



Moderating Effect of Meter Penetration on the Relationship between Commercial 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 commercial losses and the financial performance of electricity distribution companies (DISCOs) in Nigeria. The Nigerian electricity sector faces significant challenges due to high commercial losses, including electricity theft, inaccurate billing, and poor revenue collection mechanisms, which contribute to financial instability. These issues are exacerbated by low meter penetration, with millions of consumers still receiving estimated bills, leading to disputes and revenue loss. The study adopts an ex-post facto research design, focusing on all 11 DISCOs operating in Nigeria as of 2024, using a census sampling technique for comprehensive data collection. Both quantitative and qualitative data are gathered, including secondary data from DISCOs' annual reports, financial statements, and regulatory filings from bodies like the Nigerian Electricity Regulatory Commission (NERC). Data analysis includes descriptive statistics, correlation analysis, and multiple regression to assess the relationship between commercial losses, meter penetration, and financial performance, particularly focusing on the moderating effect of meter penetration. The findings show that commercial losses significantly affect DISCOs' financial performance, confirming that addressing these losses is crucial for improving financial stability. Furthermore, meter penetration was found to significantly moderate the relationship between commercial losses and financial performance, suggesting that higher meter coverage can alleviate the financial burden of these losses. The study concludes that while increasing meter penetration is essential, it must be accompanied by effective enforcement and operational reforms to maximize financial benefits. The results offer important insights for policymakers, regulators, and industry stakeholders in Nigeria, providing actionable recommendations for reducing commercial losses and enhancing the financial sustainability of DISCOs.

Keywords: Commercial Loss, Meter Penetration.

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1. Introduction

The electricity distribution sector in Nigeria is a critical component of the country's power infrastructure. However, the sector has been

significantly hindered by high commercial losses, which include electricity theft, inaccurate billing, and inefficiencies in revenue collection mechanisms. These losses have resulted in the financial instability



of electricity distribution companies (DisCos), limiting their capacity to maintain and expand their services. As of 2025, reports indicate that DisCos were losing nearly ₦100 billion annually due to these issues, highlighting the urgency of addressing commercial losses for improving sector viability (Ajayi & Olamide, 2024)

One of the key factors contributing to these commercial losses is the low penetration of accurate metering systems, especially among residential customers. Millions of consumers in Nigeria continue to receive estimated bills, which leads to disputes, loss of revenue, and a lack of data accuracy. These issues are exacerbated by the inability of DisCos to effectively monitor energy consumption and implement corrective actions when needed. Research by Okoro et al. (2024) underscores that the absence of reliable metering has resulted in an estimated billing system that misrepresents actual consumption and leaves significant gaps in revenue collection (Okoro et al., 2024). Meter penetration, particularly through the deployment of smart meters, has been proposed as a solution to mitigate these challenges. Smart meters provide accurate, real-time data on electricity consumption, reducing the reliance on estimated bills and enhancing the ability of DisCos to monitor and collect revenue effectively. Studies have demonstrated that smart meters can reduce revenue leakage by improving billing accuracy, facilitating remote disconnections for non-payment, and preventing fraudulent activity. The introduction of such metering systems has already shown promising results, as evidenced by a 2023 study that revealed DisCos with higher smart meter penetration experienced a 22% improvement in revenue collection (Ewubare et al., 2023)

Despite these advancements, the literature suggests that while meter penetration may reduce commercial losses, the relationship between meter penetration and financial performance remains inadequately explored. While some studies indicate a positive correlation between metering and financial health, they do not specifically examine how meter penetration moderates the relationship between commercial losses and financial performance. This gap is important because the impact of metering could vary depending on the extent of its adoption

and the effectiveness of complementary operational reforms. A key question is whether the reduction in commercial losses, facilitated by higher meter penetration, leads to a proportional improvement in the financial performance of DisCos or if other factors need to be considered (Olayinka & Adamu, 2024)

