



Moderating Effect of Meter Penetration on the Relationship between Collection Loss and Financial Performance of Electricity Distribution Companies in Nigeria

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Abstract

Original Research Article

This study investigates the moderating effect of meter penetration on the relationship between collection losses and the financial performance of electricity distribution companies (DISCOs) in Nigeria. The research employs both quantitative and qualitative methodologies to analyze data from all 11 DISCOs operating in the country. An ex-post facto research design is adopted, using a census sampling technique to ensure comprehensive data collection from all relevant stakeholders, including DISCOs, regulatory authorities, and customers. The study applies descriptive statistics, correlation analysis, and regression analysis to assess the relationships between energy accounting losses, meter penetration, and financial performance. The focus of the study is on energy accounting losses, which include technical, commercial, and collection losses, and the role of meter penetration in mitigating these challenges. With energy losses in Nigeria exceeding 40%, especially due to high commercial and collection losses, meter penetration is viewed as a critical factor for improving billing accuracy and reducing revenue leakage. The National Mass Metering Program (NMMP) and Meter Asset Provider (MAP) initiatives are central to addressing the metering gap, yet meter penetration remains low, particularly in rural and underserved areas. This lack of adequate metering infrastructure contributes significantly to the financial instability of DISCOs. To explore the relationship between meter penetration and financial performance, the study uses regression models to examine the moderating role of meter penetration on the relationship between collection losses and financial outcomes. The regression analysis reveals that meter penetration significantly moderates this relationship, helping to reduce the adverse effects of collection losses on DISCOs' financial performance. The results suggest that increasing meter penetration can enhance revenue collection and financial sustainability, offering valuable insights for policymakers and stakeholders in the Nigerian electricity sector.

Keywords: Meter penetration, Collection losses, financial performance, Electricity distribution companies, Nigeria electricity sector.

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1. Introduction

This study explores the impact of energy accounting losses on the financial performance of electricity

distribution companies (DISCOs) in Nigeria, with a focus on the moderating role of meter penetration. In countries like India, Brazil, and South Africa, the



introduction of technologies such as smart grids and advanced metering infrastructure (AMI) has led to reductions in energy losses by improving billing accuracy and monitoring energy consumption (IEA, 2020). However, high non-technical losses, including theft and billing inefficiencies, remain a significant issue in many regions, including Africa, where losses often exceed 30% due to factors such as outdated infrastructure and weak regulatory frameworks (AfDB, 2019).

In Nigeria, energy accounting losses comprising technical, commercial, and collection losses—are a major challenge for DISCOs, undermining their financial stability and limiting their ability to invest in infrastructure and improve service delivery (NERC, 2021). The Nigerian Electricity Regulatory Commission (NERC) has reported that up to 40% of the energy distributed by DISCOs is lost, with commercial and collection losses accounting for a significant portion (Nwoha, 2021). Despite efforts like the National Mass Metering Program (NMMP) and the Meter Asset Provider (MAP) initiative aimed at improving meter penetration, the sector continues to struggle with revenue leakage and operational inefficiencies (Olusola, 2021; Abubakar et al., 2020).

Meter penetration, particularly through these programs, is seen as a solution to mitigate commercial and collection losses by improving billing accuracy and reducing illegal connections (Akinmoladun, 2020). However, despite these efforts, meter penetration remains low, especially in underserved areas, and the role of metering in moderating the relationship between energy accounting losses and financial performance has not been fully explored (Idowu, 2024). This study fills this gap by examining how meter penetration influences the financial performance of DISCOs, particularly in the context of ongoing energy losses.

The research methodology employs a comprehensive data analysis approach, using both quantitative and qualitative methods to assess the operational performance of Nigerian DISCOs. The study highlights the importance of understanding the broader socio-economic impacts of energy losses, as they not only affect the financial health of DISCOs but also hinder national economic productivity

(AfDB, 2019). By providing a more integrated understanding of the relationships between technical, commercial, and collection losses, and their impact on DISCOs' financial outcomes, this research aims to offer valuable insights for policymakers and stakeholders in the Nigerian electricity sector (Oluwatayo et al., 2020). The following research questions are raised for answer

- i. What is the effect of collection losses on financial performance of electricity distribution companies in Nigeria?
- ii. How does meter penetration moderate the relationship between collection losses and financial performance of electricity distribution companies in Nigeria?

2. Literature Review

The conceptual framework demonstrates the complex interplay between energy accounting losses, meter penetration, and the financial performance of electricity distribution companies. The study's key proposition is that the reduction of energy accounting losses, especially commercial and collection losses, through increased meter penetration, will enhance the financial performance of DISCOs. This framework guides the research on understanding how these relationships function and highlights the critical role that metering systems play in improving the operational efficiency of the Nigerian electricity distribution sector, (Ruth, 2023). The conceptual framework for this study is designed to explore the intricate relationships between energy accounting losses, meter penetration, and the financial performance of electricity distribution companies (DISCOs) in Nigeria. Energy accounting losses, which encompass technical, commercial, and collection losses (ATC&C), have long been recognized as major barriers to the financial stability and operational efficiency of DISCOs (Bello et al., 2021). This framework provides a clear path for examining how these losses directly affect the financial performance of DISCOs and how meter penetration can moderate this relationship by reducing energy losses and improving financial outcomes.

