Efficiency Performance of Electricity Distribution Companies in Nigeria

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Abstract

This paper examines the technical efficiency of electricity supply across 11 electricity distribution companies using the Data Envelopment Analysis (DEA). The analysis was performed with a recent and extended data from 2015 to 2022. The output indicator for calculating electricity supply efficiency is electricity supply proxy by energy received by each electricity distribution company. The input indicators are network losses (proxy by transmission losses) and aggregate technical commercial and collection losses (ATC&C). The results show that all electricity distribution utilities are technically inefficient in electricity supply to a varying degree. Four electricity distribution companies performed above 45 percent level of technical efficiency, while two operate at less than 80 percent. Also, the efficiency performance of the 11 distribution companies worsened since the beginning of the COVID-19 pandemic era. Thus, privatization has not eradicated technical inefficiencies in the electricity supply. The inefficiencies in the electricity distribution sub-sector are partly due to technical constraints from network losses.

Keyword: Efficiency; Electricity supply; Data envelopment analysis; Distribution companies; Nigeria

JEL Classification Codes: C61, D24, D41

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1. Introduction

The Nigerian electricity sector privatisation process began with the enactment of the Electric Power Sector Reform (EPSR) in 2005. The EPSR was introduced as a legal and regulatory framework for private sector participation at the instance of unbundling the sector's monopoly. Consequent to the 2005 EPSR Act, the Power Holding Company of Nigeria (PHCN) took over the assets and liabilities of the erstwhile Nigerian Electricity Power Authority (NEPA). The PHCN was unbundled into eighteen entities; comprising six generation companies (GENCOs), a single transmission company (TRANSCO), and eleven distribution companies (DISCOs). In 2013, privatisation reform was fully introduced to both the electricity generation and distribution value chains to match the growing demand for a stable and reliable electricity supply, while enhancing efficient generation and distribution.

Some African countries, including Nigeria, privatized their electricity distribution sub-sector to correct some inefficiencies that undermined the performance of the value chain.[1] Traditionally, electricity sector operates under a natural monopoly due to economies of scale and scope. The monopolization of the electricity sector gives rise to its vertical integration, mostly under government control. Since the 1990s, a paradigm shift towards a liberalized electricity market was advocated to limit government involvement in electricity sector. A strong impetus came from Colclough (1991) and Espinal (1992), who assert that the market is the optimal space for efficient production and distribution of goods and services. This belief in market extends to the privatisation of essential public properties like electricity. The ideology is underpinned by technological change, government budget constraint, and the other environmental factors limiting efficiency of public good production. Besides, the neoliberal ideology dominates the discourse of international organisations, like the International Monetary Fund (IMF) and the World Bank; as a requirement to replace interventionist developmental state by encouraging the expansion of market forces through market-friendly policies (Walton and Seddon, 1994). Hence, privatisation is meant to correct structural imbalances associated with public-owned goods (Oji *et. al.* 2014). Privatisation is also presumed an effective means of improving efficiency and increasing investment (Vlahinic, 2011).

According to (Ahmed, 2007), the proponents of neoliberalism contend that in the electricity sector; electricity generation and distribution are entrenched in the ideologies of efficiency and profit maximization than on welfare objectives, for improved performance. Efficiency gains following cost reductions, depending on the severity of competition and the quality of the regulatory framework in place, are assumed to benefit consumers through price reductions and improvements in the quality of service. State intervention is being seen as the beginning of inefficiency. Thus, private control as against bureaucratic management is preferred for maximum efficiency gains. Firstly, social objectives, such as employment opportunities, associated with state control is criticized for enhancing inefficiency. Likewise, state's objective of providing electricity access to underserved and unserved, as well as those that cannot afford the cost of electrification is criticized as being politically motivated.

Nigeria's DISCOs play a critical role in the electricity sector; it interfaces directly with end users and indirectly with the generators through the transmission company and the Nigeria Bulk Electricity Trader (NBET). The privatisation is expected to enhance its competition and

[1] Some of the African countries that have privatized their electricity sector are: Cote d'Ivoire, Uganda and Cameroon

efficiency, thereby attracting the needed financial resources and management expertise (Parker, 2003). To what extent has the privatised Nigerian electricity distribution companies optimised operations in terms of electricity supply? Overall, electricity supply from the Nigerian central grid is epileptic and mostly unavailable to consumers. While average electricity generation hovers between 2000 Megawatts (MW) and 4500MW, a significant quantity ends up as aggregate technical, commercial and collection (ATC&C) losses. About 47 percent of 3127.3MW electricity generated in 2017 ends up as ATC&C (NERC Quarterly Report, 2017). By 2020 and 2022, the ATC&C has increased to 53.9 percent and 50.1 percent, suggesting weak and huge infrastructural gap in the distribution grid. The problem explains why Nigeria's electricity consumption remains low in absolute and per capital terms.