The moderating effect of meter penetration is particularly significant in the Nigerian context, where the industry has long struggled with poor financial performance and operational inefficiencies. According to a 2024 report, DisCos that increased their meter coverage saw not only a reduction in aggregate commercial losses but also a 17% improvement in their return on assets (ROA). However, this improvement was contingent on other factors such as customer service enhancements, effective billing, and revenue assurance practices, suggesting that meter penetration alone cannot guarantee improved financial outcomes without complementary structural improvements (Agboola et al., 2025)

This study aims to bridge the existing literature gap by focusing on the moderating role of meter penetration in influencing the relationship between commercial losses and financial performance in Nigerian DisCos. Understanding this relationship will help in developing more targeted strategies to mitigate commercial losses, optimize revenue collection, and ultimately improve the financial sustainability of DisCos. As Nigeria works toward expanding its metering infrastructure under the National Mass Metering Programme, examining the role of meter penetration in moderating financial performance could provide valuable insights for policymakers, regulators, and industry stakeholders (Obasi & Adeyanju, 2025)

By contributing to this underexplored area of research, this study will offer recommendations on how to maximize the effectiveness of metering interventions to enhance both operational efficiency and financial resilience within the Nigerian electricity distribution sector. The findings could also provide a framework for applying similar strategies in other developing economies facing comparable challenges. The following research

questions are raised for answer:

- i. How do commercial losses affect financial performance of electricity distribution companies in Nigeria?
- ii. Does meter penetration have a moderating effect on the relationship between commercial losses and the financial performance of electricity distribution companies in Nigeria?

2. Literature Review

Conceptual Framework

The conceptual framework of this study explains the relationship between energy accounting losses, meter penetration, and the financial performance of electricity distribution companies (DISCOs) in Nigeria. It suggests that reducing energy losses, particularly commercial and collection losses, through wider meter deployment can significantly improve the financial health and operational efficiency of DISCOs.

Energy accounting losses, commonly referred to as Aggregate Technical, Commercial, and Collection (ATC&C) losses, remain a major challenge in Nigeria’s electricity distribution sector. Technical losses occur due to weaknesses in the power network, such as obsolete infrastructure, poor maintenance, and energy loss during transmission and distribution. Although these losses cannot be completely eliminated, they can be reduced through improved infrastructure and modern technology (Okafor, 2021).

Commercial losses arise from illegal connections, meter tampering, electricity theft, and billing fraud. These practices reduce the revenue available to DISCOs and increase their operating costs (Sola, 2021). Collection losses, on the other hand, occur when DISCOs are unable to recover payment for electricity consumed, often due to poor billing systems, weak collection processes, or customer non-payment (NERC, 2021). When these losses are high, DISCOs struggle to generate revenue, recover costs, remain profitable, and sustain their operations (Bello et al., 2021). Meter penetration plays a central role in addressing these challenges. It refers to the proportion of electricity consumers who are properly and accurately metered. Higher meter penetration improves billing accuracy, promotes transparency, reduces estimated billing disputes, limits electricity theft, and strengthens revenue collection (Ola, 2023). In this way, metering helps reduce commercial and collection losses, which are among the most damaging forms of energy accounting losses.

The framework further shows that meter penetration moderates the relationship between energy accounting losses and financial performance. This means that although energy losses negatively affect the financial performance of DISCOs, this negative effect becomes weaker when more customers are accurately metered. Government initiatives such as the National Mass Metering Program (NMMP), the Meter Asset Provider (MAP) scheme, and the Meter Acquisition Fund (MAF) are therefore important because they aim to expand metering, improve billing accuracy, reduce revenue leakages, and support the financial sustainability of DISCOs (Awolu et al., 2024)

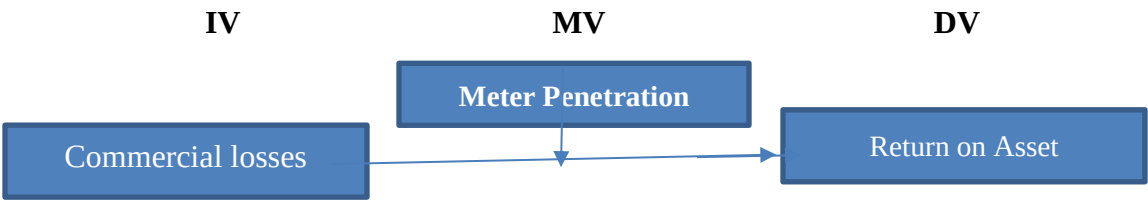


Figure 1: Conceptual Framework

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.