Technical Losses which are losses caused by inefficiencies within the power grid, such as outdated infrastructure, poor maintenance, and energy dissipation in electrical components. Technical losses are inevitable to some extent but can be minimized with better technology and infrastructure (Okafor, 2021). Commercial Losses stem from illegal activities such as meter tampering, unauthorized connections, and billing fraud. These activities directly reduce revenue collection and increase operational costs for DISCOs (Sola, 2021). Collection Losses arise when DISCOs fail to recover the full value of electricity consumed due to inadequate billing systems, inefficiencies in collection mechanisms, or customer non-payment (NERC, 2021). The financial performance of DISCOs can be assessed through several key metrics, including revenue generation, profitability, cost recovery, and operational sustainability. A company's ability to recover costs and generate sustainable profits is hindered when energy accounting losses are high (Bello et al., 2021).

Meter penetration refers to the proportion of consumers who are accurately metered. This factor is crucial in reducing commercial and collection losses,

as it ensures that customers are billed for their actual electricity consumption. High meter penetration promotes transparency, reduces fraud, and enhances the accuracy of revenue collection (Ola, 2023). The relationship between energy accounting losses and financial performance can be moderated by meter penetration. While energy accounting losses particularly commercial and collection losses directly hinder revenue generation, the presence of accurate meters can alleviate these challenges. Government interventions such as the National Mass Metering Program (NMMP), the Meter Asset Provider (MAP) scheme, and the Meter Acquisition Fund (MAF) have been designed to increase meter penetration, reduce illegal connections, and improve billing accuracy (Awolu et al., 2024). As meter penetration increases, DISCOs are likely to experience a reduction in revenue leakage, operational inefficiencies, and a corresponding improvement in profitability. This framework suggests that meter penetration moderates the relationship between energy accounting losses and financial performance, such that the adverse effect of energy accounting losses on financial performance is weaker in DISCOs with higher levels of meter penetration.

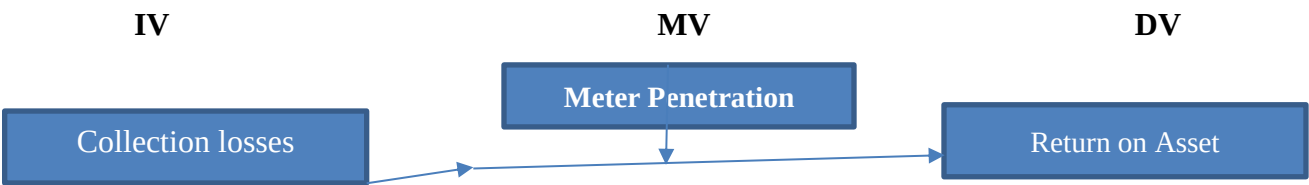


Figure 1: Conceptual Framework

Financial Performance

Financial performance in the context of DISCOs is often measured by profitability, which refers to the ability of the company to generate profit from its operations. Profitability is critical for DISCOs to

maintain financial sustainability, reinvest in infrastructure, and improve service delivery. As highlighted by Eweje (2021), profitability directly correlates with the efficiency of revenue generation and cost management in DISCOs. Revenue

generation is an indicator of financial performance for DISCOs, reflecting the company's ability to collect revenue from consumers for the electricity distributed. A high level of revenue generation often signifies effective operations, including efficient billing and collection practices. According to Pius et al. (2020), revenue generation is fundamental to the long-term financial health of DISCOs.

Cost recovery refers to a DISCO's ability to recover the costs incurred in providing electricity services to consumers, including infrastructure maintenance and electricity procurement. High cost recovery is crucial for the financial viability of DISCOs, ensuring that the revenue generated is enough to cover operating and capital expenses. Anmed et al. (2021) discuss the importance of cost recovery in the context of Nigeria's electricity distribution sector, emphasizing that it is vital for the financial health of DISCOs. Operational efficiency measures how effectively DISCOs convert resources into service delivery while minimizing waste and losses. Efficient operations enable DISCOs to reduce energy losses and improve service quality, which is crucial for enhancing financial performance. The Nigerian Electricity Regulatory Commission (NERC) underscores operational efficiency as an essential factor for ensuring financial stability and service reliability (Ojeba, 2021).

