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Article

Post-Privatisation Assessment: A Panel Regression Analysis of Metering Penetration and Revenue Performance of Nigerian Distribution Companies (Discos)

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Abstract

Nationwide electrification and consistent power supply remain a forlorn dream in Nigeria, over a decade after the privatisation of the electricity sector. Most studies attribute it to corruption and weak institutions; however, these are just proximate causes. The real causes are underlying variables influencing the slowed metering penetration and poor revenue collection rates. This study examines all 11 DISCOS using monthly data of key performance indicators to assess each DISCOS' post-privatisation metering and revenue performance. The study adopts an analytical framework comprising descriptive statistics for foundational analysis of key performance indicators (KPIs), Linear and Panel Fixed Effects (FE) regression, and Extension models to accurately quantify the conditional associations between key variables. The R^2 values for the clustered robust standard errors (SEs) ranged from 0.715 to 0.879. The metering ratio is a strong positive and statistically significant determinant of revenue collected and collection rate. However, the metering impact trajectories are heterogeneous, with negative metering-collection efficiencies in Benin, Yola, Kaduna, and Enugu. The following structural archetypes were observed: Leaders (Ikeja, Eko, and Abuja); Mid-performers (Port Harcourt, Ibadan, and Kano); Laggards (Benin, Yola, Jos, Enugu, and Kaduna). Also, increasing the total customer base will not yield a proportional increase in energy billed or revenue growth, given the sector's current overreliance on estimated billing. The value of this research lies in its sector-wide assessment of the DISCOS financial and metering profiles. It buttresses the argument for DISOC-specific frameworks and the dissolution of a uniform regulatory and operational strategy.

Keywords: Nigerian DISCOS; metering; revenue collection; energy billed; post-privatisation; electricity distribution

1. Introduction

The generation and use of electricity in Nigeria dates back over a century, as shown in Figure 1; however, 1929 is widely regarded as a critical starting point due to the establishment of the Nigerian Electricity Supply Company [1]. Since then, the process of electrification in Nigeria has undergone significant change and reformation, with the most crucial in recent times being the unbundling and privatisation of the Power Holding Corporation of Nigeria (PHCN) [2]. At the time, there were 6 generating companies (GENCOS), 1 transmission company (TCN), and 11 distribution companies (DISCOS). While the Nigerian Electricity Regulatory Commission (NERC) 2024 quarterly reports

show an increase in the number of GENCOs (28 as of December 2024), and the DISCOS revenue and energy output reveal significant improvement, there remains the stark nightmare of energy poverty across Nigeria [3].

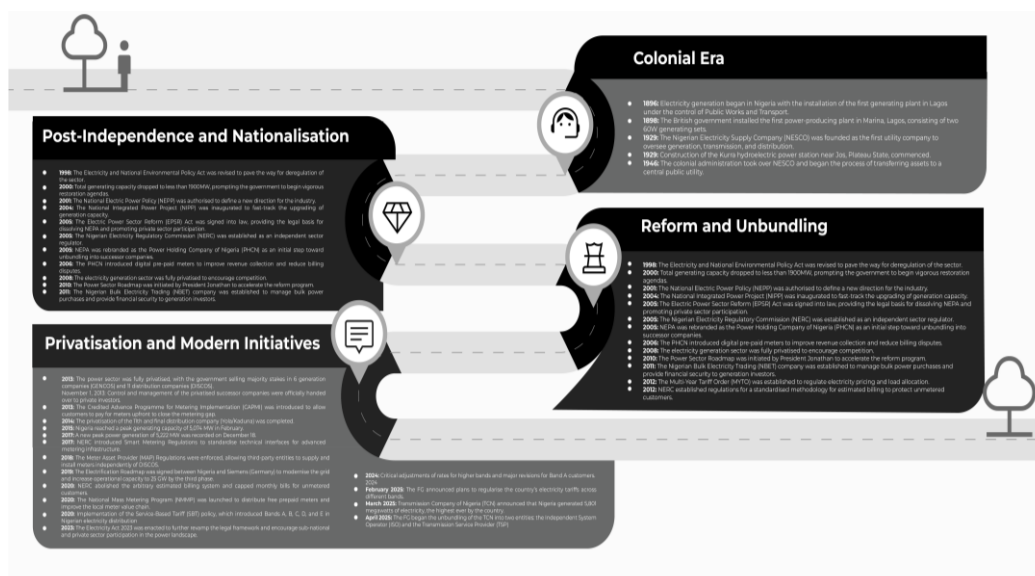


Figure 1. Timeline of Electricity Development in Nigeria.

According to [4], the dilemma of limited energy access is the result of multiple factors. However, their study prioritises the inability of DISCOS to realise full revenue based on the amount of energy billed to consumers. [5] earlier argued that the GENCOs are not without blame, as they consistently underperform in electricity generation. The results are a heightened Aggregate Technical, Commercial, and Collection (ATC&C) loss, often exceeding 50%. [6] cites the major barriers to sustainable electricity provision, including failing energy and electricity infrastructure and DISCOS management's negligence in improving the distribution facilities they inherited from the now-defunct PHCN, further explaining that no normal individual would be overjoyed to pay for services that they have not properly received. Given the current reality of inefficient billing, a 24-hour supply of electricity nationwide remains a forlorn dream.

Beyond generation and distribution challenges is the electricity billing system, which has incited a ubiquitous criticism of DISCOS' continued reliance on estimated billing. According to [2], NERC has assisted the reluctant DISCOS in fast-tracking the deployment of independent and competitive meter services through its Meter Assets Provider (MAP) scheme. The MAP scheme was structured to permit the provision of meters by separate business entities other than DISCOS, as DISCOS has consistently shown an inability to provide the needed meters for customers [4] proactively. However, the metering implementation has met resistance from the DISCOS, who have deliberately undermined any sector-wide approach they believe would break their monopoly over their state markets and weaken their control. [7] concurs on this, citing current DISCOS negligence as proof of their unwillingness to align with NERC's initiative and waive control on positing exorbitant electricity bills, which are largely uncollectible revenue and constitute their 'paper profits'.

1.1. Related Work

Existing literature on Nigeria's DISCOS shows that unit (single DISCO) analysis is the most widely adopted approach for investigating DISCOS billing and revenue performance. Other studies attempt DISCOS' performance analysis through surveys of either staff or members. Such approaches are limited when considering that the fundamental purpose of DISCOS' establishment is the provision of energy to geographic franchises that span urban vs rural, industrial, commercial, and residential delineations of human activity. Regardless of the investments in the Meter Asset Provider

(MAP) framework and NERC's interactive actions, the ATC&C losses remain considerably high, especially in revenue collection. This revenue gap, the unrealised monetary gains between revenue generated and revenue actually collected, is indicative of the ubiquitous operational dilemma faced in distribution. The implications, including inadequate infrastructure investments, limited electrification in peri-urban and rural peripheries, and poor service quality, continue to worsen.

The research on Nigerian DISCOS' revenue and metering performance is limited in its examination of revenue gaps and commercial losses as a singular challenge. This problem may be attributed to the data collection challenge that impedes in-depth analysis, or to researchers seemingly being more focused on technical losses. Nevertheless, this analytical approach of aggregating revenue performance without consideration of the variable influence within DISCOS' heterogeneity limits the accuracy of identifying revenue gap leakages for each DISCO and of formulating an objective comparison assessment of their operations. The revenue gap results from many variables. First, difficulties in the billing stage where DISCOS do not invoice their customers for the correct consumption. This is likely due to the significant number of customers still relying on estimated billing and a possible underestimation of units consumed. Second, in the collection stage, where revenue generated and revenue billed reveal a stark gap due to customer resistance to full payment, disputes over service quality and bill affordability, and DISCOS' weak enforcement. Regardless of the unique and daunting challenges, there is little literature that rigorously examines the actual revenue collection of Nigerian DISCOS in current electricity research.

Table 1. Review of Nigerian DISCOS' literature that conducted quantitative assessment post-privatisation.

Author	Aim	Methodology	Findings	Limitations
[8]	To assess the impact of privatisation on technical performance for the Benin Electricity Distribution Company	<ul style="list-style-type: none"> Survey questionnaire Analysis: Standard deviation and regression analysis 	<ul style="list-style-type: none"> Improvement in resource allocation, and moderate replacement of failed transformers. Strong association between poor workers' training and inefficient energy supply. 	<ul style="list-style-type: none"> Focused solely on BEDC. Most respondents had less than 10 years of experience, suggesting ignorance of pre-privatisation BEDC's performance. Non-utilisation of

				operational data.
[9]	To investigate the technical efficiency (TE) of Nigerian DISCOS, and examine drivers influencing efficiency deviations.	<ul style="list-style-type: none"> Deterministic Data Envelopment Analysis for all 11 DISCOS using panel data from 2014 to 2021 	<ul style="list-style-type: none"> Low industry TE of 0.33 Northern DISCOS are more inefficient than their Southern counterparts. Metering showed a negative impact on TE. 	<ul style="list-style-type: none"> No bootstrapping to ensure true efficacy scores were obtained.
[10]	To assess impact of Nigeria's power sector reform on Abuja Electricity Distribution Company (AEDC) efficiency.	<ul style="list-style-type: none"> Survey design encompassing 381 residential customers within Abuja and Suleja. 	<ul style="list-style-type: none"> Deregulation of the sector has not achieved its intended effect in improving efficiency Power supply remains intermittent regardless of reforms and initiatives 	<ul style="list-style-type: none"> Limited to one DISCO; AEDC
[11]	To examine strategy formulation and	<ul style="list-style-type: none"> Cross-sectional survey of 400 	<ul style="list-style-type: none"> Strategy formulation shows marginal 	<ul style="list-style-type: none"> Limited to AEDC.

	resource allocation impact on AEDC operational efficiency	AEDC critical staff members. • Data Analysis: Multiple Regression	influence on AEDC's operational efficiency. • Resource allocation and strategy formulation together influence 72.9% variation in operation efficiency.	• No use of operations data in determining why strategy formulation has marginal influence on AEDC's operational efficiency.
[12]	To investigate Ikeja Electricity Distribution Company (IKEDC) commitment to profit affects spirituality in their consumer value creation and their continued use of the estimated billing system.	• Quantitative survey of 322 consumers in Alimosho, Lagos. • Z-test for testing hypotheses.	• Significant correlation between DISCOS' refusal to invest in metering and fixation on paper profit.	• Respondents sample size is significantly limited when compared to the actual Ikeja customer market • No use of operations data.
[2]	To identify a technical gain ratio to assess the	• Mathematical modelling between	• A 1% increase in smart metering installation results in 0.8%	• Several data points from 2019 were missing and