An aspect of the electricity reform is to crowd-in more infrastructural investment in the distribution subsector, but high network losses remain above 10 percent international threshold and twice higher than the Multi-Year Tariff Order (MYTO) allowable thresholds by the regulator (NERC Quarterly Reports, Various Issues). However weak distribution lines, transformers, and feeder pillars are some of the challenges in the distribution sub-sector due to poor maintenance and underfunding (Babatunde, *et.al.*, 2022). Likewise, World Bank (2021) identifies lack of network infrastructure as the reason for the distribution companies' poor technical performance.

An assessment of the efficiency performance of the distribution companies is pertinent in determining the effectiveness of the electricity sector privatisation. Thus, evaluating the performance of the DISCOs is an avenue for the policy review. Several debates across private and public stakeholders have ensued on the effectiveness of privatisation on Nigeria's electricity supply. Beyond the speculations, this paper contributes to the literature by assessing the technical efficiency of electricity supply, across the 11 distribution companies, using the Data Envelopment Analysis (DEA). The DEA is widely adopted as a standard method for measuring firm-level efficiency, and as such, its application in this study adds to the empirical literature on the electricity sector's outlook after the privatisation reform.

Existing studies in Nigeria assessed DISCOs performance from the political economy perspective (Aminu and Peterside, 2014; Audu *et. al.*., 2017) and cross-national analysis (Samuel *et. al.*, 2019). Other studies also investigated the effect of privatisation on selected electricity distribution company performance (Samuel *et. al.*., 2019; Umar, 2020). Such partial analysis tends to be bias; as the outcome are limited, and as such, cannot be used to make a general inference about the performance of the electricity distribution value chain. A study close to this in the literature (Adenikinju, *et. al.* 2016) assessed the impacts of privatisation on electricity supply in Nigeria. The study utilised data from the period 2013 to 2016. Assessing the effect of the privatisation after three years of the reform may not suffice to show the effectiveness of the policy. Differently, the empirical analysis provided in this paper use a recent dataset with a wider coverage (2015-202 2), thus increasing the reliability of the inferences for policymaking.

The paper is structured into five sections including the introduction. Section 2 provides a review of relevant literature. The description of data and methodology are provided in section 3. Empirical findings on technical efficiency of the electricity distribution companies are presented in section 4. Section 5 concludes and provides some policy implications.

2. Literature Review

It is presumed that the privatization of the electricity sector situated within the neoliberal ideology provides market-oriented services at the value-chains. Change in ownership structure develops property rights due to new investment, technological change, and improved management control. Thus, efficiency gains ensued as a result of improved service delivery. The review shows that a plethora of investigations have been carried out on privatisation across different sectors. However, evidence on the efficiency gains of privatisation remained mixed both in developing and developed economies. The study by Adenikinju *et. al.* (2016) analysed the impacts of privatisation on the technical efficiency of 11 distribution companies in Nigeria. Technical efficiency of the distribution companies was calculated with DEA using data from 2013 to 2016. They find that privatisation has not significantly improve electricity supply. The conclusion is that privatisation of the electricity sector is a step taken in a right direction, although performance has not significantly improved due to lingering challenges. The state of Nigeria's power supply in the post privatisation period was investigated by Audu *et. al.* (2017). The study was exploratory within the framework of the elite theory. Due to the lop-sidedness of the privatisation process, the level of electricity supply has not improved differently from the pre privatisation era.

Samuel at al. (2019) examined the impact of Ibadan and Ikeja electricity distribution companies after electricity sector privatisation. The analysis was conducted based on descriptive and regression analysis. The distribution companies made no significant contribution to electricity supply due to poor service quality and billing, low metering level, among other factors. Likewise, Umar (2020) investigates the effect of privatisation on organisational performance of the Abuja electricity Distribution Company using primary data collected under the jurisdiction of the company. Information such as duration of electricity supply, infrastructure, compliant response time, quality of electricity supply, estimated billing, metering, power supply rationing, etc., were used in the Ordinary Least Squares (OLS) analysis. The empirical result shows that electricity supply in the assessed jurisdiction has not increased in the post privatisation period. Likewise, a study by Idowu *et. al.* (2019) reveals that the electricity sector reform has not yielded a desired outcome as technical and market constraints posed limitation to the privatisation gains.