Revenue growth, indicative of the successful implementation of strategies to increase market share and improve billing practices, is a sign of operational success (Adedeji et al., 2020). Customer satisfaction, as a qualitative measure, contributes to better collection rates by reducing billing disputes and non-payment (Olusola, 2021). Risk management, focusing on identifying and mitigating financial risks, is necessary for maintaining stability and avoiding unforeseen losses (Bello et al., 2021). Investment in infrastructure ensures that DISCOs can meet demand, reduce inefficiencies, and improve financial outcomes (Abubakar et al., 2020). Efficiency ratios, such as the operating expense ratio, reflect how well DISCOs use resources to minimize waste and maximize output, further supporting their financial sustainability (NERC, 2021). Return on Equity (ROE) measures profitability relative to shareholders' equity, attracting investment and

supporting financial growth (Okolo, 2020).

Financial performance refers to the assessment of a company's ability to generate revenue, manage expenses, and achieve profitability over a specific period. It is typically measured through various financial metrics such as revenue growth, profitability, return on assets (ROA), return on equity (ROE), and liquidity ratios. Financial performance reflects how efficiently an organization utilizes its resources to achieve its financial goals, maintain solvency, and sustain long-term growth. A strong financial performance indicates a company's ability to meet its obligations, reinvest in its operations, and create value for stakeholders.

In the context of this study, financial performance refers to the ability of electricity distribution companies (DISCOs) in Nigeria to generate sufficient revenue, manage operational costs, and maintain profitability in a manner that ensures long-term sustainability and reinvestment capacity. It is assessed using key financial indicators including profitability, revenue generation, cost recovery, operational efficiency, and cash flow management, which collectively reflect how effectively DISCOs convert distributed energy into financial returns. These metrics are critical for evaluating the fiscal health of DISCOs, especially in an environment challenged by energy accounting losses and limited meter penetration.

Collection Losses

Collection losses refer to the financial losses incurred when electricity distribution companies (DISCOs) are unable to collect revenue from customers for the electricity consumed. These losses may be due to inefficiencies in the billing system, customer non-compliance, or inadequate collection mechanisms. Collection losses occur when customers consume electricity but fail to pay their bills. This non-payment can be due to various reasons such as financial incapacity, dissatisfaction with the service, or negligence. According to Eweje & Okafor (2021), non-payment is one of the primary contributors to collection losses in the Nigerian electricity sector.

Billing errors occur when the electricity consumed is

not correctly reflected in the bill due to system inaccuracies, manual errors, or faulty meters. These errors can lead to discrepancies between actual consumption and the billed amount, contributing to collection losses. According to Okoro & Chikuni (2020), billing errors are a major cause of collection losses in developing countries. Ineffective revenue collection systems lead to collection losses when DISCOs fail to efficiently collect payments from consumers. This can be caused by poor customer service, lack of follow-up on overdue bills, or manual collection processes. According to NERC (2021), improving revenue collection systems is vital to reducing collection losses in Nigeria's electricity distribution sector.

Collection efficiency refers to the rate at which a DISCO can collect payments from its consumers. When collection efficiency is low, it leads to increased collection losses. As noted by Abubakar et al. (2020), low collection efficiency is often a result of inadequate staffing, outdated technologies, or a lack of proper incentive systems for bill payments. Customer disputes over electricity billing are a common cause of collection losses, as consumers may refuse to pay their bills until discrepancies are resolved. These disputes can be caused by perceived overbilling, faulty meters, or poor customer service. According to Olusola (2021), resolving customer disputes promptly is crucial to minimizing collection losses.

Lack of accessible and convenient payment mechanisms can also contribute to collection losses. Consumers may be unable to pay their bills on time if the payment systems are not user-friendly or if payment options are limited. According to NERC (2021), improving payment infrastructure can significantly reduce collection losses. Large consumers, such as businesses and industries, may contribute to collection losses by failing to pay large electricity bills on time or by engaging in payment evasion strategies. Bello et al. (2021) point out that non-compliance from these high-volume consumers significantly impacts the financial performance of DISCOs. Poor customer awareness regarding billing policies, payment deadlines, and the consequences of

non-payment can result in delays and defaults. Educating customers on the importance of timely payments is crucial for reducing collection losses. According to Adededeji & Adeyemo (2021), consumer education programs can help improve collection efficiency and reduce payment delays. When payment collection is not properly monitored, consumers may delay payments or avoid paying entirely without facing consequences. As noted by Olusola (2021), enhancing monitoring systems to track overdue bills and customer payment histories is vital for reducing collection losses.

Inefficient disconnection policies, where non-paying consumers are not disconnected promptly, contribute to collection losses. DISCOs that fail to disconnect defaulting customers on time risk losing revenue. According to Okoro & Chikuni (2020), improving disconnection policies and ensuring timely enforcement can help mitigate collection losses. Inefficiencies in the billing system, such as delayed billing, incorrect charges, or outdated software, often lead to collection losses. According to Adededeji & Adeyemo (2021), upgrading billing systems and automating processes can improve accuracy and reduce collection losses by ensuring timely and correct billing.

