity prices in Nigeria. An increase in GDP is associated with an increase in electricity prices. A 1% change in GDP will lead to a 0.09% positive change in electricity prices. Thus, the influence is very diminutive. Likewise, crude oil price has a positive and statistically significant effect on electricity prices in Nigeria. An increase in crude oil prices is associated with an increase in electricity prices. A 1% increase in crude oil prices will lead to a 0.08% increase in electricity prices.

However, in the long run, the results revealed a negative and statistically insignificant relationship between electricity consumption and electricity prices in Nigeria. An increase in electricity consumption leads to a decrease

in electricity prices in Nigeria. A 1% increase in electricity consumption is associated with a 2.0% decrease in electricity prices in Nigeria.

#### 4.4.2. Estimated Short-run Co-efficient

The short-run estimates of the variables (dependent and independent) are presented in Table 5 to identify the short-run coefficients of the variables in the study using the ARDL approach.

**Table 5.** Result of Estimated Short-Run Co-efficient of the: ARDL.

| Dependent variable: ELP |             |            |             |        |
|-------------------------|-------------|------------|-------------|--------|
| Variables               | Coefficient | Std. Error | t-Statistic | Prob.  |
| <i>D(ELP(-1))</i>       | 1.089865    | 0.127675   | 8.536214    | 0.0000 |
| <i>D(ELP(-2))</i>       | 0.503160    | 0.139287   | 3.612412    | 0.0026 |
| <i>D(ELP(-3))</i>       | 0.585385    | 0.124869   | 4.687990    | 0.0003 |
| <i>D(PG)</i>            | -0.001828   | 0.000554   | 3.297966    | 0.0049 |
| <i>D(PG(-1))</i>        | -0.002666   | 0.000783   | -3.406091   | 0.0039 |
| <i>D(PG(-2))</i>        | -0.000715   | 0.000632   | -1.130922   | 0.2758 |
| <i>D(PG(-3))</i>        | -0.002856   | 0.000590   | -4.842077   | 0.0002 |
| <i>D(GDP)</i>           | 0.015914    | 0.002284   | 6.966601    | 0.0000 |
| <i>D(GDP(-1))</i>       | 0.005038    | 0.001944   | 2.592028    | 0.0204 |
| <i>D(GDP(-2))</i>       | 0.002331    | 0.002055   | 1.134447    | 0.2744 |
| <i>D(GDP(-3))</i>       | 0.013153    | 0.002282   | 5.763074    | 0.0000 |
| <i>D(COPR)</i>          | 0.000232    | 0.001261   | 0.184002    | 0.0365 |
| <i>D(COPR(-1))</i>      | 0.004661    | 0.001562   | -2.983909   | 0.0093 |
| <i>D(COPR(-2))</i>      | 0.002811    | 0.001375   | -2.044117   | 0.0589 |
| <i>D(ELC)</i>           | 0.075948    | 0.021725   | -3.495837   | 0.0033 |
| <i>D(ELC(-1))</i>       | 0.077555    | 0.024360   | -3.183741   | 0.0062 |
| <i>D(ELC(-2))</i>       | 0.074953    | 0.022211   | -3.374640   | 0.0042 |
| <i>D(ELC(-3))</i>       | 0.033912    | 0.022551   | -1.503800   | 0.1534 |
| <i>EMC(-1)*</i>         | -1.478337   | 0.167582   | -8.821548   | 0.0000 |

Source: Authors' computation using EViews 10.

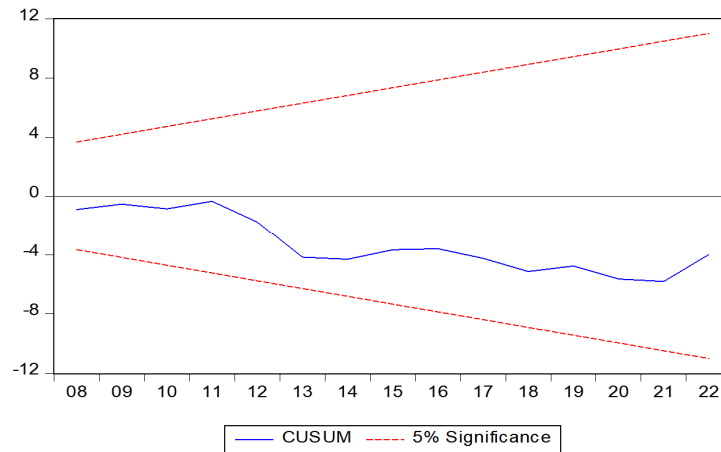
The estimated short-run coefficients from Table 5 show a statistically significant positive relationship between the lag values of electricity prices and their current values at a 1% level of significance. This implies that a 1% increase in the lag values of electricity price is associated with an approximately 1.08%, 0.50%, and 0.58% increase in its current value respectively. The result also demonstrated that population growth co-moves negatively with electricity prices in Nigeria, unlike in the long run. The implication is that at the level form, a 1% increase in population growth is associated with a 0.001% decrease in electricity prices in Nigeria.