	<p>impact of smart metering and decrease in 2020 is metering in ATC&C ATC&C losses, incomplete. reducing ATC&C losses. where other losses.</p> <ul style="list-style-type: none"> • 5 years of technical factors NERC data are held at a constant for the 11 DISCOS.
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[13]	<p>To examine DISCOS' financial motivation for preferring estimated billing over smart pre-paid meters.</p> <ul style="list-style-type: none"> • Comparison of four (4) Enugu Electricity Distribution Company (EEDC) customers within Owerri. • Examining one year of their monthly estimated bills with one-year pre-paid bills. 	<ul style="list-style-type: none"> • Overbilling of unmetered customer by an average of ₦ 64,901.67 per customer. • Sample size is severely limited. Cannot serve as a robust statistical survey
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[14]	<p>To investigate privatisation impact in improving</p> <ul style="list-style-type: none"> • 881 residential and commercial 	<ul style="list-style-type: none"> • No significant improvement on electricity supply. • Limited examination of only two DISCOS.
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	electricity supply based on supply quality, billing and DISCIOS' responsiveness.	customers of Ibadan and Ikeja distribution companies (IBEDC and IKEDC).	<ul style="list-style-type: none"> • General consensus on privatisation not improving customer satisfaction. • Analysis: Multi-regression statistics
[15]	To assess DISCOS technical efficiency in their electricity supply.	<ul style="list-style-type: none"> • Data Envelopment Analysis (DEA) using energy output data and collection losses between 2015 and 2022 for all 11 DISCOS. 	<ul style="list-style-type: none"> • A strong pattern of low output performance. • Ikeja is leading, while Jos and Yola are the least efficient, both having efficiency of less than 20%. • Broader examination of 11 DISCOS does not consider metering as a critical variable in collection losses and comparison with global average is unclear.

1.2. Significance, Aim and Objectives

The research's significance is unique at many layers. First, there is arguably no holistic research on DISCOS' metering and revenue performance that systematically decomposes the billing and revenue collection operations of Nigeria's electricity distribution sectors. From a research methodology standpoint, the study seeks to demonstrate the advantages of utilising panel fixed

effects (FE) and effect heterogeneity analyses to assess DISCOS' performance in a developing economy with a failing data collection infrastructure.

Second, the findings of this study hold immense value for electrification and energy distribution policy, especially in examining whether a uniform national policy is unintentionally aggravating rather than mitigating performance differences across DISCOS. Third, the theoretical benefits offer a better, more nuanced understanding of institutional heterogeneity across utility environments and conditions that influence the success of electrification interventions in developing economies with weak institutions and inefficient regulatory frameworks.

Undoubtedly, as a developing economy, Nigeria faces recurring challenges in infrastructure financing. Therefore, strategies that prioritise financial sustainability whilst improving energy distribution and electrification require policy interventions that strike a careful, sustainable balance across metering and enforcement, technology and governance, and the adoption of uniform or differentiated interventions.

This study aims to provide an in-depth examination of Nigeria's DISCOS' commercial and metering performance post-privatisation using linear and multiple regression models. This will be achieved through the utilisation of 10-year monthly-based data using critical DISCOS' indicators. The study's specific objectives include:

- i. To critically assess factors and barriers to Nigerian DISCOS' energy billing and revenue collection performance.
- ii. To accurately quantify the conditional associations between DISCOS' metering strategy and their collection rate, and the potential of metering in overcoming payment resistance.
- iii. To examine the conditional relationship between service market expansion, individual DISCOS' revenue growth, and the corresponding monetisation.
- iv. To proffer aligned policies and operations recommendations based on observed structural archetypes of the DISCOS' performance.

2. Methodology

2.1. Materials

2.1.1. Data Sourcing

The monthly data are based on DISCOS' operations, as illustrated in Figure 2, and are entirely quantitative. The data were sourced from both the National Bureau of Statistics (NBS) and the Nigerian Electricity Regulatory Commission (NERC) quarterly reports to address the former's shortfall in data presentation for the 2024 third and fourth quarters on 'revenue collected' and 'energy billed'

2.1.2. Dataset Indicators

The dataset obtained comprised five unique indicators, namely: Total Number of Customers, Number of Estimated Customers, Number of Metered Customers, Revenue Collected (Millions of Naira), and Energy Billed. While the first three are simple, the last two require clarity. The 'revenue collected' is the money DISCOS have collected as payment for energy used. This differs from 'revenue generated' due to the reluctance to pay the full electricity bill for energy use in Nigeria. Whereas, 'energy billed' is the total GWh invoiced to Nigerian customers (metered + estimated) per their service DISCOS. This differs significantly from 'energy supplied' or 'energy offtake', which is the total GWh the DISCOS injects into the distribution network.

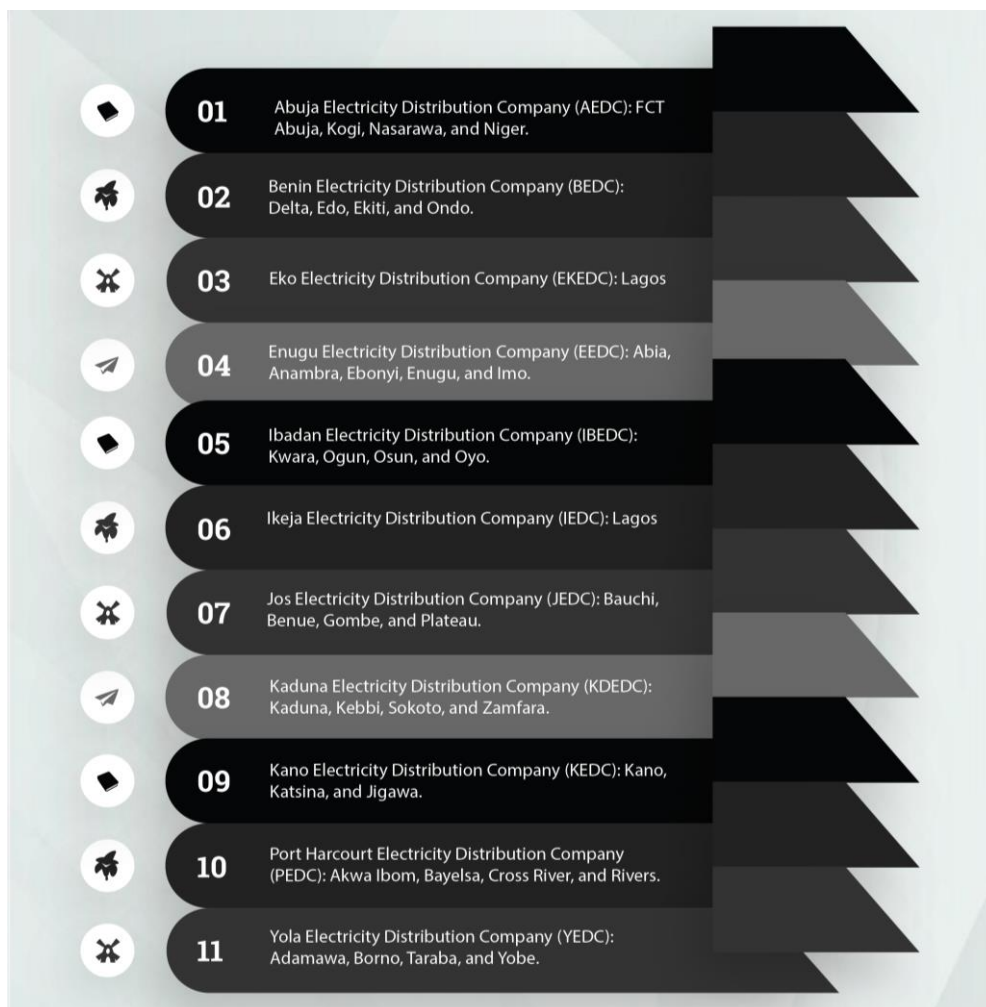


Figure 2. DISCOS and their associated state operations.

2.1.3. Software Employed

The research employed Microsoft Excel for initial cleaning and reformatting before feeding the data into a Jupyter notebook in Python for regression analyses.

2.2. Methods

The methods for analysis of DISCOS' data are threefold:

2.2.1. Descriptive Statistics

This section calculates averages for several key performance indicators and presents a general view of DISCOS' performance over the last 10 years, while providing primary context for how they compare. These include: average revenue collected, average energy billed, average metering ratio (metering penetration), average revenue collected per energy billed (collection rate: ₦/kWh), average revenue collected per customer (customer monetisation), average energy billed per customer (customer consumption)

$$\text{Metering Ratio} = \frac{\text{Number of Metered Customers}}{\text{Total Number of Customers}} \quad (1)$$

$$\text{Collection Rate} = \frac{\text{Revenue Collected}}{\text{Energy Billed}} \quad (2)$$

$$\text{Customer Monetisation} = \frac{\text{Revenue Collected}}{\text{Number of Total Customers}} \quad (3)$$

$$\text{Customer Consumption} = \frac{\text{Energy Billed}}{\text{Number of Total Customers}} \quad (4)$$

2.2.2. Linear Regression Models

This section presents the methodological approach to obtaining linear regression results between critical KPIs:

i. Li-Regression Model 1: Collection Rate & Metering Ratio (Metering Effectiveness)

$$\text{Collection Rate}_{it} = \beta_0 + \beta_1 \text{Metering Ratio}_{it} + \varepsilon_{it} \quad (5)$$

Where;

- i = DISCO identifier (i = Abuja, Benin, ..., Yola)
- t = Year (t = 2015, 2016, ..., 2024)
- β_0 = Intercept (collection rate when metering ratio = 0)
- β_1 = Slope (change in the collection per unit per increment in the metering ratio).
- ε_{it} = Error term

ii. Li-Regression Model 2: Revenue Collected & Energy Billed (Commercial Effectiveness)

$$\text{Revenue Collected}_{it} = \beta_0 + \beta_1 \text{Energy Billed}_{it} + \varepsilon_{it} \quad (6)$$

Where;

- β_0 = Intercept (fixed revenue component when energy billed = 0GWh)
- β_1 = Operational tariff rate (₦/kWh after conversion)

iii. Li-Regression Model 3: Revenue per Customer & Metering Ratio (Billing Accuracy and Payment Compliance)

$$\text{Revenue Collected per Customer}_{it} = \beta_0 + \beta_1 \text{Metering Ratio}_{it} + \varepsilon_{it} \quad (7)$$

Where;

- β_0 = Baseline revenue per customer at zero metering
- β_1 = Additional revenue per customer from 100% metering

Li-Reg Model 1 seeks to provide a basic understanding of how metering is associated with the collection rate and whether each DISCO's investment and approach to metering is reflected in improvements within revenue collection. The Li-Reg Model 2 reveals the commercial health of the DISCOS and shows how reliably each DISCO converts energy billed into revenue. The slope in this model indicates the effective tariff of the DISCOS, influenced by individual characteristics of service markets, collection efficiency, billing losses, and customer mix. Lastly, Li-Reg Model 3 examines the customer monetisation as a return-on-investment (ROI) metric. Assuming metering uses accurate billing and that its customers have higher payment compliance, the slope across DISCOS is used to identify which DISCOS benefit most from metering investment.