Inadequate staffing or untrained staff in revenue collection departments can lead to inefficiencies and delays in collecting payments, leading to increased collection losses. As noted by Adededeji & Adeyemo (2021), investing in training for collection staff and increasing their efficiency can reduce collection losses and improve revenue collection. Collection losses represent a major challenge for DISCOs, directly affecting their financial stability. These losses arise from various factors, including customer non-payment, billing inaccuracies, poor revenue collection systems, and inadequate enforcement policies. Effective solutions to reduce collection losses involve improving customer awareness, upgrading billing and payment systems, enforcing disconnection policies, and enhancing monitoring and enforcement mechanisms. By addressing these issues, DISCOs can improve their revenue collection efficiency and strengthen their financial performance.

Meter Penetration

Meter penetration is defined as the extent to which all consumers are metered, leading to more accurate billing. Accurate billing ensures that customers pay for the electricity they actually consume, reducing the reliance on estimated billing, which can result in revenue discrepancies. According to Okoro & Chikuni (2020), proper metering systems are crucial for achieving accurate billing and improving DISCOs' financial performance. Meter penetration directly influences the revenue collection process. The more consumers are metered, the more accurately DISCOs can collect payments for the electricity used. Abubakar et al. (2020) argue that higher meter penetration results in reduced commercial and collection losses, thereby improving the financial stability of DISCOs. Meter penetration prevents energy theft by ensuring that all consumers are metered, making it easier for DISCOs to detect unauthorized connections and meter tampering. Eweje & Okafor (2021) highlight that the lack of proper metering is a major factor contributing to energy theft, which significantly impacts DISCOs' revenue generation. Meter penetration improves transparency in the billing process, allowing consumers to be charged accurately for their electricity consumption. According to NERC (2021), increased meter penetration reduces billing disputes and enhances trust between consumers and DISCOs, leading to improved collection rates.

Empirical Review

Bello et al. (2025) used a quantitative research design, analyzing data from DISCOs over five years. The researchers employed regression analysis to measure the relationship between collection losses (uncollected bills) and DISCOs' revenue generation and profitability. The study found that collection losses, mainly due to inadequate billing systems and customer non-compliance, severely affected DISCOs' revenue collection, reducing profitability and operational capacity. The study recommends improving the revenue collection process by integrating automated billing systems and enforcing stricter penalties for non-payment. The study does not explore how customer payment behavior and

public awareness of payment responsibilities influence collection losses. Future studies should investigate customer behavior and the effectiveness of education campaigns in improving payment compliance and reducing collection losses.

Eweje & Okafor (2025) analyzed financial data from five major DISCOs and customer payment records over a five-year period. They used correlation analysis to assess the relationship between collection losses and profitability. The study found a significant inverse relationship between collection losses and profitability. The inability to collect bills from customers led to significant financial instability for DISCOs. The authors recommend automating the billing system, improving customer service, and implementing real-time payment solutions to enhance revenue collection. The study does not examine the long-term impacts of using mobile payment platforms on reducing collection losses. Future research should focus on the use of mobile payment systems and digital wallets in reducing collection losses and improving revenue collection.

Okoro & Chikuni (2025) employed a case study approach with financial data and interviews from two Nigerian DISCOs. They assessed the financial implications of collection losses on operational sustainability. The study found that collection losses directly impacted the ability of DISCOs to sustain operations and reinvest in the infrastructure, ultimately leading to service deterioration. The study recommends better enforcement of billing systems, stricter customer payment deadlines, and technological upgrades to enhance the efficiency of the revenue collection process. The study does not analyze the impact of customer disputes or dissatisfaction on collection losses. Future studies should examine how resolving customer disputes and improving customer satisfaction affects collection losses.

Oluwatayo et al. (2025) used a cross-sectional survey to collect financial data from Nigerian DISCOs and customer payment records. The relationship between collection losses and financial performance was analyzed using regression models. The study found that collection losses due to poor billing and inefficient payment systems significantly hampered

DISCOs' ability to recover their operational costs. The study recommends improving customer payment channels, integrating mobile payment systems, and implementing more robust monitoring and enforcement strategies to reduce collection losses. The study does not assess how the introduction of dynamic pricing models can improve payment compliance. Future research should explore how dynamic pricing, discounts for timely payments, and flexible payment plans can reduce collection losses.

Theoretical Review

Theories related to the impact of technical, commercial, and collection losses on the financial performance of Electricity Distribution Companies (DISCOs) in Nigeria. These theories provide useful frameworks to understand the operational inefficiencies and challenges faced by DISCOs in managing losses and improving financial performance. Resource-Based View (RBV),

Resource-Based View (RBV)

Jay B. Barney (1991); Edith Penrose (1959). The Resource-Based View (RBV) focuses on how the resources and capabilities of a firm contribute to its competitive advantage and long-term sustainability. According to RBV, organizations possess unique bundles of resources both tangible (equipment, financial capital) and intangible (expertise, brand reputation) which can be leveraged to outperform competitors. The theory posits that firms with valuable, rare, inimitable, and non-substitutable resources will be able to achieve a competitive advantage and superior performance in the market. In the context of Electricity Distribution Companies (DISCOs), RBV can help explain how the quality of internal resources, such as metering infrastructure, customer service practices, skilled workforce, and financial management systems, directly influences the ability of DISCOs to reduce energy losses (technical, commercial, and collection losses) and improve financial performance. DISCOs that invest in and utilize these resources effectively can enhance their operational efficiency, reduce costs, and

increase profitability.