Empirical studies carried out else yielded mixed outcomes also. For instance, Domah and Pollitt (2001) conducted a social cost-benefit analysis of restructuring and privatisation of electricity distribution and supply in England and Wales. They found that electricity prices fell by 15 percent due to increase electricity sales and improved efficiency as a result of electricity sector privatisation and restructuring. In Turkey, one of the targets of electricity sector liberalisation is to reduced consumer's electricity prices. However, the study by Karahan and Toptas (2013) find that privatisation of electricity distribution companies did not yield the expected decline in retail price of electricity, four years after privatisation. Estache *et. al*. (2004) used DEA and a stochastic cost frontier approach to estimate the effect of competition, regulation and privatisation on 84 South American electricity utilities in the period 1994 to 2001. The study did not specify the individual effects of competition, regulation and privatisation on the electricity utilities. Moreover, Pombo and Taborda (2006) used DEA in estimating technical efficiency of Columbia's twelve power distribution companies with or without privatisation. The results confirm improved output, and positive effect of privatisation on the distribution companies.

In Cardoso de Mendonça, *et. al*. (2021), they analysed the efficiency of the electricity distribution companies in Brazil. They employed a stochastic frontier model to analyse a panel of 61 electricity distribution companies for the period 2003 and 2016. The study finds that electricity tariff review positively and significantly affects the efficiency of the distribution companies. However, Medeiros *et. al.* (2022) adopts a data envelopment analysis to analysed efficiency performance of 61 regulated electricity distribution companies in Brazil. Their estimations show that the heterogeneity of the location of the distribution companies significantly affect their efficiency performance.

Asides from the electricity sector, there is a broad belief that privatisation is also key to the efficient performance of other sectors. These categories of studies include the work done by Chris (2018) on the technical efficiency performance of privatised manufacturing firms in Nigeria. Firm technical efficiency was calculated using DEA. The study established that firms were more efficient after privatisation, as the mean efficiency value of output after privatisation was higher than the pre-privatisation value. In Anderson *et. al*. (2000), the effect of competition and ownership on the performance of 211 newly privatized firms in Mongolia was examined. The effect of competition on efficiency was significant. Enterprises under public ownership fared better to those under private control. The findings were due to the fragile nature of the Mongolian institutions that inhibit the performance of non-state actors.

In the literature, studies that examined the case of the Nigerian electricity distribution sub-sector in a detail empirical approach are scant. The available studies failed to utilise extended data in calculating supply efficiency when competition was introduced. The only known study (Adenikinju *et. al.*, 2016) was biased in drawing inferences as the analyses covered three years after privatisation. The authors acknowledged this limitation in their work and recommended further studies to use an extended period for a robust outcome.

3. Data and Methodology

3.1 Data

This study uses a panel of 11 electricity distribution companies to calculate their ability to maximize outputs commensurate with minimum inputs consumption. The firms are Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port-Harcourt, and Yola electricity distribution companies. Thus, energy received (Megawatt/hour) by each distribution companies is the output indicators for energy supply. The input indicators are network losses (proxy by transmission losses) and aggregate technical commercial and collection losses (ATC&C). The privatisation of the electricity sector was in 2013, the effective date for take-over by all successor companies was 1st November 2014; hence, 2013 and 2014 are the years of public and private ownership of some distribution companies.[2] Thus, the year 2013 and 2014 were excluded from the analysis. The data for the empirical analysis spans from 2015 to 2022 collected across the 11 distribution companies.

The study used the annual data available in the reports of the Nigerian Electricity Regulatory Commission Quarterly Reports. The summary of the dataset is in Table 1.

[2] https://nerc.gov.ng/index.php/home/nesi/401-history
https://www.internationallawoffice.com/Newsletters/Energy-Natural-Resources/Nigeria/Udo-Udoma-Belo-Osagie/Privatisation-of-the-Power-Holding-Company-of-Nigeria-recent-developments.
https://prog.lmu.edu.ng/colleges_CMS/document/books/Iseolorunkanmi%203%20-%20Issues%20and%20challenges%20in%20the%20Privatized%20Power%20Sector%20in%20Nigeria.pdf

Table 1: Dataset Description

S/N	Variable	Unit of Measurement	Source
1	Electricity Received by Distribution Companies (MWh)	MWh	NERC Quarterly Report
3	Transmission Losses Factor	Percent	NERC Quarterly Report
4	Aggregate Technical Commercial& Collection Losses	Percent	NERC Quarterly Report

3.2 Methodology

The study determines technical efficiency of the electricity supply.[3] Specifically, the study calculates the technical efficiency of electricity supply based on the assumption of Variable Returns to Scale. Several empirical studies in the literature adopted the DEA approach to evaluate firm technical efficiency across different sectors (Jerome, 2008; Chris, 2018). These investigations also include studies on the electricity sector (Adenikinju *et. al.*., 2016; Wang *et. al.*., 2018). In this study, an output-oriented DEA technical efficiency is calculated based on maximum electricity supply by a given level of inputs. In the case of the Nigerian electricity distribution companies, the paper considers output (electricity supply) maximization with respect to the given level of inputs at the distribution value chain. It is impossible to do a 'before' and 'after' comparison, because the distribution value chain became competitive after privatisation. Nevertheless, the outcome could provide information about the level of output-oriented technical efficiency of each of the electricity distribution firms.