2.2.3. Multi-Regression Models

This section presents the methodology for the multi-regression analyses for several DISCOS' variables using key independent and dependent variables within a panel framework, with both fixed and random effects (FE and RE). All the multi-regression models adopt a two-way fixed effects (DISCOS + Year) with cluster-robust standard errors at the DISCO level, and the primary aim is to establish meaningful associations under conditional controls

i. Multi-Regression Model 1: DISCOS' Revenue Determination

$$\begin{aligned} \text{Revenue Collected}_{it} = & \beta_0 + \beta_1 \text{Energy Billed}_{it} + \beta_2 \text{Metering Ratio}_{it} + \\ & \beta_3 \text{Total Customers}_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \end{aligned} \quad (8)$$

Where;

- β_1 = Coefficient denoting the marginal effect of energy billed on revenue collected
- β_2 = Coefficient denoting the effect of metering ratio on revenue collected
- β_3 = Coefficient denoting the effect of the consumer base on the revenue collected.
- α_i = Fixed effect for DISCOS
- γ_t = Fixed effect for years
- ε_{it} = Error term (clustered standard errors)
- Constraints = $\sum_{i=1}^{11} \alpha_i = 0$ and $\sum_{t=1}^T \gamma_t = 0$

ii. Multi-Regression Model 2: DISCOS' Collection Efficiency

$$\begin{aligned} \text{Collection Rate}_{it} = & \beta_0 + \beta_1 \text{Metering Ratio}_{it} + \beta_2 \text{Energy Billed per Customer}_{it} + \alpha_i + \gamma_t + \\ & \varepsilon_{it} \end{aligned} \quad (9)$$

Where;

- β_1 = Coefficient denoting the marginal effect of metering on DISCOS' collection rate
- β_2 = Coefficient denoting the operational effect of consumer consumption intensity on collection rate

iii. Multi-Regression Model 3: DISCOS' Billing Volume

$$\begin{aligned} \text{Energy Billed}_{it} = & \beta_0 + \beta_1 \text{Metering Ratio}_{it} + \beta_2 \text{Total Customers}_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \end{aligned} \quad (10)$$

Where;

- β_1 = Coefficient for the effect of increasing metering ratio on total energy billed
- β_2 = Coefficient denoting the operational effect of consumer scale on energy billed

The Model 1 seeks to examine the association between revenue collected and contributory factors, such as poor billing, poor metering, and an inadequate customer base. Model 2, using the control rate as the dependent variable, employs the metering ratio and energy billed per customer as

independent variables. There is no categorisation of customer types into residential, commercial, industrial, rural, or urban. Customer type is held constant, and the study seeks to quantify the conditional association between metering and customer bill payment. Model 3 tests the influence of the metering ratio and the total number of customers on the energy billed, with the customers' coefficient indicating the energy billed per customer, conditional on the metering ratio.

2.2.4. Extension Models

i. Ex-Model 1: Time Trend Comparison Model

This extension model employs a differential trend to identify which DISCOS are growing fastest over time. The average annual collection rate quantifies this growth.

$$\text{Collection Rate}_{it} = \beta_0 + \beta_1 \text{Year}_t + \sum_{j=2}^{11} \beta_{2j} D_{ij} + \sum_{j=2}^{11} \beta_{3j} (\text{Year}_t \times D_{ij}) + \varepsilon_{it} \quad (11) \text{ Where;}$$

- D_{ij} = Dummy variable for each DISCO
- Year_t = Continuous time variable (mean centred)
- β_0 = Intercept for reference DISCO at the mean year
- β_1 = Baseline time trend (improvement rate for the reference DISCO)
- β_{2j} = Level difference for DISCO j relative to the reference at the mean year
- β_{3j} = Differential trend for DISCO j
- ε_{it} = Error term for standard errors at DISCO level

ii. Ex-Model 2: Customer Scale Efficiency Model

This model examines DISCOS' structural monetisation capabilities while controlling for metering. It examines DISCOS' operational revenue per customer, averaged over the years.

$$\text{Revenue Collected per Customer}_{it} = \beta_0 + \beta_1 \text{Metering Ratio}_{it} + \sum_{j=2}^{11} \beta_{2j} D_{ij} + \varepsilon_{it} \quad (12)$$

Where;

- β_0 = Intercept for reference DISCO at zero metering
- β_1 = Metering effect that is assumed to be constant for each DISCO
- β_{2j} = Adjusted mean difference for DISCO j against reference
- ε_{it} = Error term for standard errors at DISCO level

2.3. Endogeneity Defence

The research acknowledges the potential endogeneity bias in the metering ratio, especially as reverse causality may make higher-revenue DISCOS more buoyant in their ability to implement meter deployment. Nevertheless, the methodology itself is designed to mitigate these limitations:

- i. The DISCOS FE has absorbed all time-invariant confounders, which constitute the principal source of bias. Thereby isolating identification to DISCOS-temporal variations only.
- ii. The Year FE eliminates all critical events and policy shocks that would have conflated secular trends within the metering-revenue nexus.

- iii. The weak institutional inertia slowing metering makes the monthly metering ratio values a product of prior investment rather than current revenue outcomes. This significantly weakens the inertia that slows metering, making the monthly metering ratio values a product of prior investment rather than current revenue outcomes.

3. Results and Findings

3.1. Descriptive Statistics Results

i. Revenue Collected

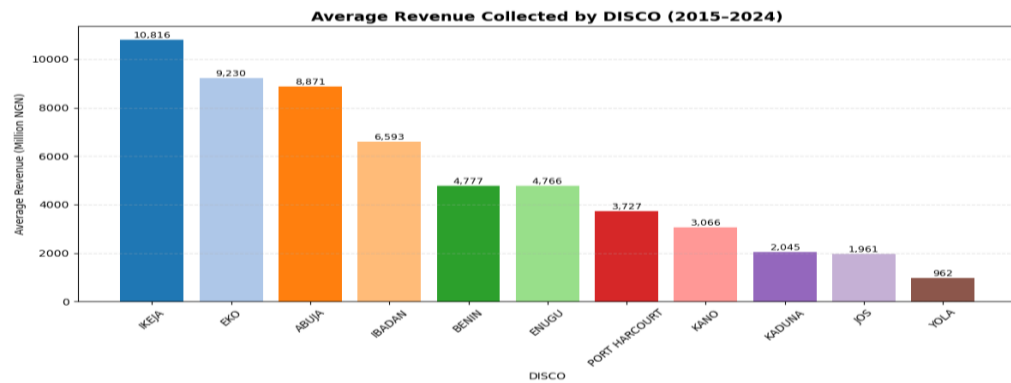


Figure 3. Average Revenue Collected by the 11 DISCOS.

ii. Energy Billed

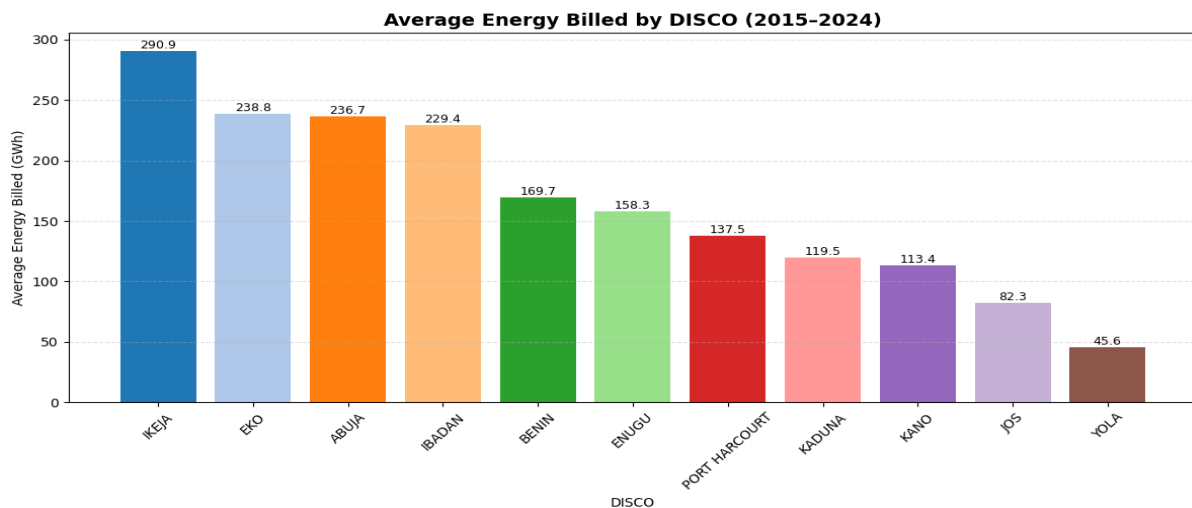


Figure 4. Average Energy Billed by the 11 DISCOS.