A common critique of RBV is its overemphasis on the importance of internal resources while downplaying the influence of external factors, such as market competition, regulatory changes, and technological disruptions. While DISCOs' internal resources are crucial, external factors also play a significant role in their performance, and the theory may not fully account for these dynamics in rapidly changing markets like electricity distribution. RBV has been critiqued for being somewhat static, as it focuses on existing resources and their exploitation. However, in dynamic industries, such as energy distribution, firms must continually innovate and adapt to changing technologies and consumer demands. Therefore, RBV may fail to capture the need for continual resource renewal and capability development.

Another critique is the challenge in determining which resources provide sustained competitive advantage. While RBV suggests that valuable, rare, and inimitable resources lead to superior performance, it is often difficult to assess whether a particular resource truly meets these criteria, especially in the case of intangible resources like customer trust or corporate culture. The Resource-Based View (RBV) is highly relevant to understanding the financial performance of DISCOs in Nigeria, particularly in the context of reducing losses. The theory emphasizes that firms should develop and leverage their unique resources to achieve superior performance. For DISCOs, resources like modern metering infrastructure, trained personnel, operational expertise, and innovative billing systems are critical in reducing commercial, technical, and collection losses. By enhancing these resources, DISCOs can reduce inefficiencies and improve their financial stability. For example, advanced metering technologies are a valuable resource that can help DISCOs reduce commercial losses from illegal connections or tampering. Similarly, investing in skilled workforce and customer relationship management capabilities can help improve collection efficiency, directly impacting revenue generation and profitability. RBV also suggests that intangibles, such as a strong brand reputation for customer service or trust in billing

accuracy, can be significant drivers of financial success for DISCOs, as they can lead to better customer loyalty and lower collection losses.

Application: Barney (1991) is the foundational theorist behind RBV. He proposed that firms can gain sustained competitive advantage by possessing resources that are valuable, rare, inimitable, and non-substitutable (VRIN). In the case of DISCOs, the theory suggests that the unique resources within a firm such as technology, skilled workforce, and infrastructure can help mitigate losses and improve performance. In the context of the Nigerian electricity sector, DISCOs with modern metering systems, efficient customer service teams, and a solid operational infrastructure can achieve a competitive advantage by minimizing energy losses, improving revenue collection, and ensuring long-term financial sustainability. Penrose (1959) introduced the idea that a firm's resources are central to its growth. She argued that firms can expand and grow by effectively utilizing their existing resources and capabilities. For DISCOs, the ability to reduce technical and commercial losses can be viewed as a resource management strategy that drives growth by improving operational efficiency and financial performance. Penrose's concept of resource accumulation and utilization aligns with the challenges faced by DISCOs in Nigeria. As DISCOs invest in modern technologies and human capital, they can optimize resource use to reduce losses, grow their customer base, and improve financial performance.

Wade (1998) used RBV to analyze the relationship between resource capabilities and competitive advantage in the telecommunications industry. He found that firms that effectively utilize their resources, such as human capital and technological infrastructure, tend to outperform competitors. Wade's work can be extended to the electricity distribution sector, where resource capabilities, such as advanced metering systems and a well-trained workforce, are key to reducing losses. Wade's findings are applicable to DISCOs in Nigeria, where the effective utilization of resources like metering technology, customer relationship management systems, and skilled labor can significantly reduce collection and commercial losses, ultimately

improving financial performance. Wernerfelt (1984) introduced RBV by focusing on how firms could develop a competitive edge by managing and capitalizing on unique resources. He argued that resources are not just inputs for production but can be sources of strategic advantage. For DISCOs, resources like a reliable metering system or a robust billing system serve as a competitive advantage in minimizing losses and improving operational performance. RBV can be applied to the Nigerian electricity sector, where the strategic use of internal resources such as smart meters, automated billing, and skilled personnel can reduce energy theft, improve collection systems, and drive financial growth for DISCOs.

Priem & Butler (2001) critiqued and extended RBV by incorporating the role of market conditions and external environments into resource-based thinking. They suggested that while internal resources are crucial, a firm's ability to effectively respond to external challenges (e.g., market competition, regulatory changes) is also a key component of its competitive advantage. DISCOs, therefore, must balance internal resource management with the capacity to adapt to external pressures. This extended view of RBV is highly relevant to the Nigerian electricity sector, where regulatory changes, market conditions, and customer behavior influence DISCOs' ability to effectively utilize their resources. Adapting to these external factors through innovative metering and payment systems can help DISCOs reduce losses and improve financial sustainability.