The DEA is a linear programming technique that analyses all potential output for a given set of inputs (Coelli, 1996); where the outcome assumes a value between zero and one. Thus, the DEA simultaneously utilizes multiple outputs and multiple inputs, each stated in different units (Theodoridis and Psychoudakis, 2008). The technical efficiency is measured relative to the highest observed performance, rather than an average, which ranges from zero to one (Hjalmarsson and Veiderpass; 1992 as cited in Hossain *et. al.*., 2012). A firm is technically efficient when its efficiency score is one. Unlike the Stochastic Frontier Analysis (SFA) that is parametric, the DEA is a non-parametric method that allows efficiency to be measured a priori without specifying the analytical form of the production function, thus making the DEA a superior model (Forsund *et. al.*., 1980 as cited in Jerome, 2008). By implication, SFA is an econometric approach, while DEA is not. The DEA also focuses on revealed best practice frontiers rather than on central-tendency properties, and it generates a set of peer units for comparison (Theodoridis and Psychoudakis, 2008).

Based on Coelli (1996), the study adopts the DEA model that assumes Variable Returns to Scale (VRS) against Constants Returns to Scale (CRS) model suggested by Charnes *et. al.* (1978). A major setback of the constant returns to scale is that it has an infinite solution, which results in higher estimates than assuming a variable returns to scale. Also, CRS approach assumes that all Decision-Making Units (DMUs) operates optimally. In reality, this assumption is far from the truth, thus the VRS model by Coelli (1996) is much preferred.

[3] According to Farrell (1957), the efficiency of a firm consists of technical or allocative efficiency. The technical efficiency of a firm reflects its ability to obtain maximal output from a given set of inputs while allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices.

The standard model provided by Coelli (1996) is specified as:

$$max_{u,v}\ (\mu' y_i / v' x_i) \tag{1}$$
$$st \quad v' x_i = 1,$$
$$\mu' v_j - v' y_i \ \leq 0, \qquad j = 1,2, \dots , N$$
$$\mu, v \geq 0,$$

The model in eq. (1) involves obtaining values for $\mu\ and\ v$, such that the efficiency measure of the *i*th Decision-Making Unit (DMU) is maximized subject to the constraint that all efficiency measure is less than or equal to one. In the model a constraint $v'x\ =1$ is imposed to avoid generating infinite solution as with the case of constant returns to scale model. This transformation provides the multiplier form of the linear programming problem.

A duality linear programming is applied to the model in eq. (1) to derive an equivalent envelopment form. This form is most preferred to solve due to the lesser constraints relative to the multiplier form. An equivalent envelopment form of the model is given as:

$$min_{\emptyset,\lambda}(\emptyset), \tag{2}$$
$$st \quad -Y_i + \ Y\lambda \geq 0,$$
$$\emptyset X_i - \ X\lambda \geq 0,$$
$$\lambda \geq 0,$$

Where $\emptyset$ is scalar and λ is *Nx1* vector of constants. *X* and *Y* are the firms' input and output vectors, respectively, while, *Xi* and *Yi* are inputs and outputs of the firm that is being evaluated. The value of $\emptyset$ is the efficiency score for the *i*th (firm) DMU. This value satisfies $0 \leq 1$, where a value of 1 indicates a point on the frontier, hence a technically efficient DMU (Perez-Reyes and Tova (2009).

In this study, the output is electricity supply proxy by energy received (MWh) by each electricity distribution company. The efficiency of electricity supply across the 11 distribution companies is calculated based on their ability to maximize outputs commensurate with minimum inputs requirements. Thus, energy received by each distribution companies is the output indicator for energy supply. The input indicators are network losses (proxy by transmission losses) and aggregate technical commercial and collection losses (ATC&C). The choice of these indicators is to reflect the level of technical efficiency that arises from infrastructural constrain or its availability. The selection of output and inputs indicators are justified in extant studies and based on the prior knowledge of the operational characteristics of Nigeria's electricity Distribution Companies (Milliotis, 1992; Bagdadioglu, 1995; Wang, 2018; Adenikinju; 2016, NERC, 2021).