iii. Metering Ratio

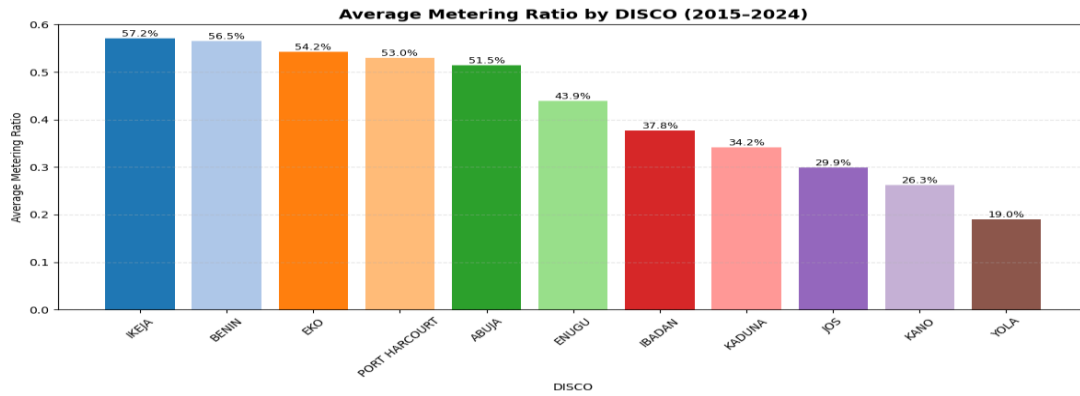


Figure 5. Average Metering Ratio for the 11 DISCOS.

iv. Collection Rate

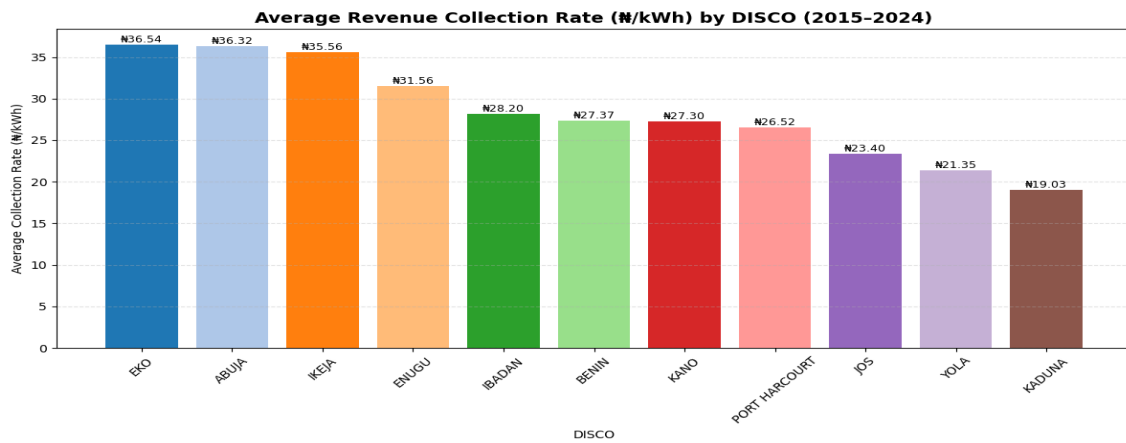


Figure 6. Average Revenue Collection Rate for the 11 DISCOS.

v. Revenue Collected per Customer

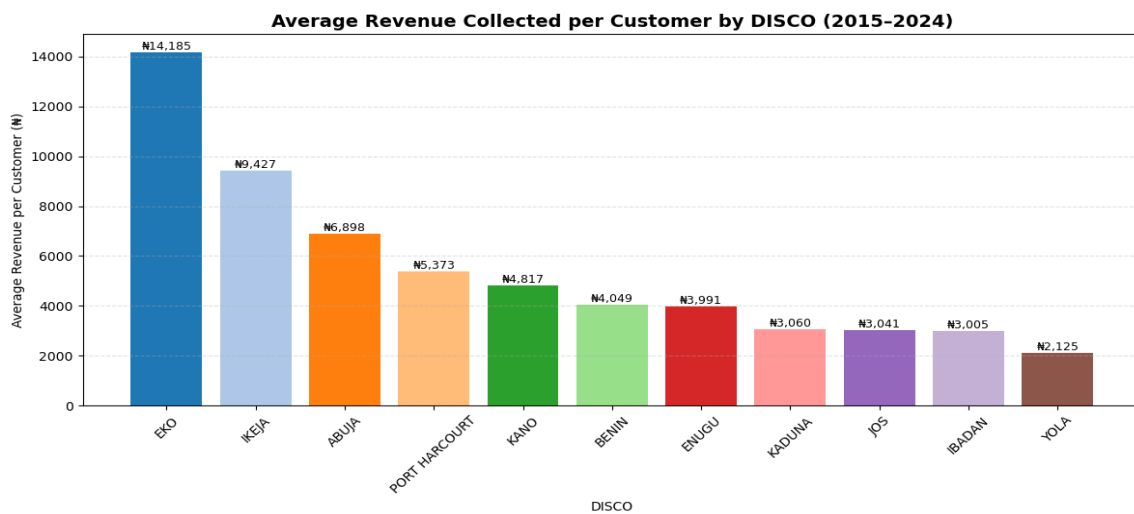


Figure 7. Average Revenue Collected per Customer for the 11 DISCOS.

vi. Energy Billed per Customer

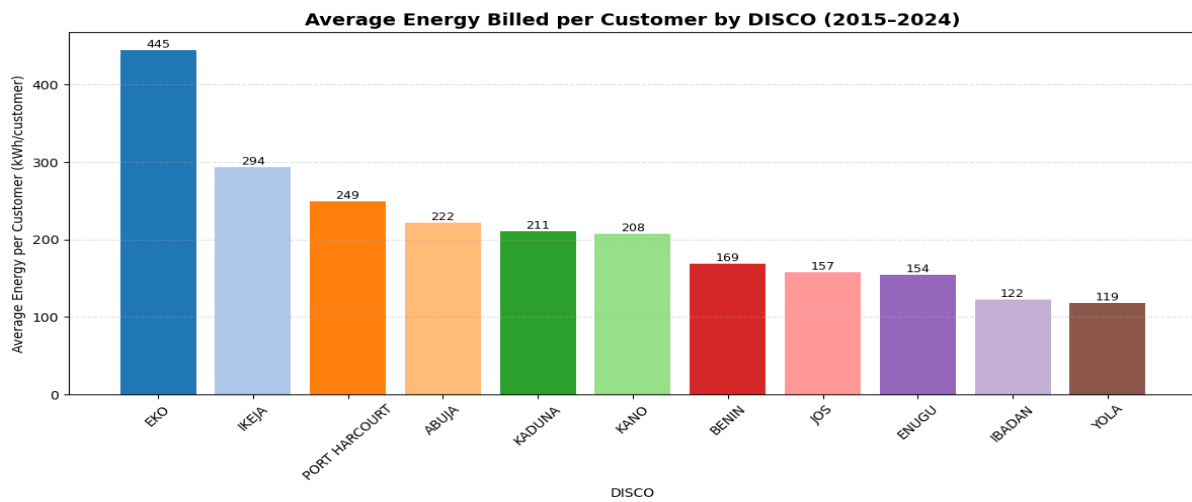


Figure 8. Average Energy Billed per Customer for the 11 DISCOS.

Figure 3 illustrates the revenue collected in millions of naira and depicts Ikeja, Eko, Abuja and Ibadan to be the biggest four DISCOS. Ikeja is the only DISCO exceeding the ₦10 billion, an overwhelming difference of over ₦1.5 billion to the immediate runner-up (Ikeja). The first and second positions are due to the commercial and industrial nature of Lagos State. In contrast, Abuja's ranking third may be attributed to its position as the Federal Capital Territory (FCT). Port Harcourt, ranking 7th is quite concerning given its commercial and industrial value to the nation's South-South geopolitical zone. This is similarly observed in Figure 4, with only the first four DISCOS exceeding an average of 200GWh.

Figure 5 illustrates the metering ratio for DISCOS and provides a different ranking than Figures 3 and 4. Only 5 DISCOS attained a metering rate of $\geq 50\%$, namely, Ikeja, Benin, Eko, Port Harcourt and Abuja. Benin and Port Harcourt show significantly higher metering effort, regardless of not being among the top four in terms of revenue collected and energy billed. Figure 6, illustrating the collection rate, shows only four DISCOS exceeding ₦30/kWh (Eko, Abuja, Ikeja, and Enugu). The rest are in the ₦20/kWh range, except for Kaduna, which recorded ₦19.03/kWh. This implies that the operational tariff is significantly lower than the stipulated tariff, with many DISCOS likely operating at a financial loss.

Figure 7 illustrates revenue collected per customer; only 4 DISCOS exceeded ₦5,000/customer. These are Eko, Ikeja, Abuja and Port Harcourt. Only Eko exceeded ₦10,000; however, Port Harcourt's inclusion in the top four, despite ranking 7th in average revenue, is attributable to its metering ratio. This implies that Port Harcourt, while generating lower revenue, operates a robust metering and billing system that ensures many of its customers pay their bills to a significant degree. Additionally, Figure 8 shows each DISCOS' energy billed per customer, indicating the energy consumed by each customer after accounting for losses. 6 of the 11 DISCOS exceed 200kWh per customer; however, only Eko exceeds 300kWh per customer. Port Harcourt also ranks 3rd, indicating increased customer consumption, likely due to its oil and gas industrial activities. Yola ranks perpetually last in all assessments except for collection rate, where it ranks 10th. This solidifies its position as the smallest operational DISCO, as shown in Table 2.

Table 2. Heat Map Summary Table Ranking for DISCOS' Averages.