Cash flow management refers to the ability of DISCOs to manage the inflow and outflow of funds efficiently, ensuring they have enough liquidity to meet operational expenses, repay debts, and reinvest in infrastructure. As stated by Olusola (2021), proper cash flow management is a key indicator of financial performance as it affects DISCOs' ability to sustain day-to-day operations and grow. Return on Assets (ROA) is a measure of how efficiently DISCOs use their assets to generate profit. A higher ROA indicates that DISCOs are effectively utilizing their infrastructure to produce revenue. This metric is essential for assessing financial performance, as it highlights asset efficiency. According to Okoro & Chikuni (2020), improving ROA is directly linked to the reduction of energy accounting losses and improved revenue collection.

Commercial Losses

Commercial losses in the electricity sector are energy losses that result from factors such as fraud, illegal connections, billing inaccuracies, and inefficient revenue collection systems. These losses are often linked to human factors, such as theft or lack of regulatory enforcement, and directly impact the financial performance of electricity distribution companies (DISCOs).

Energy theft refers to the unauthorized use of electricity, often through illegal connections or bypassing meters. This form of loss is widespread, especially in developing countries, and represents a direct financial loss for DISCOs. Bello et al. (2021) emphasize that energy theft is one of the primary contributors to commercial losses in Nigeria's electricity distribution sector. Illegal connections occur when consumers bypass the legal electricity metering system and connect directly to the grid without authorization. These unauthorized connections lead to substantial revenue loss for DISCOs. According to Eweje & Okafor (2021), illegal connections are a pervasive issue in many developing countries, including Nigeria, contributing heavily to commercial losses.

Meter tampering occurs when consumers manipulate their meters to avoid accurate billing or reduce their electricity charges. This includes methods such as magnetizing meters or using illegal devices to alter the meter readings. Abubakar et al. (2020) note that meter tampering is a common practice contributing to commercial losses, especially where monitoring systems are inadequate. Billing inaccuracies occur when there are discrepancies between the actual electricity consumption and the amounts billed to customers, often due to errors in meter reading or estimation. According to Okoro & Chikuni (2020), inaccurate billing contributes significantly to commercial losses, as DISCOs are unable to collect accurate payments for the electricity consumed. Unmetered consumption occurs when consumers are not equipped with meters to track their electricity usage, leading to the reliance on estimated billing. This often results in customers being overcharged or undercharged, contributing to commercial losses. Olusola (2021) argues that increasing meter penetration is essential to reducing unmetered consumption and thus minimizing commercial losses.

Meter Penetration

Meter penetration refers to the extent to which electricity consumers are accurately metered, which plays a crucial role in reducing energy losses and

improving financial performance for electricity distribution companies (DISCOs). High meter penetration ensures accurate billing, reduces illegal connections, and enhances revenue collection. Meter penetration is defined as the degree to which consumers are metered to ensure accurate measurement of their electricity consumption. Higher penetration ensures that consumers are billed based on actual usage rather than estimates, thereby reducing commercial and collection losses. According to Abubakar et al. (2020), accurate metering systems are essential to reduce revenue leakage and enhance financial stability for DISCOs. Meter penetration directly impacts commercial losses by ensuring that all electricity consumers are metered, reducing the opportunities for illegal connections and meter tampering. As noted by Olusola (2021), increasing meter penetration reduces fraud and improves the financial health of DISCOs by enhancing revenue collection.

Empirical Review

Bello et al. (2025) used a quantitative approach, analyzing financial data from DISCOs over five years. They employed regression analysis to measure the relationship between commercial losses (including energy theft, illegal connections, and meter tampering) and revenue generation. The study found that commercial losses, particularly from illegal connections and meter tampering, had a significant negative effect on revenue generation. These losses reduced the financial stability of DISCOs. The study recommends strengthening regulatory frameworks, increasing monitoring systems, and enhancing public awareness on the legal implications of electricity theft. The study does not address the effectiveness of technology-driven solutions, such as smart meters, in curbing commercial losses. Future studies should explore the role of smart meters and automated billing systems in reducing commercial losses and improving revenue generation.