In this paper, decisions are based on the mean values and ranking of the generated peer units. This approach streamlines and eases results interpretation. Eq. (2) is modified by adding a convexity constraint as relates to variable returns to scale assumption:

$$min_{\emptyset,\lambda}(\emptyset), \tag{3}$$
$$st \quad -Y_i + \ Y\lambda \geq 0,$$
$$\emptyset X_i - \ X\lambda \geq 0,$$
$$N1'\lambda = 1,$$

$\lambda \geq 0,$

In eq. (3) *N1* is an *Nx1* vectors of ones. This variable returns to scale specification forms a convex hull of intersecting planes that envelope the data points more tightly than the constant returns to scale conical hull and thus provide a technical efficiency score that are greater than or equal to those obtained using constant returns to scale (Jerome, 1998).

4. Results and Discussion

The results in Tables 2 and 3 summarised the technical efficiency scores of the 11 electricity distribution companies based on VRS and CRTS. In the period observed, all electricity distribution companies are technically inefficient based on their mean values. The same condition holds for yearly-specific estimates, except for Ikeja electricity distribution company, which was technically efficient in 2019. Averagely, all DISCOs performed inefficiently, the level of performance was uneven among the companies. The global average for the variable returns to scale and constant returns to scale of 0.40 and 0.38 surpasses the mean efficiency scores of about 54% of the distribution companies. Suggesting that only about 46 percent of the distribution companies had efficiency scores above the global average. Overall, these findings indicate a sustain low output performance partly due to infrastructural constraint reflected in high transmission and distribution losses; thus, suggesting that weak technical capabilities undermine the efficient supply of electricity by the distribution companies (Oruwari, 2021).

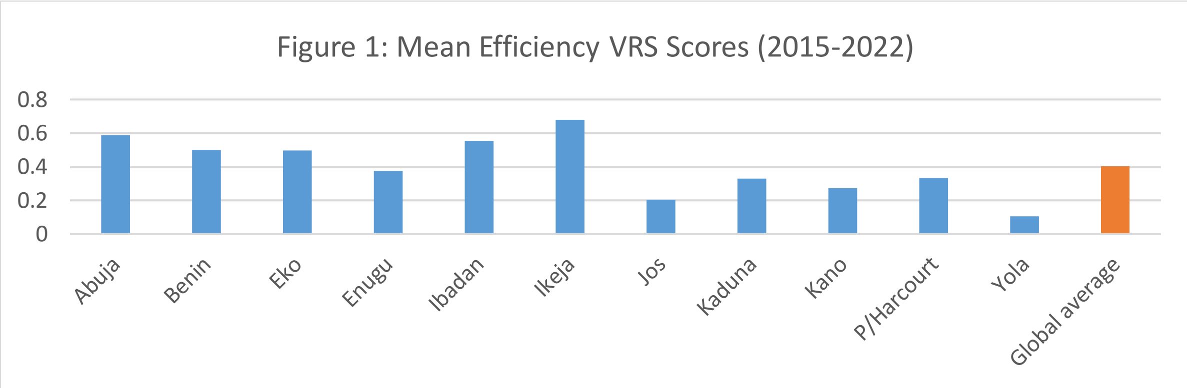
The interpretation of results and decisions are also based on the ranking of the generated peer units, in this case, each electricity distribution company. Ikeja electricity distribution company ranked 1st among other distribution companies. This outcome suggests that the distribution company operates the highest level of technical efficiency among its peers. This situation could be due partly to the optimal performance of the company in 2019. Abuja, Ibadan, and Benin electricity distribution companies ranked 2nd, 3rd, and 4th, respectively (Tables 2 and 3). The three companies performed above 45 percent in terms of electricity supply efficiency. However, laggard distribution companies experience low efficiency performance due to high degree of input constraints. Their poor performances can be attributed to the low level of electricity infrastructure, in their operational domain, due in part to the high rate of network losses (NERC Quarterly Report, Various Issues). Specifically, Jos and Yola utility companies, in northern Nigeria, were the least technically efficient among the 11 distribution companies. The companies ranked 10th and 11th. Their mean inefficiency scores in electricity supply based on VRS and CRS hover above 80 percent. This situation suggests only less or equal to 20 percent level of efficiency performance among these distribution companies. The findings above align with similar ones that shows that privatisation does not exclusively lead to efficient performance (Adenikinju, et.al.; 2026; Meher and Sahu, 2016). Most striking is the fact that operational context peculiarity shapes the efficiency performance, thus, confirming that heterogeneity of the distribution companies affect their outcomes after the electricity privatisation reform (Sen, *et. al.* 2016; Medeiros *et. al.* 2022)