DISCOS	Revenue Collected (Millions ₦)	Energy Billed (GWh)	Metering Rate (%)	Collection Rate (₦/kWh)	Revenue per Customer (₦)	Energy Billed by Customer (kWh)
ABUJA	3	3	5	2	3	4
BENIN	5	5	2	6	6	7
EKO	2	2	3	1	1	1
ENUGU	6	6	6	4	7	9
IBADAN	4	4	7	5	10	10
IKEJA	1	1	1	3	2	2
JOS	10	10	9	9	9	8
KADUNA	9	8	8	11	8	5
KANO	8	9	10	7	5	6
PORT HARCOURT	7	7	4	8	4	3
YOLA	11	11	11	10	11	11

3.2. Linear Regression

i. Li-Reg 1: Collection Rate vs Metering Ratio

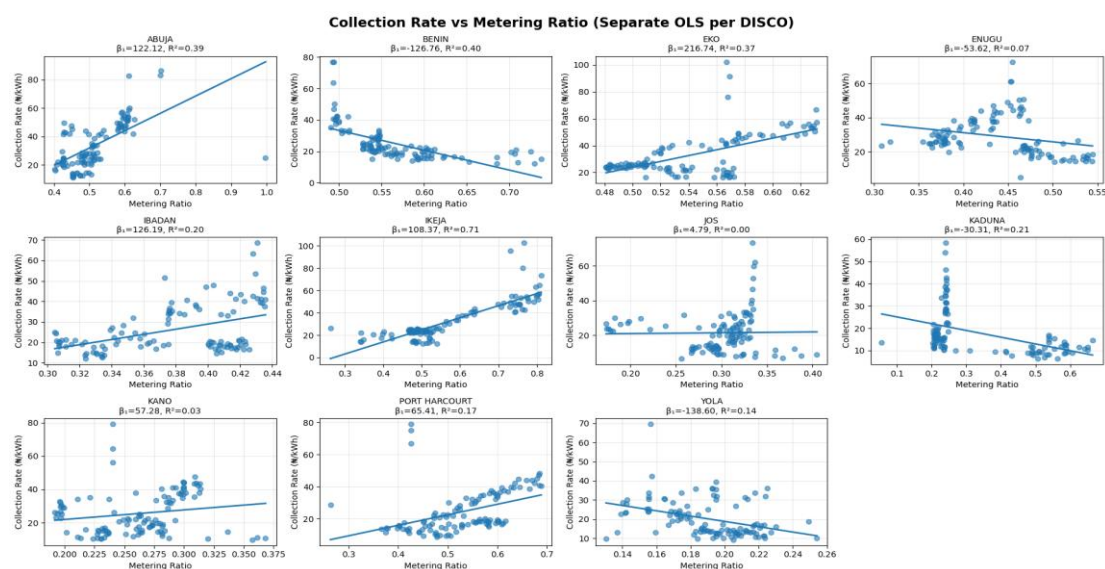


Figure 9. Linear Regression Results on Collection Rate vs Metering Ratio for all 11 DISCOS.

Where:

- i. $p < 0.01$: Strong Statistical Significance
- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant
- v. The results depicted in Figure 9 and shown in Table 3 ranking reveal Eko, Ibadan, Abuja and Ikeja to be the only four DISCOS whose β_1 exceeds ₦100/kWh. These suggest that metered customers pay more per kWh than estimated customers, as metering is strongly and positively associated with their collection rate. However, Kaduna, Enugu, Benin, and Yola show negative coefficients, with all five having strongly significant p-values. The implication is that estimated customers pay more per kWh for these DISCOS. Nevertheless, this hints at a few additional possibilities, such as poor metering strategy, individual structural inefficiencies affecting billing and collection, and significant reliance on estimated billing. The results for Kano and Jos are uncertain, not necessarily due to their coefficients, but because they have the lowest p-values and R^2 values. This suggests a variance in the conditional explanatory relationship between metering on DISCOS' collection rate. Further implying that metering or non-metering is not a

significant conditional correlate of collection rate in the case of Kano and Jos. **Li-Reg 2: Revenue Collected vs Energy Billed**

Table 3. DISCOS' Ranking Table for Li-Reg 1.

DISCOS	n	β_1	p-value	Statistical Significance	R ²
EKO	114	216.7414	9.849×10^{-13}	Strong	0.366
IBADAN	114	126.1899	4.392×10^{-7}	Strong	0.205
ABUJA	114	122.1155	7.448×10^{-14}	Strong	0.394
IKEJA	114	108.3728	3.432×10^{-32}	Strong	0.714
PORT HARCOURT	114	65.4059	3.725×10^{-6}	Strong	0.175
KADUNA	114	-30.3137	2.811×10^{-7}	Strong	0.211
ENUGU	114	-53.6210	5.708×10^{-3}	Strong	0.066
BENIN	114	-126.7641	5.103×10^{-14}	Strong	0.398
YOLA	114	-138.5993	4.31×10^{-5}	Strong	0.139
KANO	114	57.2792	0.06189	Marginal	0.031
JOS	114	4.7914	0.8447	Not Significant	0.000

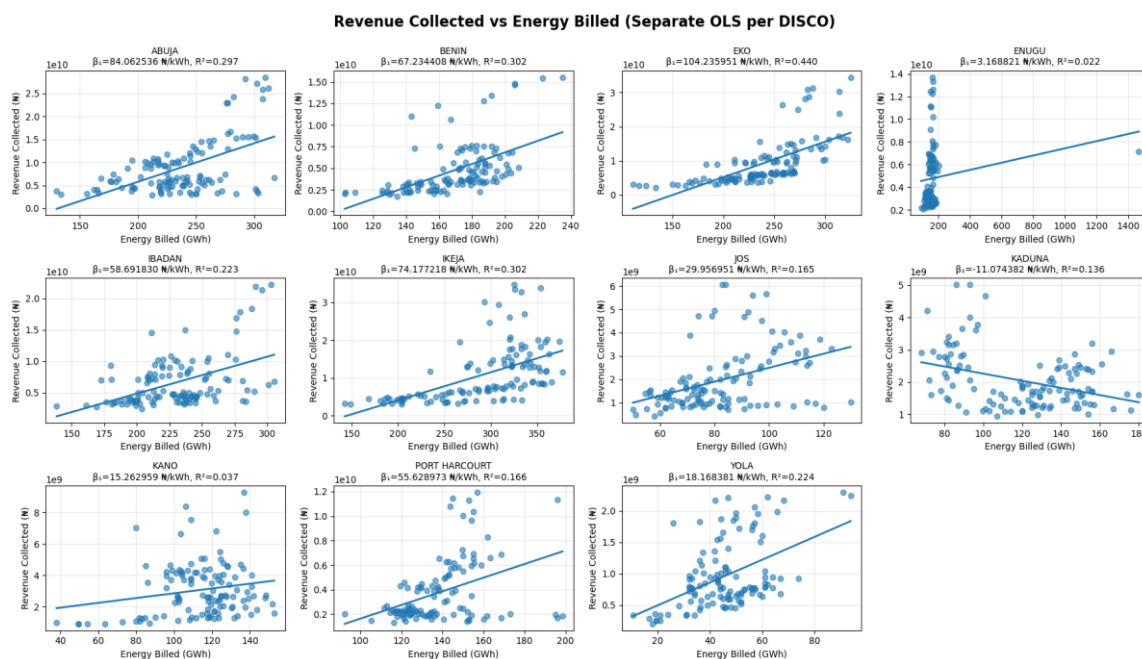


Figure 10. Linear Regression Results on Revenue Collected vs Energy Billed for all 11 DISCOS.

Where:

- i. $p < 0.01$: Strong Statistical Significance

- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant

Figure 10 and Table 4 show all DISCOS exhibiting a positive correlation between revenue collected, except for Kaduna ($\beta_1 = -\text{₦}11.0744/\text{kWh}$; $p\text{-value} = 3.5270 \times 10^{-5}$). This makes it the DISCO with the least performing collection rate. However, its negative coefficient indicates Kaduna's operational failure to collect sufficient revenue to break even. Only Eko exceeded $\text{₦}100/\text{kWh}$. Enugu is ranked 10th because it has the lowest positive coefficient and a non-significant p -value ($\text{₦}3.1689/\text{kWh}$; $p\text{-value} = 1.0618 \times 10^{-1}$). The implication is that 10 of the 11 DISCOS operational tariffs actually collected are below $\text{₦}100/\text{kWh}$. While this is a critical challenge, the R^2 values are equally concerning, with only Eko exceeding 0.40. The rest are below 0.3, except for Ikeja and Benin, both recording 0.302. The implication is that, while the relationships are significant, there are several other factors that this linear regression does not account for.

Table 4. DISCOS' Ranking Table for Li-Reg 2.

DISCOS	n	β_1	p-value	Statistical Significance	R^2
EKO	120	104.2360	1.5476×10^{-16}	Strong	0.440
ABUJA	120	84.0625	1.2025×10^{-10}	Strong	0.297
IKEJA	120	74.1772	7.8581×10^{-11}	Strong	0.302
BENIN	120	67.2344	7.7205×10^{-11}	Strong	0.302
IBADAN	120	58.6918	5.0779×10^{-8}	Strong	0.223
PORT HACOURT	120	55.6290	3.7990×10^{-6}	Strong	0.166
JOS	120	29.9570	4.2573×10^{-6}	Strong	0.165
YOLA	120	18.1683	4.9629×10^{-8}	Strong	0.224
KANO	120	15.2630	3.5621×10^{-2}	Moderate	0.037
ENUGU	120	3.1689	1.0618×10^{-1}	Not Significant	0.022
KADUNA	120	-11.0744	3.5270×10^{-5}	Strong	0.136

ii. **Li-Reg 3: Revenue per Customer vs Metering Ratio**

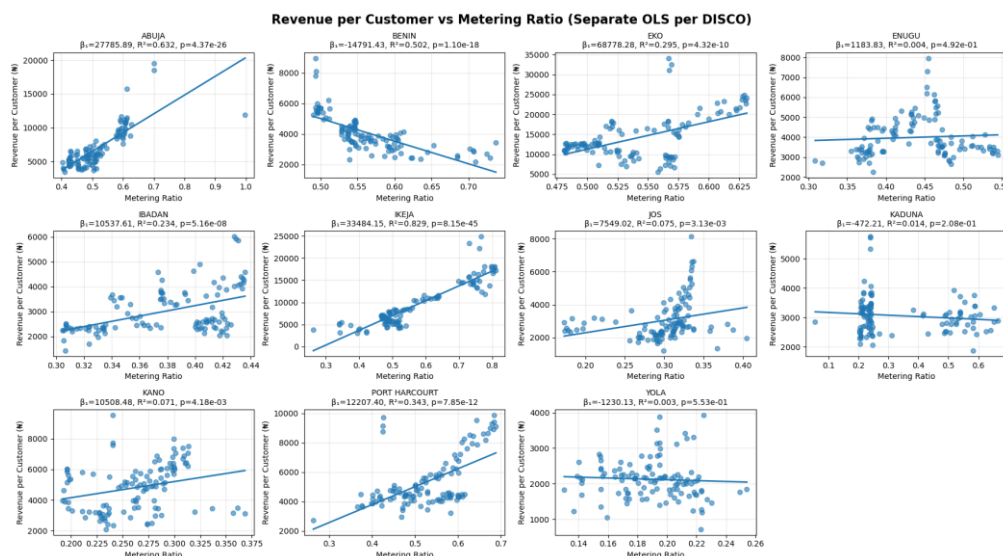


Figure 11. Linear Regression Results on Revenue per Customer vs Metering Ratio for all 11 DISCOS.