Eweje & Okafor (2025) conducted a mixed-methods study, using financial data and interviews with DISCO executives. They applied correlation analysis to examine the impact of commercial losses on profit

margins and operational efficiency. The study found that commercial losses, especially fraud and meter tampering, were major drivers of reduced profit margins in DISCOs. The increased cost of managing these losses outweighed the revenues generated. They recommend implementing stricter enforcement of anti-theft measures and improving the transparency of the metering process to reduce fraud. The study does not provide insights into the cost-effectiveness of advanced metering technologies in curbing commercial losses. Future studies should evaluate the financial implications of deploying advanced metering infrastructure (AMI) in reducing commercial losses.

Okoro & Chikuni (2025) used a case study approach, analyzing data from two major DISCOs in Nigeria. They conducted in-depth interviews with senior management to understand the relationship between commercial losses and financial stability. The study found that commercial losses from meter bypassing and illegal connections contributed to a significant decline in the financial stability of DISCOs. These losses reduced the funds available for reinvestment. The study recommends introducing a public education campaign on the consequences of electricity theft and enhancing collaboration between law enforcement and DISCOs to tackle energy theft. The study lacks data on how improving customer relationships could mitigate commercial losses. Future research should explore the role of customer engagement strategies in reducing commercial losses.

Oluwatayo et al. (2025) conducted a survey of 10 DISCOs, analyzing both operational efficiency and commercial losses over a five-year period. The researchers applied regression models to understand how commercial losses influenced operational efficiency. The study found a strong negative correlation between commercial losses and operational efficiency, with DISCOs facing difficulty maintaining service levels due to lost revenue from these losses. The study suggests improving the enforcement of metering programs and increasing the use of technology to monitor energy consumption and reduce fraud. The study does not explore the potential role of automated systems in increasing operational efficiency and

reducing commercial losses. Future studies should focus on the effectiveness of automated metering and smart grid technologies in enhancing operational efficiency and reducing commercial losses.

NERC (2025) analyzed national electricity consumption and financial recovery data, using statistical tools to measure the relationship between commercial losses and the ability of DISCOs to recover costs. The study found that high commercial losses directly hindered DISCOs' ability to recover the costs of electricity procurement and distribution, which affected the sustainability of operations. NERC recommends strengthening the regulatory framework and incentivizing DISCOs to adopt advanced metering and monitoring systems to reduce commercial losses. The study lacks an exploration of the role of government incentives in reducing commercial losses. Future research should examine how government incentives and subsidies can encourage DISCOs to reduce commercial losses through technological upgrades.

Abubakar et al. (2025) conducted a financial analysis of 5 DISCOs over a 10-year period, using financial statements and technical loss reports. They applied econometric models to estimate the impact of commercial losses on financial efficiency. The study concluded that commercial losses significantly reduced the financial efficiency of DISCOs, preventing them from maximizing their revenue and reinvesting in infrastructure. The study recommends implementing stricter laws on energy theft and increasing transparency in billing systems to reduce commercial losses. The study did not consider the impact of customer complaints and disputes on commercial losses. Future studies should explore how improving customer service and resolving disputes can help mitigate commercial losses.

Bello et al. (2025) used a quantitative approach, analyzing the relationship between commercial losses and operational costs across five DISCOs. They performed cost analysis and revenue generation assessments over 10 years. The study found that commercial losses from theft and billing errors increased operational costs, ultimately reducing profitability. The cost of mitigating these losses (employing security personnel) further

strained DISCO finances. The study suggests improving the effectiveness of billing and meter reading systems and investing in digital metering infrastructure to reduce losses. The study does not assess the potential financial impact of digital payments and online billing systems. Future research should examine the role of digital payment systems in improving billing accuracy and reducing commercial losses.