Table 2: Summary of Variable Returns to Scale Efficiency of Electricity Distribution Companies

Variables Returns to Scale DEA

	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Mean Score**	**Rank**
Abuja	0.83	0.74	0.80	0.86	0.89	0.12	0.24	0.23	0.589	2
Benin	0.67	0.50	0.55	0.60	0.55	0.08	0.16	0.16	0.499	4
Eko	0.52	0.57	0.71	0.76	0.79	0.14	0.22	0.26	0.496	5
Enugu	0.63	0.60	0.56	0.51	0.28	0.09	0.17	0.15	0.374	6
Ibadan	0.73	0.67	0.81	0.81	0.83	0.13	0.25	0.20	0.554	3
Ikeja	0.81	0.73	0.79	0.94	1	0.20	0.42	0.54	0.679	1
Jos	0.27	0.28	0.32	0.28	0.29	0.04	0.08	0.09	0.206	10
Kaduna	0.45	0.46	0.48	0.50	0.46	0.07	0.14	0.09	0.331	8
Kano	0.27	0.34	0.42	0.46	0.42	0.06	0.11	0.11	0.274	9
P/Harcourt	0.45	0.48	0.49	0.47	0.47	0.06	0.13	0.12	0.334	7
Yola	0.09	0.14	0.20	0.23	0.02	0.03	0.06	0.06	0.104	11

Source: *Author's Computation with STATA 17*



Source: Author's Computation

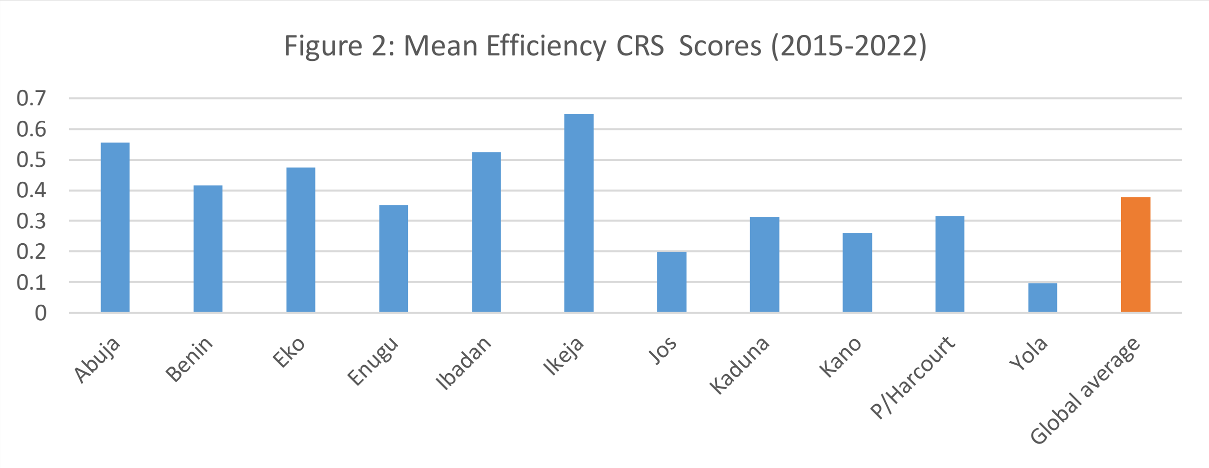
The yearly efficiency performance among the distribution companies is an indication that the distribution value chain still suffers some of the legacy challenges inherent with the state-owned utility. A peculiar feature observed is the drastic decline in the level of efficiency across the distribution companies in 2020, the COVID-19 pandemic epi-year. Although gradual improvements occur in 2021 and 2022, the efficiency performance of the 11 distribution companies did not return to the pre-pandemic levels. Thus, the pandemic affects electricity supply efficiency, possibly due to reduced economic activities that weaken the financial viability of every economic sector, including, the distribution electricity sub-sector. Before and after the COVID-19 pandemic, the electricity sector benefits from the Federal Government intervention funds, through the Nigerian Electricity Market Stabilisation Facility, for enhanced technical and operational performance (ICIR, 2023). Despite the interventions and other assistances enjoyed by the electricity distribution sector since the privatisation, poor electricity supply persists.

Table 3 presents results based on a CRS frontier on the assumption that the proportionate input increase (reduction) will be followed by the same output increase (reduction). The assumption holds only if all DMUs operates at an optimal scale. This situation does not hold in reality due to constraints like imperfect competition, lack of finance, etc. But the CRS DEA results are presented to compare and to show that the VRS model (Table 2) provides technical efficiency scores greater than or equal to those obtained by the CRS model (Coelli, 1996).