Where:

- i. $p < 0.01$: Strong Statistical Significance
- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant

Figure 11 and Table 5 results indicate that, under the assumption of 100% metering, each DISCOS' operation adds the coefficient (β_1) per customer per year in revenue. Kaduna, Yola and Benin rank 9th, 10th and 11th with negative coefficients, while the rest show positive coefficients. While the first six exceed ₦10,000 per customer, only Eko exceeds ₦40,000 per customer ($\beta_1 = ₦68,778.28$ per customer; $p\text{-value} = 4.3167 \times 10^{-10}$). Eko, Ikeja, and Abuja show that metering is significantly and positively associated with customer monetisation, and validate that their operations are returning significant ROI from metering interventions. Port Harcourt, Ibadan and Kano show some medium impact. Jos and Enugu show a negligible conditional association between metering and revenue per customer per year. Kaduna, Yola, and Benin's negative slopes strongly indicate severe payment resistance, likely due to DISCOS' overreliance on estimated billing. The implication is that these last three DISCOS are consistently at a loss in terms of customer monetisation. The p - and R^2 -values for Enugu, Kaduna, and Yola are Not Significant and Low for all three, implying the presence of another influencing variable for such dismal monetisation. However, Benin's p - and R^2 -values are highly significant ($p = 1.1035 \times 10^{-18}$; $R^2 = 0.502$), implying the operational loss in revenue per customer is a significant result of its poor metering ratio.

Table 5. DISCOS' Ranking Table for Li-Reg 3.

DISCOS	n	β_1	p-value	Statistical Significance	R^2
EKO	114	68778.28	4.3167×10^{-10}	Strong	0.295
IKEJA	114	33484.15	8.1499×10^{-45}	Strong	0.829
ABUJA	114	27785.89	4.3710×10^{-26}	Strong	0.632
PORT HARCOURT	114	12207.40	7.8492×10^{-12}	Strong	0.343

IBADAN	114	10537.61	5.1568×10^{-8}	Strong	0.234
KANO	114	10508.48	4.1783×10^{-3}	Strong	0.071
JOS	114	7549.02	3.1311×10^{-3}	Strong	0.075
ENUGU	114	1183.83	4.9192×10^{-1}	Not Significant	0.004
KADUNA	114	-472.21	2.0833×10^{-1}	Not Significant	0.014
YOLA	114	-1230.13	5.5299×10^{-1}	Not Significant	0.003
BENIN	114	-14791.43	1.1035×10^{-18}	Strong	0.502

3.3. Multi-Regression Results

i. Multi-Reg 1: DISCOS' Revenue Determination

Where:

- i. $p < 0.01$: Strong Statistical Significance
- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant

Table 6, which presents the coefficients for the independent variables, shows strong similarities between the FE and RE models. However, the RE's results show a more significant p-value due to efficiency gains originating from the RE's within and between DISCOS' variations. Metering ratio is strong and positive, with strong statistical significance ($\beta = 12.2833$; p-value = 7.6161×10^{-3}), implying a significant conditional association between metering and collectable revenue beyond the billing volume effect. Energy billed exhibits a positive but negligible association with revenue collected ($\beta = 0.0081$; p-value = 2.2873×10^{-1}). Similarly, the estimated coefficient for customer base is negligible. The coefficient for DISCOS fixed effects (α_i) employing Benin as a reference shows significant heterogeneity among DISCOs, even with energy billed, metering ratio and customer base at constant. Ikeja and Eko are leading, exceeding 4.0, while Kano, Abuja, and Yola exceed 3.0. The DISCOS' FE coefficients are all positive, implying that all DISCOS outperform Benin regardless of controls for energy billed, metering, and customer-number scale, though Port Harcourt's coefficient is marginal. However, the results for Yola, Jos, Ibadan, Kaduna, and Port Harcourt are not significant.

Table 6. Multi-Reg Model 1 (FE vs RE Results): Panel Estimates of Revenue Determination.

Variable		FE (β)	FE SE	FE (p-value)	RE (β)	RE SE	RE (p-value)
Energy Billed	(GWh)	0.0081	0.0067	2.2873×10^{-1}	0.0082	0.0010	2.1973×10^{-17}
Metering Ratio		12.2833	4.6028	7.6161×10^{-3}	12.1887	0.5756	1.6419×10^{-99}
Total Customers	(millions)	1.9470	1.9341	3.1409×10^{-1}	1.8086	0.4356	3.289×10^{-5}

Group Var	--	--	--	2.0290	0.607	--
DISCO FE		YES			NO	
YEAR FE		YES			YES	
OBSERVATIONS		1254			1254	

DISCOS	FE Coefficient (α_i)	FE SE	FE (p- value)	Significance Level
IKEJA	4.4615	0.817	0.000	Strong
EKO	4.4869	1.103	0.000	Strong
KANO	3.6180	1.700	0.033	Moderate
ABUJA	3.5788	0.504	0.000	Strong
YOLA	3.3969	2.225	0.127	Not Significant
JOS	2.3692	1.610	0.141	Not Significant
IBADAN	1.7396	1.826	0.341	Not Significant
ENUGU	1.6218	0.577	0.005	Strong
KADUNA	1.5423	1.319	0.242	Not Significant
PORT HARCOURT	0.5985	0.828	0.470	Not Significant
BENIN	0.0000	----	----	----

(BASELINE)

Dependent variable: Revenue Collected (₦ billions) Notes: FE includes DISCO and time fixed effects; SEs clustered by DISCOS Sample: N=1254, DISCOS=11, R²=0.875.

ii. Multi-Reg 2: DISCOS' Collection Efficiency

Where:

- i. $p < 0.01$: Strong Statistical Significance
- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant

Table 7 confirms that the metering ratio ($\beta = 24.6102$; p -value = 0.002) has a positive and significant relationship with the collection rate. This implies that DISCOS' metered customers pay more per kWh billed, validating metering to be a payment enforcement mechanism. Also, for +10 pp in metering FE and RE results, the increases are ₦2.46/kWh and ₦2.48/kWh, respectively. However,

the energy per customer shows a negative but negligible coefficient ($\beta = -0.0406$), implying that as energy billed per customer increases, there is a complementary but minuscule decline in the collection rate. This suggests a structural disconnect between customer consumption and DISCOS' collection, likely the estimated billing. Therefore, higher energy billed, even accounting for technical losses, is not an indicator of improved revenue collection. This is consistent with the dependence on estimated billing, resulting in customers' delayed payments, disputed bills, and significantly accumulated arrears. Nevertheless, the small magnitude of the FE coefficients for the DISCOS is all positive except for Kaduna (-0.2038). Kaduna is the only DISCO underperforming in the collection rate below the baseline of Benin; however, the significance level of the results is denoted as 'not significant'.

Table 7. Multi-Reg Model 2 (FE vs RE Results): Panel Estimates of Collection Efficiency.

Variable	FE (β)	FE SE	FE (p-value)	RE (β)	RE SE	RE (p-value)
Metering Ratio	24.6102	7.966	0.002	24.801	1.848	0.000
Energy per Customer (kWh)	-0.0406	0.006	0.000	-0.040	0.003	0.000
Group Var	--	--	--	33.648	3.008	--
DISCO FE		YES			NO	
YEAR FE		YES			YES	
OBSERVATIONS		1254			1254	
DISCOS	FE Coefficient (α_i)	FE SE	FE (p-value)	Significance Level		
EKO	19.6054	1.874	0.000	Strong		
IKEJA	12.1809	0.747	0.000	Strong		
ABUJA	11.8462	0.677	0.000	Strong		
KANO	9.4084	2.584	0.000	Strong		
ENUGU	6.3850	0.936	0.000	Strong		
IBADAN	3.6478	1.295	0.005	Strong		
PORT HARCOURT	3.4721	0.733	0.000	Strong		
JOS	2.3945	2.062	0.246	Not Significant		

YOLA	2.1924	2.764	0.428	Not Significant
BENIN	0.0000	----	----	----
(BASELINE)				
KADUNA	-0.2038	1.974	0.918	Not Significant

Dependent variable: Collection Rate (₦/kWh) Notes: FE includes DISCO and time fixed effects; SEs clustered by DISCOS Sample: N=1254, DISCOS=11, R²=0.879.

iii. Multi-Reg 3: DISCOS' Billing Volume

Where:

- i. $p < 0.01$: Strong Statistical Significance
- ii. $p < 0.05$: Moderate Statistical Significance
- iii. $p < 0.10$: Marginal Statistical Significance
- iv. $p \geq 0.10$: Not Statistically Significant

Table 8 results show that while metering ratio shows a strong and positive correlation with energy billed, it is marginally significant ($\beta = 78.2099$; p -value = 0.0632). The customer scale shows a weak, non-significant negative correlation. This implies an increase in the metering ratio, which is similarly associated with some increase in energy billed; however, the relationship between energy billed and customer number is inverse. This indicates that a larger customer base does not necessarily translate to increased billing volume; this may be due to poor electrification and structural challenges that impede the 24-hour provision of light. The results for DISCO effects show great significance across the board, except for Enugu. Enugu shows a marginal difference, while Port Harcourt, Kaduna, Kano, Jos, and Yola are underperforming below the Benin baseline, and the results, aside from Kaduna and Kano, are statistically significant. This indicates that the 5 underperforming DISCOS are losing energy conversion either through illegal taps or poor monitoring.

Table 8. Multi-Reg Model 3 (FE vs RE Results): Panel Estimates of Billing Volume.