Moreover, just like in the long run, the short-run ARDL result indicates a positive and statistically significant relationship between the growth domestic product and electricity prices in Nigeria. This positive relationship implies that a 1% increase in GDP is associated with a 0.01% increase in the electricity price in Nigeria. This conforms to the findings of Ologundudu and Abioro (2018), unlike Adeniran (2016), who found a negative influence between electricity price and GDP. That is, an increase in oil price reverses the production of the firms, individuals (households), or government institutions, which will consequently lead to a fall in real GDP. Additionally, just like in the long run, the short-run ARDL result also shows that crude oil price has a positive but statistically insignificant relationship with electricity price in Nigeria, and this is at the level value of crude oil price. This implies that at a 1% level of significance, a 1% increase in crude oil prices results in a 0.0002% increase in electricity prices in Nigeria. This conforms to the findings of Ologbenla et al., (2021). This is in line with the theoretical expectation. Similarly, the short-run ARDL result indicated a positive and statistically significant relationship between electricity consumption and electricity prices in Nigeria, both at its level form and at its lag values. Interestingly, the error

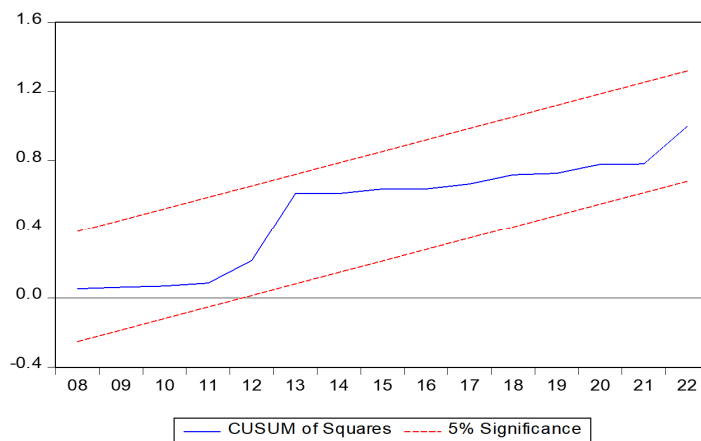
correction term is statistically significant at 1%, negative, and smaller than one. This supports evidence of the series' long-term relationships. Furthermore, the error correction term will self-correct at a speed of approximately 147% from the disequilibrium towards the equilibrium in the case of any economic distortion.

#### 4.5. Stability Test

The results of the stability test are shown in the figure below. The stability of our model equation and parameters is achieved since the entire sum of recursive errors lies between zero critical lines. Hence, our parameters are set to be stable, and we conclude that the residual is stable because it falls between the two lines.



**Figure 1.** Plot of Cumulative Sum of Recursive Residual (CUSUM).



**Figure 2.** Plot of Cumulative Sum of Square Recursive Residuals (CUSUMSQ).

#### 4.6. Diagnostic Test of ARDL

Table 4.6 presents some diagnostic tests conducted to ensure the reliability and validity of our model as well as the variables employed in this study.

**Table 6.** Results of the Diagnostic Test of the ARDL Approach.

| Diagnostic tests           | F-statistics | Prob.          |
|----------------------------|--------------|----------------|
| Serial correlation LM test | 1.095276     | F(2,3) 0.4394  |
| Heteroskedasticity Test    | 2.495839     | F(33,5) 0.1552 |

|                |                         |                   |
|----------------|-------------------------|-------------------|
| Normality Test | Jarque-Bera<br>0.305829 | Prob.<br>0.858203 |
|----------------|-------------------------|-------------------|

Source: Authors' computation using EViews 10.

To ensure the reliability of the estimate, this study conducted post-estimation tests to identify the fitness of the results. Autocorrelation, heteroskedasticity, and normality tests were used in the examinations, and the tabulated results are presented in Table 6. The model is shown to be free of heteroskedasticity and serial correlation issues by the serial correlation test. This is because, even at the 10% level, the test probability values are not significant. The model's normal distribution was confirmed by the normality test. This resulted from the Jarque-Bera probability value not being statistically significant, even at the 10% level.