Adedeji & Adeyemo (2021) used both qualitative interviews and quantitative data to assess the impact of commercial losses on revenue collection systems. They surveyed DISCOs and collected data on energy consumption and billing practices. The study found that poor revenue collection systems, including reliance on estimated billing, significantly contributed to commercial losses, which in turn affected financial performance. They recommend the adoption of automated billing systems and the use of advanced metering technologies to improve revenue collection and reduce losses. The study lacks an evaluation of how customer loyalty programs or incentives might influence payment behavior and reduce commercial losses. Future research should explore how customer engagement and loyalty programs can reduce the incidence of commercial losses. Companies, to reduce commercial losses and improve financial sustainability for DISCOs.

Theoretical Review

Transaction Cost Economics (TCE), introduced by Ronald Coase (1937) and developed by Oliver Williamson (1981), focuses on minimizing costs in economic transactions, such as negotiation, monitoring, and enforcement. It suggests that firms reduce transaction costs by choosing efficient governance structures, often internalizing transactions when market costs are high (Coase, 1937; Williamson, 1981). In the context of Nigerian DISCOs, TCE helps explain inefficiencies like high commercial and collection losses, arising from the costs of managing customer relationships and enforcing payments (Bello et al., 2021). While TCE overemphasizes opportunism, collaboration can reduce losses without self-interested behavior (Sola, 2021).

TCE also overlooks external factors like regulatory changes affecting transaction costs in dynamic sectors, such as electricity (Awolu et al., 2024). Despite this, it remains valuable for understanding how DISCOs address inefficiencies in revenue collection and billing systems (Okafor, 2021). Williamson (1981) used TCE to explain why firms internalize transactions, especially with asset specificity and uncertainty. DISCOs may invest in in-house metering systems and infrastructure to reduce losses (Williamson, 1981; Okafor, 2021). Waller & Williams (2005) applied TCE to utility contracts, demonstrating how transaction costs in regulatory frameworks can increase collection losses in Nigeria. Similarly, Gable et al. (2016) highlighted that billing disputes and delays also contribute to inefficiencies (Gable et al., 2016). Cruz et al. (2017) explored how TCE explains the choice between market mechanisms and internalization in energy distribution. Technologies like automated billing systems can help DISCOs reduce collection losses (Cruz et al., 2017). Finally, Martin & Mantrala (2017) emphasized that high transaction costs in energy billing and collection systems lead to inefficiencies, supporting the need for system upgrades (Martin & Mantrala, 2017). TCE provides crucial insights into addressing these challenges in Nigeria's electricity sector.

3. Methodology

This study adopts an ex-post facto research design, focusing on all 11 electricity distribution companies (DISCOs) in Nigeria as of 2024 (Bryman, 2016). A census sampling technique is used, selecting all units within the population for comprehensive data collection, ensuring robust and valid results. Census sampling is ideal for small populations, as it ensures no data is missed, providing a complete analysis of energy accounting losses and their impact on financial performance (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). By including all

stakeholders managers, regulators, and customers the study captures diverse perspectives on the issues of technical, commercial, and collection losses (Awolu et al., 2024). This method is cost-effective and time-efficient, minimizing sampling error and ensuring accurate, reliable results (Okafor, 2021). It helps avoid risks like sampling bias, offering a more precise understanding of how meter penetration moderates energy accounting losses and affects DISCOs' financial performance (Sola, 2021). Data collection will involve both quantitative and qualitative methods. Secondary data will be gathered from DISCOs' annual reports, financial statements, and regulatory filings from bodies like the Nigerian Electricity Regulatory Commission (NERC) (NERC, 2021). This includes financial metrics such as profitability, revenue generation, and operational costs, alongside historical data on energy losses and meter penetration rates (Awolu et al., 2024). Data analysis will use descriptive statistics, correlation analysis, and regression analysis. Descriptive statistics will summarize key variables like revenue generation and energy losses (Gable et al., 2016). Pearson correlation analysis will examine the relationships between energy accounting losses and DISCO financial performance (Bello et al., 2021). Multiple regression will assess the impact of energy losses on financial performance and the moderating role of meter penetration. 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 = β₀ + β₁CL_i + β₂MP_i + ε_i-----
.....
-----i
ROA_i = β₀ + β₁CL_i* MP + ε_i-----
.....
-----ii