Table 3: Summary of Constant Returns to Scale Efficiency of Electricity Distribution Companies

	2015	2016	2017	2018	2019	2020	2021	2022	Mean Score	Rank
Abuja	0.75	0.69	0.70	0.83	0.89	0.12	0.24	0.22	0.555	2
Benin	0.61	0.46	0.48	0.58	0.55	0.08	0;16	0.15	0.416	5
Eko	0.47	0.53	0.63	0.74	0.79	0.15	0.22	0.26	0.474	4
Enugu	0.57	0.57	0.49	0.49	0.28	0.09	0.17	0.15	0.351	6
Ibadan	0.67	0.62	0.71	0.79	0.83	0.13	0.25	0.20	0.525	3
Ikeja	0.74	0.68	0.70	0.93	1	0.20	0.41	0.54	0.650	1
Jos	0.26	0.27	0.28	0.28	0.29	0.04	0.08	0.09	0.199	10
Kaduna	0.41	0.43	0.42	0.49	0.46	0.07	0.14	0.09	0.314	8
Kano	0.24	0.32	0.38	0.45	0.41	0.06	0.11	0.12	0.261	9
P/Harcourt	0.41	0.44	0.43	0.46	0.47	0.06	0.13	0.12	0.315	7
Yola	0.08	0.13	0.17	0.23	0.02	0.03	0.06	0.05	0.096	11

Source: Author's Computation with STATA 17



Source: *Author's Computation*

5. Conclusion and Policy Implications

The privatization of the electricity sector involved some changes in the institutional and property rights arrangement of the sector. Change in ownership structure supposedly removes some previous constraints imposed by government ownership, and as such, the electricity sector is expected to experience some efficiency gains in electricity supply due to new investment, technological change, and improved management control. Thus, this study examined the technical efficiency of the electricity supply across the 11 distribution companies after privatization. Empirical findings were reinforcing and in line with other findings in the literature. An analysis of technical efficiency within the DEA framework shows all electricity distribution utilities are technically inefficient in electricity supply to a varying degree. Four electricity distribution companies performed above 45 percent level of technical efficiency, while two operates at less than 80 percent. As such, privatization has not eradicated technical inefficiencies in electricity supply by the distribution companies.

The inadequacies in the electricity sector, which are partly due to technical and commercial limitations have some implications for policy reform in the electricity distribution companies. Firstly, there is a need for infrastructure investment across all distribution companies, especially among the worst-performed companies. The strategy is to revisit the 2013 privatization and design a new roadmap for investment commitments to reduce network losses while bridging metering gaps. This capacity improvement is required yearly to meet increasing electricity demand and limits network losses to an acceptable threshold. Importantly, the implementation hinges on strict compliance to industry standards and regulations set by the industry regulator-the Nigerian Electricity Regulatory Commission. The NERC may tie its enforcement strategy to sanctions, while rewarding compliance to industry requirements.

References

Adenikinju A., Dikko, H. and Sanusi, G. (2016), "Impacts of privatisation on electricity supply in Nigeria" In: The Quest for Development: Essays in Honour of Prof. Iwayemi at 70, Adenikinju A., Jerome, A. and Ogunkola, O, 426-445.

Ahmed, W. (2007), "Neoliberalism and contested policies of the power industry in India" *The Industrial Geographer,* **5 (1)**, 44-57

Anderson, J., Lee, Y. and Murrell, P. (2000), "Do competition and ownership affect enterprises efficiency in the absence of market institutions? Evidence after privatization in Mongolia" Working paper, Department of Economics and IRIS Center, University of Maryland, College Park, Maryland

Aminu, I. and Peterside, Z. (2014), "The impact of privatisation of power sector in Nigeria: a political economy approach" *Mediterranean Journal of Social Sciences,* **5 (26)**

Audu, E., Paul, S. O and Ameh, E. (2017), "Privatisation of power sector and poverty of power supply in Nigeria: A policy analysis" *International Journal of Development and Sustainability,* **6 (10)**, 1218-1231.