Variable	FE (β)	FE SE	FE (p-value)	RE (β)	RE SE	RE (p-value)
Metering Ratio	78.2099	42.096	0.0632	87.149	18.162	1.598410 ⁻⁶
Customer (Millions)	-1.0662	23.365	0.9636	9.125	14.316	0.524
Group Var	--	--	--	3642.736	35.846	--
DISCO FE	YES		NO			
YEAR FE	YES		YES			
OBSERVATIONS	1254		1254			

DISCOS	FE Coefficient (α_i)	FE SE	FE (p-value)	Significance Level
IKEJA	120.7916	0.479	0.000	Strong
IBADAN	74.2279	21.189	0.000	Strong
ABUJA	69.4766	2.795	0.000	Strong
EKO	69.3979	11.238	0.000	Strong
ENUGU	0.4459	5.261	0.932	Not Significant
BENIN	0.0000	----	----	----
(BASELINE)				
PORT HARCOURT	-29.1017	9.984	0.004	Strong
HARCOURT				
KADUNA	-29.4341	13.669	0.031	Moderate
KANO	-31.1645	17.319	0.072	Marginal
JOS	-65.2618	16.356	0.000	Strong
YOLA	-93.3648	22.310	0.000	Strong

Dependent variable: Energy Billed (GWh) Notes: FE includes DISCO and time fixed effects; SEs clustered by DISCOS Sample: N=1254, DISCOS=11, R²=0.715.

3.4. Extension Models

i. Time Trend Comparison Model: Collection Rate

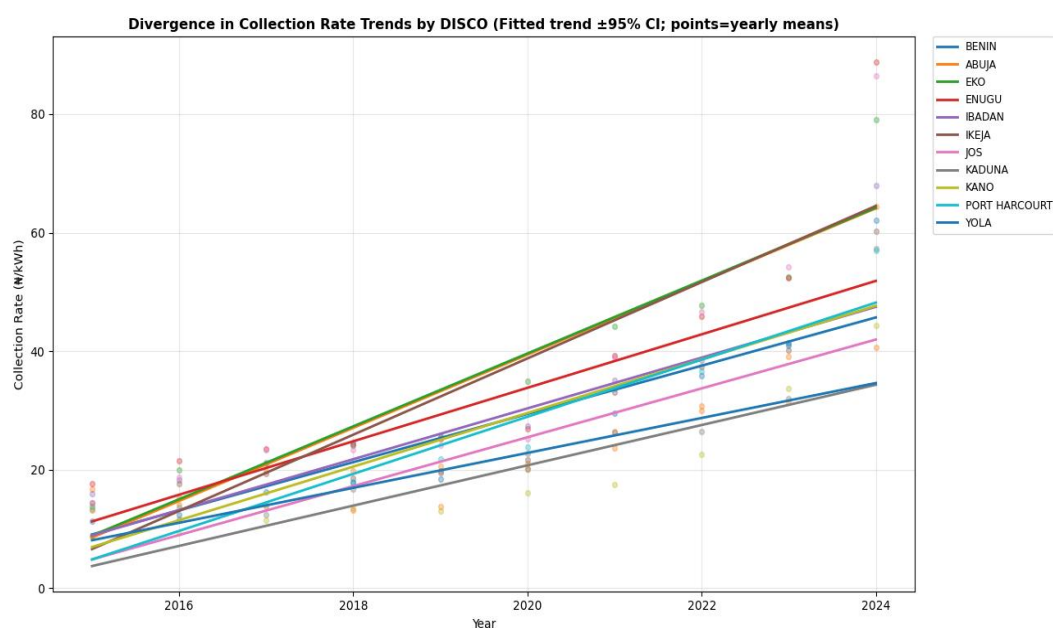


Figure 12. Divergence in Collection Rate Trends by DISCOS.

Table 9 and Figure 12 present the annual trend in the collection rate and the divergence in it across the 10 years examined, using Benin as the reference DISCO. The justification for Benin is that it ranks 6th in the overall average collection rate, as seen in Figure 6. The table results reveal a significant gap between the leading Ikeja (₦6.44/kWh/year) and the lagging Yola (₦2.95/kWh/year). Benin ranks 9th superseding Kaduna and Yola, which rank 10th and 11th, respectively. These positions and annual trends remain constant even if another DISCO was used as a reference. This was tested with Abuja, and the consistently high significance is due to the clustering of standard errors.

Table 9. Results for Time Trend Comparison Analysis: Cluster-Robust SEs by DISCOS (Reference = Benin; Covariance Type: Cluster; $R^2 = 0.749$).

DISCOS	Annual Trend (₦ /kWh/year)	Reference Comparison (DISCOS vs Ref)	p-value	Significance Level
IKEJA	6.44	+58.23%	0.000000	Strong
ABUJA	6.18	+52.23%	0.000000	Strong
EKO	6.15	+51.11%	0.000000	Strong
PORT	4.82	+18.43%	0.000000	Strong
HARCOURT				
KANO	4.52	+11.06%	0.000000	Strong
ENUGU	4.51	+10.81%	0.000000	Strong
IBADAN	4.29	+5.41%	0.000000	Strong
JOS	4.12	+1.23%	0.000000	Strong
BENIN	4.07	Reference	---	---
KADUNA	3.40	-16.46%	0.000000	Strong
YOLA	2.95	-27.52%	0.000000	Strong

Figure 12 illustrates the collection rate over 10 years, with the estimated 2024 value for DISCOS' annual collection rate trend set at 10 times the annual trend shown in Table 8. The graph line constitutes the fitted time trends while the dots indicate each DISCO's observed yearly means. There is an upward slope for all DISCOS, suggesting increasing monetisation efficiency sector-wise. However, the lines do not behave in parallel, indicating structural heterogeneity across the DISCOS. This plausibly reflects differences in operational efficiency, customer mix, and metering enforcement. The slugging slopes for Benin, Kaduna and Yola indicate poor development in structural monetisation.

ii. Customer Scale Efficiency Model: Customer Monetisation, Adjusted for Metering

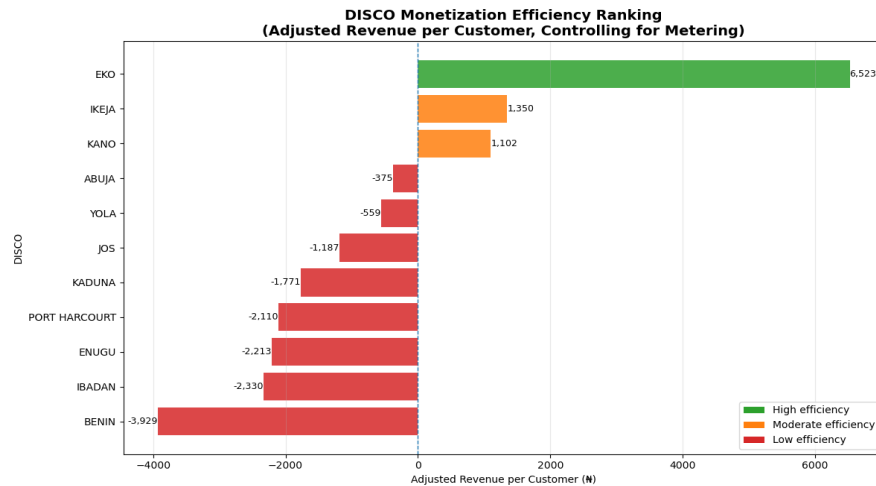


Figure 13. DISCOS' Ranking on Monetisation Efficiency with Controlled Metering.

Table 10 and Figure 13 show DISCOS' rankings when different metering levels are controlled for across the sector, with other structural motivation variables held constant except for metering. Hence, all DISCOS are assumed to be on equal metering footing. The coefficient (β_1) for metering ratio indicates that a hypothetical 100% increase in metering ratio is associated with an increase of ₦ 14,130.11 per customer. Only Eko, Ikeja and Kano present actual positive adjusted revenue per customer values. The rest are all in the negative. However, Yola's 5th position in monetisation as opposed to a consistent 11th position in earlier assessment requires further investigation, even if the data points to a smaller customer market and the significance level denotes 'not significant'.

Table 10. Results for customer Scale efficiency Analysis (Cluster-Robust SEs by DISCOS) (Reference = Benin; Covariance Type: Cluster; $R^2 = 0.704$).

DISCOS	Adjusted Revenue per Customer (₦)	Reference Comparison (DISCOS vs Ref)	p-value	Significance Level
EKO	6523.18	+266.04%	0.000000	Strong
IKEJA	1349.65	+134.35%	0.000000	Strong
KANO	1102.32	+128.06%	3.4718×10^{-2}	Moderate
ABUJA	-374.96	+90.46%	1.7958×10^{-19}	Strong
YOLA	-558.83	+85.78%	2.5466×10^{-1}	Not Significant
JOS	-1186.78	+69.79%	1.9078×10^{-1}	Not Significant
KADUNA	-1771.08	+54.92%	2.1986×10^{-1}	Not Significant

PORT	-2110.10	+46.29%	4.7022×10^{-11}	Strong
HARCOURT				
ENUGU	-2213.01	+43.67%	8.3479×10^{-2}	Marginal
IBADAN	-2329.96	+40.69%	2.7899×10^{-1}	Not Significant
BENIN	-3928.61	Reference	---	---

Note: β_1 (Metering Ratio): ₦14,130.1128 per customer for +1.0 metering ratio (i.e., +100pp) Implied effect of +10pp metering: ₦1,413.01 per customer.

4. Discussion

4.1. Billing and Revenue Collection Performance

Section 3.1's results present a foundational analysis of DISCOS performance that aligns with the findings in existing literature. The inequality in revenue collection reveals the structural deficiencies that identified as a poor ubiquitous revenue performance via the Data Envelopment Analysis (DEA). This study's findings provide an accurate picture of the revenue disparity among Ikeja, Eko, and FCT Abuja, compared with other DISCOS, revealing a significant gap in commercial and industrial operations among Lagos, FCT, and other states. [11] findings corroborate this, showing that resource allocation and strategic orientation influence 72.9% of Abuja's operational efficiency

Table 7's negative result for the effect of energy billed per customer per collection rate ($\beta = -0.0406$; p-value = 0.000) is further evidence that increasing billing volumes without a mechanism to ensure metering accuracy is not a suitable solution for revenue recovery. [12] corroborates this further, citing DISCOS' obsession with paper profits as a reactive mechanism in response to customers' resistance to full payment. Conversely, the results in Table 8 indicate that ATC&C losses are more insidious than initially thought. This is because the fixed-effects coefficients for Port Harcourt, Kaduna, Kano, Jos, and Yola are all significantly negative, well below those for Benin (the baseline). This includes Enugu, with a negligible positive coefficient of 0.446. The results buttress the findings of [6], showing the multi-dimensional nature of revenue leakage as a prevalent structural deficiency for 7 of the 11 DISCOS.