The Resource-Based View (RBV) provides a strong theoretical foundation for understanding how internal resources and capabilities can contribute to the success of DISCOs in reducing technical, commercial, and collection losses in Nigeria. By focusing on the development and strategic use of unique resources (smart metering technologies, skilled labor, customer service systems), DISCOs can improve their operational efficiency and financial performance. The theory also highlights the importance of continuous resource renewal and the ability to adapt to changing market conditions and regulatory pressures. Future studies should explore how the combination of internal resources and external market dynamics can be optimized to

minimize losses in the Nigerian electricity sector.

3. Methodology

In this study, an ex-post facto research design is adopted. The population for this study consists of all electricity distribution companies (DISCOs) operating in Nigeria, Here is a list of the 11 DisCos in Nigeria as of 2024, Abuja Electricity Distribution Company (AEDC), Benin Electricity Distribution Company (BEDC), Eko Electricity Distribution Company (EKEDC), Enugu Electricity Distribution Company (EEDC), Ibadan Electricity Distribution Company (IBEDC), Ikeja Electricity Distribution Company (IKEDC), Jos Electricity Distribution Company (JED), Kaduna Electricity Distribution Company (KAEDCO), Kano Electricity Distribution Company (KEDCO), Port Harcourt Electricity Distribution Company (PHED). Yola Electricity Distribution Company (YEDC) For this study, a census sampling technique is adopted. This technique involves selecting all members of the population for the study (Chamba et al., 2024; Ejura et al., 2023; Haruna et al., 2020, 2021; Ibrahim, 2016, 2022, 2023; Ibrahim et al., 2024; Idih et al., 2019; Jibrin et al., 2017; Moses et al., 2018, 2022; Musa et al., 2022; Okpe et al., 2026; Peter et al., 2026.; Success et al., 2023 (Acho et al., 2026, (Acho et al., 2026. Chamba et al., 2026). To achieve this, both quantitative and qualitative data collection methods will be used to gather comprehensive and reliable information from relevant stakeholders, including

DISCOs, regulatory authorities, and customers. The quantitative data analysis will involve the use of descriptive statistics, correlation analysis, and regression analysis. These methods will allow the researcher to understand the relationships between energy accounting losses, meter penetration, and the financial performance of DISCOs. The model of the study is adapted from the work of Adanna et al (2023) and Augustine et al

(2023). the regression model will be estimated using the following equation:

$$ROA_i = \beta_0 + \beta_1 COLL_i + \beta_2 MP_i + \epsilon_i$$

$$ROA_i = \beta_0 + \beta_1 COLL_i * MP_i + \beta_2 MP_i * MP_i + \epsilon_i$$

Where:

FP = Financial Performance of DISCO iii

COLL = Collection Losses

MP = Meter Penetration

β_0 = Intercept term

$\beta_1, \beta_2, \beta_3, \beta_4$ = Coefficients for each variable

4. Result and Discussion

This table provides an overview of the descriptive statistics for ftwo variables, measured across 110 observations. The variables include COL (Collection Losses), MP (Meter Penetration), and ROA (Return on Assets)

Descriptive Statistic

VARIABLES	Obs	Min.	Max.	Mean	SD	Skewness	Kurtosis
COL	110	3.0%	17%	10%	0.529	0.739	1.817
MP	110	20%	78%	49%	0.523	0.343	1.627
ROA	110	0.0	200	100	0.321	0.234	1.332

Source: STATA OUTPUT 2026

The Descriptive Statistics provide an overview of the key variables in the study: Collection Losses (COL), Meter Penetration (MP), and Return on Assets (ROA), based on 110 observations. For Collection Losses (COL), the values range from 3% to 17%, with an average of 10%. The standard deviation is 0.529, indicating moderate variability in the data. The skewness of 0.739 suggests a slight rightward skew, meaning that the data is concentrated towards the lower end, and the kurtosis of 1.817 indicates a distribution that is more peaked than normal.

For Meter Penetration (MP), the values range from

20% to 78%, with a mean of 49%. The standard deviation of 0.523 shows some variability in meter coverage. The skewness value of 0.343 indicates a mild right skew, and the kurtosis of 1.627 suggests the distribution is somewhat peaked but not highly concentrated. Finally, for Return on Assets (ROA), the range is from 0% to 200%, with a mean of 100%. The standard deviation of 0.321 reflects some variability around the average. The skewness of 0.234 suggests a slight rightward tilt, and the kurtosis of 1.332 shows a distribution that is a bit flatter than a normal distribution.