Babatunde, O., Buraimoh, E., Tinuoye, O., Ayegbusi, C., Davidson, I., Ighravwe, D. (2023), "Electricity sector assessment in Nigeria: the post-liberation era". *Cogent Engineering*. doi: 10.1080/23311916.2022.2157536

Cardoso de Mendonça, A. Pereira, M., Medrano, A., José Francisco, M. (2021), "Analysis of electric distribution utilities efficiency levels by stochastic frontier in Brazilian power sector", *Socio-Economic Planning Sciences*, **76**, 100973, ISSN 0038-0121, https://doi.org/10.1016/j.seps.2020.100973

Chris A. O (2018), "Determinants of the technical efficiency performance of privatized manufacturing firms in Nigeria: an econometric analysis" *International Journal of Development and Economic Sustainability,* **6(1)**,19-28

Coelli, T. (1996), "A Guide to DEAP Version 2.0. A Data Envelopment Analysis (Computer Program)" Centre for Efficiency and Productivity Analysis", Department of Econometrics, University of New England, Australia

Colclough, C. (1991), "Structuralism versus neo-liberalism: an introduction", in C. Colclough and J. Manor (Eds.), States or Markets? Neo-Liberalism and the Development Policy Debate (Oxford: Clarendon Press, 1991), 1-25

Domah, P. and M.G.Pollitt (2001), "The restructuring and privatisation of electricity distribution and supply businesses in England and Wales: a social cost–benefit analysis" *Fiscal Studies*, **22 (1)**,107–146

Espinal R. (1992), "Development, neoliberalism and electoral politics in Latin America" *Development and Change*, **23 (4)**, 27-47

Hjalmarsson, L. and Veiderpass A. (1992), "Productivity in Swedish electricity retail Distribution" *Scandinavian Journal of Economics*, **9,** 193-S205.

Bjurek, H., L. Hjalmarsson, F. Forsund, R. (1990), “Deterministic parametric and nonparametric estimation of efficiency in service production: a comparison” *Journal of Econometrics*, **46**, 213-227.

Hossain M. K., Kamil, A.A.. Baten, M.A and Mustafa, A. (2012), “Stochastic frontier approach and data envelopment analysis to total factor productivity and efficiency measurement of Bangladeshi Rice” *PLoS ONE* **7 (10)**: e46081.

ICIR (2023). “Central Bank of Nigerian confirms latest N3.01 billion release to DISCOs for power sector intervention”. Available at: https://www.icirnigeria.org/cbn-confirms-latest-n3-01bn-release-to-discos-for-power-sector-intervention/

Jerome, A. (2008) “Privatisation and enterprise performance in Nigeria: Case study of some privatized enterprises” AERC Research Paper 175 African Economic Research Consortium, Nairobi February 2008

Karahan, H and Toptas, M. (2013), “The effect of power distribution privatization on electricity prices in Turkey: Has liberalization served the purpose?” *Energy Policy*, **63**, 614-621

Meher, S., and Sahu, A. (2016), “Efficiency of electricity distribution utilities in India: a data envelopment analysis”. *OPEC Energy Review*, **40 (2)**, 155–179. https://doi.org/10.1111/opec.12072

Medeiros, G. O. S., Marangon-Lima, L. M., de Queiroz, A. R., Marangon-Lima, J. W., dos Santos, L. C. B., Barbosa, M. A., and Alvares, J. E. (2022), “Efficiency analysis for performance evaluation of electric distribution companies”. *International Journal of Electrical Power & Energy Systems*, **134,** 107430

Nigerian Electricity Regulatory Commission (2019), “NERC Quarterly reports” Retrieved from https://nerc.gov.ng/index.php/library/documents/NERC-Reports/NERC-Quarterly- Reports/

Perez-Reyes, R. and Tovar. B. (2009), “Measuring efficiency and productivity change (PTF) in the Peruvian electricity distribution companies after reforms” *Energy Policy*, **37,** 1536-61

Pombo, H. and Taborda. R. (2006), “Performance of efficiency in Colombia’s power distribution system: effects of the 1994 reform” *Energy Economics*, **28(3)**, 339-369

Samuel S.I., Jide, I. and Ayo, O. (2019) “Privatisation of Power Sector in Nigeria: An evaluation of Ibadan and Ikeja Electricity Distribution Companies Performance (2005–2018)” *International Journal of Public Administration*, DOI: 10.1080/01900692.2019.1672183

Theodoridis, A. M.; Psychoudakis A. (2008), “Efficiency measurement in Greek dairy farms: Stochastic frontier vs. data envelopment analysis” *International Journal of Economic Sciences and Applied Research*, **1 (2),**53-66

Umar, A. A. (2020), "The effect of privatisation on organizational performance of Abuja electricity Distribution Company" *International Journal of Management Research and Review,* **10 (1)**, 01-10

Wang, K., Chia-Yen, L., Jieming, Z. and Yi-Ming, W. (2018) "Operational performance management of the power industry: a distinguishing analysis between effectiveness and efficiency" *Annals of Operations Research, Springer*, **268 (1)**, 513-537

World Bank (2021), "The PSRP financing Plan and Model, World Bank training to PSRP Secretariat and Stakeholders, Abuja Nigeria