Figure 12 presents an alarming and continuously widening divergence in the DISCOS' collection rate trends. From the graph, the leading (Ikeja, Abuja, and Eko) and the lagging (Kaduna and Yola) DISCOS show economically meaningful differences in trends. The implication is a divergence from sector-uniform performance, with increasing inter-DISCO inequalities, as shown by the 2024 endpoints. This escalating divergence counters the belief in adopting a uniform sector policy for the DISCOS through a single regulatory framework for energy, metering, and billing. The observed divergence supports [6] argument that institutional heterogeneity is affected by inherited assets from the defunct PHCN, asymmetries in governance, and differences in socioeconomic strengths (commercial and industrial strength), which are contributing factors to the observed divergence.

4.2. Metering's Association with Collection Rate and Payment Compliance

Results from Tables 6 and 7 show a clear quantification of metering's association with revenue collected ($\beta = 12.2833$; $p = 7.6161 \times 10^{-3}$) and collection rate ($\beta = 24.6102$; $p = 0.002$), while controlling for energy billed, customer base, individual DISCOs, and year fixed effects. The findings support [2] conclusion, where a percentage increase in smart metering installations is associated with 0.8% reduction in ATC&C losses. The energy implications are that a 10-point increment in metering ratio corresponds to a ₦2.46/kWh incremental improvement in collection rate. The values may look small, but when the effective tariff rate from the collection efficiency model is below ₦20/kWh, it becomes

critical. Regardless, the effective tariff rate reveals a poor comparison to the stipulated MYTO benchmarks, further confirming the insidious magnitude of operational tariff deficits.

The coefficients for Eko ($\beta_1 = \text{₦}216.74/\text{kWh}$), Ibadan ($\beta_1 = \text{₦}126.19/\text{kWh}$), Abuja ($\beta_1 = \text{₦}122.12/\text{kWh}$), and Ikeja ($\beta_1 = \text{₦}108.37/\text{kWh}$) in Table 3 support the hypothesis that metering in commercially active service markets provides a higher payment compliance. However, the following states, Kaduna ($\beta_1 = -\text{₦}30.31/\text{kWh}$), Enugu ($\beta_1 = -\text{₦}53.62/\text{kWh}$), Benin ($\beta_1 = -\text{₦}126.76/\text{kWh}$), and Yola ($\beta_1 = -\text{₦}138.60/\text{kWh}$) present a conundrum in analysis. This is because a simplistic conclusion that metering reduces collection rates for these DISCOS is highly flawed. It would be more tenable to view such underperformance as the culmination of several factors, including overreliance on estimated billing, individual metering implementations, and customers' socio-economic profiles. This route is supported by evidence from both [14] and [10]. The former found no statistical significance in customer satisfaction/payment compliance post-privatisation. At the same time, the latter results showed that deregulation of the electricity sector failed to attain its efficiency improvement goals for Abuja DISCO. Therefore, metering alone can fail to influence DISCOS' revenue collection, especially where variables such as improved service delivery and collection enforcement mechanisms are non-existent.

4.3. Service Market Expansion Impact on Revenue Growth and Customer Monetisation

The total customers coefficient in Table 6 shows a weak positive but negligible effect under FE ($\beta = 1.947$; $p = 0.314$). Similarly, Table 8 shows a weak negative but not significant relationship between total customers and energy billed ($\beta = -1.0662$; $p = 0.964$). These invalidate any linear assumption on revenue-customer growth that is often embedded in DISCOS reports on possible improvement strategies. It raises critical questions about DISCOS' management actions to improve monetisation productivity and service market expansion when weak institutions are incapable of financing metering investments. Additionally, the negative coefficient corroborates the findings of [8], which identify poor workforce training and inefficient resource allocation as key factors contributing to Benin DISCOS' billing and distribution inefficiencies.

Table 10 and Figure 13 present the customer-scale efficiency model, in which metering heterogeneity, when held constant, showed that only Eko, Ikeja, and Kano had positive adjusted revenue per customer; the remaining 8 DISCOS had negative adjusted monetisation. Eko's adjusted premium of $\text{₦}6,523.18$ per customer, relative to the Benin baseline (a 266.04% differential), is due to Lagos State's high level of commercial and industrial activity. Regarding Yola, the unusual improvement in the customer scale efficiency model from the usual 11th position (metrics in Table 2) to the 5th position (adjusted monetisation in Table 10) warrants deeper investigation. It subtly suggests that Yola's consistently poor performance on key metrics is a function of inequality in total customers rather than any inherent monetisation inefficiency. Similarly, the divergent collection rates in Table 9 emphasise the need for targeted, DISCO-specific interventions to address existing asymmetries in revenue performance across the distribution sector. Critically understanding the variables that influence financial sustainability and infrastructural viability at the individual-DISCO level is the most salient approach to improving national-level electrification.

4.4. Structural Archetypes

Careful assessment of the results in section three presents a clear delineation of DISCOS' performance, facilitating the emergence of structural archetypes. Ikeja, Eko and Abuja constitute the first archetype. They are the leading DISCOS, with significant growth in metering penetration, higher collection rates, strong, positive metering-revenue dynamics, and the highest growth in monetisation. Such performance is largely associated with the commercial and industrial nature of their respective operating service markets. Secondly, Port Harcourt, Ibadan, and Kano show moderate performance for most indicators and regression analyses. However, the metering penetration analysis shows that Port Harcourt has a high metering penetration despite low revenue performance, as shown in Figure

3 and Table 6. This indicates a significant influence of external variables on the dynamics of energy availability, customer mix, and propensity to pay over the examined timeframe. The last archetype encompasses Kaduna, Yola, Benin, Enugu and Jos, which reflect poor metering-revenue elasticities and a deteriorating monetisation efficiency amidst low metering penetration. These DISCOS are the most constrained by the structural deficits inherited from the defunct PHCN and inefficient management in prioritising a speedier transition from estimated to metering billing systems. This corroborates the findings of [7] on DISCOS' resistance to fully implementing the MAP scheme and [10] observation of the inefficiency of adopting a sector-wide deregulation policy as opposed to DISCO-specific strategies.

5. Limitations

The study's limitations are fundamentally a product of the nation's inability to establish a robust data-collection framework that would enable a more rigorous, technical assessment of DISCOS' performance over the last 10 years.

- i. There is no 'revenue generated' data or 'energy supplied' data for the timeframe. This would have enabled an in-depth investigation into associated losses. This study could neither measure total losses nor test a loss regression model ('energy supplied' data is absent). This applies to collection efficiency ('revenue generated'/'total billing') when data is absent.
- ii. The data obtained from NBS ended at the second quarter of 2024, even though the data search was conducted in January 2026. However, the NERC quarterly reports for the third and fourth quarters of 2024 provided the monthly data on 'energy billed' and 'revenue collected'. The absence of this data may limit future forecasting studies on metering customers.
- iii. The non-categorisation of 'total customers' data limits the in-depth examination into the DISCO geographical differences (rural vs peri-urban vs urban), and energy usage-based customer type (residential, commercial or industrial).
- iv. There is no differentiation in the sources of the revenue collected. For instance, revenue collected from residential customers versus revenue collected from industrial customers, and there is no distinction between the revenue collected from either the metered customers or the estimated customers. The absence of this data makes it impossible to assess revenue collected by customer type.

6. Industry and Operational Recommendations

The following recommendations, if implemented, would improve service delivery, metering, and revenue performance.

- i. Implementing DISCO-specific metering deployment strategies with contextual risk-stratified mechanisms
There should be an immediate dissolution of any uniform policy for the metering rollout timeframes. Rather, adopting a risk-stratified approach for metering development based on the previously identified archetypes would be suitable. For the lagging DISCOS in the third archetype, any metering investment would require more attuned strategies, such as a tariff advocacy campaign and a feasible enforcement mechanism. From a holistic perspective, NERC may need to develop DISCO-specific performance improvement Plans (PIPs) with individual milestones for measuring penetration and collection rates.
- ii. Separate Categorisation of Customer Expansion Targets from Revenue Growth Metrics
The results from Tables 6 and 8 show that the total number of customers has little influence on energy billed and revenue outcomes in the current DISCOS realities. This counters the common assumption within national electrification plans and goals that expanding the customer base would improve revenue collection. All reports and projections must present customer electrification targets and revenue growth projections as separate and unrelated entities. This continues until each DISCO attains a minimum metering penetration of 70%. Achieving this

requires that all new customers be metered, as estimated billing only increases energy billing volume without any corresponding increase in ensuring DISCOS revenue recovery.

iii. **Mandate Aggregated Reporting of Key Datasets as a Condition for Maintaining Operational License**

Based on the limitations outlined in Section 5.0, the sector faces a challenge in data collection and aggregation. This constitutes a critical flaw in strategy development and policy design. Therefore, NERC must ensure that all DISCOS submit the following data aggregates: (revenue collected by customer category (residential, commercial, and industrial); energy billed disaggregated by metered and estimated customer segments. Lastly, the data must be disaggregated by state, as this will enable state-level electrification studies and analyses rather than limiting them to the regional decomposition of each DISCOS service market. Since each of the 36 states in Nigeria possesses unique socio-economic behaviours.

7. Conclusion

The study examined the metering penetration and revenue collection performance in Nigeria's DISCOS post-privatisation between 2015 and 2024. The findings show that the metering ratio is a strong positive and statistically significant determinant of revenue collected and collection rate. However, the metering impact trajectories are heterogeneous, with negative metering-collection efficiencies in Benin, Yola, Kaduna, and Enugu indicating the need for enforcement and service delivery mechanisms. Therefore, additional effort is required to mitigate the idiosyncrasies of this disenfranchised service market. Contrary to general expansion logic, increasing the total customer base will not yield a proportional increase in energy billed or revenue growth, given the current overreliance on estimated billing. Regarding structural archetypes, the consistent widening asymmetries in collection-rate trajectories reveal the inadequacies of the current uniform policy, thereby making the actualisation of national electrification a formal goal. Hence, data collection in a disaggregated reporting structure is crucial to enable DISCO- and state-specific policy design and a strategic framework for improved design and statistical precision within sector operations.

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