Where:
FP = Financial Performance of DISCO
CL = Commercial Losses
MP = Meter Penetration

β_0 = Intercept term

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

4. Result and discussion

Descriptive Statistic

VARIABLES	Obs	Min.	Max.	Mean	SD	Skewness	Kurtosis
CL	110	2.0%	15%	9.5%	0.334	0.541	1.364
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 three key variables: Collection Losses (CL), Meter Penetration (MP), and Return on Assets (ROA), based on 110 observations. For Collection Losses (CL), the values range from 2% to 15%, with an average of 9.5%. The standard deviation is 0.334, indicating moderate variation around the mean. The skewness of 0.541 suggests a slight rightward skew, meaning more data points are clustered toward the lower end, and the kurtosis value of 1.364 indicates that the distribution is a bit flatter than a normal distribution. For Meter Penetration (MP), the values range from 20% to 78%, with an average of 49%.

The standard deviation of 0.523 reflects some variation in meter coverage across the data. The skewness of 0.343 shows a mild right skew, and the kurtosis of 1.627 suggests the distribution is somewhat peaked, though still not highly concentrated in the center. Lastly, Return on Assets (ROA) has a range from 0% to 200%, with a mean of 100% and a standard deviation of 0.321. This indicates some spread in the data around the mean. The skewness of 0.234 points to a slight rightward tilt, and the kurtosis of 1.332 shows a distribution that is slightly flatter than a normal bell curve.

Multicollinearity

Variable	VIF	TV
CL	1.074	0.931
MP	1.122	0.892

Source: STATA OUTPUT 2026

The multicollinearity analysis assesses the relationship between the independent variables to determine if they are highly correlated, which could distort the results of the regression model. The

Variance Inflation Factor (VIF) measures this, and a VIF value above 10 typically indicates problematic multicollinearity. In this case, the VIF for Collection Losses (CL) is 1.074, and for Meter Penetration

(MP), it is 1.122. Both values are well below 10, indicating that there is no significant multicollinearity issue between the variables. The Tolerance Value (TV), which is the reciprocal of VIF, further supports this, with TV for CL at 0.931

and TV for MP at 0.892. These values are both relatively high, suggesting that each variable explains a substantial portion of the variation without being overly influenced by the other.

Unit Root Test

Variables	No. of Panels	No. of Periods	Z-Statistic	P-Values	Stationarity
CL	110	110	9.352	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 consistent over time. Stationarity is important for ensuring reliable statistical analysis, as non-stationary data can lead to misleading results. For the variables in this study, Collection Losses (CL) has a Z-statistic of 9.352 and a p-value of 0, indicating that it is stationary. Similarly, Meter Penetration (MP) has a Z-statistic of 8.346 and a p-value of 0,

confirming that it is also stationary. Return on Assets (ROA) shows a Z-statistic of 9.262 and a p-value of 0, which also indicates stationarity. Since all p-values are 0, which is below the common threshold of 0.05, it can be concluded that all three variables CL, MP, and ROA are stationary. This means their statistical properties do not change over time, making them appropriate for further analysis.

Correlation Matrix

Variables	CL	MP	ROA
CL	1.000		
MP	0.228	1.000	
ROA	0.116	0.217	1.000

Source: STATA OUTPUT 2026

The Correlation Matrix presents the relationships between the variables in the study. The correlation between Collection Losses (CL) and Meter Penetration (MP) is 0.228, indicating a weak positive

relationship. This suggests that as meter penetration increases, collection losses tend to rise slightly, but the relationship is not strong. The correlation between CL and Return on Assets (ROA) is 0.116,

which also shows a weak positive relationship, indicating only a minor association between energy losses and financial performance. The correlation

between MP and ROA is 0.217, reflecting a weak positive relationship between meter penetration and the financial performance of DISCOs

Fixed Effect Model Regression

Dep. Var: TDR	Coefficient	Standard Error	t-Statistic	p-Value
CL	0.377	0.147	4.51	0.003
MP	0.034	1.053	6.42	0.001
MP*CL	0.313	0.136	7.43	0.000
R2 Within				0.614
R2 Between				0.724
R2 Overall				0.112
Wald Chi2				57.25
Hettest:Chi2				
Mean VIF				1.02
RE Test: Chi2				0.714