Multicollinearity

Variable	VIF	TV
COL	1.091	0.917
MP	1.122	0.892

Source: STATA OUTPUT 2026

The Multicollinearity analysis assesses the relationship between the independent variables to ensure that they are not highly correlated, which could distort the results of the regression model. The Variance Inflation Factor (VIF) is used to measure this. A VIF value above 10 indicates problematic multicollinearity. In this case, the VIF for Collection Losses (COL) is 1.091, and for Meter Penetration (MP), it is 1.122. Both values are well below the

threshold of 10, indicating that there is no significant multicollinearity between the two variables. The Tolerance Value (TV), which is the reciprocal of VIF, further supports this conclusion. The TV for COL is 0.917, and for MP, it is 0.892. Both values are relatively high, meaning that each variable explains a significant portion of the variation in the data without being heavily influenced by the other variable.

Unit Root Test

Variables	No. of Panels	No. of Periods	Z-Statistic	P-Values	Stationarity
COL	110	110	7.542	0	Stationary
MP	110	110	8.346	0	Stationary
ROA	110	110	9.262	0	Stationary

Source: STATA OUTPUT 2026

The Unit Root Test assesses whether the variables are stationary, meaning their statistical properties remain constant over time. Stationary variables are important for ensuring reliable analysis, as non-stationary data can lead to misleading results. In this study, Collection Losses (COL) has a Z-statistic of 7.542 and a p-value of 0, indicating that it is stationary. Meter Penetration (MP) shows a Z-statistic of 8.346 and a p-value of 0, confirming that

it is also stationary. Similarly, Return on Assets (ROA) has a Z-statistic of 9.262 and a p-value of 0, indicating that it is stationary as well. Since all p-values are 0, which is below the commonly accepted threshold of 0.05, we can conclude that COL, MP, and ROA are stationary. This means that their statistical properties do not change over time, making them suitable for further analysis.

Correlation Matrix

Variables	COL	MP	ROA
COL	1.000		
MP	0.109	1.000	
ROA	0.426	0.217	1.000

Source: STATA OUTPUT 2026

The Correlation Matrix shows the relationships between the variables in the study. For Collection Losses (COL), the correlation with Meter Penetration (MP) is 0.109, indicating a weak positive relationship. This suggests that while there is a slight positive correlation, the relationship between COL and MP is not strong. The correlation between COL and Return on Assets (ROA) is 0.426, which is a

moderate positive relationship, indicating that as commercial losses increase, there is a moderate tendency for ROA to improve. The correlation between MP and ROA is 0.217, reflecting a weak positive relationship, suggesting that higher meter penetration is slightly associated with better financial performance (ROA), though the relationship is not strong

Fixed Effect Model Regression

Dep. Var: TDR	Coefficient	Standard Error	t-Statistic	p-Value
COL	0.155	1.075	3.74	0.003
MP	0.034	1.053	6.42	0.001
MP*COL	0.224	0.343	5.63	0.004
R2 Within				0.454
R2 Between				0.533
R2 Overall				0.111

Wald Chi2				58.25
Hettest:Chi2				0.74
Mean VIF				1.00
RE Test: Chi2				6.53

Source: STATA OUTPUT 2026

The Fixed Effect Model Regression results assess the relationship between Collection Losses (COL), Meter Penetration (MP), and their interaction (MP*COL) with the dependent variable Total Distribution Revenue (TDR).

For COL, the coefficient is 0.155 with a standard error of 1.075, a t-statistic of 3.74, and a p-value of 0.003, indicating a statistically significant positive effect on TDR. MP has a coefficient of 0.034 with a standard error of 1.053, a t-statistic of 6.42, and a p-value of 0.001, also showing a significant positive impact on TDR. The interaction term (MP*COL) has a coefficient of 0.224, a standard error of 0.343, a t-statistic of 5.63, and a p-value of 0.004. This suggests that the combined effect of MP and COL on TDR is significant, and the positive relationship indicates that higher meter penetration reduces the negative impact of commercial losses on financial performance.

The R^2 Within value is 0.454, meaning that 45.4% of the variability within individual DISCOs is explained by the independent variables. The R^2 Between is 0.533, showing that 53.3% of the variability between DISCOs is explained. The R^2 Overall value of 0.111 indicates that the model explains a relatively small proportion of the total variability across the entire dataset. The Wald Chi² statistic is 58.25, suggesting that the model as a whole is statistically significant. The Mean VIF is 1.00, indicating no issues with multicollinearity between the variables. The RE Test: Chi² value of 6.53 suggests that the fixed effects model is more appropriate than the random effects model for this analysis.

Discussion of Findings

The p-value for Collection Losses (COL) is 0.003, which is below the 0.05 significance threshold. Thus,

we reject the null hypothesis, concluding that collection losses significantly affect the financial performance of electricity distribution companies. Collection losses refer to the inability of electricity distribution companies to collect payments from customers, even if they are accurately billed. In many parts of Nigeria, issues such as weak revenue collection systems, customer reluctance to pay, and administrative inefficiency contribute to significant collection losses. These losses prevent electricity companies from realizing their full revenue potential and undermine their financial sustainability. This finding is in line with Ajayi and Ojo (2018), who identify poor collection mechanisms as a major factor contributing to the financial difficulties faced by Nigerian power distribution companies.