#### 4.7. Discussion of the Findings

This study employed the Autoregressive Distributed Lag (ARDL) model to evaluate the influence of four key variables on electricity prices (ELP) in Nigeria. The long-run ARDL estimations revealed that all variables, except electricity consumption (ELC), exhibited statistically significant relationships with ELP. This confirms the overall model fit and indicates that the selected variables are appropriate for capturing the dynamics of electricity pricing in Nigeria. The study findings align with previous research in several areas. Notably, the positive and statistically significant relationship between current and lagged ELP values in the short-run ARDL estimate corroborates similar observations by Goutam et al., (2017), highlighting the inherent inertia within Nigerian electricity pricing, where current prices can be reliably predicted by lagged values. Additionally, the positive association between crude oil price (COPR) and ELP in both short-run and long-run ARDL estimations mirrors the findings of Ologbenla et al., (2021), demonstrating the immediate and sustained impact of international oil price fluctuations on Nigerian electricity costs. This implies that rising global oil prices directly translate into higher electricity prices within the Nigerian context.

Interestingly, the study identified asymmetric impacts of population growth (PG) on ELP across short- and long-run horizons. While positive and statistically significant in the long run, implying that increased population density puts upward pressure on electricity prices due to higher demand, the short-run effect was negative and statistically significant. This indicates a potential short-term dampening effect, possibly attributable to price-sensitive demand adjustments or temporary infrastructure expansion efforts in response to rapid population growth.

The relationship between gross domestic product (GDP) and ELP also exhibited concordance with some existing research. The positive and statistically significant association in both short- and long-run ARDL estimations aligns with the findings of Ologundudu and Abioro (2018). This implies that economic growth translates into increased demand for electricity, leading to higher prices. However, this contrasts with the negative relationship reported by Adeniran (2016), highlighting the potential complexity of the GDP-ELP interaction and the need for further investigation into the underlying mechanisms, including potential variations in sector-specific energy efficiency and the interplay between economic growth and government electricity subsidies.

The short-run ARDL unexpectedly revealed a positive and statistically significant relationship between ELC and ELP. Although, this seems to contradict the intuitive notion of lower prices with higher consumption, it may be attributable to price-sensitive demand within specific consumer segments or periods. Further research is needed to fully understand the drivers behind this seemingly counterintuitive finding and its implications for electricity pricing strategies.

## 5. Conclusions and Recommendations

In conclusion, this study provides valuable insights into the complex dynamics of electricity pricing in Nigeria by identifying the significant influences of COPR, GDP, and PG on ELP, while also highlighting the need for further exploration of the nuanced relationship between ELC and ELP. Continued research into these areas can inform effective policy interventions aimed at promoting greater price stability and affordability within the Nigerian electricity sector.

These findings offer valuable insights for policymakers and stakeholders in the Nigerian electricity sector. To lessen the negative consequences of electricity price volatility, the government must implement strategies to address the effect of the identified drivers. This includes developing plans to manage population growth and its impact on energy demand, diversifying energy sources beyond fossil fuels to reduce dependence on oil price fluctuations, and exploring alternative pricing mechanisms that promote efficient consumption and price stability. Furthermore, ensuring sustained economic growth while mitigating its immediate pressure on electricity prices requires careful planning and targeted investments in infrastructure development and renewable energy sources. By understanding the complex interplay of factors driving electricity price fluctuations in Nigeria, this study lays the groundwork for informed policy decisions aimed at ensuring a stable, affordable, and sustainable electricity supply.

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## Conflict of interest

There is no conflict of interest during the writing and submission of this work.

## Author contributions

All the contents of this work were written by the first and second authors, while the third author significantly contributed to proofreading and extensive scientific language corrections.

## References

- Adeniran, A. O., & Igbatayo, S. (2016). The impact of petroleum price volatility on Nigeria's economy. Institute for Oil, Gas, Energy, Environment and Sustainable Development. <https://scholar.google.com/scholar?cluster=14697771314491833691&hl=en&oi=scholar>
- Blanca, M., Ana J, L., & María Teresa, G.-Á. (2012). The electricity prices in the European Union: The role of renewable energies and regulatory electric market reforms. *Energy*, 48(1), 307-313. <http://dx.doi.org/10.1016/j.energy.2012.06.059>
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115-143. [https://doi.org/10.1016/S0304-4076\(98\)00009-8](https://doi.org/10.1016/S0304-4076(98)00009-8)
- Brown, R., Durbin, J., & Evans, K. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society. Series B (Methodological)*, 149-192. <http://www.jstor.org/stable/2984889?origin=JSTOR-pdf>
- Caroline, B. (2022, July 30). Theory of price. *Investopedia*. Retrieved February 10, 2022, from <https://www.investopedia.com/terms/t/theory-of-price.asp>
- Doris, D. S. (2023). Share of population with access to electricity in Nigeria 2011-2021. *Statista*. <https://www.statista.com/statistics/1307416/total-population-access-to-electricity-in-nigeria>