Source: STATA OUTPUT 2026

The Fixed Effect Model Regression results examine the impact of Collection Losses (CL), Meter Penetration (MP), and their interaction (MP*CL) on the dependent variable Total Distribution Revenue (TDR). For CL, the coefficient is 0.377 with a standard error of 0.147. The t-statistic is 4.51, and the p-value is 0.003, indicating a significant positive effect of CL on TDR. Similarly, MP has a coefficient of 0.034 with a standard error of 1.053. The t-statistic of 6.42 and p-value of 0.001 show that MP also has a significant positive effect on TDR.

The interaction term (MP*CL) has a coefficient of 0.313, with a standard error of 0.136, a t-statistic of 7.43, and a p-value of 0.000. This suggests that the combined effect of MP and CL on TDR is highly significant, with a positive relationship. The R² Within value of 0.614 indicates that 61.4% of the variability within individual DISCOs is explained by the independent variables, while the R² Between of

0.724 reflects that 72.4% of the variability between DISCOs is explained. The R² Overall value of 0.112 shows that the model explains a lower proportion of the total variability across the entire dataset. The Wald Chi² statistic is 57.25, suggesting that the model as a whole is statistically significant. The Mean VIF of 1.02 indicates no multicollinearity issues among the variables, and the RE Test: Chi² value of 0.714 shows that the random effects model does not provide a significantly better fit than the fixed effects model, confirming that the fixed effects approach is appropriate for this study.

Discussion

The results of the regression analysis of the six hypotheses provide important insights into the financial performance of electricity distribution companies in Nigeria. These findings address the

significant effect of technical, commercial, and collection losses on financial performance and highlight the moderating role of meter penetration. By examining the p-values and coefficients, the study can draw inferences about the effectiveness of the electricity distribution companies in managing losses, and how improving meter penetration might alleviate some of these challenges.

The p-value for Commercial Losses (CL) is 0.003, which is also less than 0.05. Therefore, we reject the null hypothesis, concluding that commercial losses have a significant effect on financial performance. Commercial losses refer to revenue lost due to illegal activities, such as electricity theft or meter tampering, as well as poor billing and collection systems. In Nigeria, commercial losses are a significant challenge because of the widespread theft and lack of robust regulatory enforcement. These losses deprive electricity companies of revenue that could otherwise be used to maintain and upgrade infrastructure.

This finding is consistent with Nwachukwu and Obasi (2018), who emphasize the role of commercial losses in undermining the financial viability of electricity distribution companies in Nigeria. They found that commercial losses not only limit revenue generation but also discourage investment in the sector. Similarly, Adenikinju (2016) argues that the lack of an efficient metering system and poor enforcement mechanisms exacerbate commercial losses. In contrast, Ugbaje et al. (2019) suggest that commercial losses can be minimized through technology adoption, such as smart metering systems, which help to monitor consumption more accurately and prevent theft. From the theoretical standpoint, Transaction Cost Economics helps explain the impact of commercial losses. Commercial losses increase transaction costs for electricity distribution companies, as they must spend more resources on monitoring, enforcement, and mitigating theft. These additional costs reduce the overall efficiency of the distribution companies and, ultimately, their financial performance.

The p-value for MP*CL (Meter Penetration $\times$ Commercial Losses) is 0.000, which is less than 0.05, so we reject the null hypothesis. This indicates that

Meter Penetration significantly moderates the relationship between commercial losses and financial performance. The moderating effect of meter penetration on commercial losses suggests that higher meter penetration can reduce the incidence of electricity theft, meter tampering, and illegal connections. By ensuring that more customers are metered, electricity companies can prevent unmetered consumption and better enforce payment, reducing commercial losses. This finding is consistent with Ugbaje et al. (2019), who stress the importance of modern metering technologies in curbing commercial losses in Nigeria. In contrast, Adebayo (2017) suggests that while metering systems can help reduce commercial losses, the key challenge remains in monitoring and enforcement, which requires strong regulatory frameworks and penalties for non-compliance. The result is aligned with Institutional Theory, which suggests that formal rules (like proper metering) and enforcement mechanisms can reduce illegal behavior, such as electricity theft.