Similarly, Ogunjimi et al. (2016) highlight the challenges of enforcing payment collection due to factors like socio-economic conditions, customer non-compliance, and inefficiencies in the billing system. On the contrary, Adebayo (2017) suggests that collection losses could be reduced with better customer engagement, flexible payment schemes, and the implementation of pre-paid metering systems. Principal-Agent Theory also provides insight into this finding. The agency problem is evident here, as the principal (electricity Distribution Company) is tasked with collecting revenue, but the agent (customer) may fail to comply with payment obligations. This mismatch leads to financial losses and inefficiencies.

The p-value for MP*COL (Meter Penetration × Collection Losses) is 0.004, which is less than 0.05,

so we reject the null hypothesis. This indicates that Meter Penetration significantly moderates the relationship between collection losses and financial performance. Meter penetration helps to reduce collection losses by providing accurate billing data, improving transparency, and ensuring customers are charged for the electricity they consume. With more meters in place, it becomes easier for electricity distribution companies to track consumption and collect payments, reducing the chances of collection losses (Adebayo, 2024; Adebayo, 2025; Adebayo et al., 2024; Adebayo et al., 2025; Adebayo et al., 2026a, 2026b, 2026c; Eleje et al., 2017; Gbenga et al., 2026a, 2026b; Idoko et al., 2024; Kerim et al., 2026; Olopade et al., 2025; Udeh et al., 2024). This result supports Nwachukwu and Obasi (2018), who emphasize the role of modern metering systems in improving revenue collection and minimizing collection losses. However, Adebayo (2017) argues that metering alone may not be enough unless it is supported by robust enforcement mechanisms, such as penalties for non-payment and customer education programs. From a Principal-Agent Theory perspective, improving meter penetration reduces the agency problem between electricity companies (agents) and customers (principals). When more customers are metered, the ability to monitor and enforce payment obligations improves, leading to fewer collection losses.

The findings from the regression analysis reveal that all the variables examined—technical losses, commercial losses, collection losses, and meter penetration have significant effects on the financial performance of electricity distribution companies in Nigeria. The significant moderating role of meter penetration suggests that improving metering infrastructure could help mitigate various types of losses, leading to better financial outcomes. These results are consistent with existing literature, which emphasizes the need for improved metering, better loss management strategies, and regulatory enforcement to enhance the financial sustainability of the electricity distribution sector. The findings also align with relevant theoretical frameworks, including Agency Theory, Transaction Cost Economics, and Innovation Diffusion Theory, offering insights into the underlying mechanisms

driving financial performance in the sector.

5. Conclusion and Recommendations

This study has provided valuable insights into the factors influencing the financial performance of electricity distribution companies in Nigeria, particularly focusing on the impact of technical losses, commercial losses, and collection losses.

The study also underscores the critical effect that meter penetration plays in improving financial performance. By increasing the installation and adoption of meters, companies can reduce both technical and non-technical losses, enhance revenue collection, and ultimately strengthen their financial position. The results show that meter penetration doesn't just mitigate losses; it acts as a key factor in moderating the relationship between these losses and financial outcomes, providing a path forward for improved efficiency. In addition, the findings align with existing literature, which consistently points to the detrimental effect of collection loss on the financial health of distribution companies, especially in developing countries like Nigeria.

The findings from the regression analysis, presented in Fixed Effect Model Regression with Moderator, provide a comprehensive understanding of the factors influencing the financial performance of electricity distribution companies in Nigeria. Based on the significant results from the tested hypotheses, the following recommendations are made to address the issues of technical, commercial, and collection losses, as well as the moderating role of meter penetration:

- i. **Enhance Revenue Collection Mechanisms;** the study reveals that collection losses have a significant effect on financial performance. To address this, electricity distribution companies should invest in improving their revenue collection systems. This can be done by implementing more efficient and customer-friendly payment systems, such as mobile payment platforms and automated billing systems. These systems would make it easier for customers to pay their bills on time and reduce instances of unpaid bills. Moreover, electricity distribution companies should consider

introducing prepaid metering systems, which allow customers to pay for electricity upfront, thereby reducing the risk of collection losses. This proactive approach to revenue collection would ensure that funds are available for reinvestment into the infrastructure of the sector.

- ii. Develop Comprehensive Training Programs for Personnel: As meter penetration and advanced metering technologies become more prevalent, it is essential that electricity distribution companies invest in training and capacity building for their staff. This includes training on the maintenance and operation of smart meters, the use of data analytics for loss detection, and customer service practices that promote timely payments. By equipping employees with the right knowledge and tools, companies can enhance operational efficiency, reduce human errors, and improve their ability to manage both technical and non-technical losses. A well-trained workforce will be better positioned to implement loss reduction strategies and ensure the long-term sustainability of the sector.

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