- Energy Information Administration. (2022, April 20). U.S. Energy Information Administration. Retrieved from <https://www.eia.gov/>
- Engle, R., & Patton, A. (2007). What good is a volatility model? *Quantitative Finance*, 1(2), 237-245. <https://doi.org/10.1016/B978-075066942-9.50004-2>
- Erkan, E. (2011). The impact of power market reforms on electricity price-cost margins and cross-subsidy levels: Across country panel data analysis. *Energy Policy*, 39(12), 1080-1092. <http://dx.doi.org/10.1016/j.enpol.2010.11.023>
- Eydeland, A., & Wolyniec, K. (2003). *Energy and power risk management: New developments in modeling, pricing, and hedging*. (2nd ed.). John Wiley & Sons. [https://www.wiley.com/en-ie/search?filters\[author\]=Alexander%20Eydeland&pq=++](https://www.wiley.com/en-ie/search?filters[author]=Alexander%20Eydeland&pq=++)
- Girish, P. G., & Vijayalakshmi, G. (2013). Determinants of electricity price in the competitive power market. *International Journal of Business and Management*, 8(21), 70-75. <http://dx.doi.org/10.5539/ijbm.v8n21p70>
- Goutam, D., & Krishnendranath, M. (2017). A literature review on dynamic pricing of electricity. *Journal of the Operational Research Society*, 68(10), 1131-1145. [https://ideas.repec.org/a/pal/jorsoc/v68y2017i10d10.1057\\_s41274-016-0149-4.html](https://ideas.repec.org/a/pal/jorsoc/v68y2017i10d10.1057_s41274-016-0149-4.html)
- Hadsell, L., Marathe, A., & Shawky, H. A. (2004). Estimating the volatility of wholesale electricity spot prices in the US. *The Energy Journal*, 25(4), 23-40. <https://ideas.repec.org/a/aen/journal/2004v25-04-a02.html>
- Harris, C. (2006). *Electricity markets: Pricing, structures and economics*. John Wiley & Sons. <https://www.perlego.com/book/1009703/electricity-markets-pricing-structures-and-economics-pdf>
- Karakatsani, N. V., & Bunn, D. W. (2004). Modeling the volatility of spot electricity prices. *International Journal of Forecasting*, 24(5), 764-785. <https://api.semanticscholar.org/CorpusID:27454378>
- Kirschen, D., & Strbac, G. (2004). *Fundamentals of power system economics*. John Wiley & Sons. <http://dx.doi.org/10.1002/0470020598>
- Knittel, C. R., & Roberts, M. R. (2015). An empirical examination of restructured electricity prices. *Energy Economics*, 27(5), 791-817. Retrieved from <https://ideas.repec.org/s/eee/eneeco.html>
- Li, K., Cursio, J. D., Sun, Y., & Zhu, Z. (2019). Determinants of price fluctuations in the electricity market: a study with PCA and NARDL models. *Economic Research-Ekonomska Istraživanja*, 32(1), 2404-2421. <https://doi.org/10.1080/1331677X.2019.1645712>
- Longstaff, F. A., & Wang, A. W. (2004). Electricity forward prices: A high-frequency empirical analysis. *Journal of Finance*, 59(4), 1877-1900. <http://dx.doi.org/10.1111/j.1540-6261.2004.00682.x>
- Mahadeva, L., & Robinson, P. (2004). Unit root testing to help model building. *Handbooks in Central Banking No. 22 Centre for Central Banking Studies, Bank of England, London*. Retrieved from <http://www.bankofengland.co.uk/education/Pages/ccbs/handbooks/ccbshb22.aspx>
- Nagayama, H. (2007). Effects of regulatory reforms in the electricity supply industry on electricity prices in developing countries. *Energy Policy*, 34(10), 3440-3462. <http://dx.doi.org/10.1016/j.enpol.2006.12.018>
- Nigerian Electricity Regulatory Commission (NERC). (2021, November 12). Electricity meter prices go up. *PM NEWS Nigeria*. Retrieved from <https://pmnewsnigeria.com/2021/11/12/electricity-meter-prices-go-up/>
- Oiol, P. (2019, May 20). Solar energy. Retrieved December 2022, from Solar-energy. technology: [www.ectronicalfunderblog.com](http://www.ectronicalfunderblog.com)
- Ologbenla, P. (2021). Determinants of domestic energy prices in Nigeria (1980-2020). *Obafemi Awolowo University, Ile Ife, Osun State, Nigeria*, 3(2), 305-311. <https://doi.org/10.25082/REE.2021.02.006>
- Ologundudu, M. M., & Abioro, M. A. (2018). Petroleum pump price increase and business environment: The Nigerian Economy Standpoint. *IOSR Journal of Business and Management (IOSR-JBM)*, 20(3), 60-70. <http://dx.doi.org/10.9790/487X-2003046070>
- Patrícia, S. P., & Cerqueira, P. A. (2017). Assessing the determinants of household electricity prices in the EU: A system-GMM panel data approach. *Renewable and Sustainable Energy Reviews*, 1131-1137. <https://ideas.repec.org/a/eee/rensus/v73y2017icp1131-1137.html>
- Pesaran, M. H., Smith, R. J., & Shin, Y. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326. <https://doi.org/10.1002/jae.616>
- Ralf, B., Stan, H., & Vlad, P. (2007). Modeling spikes in electricity prices. *The Economic Record*, 83(263), 371-382. <http://dx.doi.org/10.1111/j.1475-4932.2007.00427.x>
- Ricardo, D. (1817). *On the principles of political economy and taxation*. London: John Murray. <https://www.scrip.org/reference/referencespapers?referenceid=1986007>
- Smith, A. (1776). *An inquiry into the nature and causes of the wealth of nations*. Clarendon Press, the Glasgow Edition



- of the Works and Correspondence of Adam Smith. <https://www.econlib.org/library/Smith/smWN.html>
- Sonal, G., Deepankar, C., & Hiranmoy, R. (2020). Electricity prices determinants: India's perspective. *International Journal Business Excellence*, 549-560. <http://dx.doi.org/10.1504/IJBEX.2019.10019286>
- Sorokin, S. Rebennack, P. M. Pardalos, N. A. Iliadis, & M. V. F. Pereira (Eds.), *Handbook of Networks in Power Systems I* (pp. 89-121). Springer. <http://dx.doi.org/10.1007/978-3-642-02493-1>
- Steiner, F. (2001). Regulation, industry structure and performance in the electricity supply industry, OECD Economics Studies. *OECD*. <http://dx.doi.org/10.2139/ssrn.223648>
- Stephanía, M.-L., & Anjali, N. (2019). Drivers of electricity price dynamics: Comparative analysis of spot and futures markets. *Energy*, 76-87. <http://dx.doi.org/10.1016/j.enpol.2018.11.020>
- Sule, A. G. (2005). Short note on the history of capitalist and socialist economic thought (2nd ed.). October.
- Umar, H. A., Mathias, F., & Praisad, R. (2022). Towards sustainability of power utilities in Nigeria: A Bayesian network approach. *International Journal of Information Technology*, 14(2), 14-27. <http://dx.doi.org/10.1007/s41870-022-00876-2>
- Weron, R. (2006). *Modeling and forecasting electricity loads and prices: A statistical approach*. John Wiley & Sons. <https://doi.org/10.1002/9781118673362>
- Weron, R., & Misiorek, A. (2008). Forecasting spot electricity prices: A comparison of parametric and semi-parametric time series models. *International Journal of Forecasting*, 24(5), 744-76. <http://dx.doi.org/10.1016/j.ijforecast.2008.08.004>
- Windermeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, 126, 25-51. <https://doi.org/10.1016/j.jeconom.2004.02.005>
- Xiao, Y., Colwell, D. B., & Bhar, R. (2015). Risk premium in electricity prices: Evidence from the PJM market. *Journal of Futures Markets*, 35(8), 776-793. <https://doi.org/10.1002/fut.21681>
- Zareipour, H., (2012). Short-term electricity market prices: a review of characteristics and forecasting methods. In: Sorokin, A., Rebennack, S., Pardalos, P.M., Iliadis, N.A., Pereira, M.V.F. (Eds.), *Handbook of Networks in Power Systems I*. Springer, pp. 89–121. [http://dx.doi.org/10.1007/978-3-642-23193-3\\_4](http://dx.doi.org/10.1007/978-3-642-23193-3_4)
- Zareipour, H., Bhattacharya, K., & Cañizares, C. A. (2007). Electricity market price volatility: The case of Ontario. *Energy Policy*, 35(9), 4739-4748. <https://doi.org/10.1016/j.enpol.2007.04.006>