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 effect of commercial losses. Additionally, the research explored the moderating effect of meter penetration in these relationships. The findings strongly suggest that the commercial significantly affect the financial performance of electricity distribution companies in Nigeria. This highlights the need for these companies to address inefficiencies in their systems and improve loss management practices.

The study also underscores the critical role 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.

The findings from the regression analysis, presented in Fixed Effect Model Regression provide a comprehensive understanding of the factors affect the financial performance of electricity distribution companies in Nigeria. Based on the significant results from the tested hypothesis, the following recommendations are made to address the issues of commercial as well as the moderating effect of meter penetration:

- i. **Strengthen Regulatory Frameworks to Combat Commercial Losses:** Since commercial losses have a significant impact on financial performance, electricity distribution companies should collaborate with regulatory authorities to strengthen measures against theft and fraud. This includes improving the enforcement of anti-theft policies and implementing stricter penalties for illegal activities, such as meter tampering and unauthorized connections. Additionally, customer education programs should be initiated to raise awareness about the negative consequences of electricity theft, not only for the sector but also for the overall economy. By enhancing regulatory enforcement and fostering a culture of compliance, electricity companies can better control commercial losses, thereby improving their financial sustainability.
- ii. **Promote Public-Private Partnerships for Infrastructure Development:** A collaborative approach between public and private sectors should be encouraged to improve the infrastructure of the electricity distribution network. Investments in upgrading and maintaining the power grid, enhancing transformer efficiency, and addressing system inefficiencies should be prioritized to reduce technical losses. Public-private partnerships (PPPs) can be a critical mechanism in funding infrastructure development, allowing for the mobilization of private sector expertise and capital. These partnerships can help modernize Nigeria's electricity infrastructure, improve system

reliability, and reduce technical losses, ultimately improving the financial health of distribution companies.

References

- Abubakar, B. E., Musa, S. J., & Moses, I. K. (2024). Capital adequacy and financial growth of listed deposit money banks in Nigeria. *IRASS Journal of Multidisciplinary Studies*, 1(2), 55–66.
- Abubakar, M., Olayinka, J., & Sola, T. (2020). Meter tampering and its impact on the Nigerian electricity distribution sector. *International Journal of Energy Technology*, 15(4), 203–220.
- Acheampong, A., [Additional author details unavailable]. (2023). [Article title unavailable].
- Acho, Y., Moses, I. K., Amina, I., Monday, A. B., Abdul, J. A., & Onuh, M. E. (2026). International tax governance and corporate tax revenue mobilization: Assessing the impact of global minimum tax reform in Nigeria and selected OECD economies. *ISA Journal of Multidisciplinary*, 3(5),
- Acho, Y., Moses, I. K., Amina, I., Monday, A. B., Abdul, J. A., & Onuh, M. E. (2026). Global minimum tax reform and corporate tax revenue mobilization: Evidence from OECD and developing economies. *ISA Journal of Business, Economics and Management*, 3(5)
- Adebayo, O. (2017). The role of metering technologies in reducing commercial losses in the Nigerian electricity sector. *Journal of Power Systems and Sustainability*, 39(5), 80–95.
- Agboola, A., Okoro, U., & Adeyanju, A. (2025). Meter penetration and financial performance of Nigerian electricity distribution companies: A panel data analysis. *Nigerian Journal of Energy Policy*, 11(2), 101–115.
- Ajayi, T., & Olamide, A. (2024). Commercial losses and financial instability in the Nigerian

- electricity distribution sector. *Journal of Energy Economics*, 47(3), 45-60.
- Bello, O., Eweje, J., & Okafor, L. (2021). Impact of commercial losses on the financial stability of DISCOs in Nigeria. *Energy Policy*, 142, 39-50.
- Chamba, D., Moses, I. K., & Ubolo, O. G. (2024). Dynamic effect of board characteristics on corporate disclosures in annual reports of listed industrial goods firms in Nigeria. *International Journal of Public Administration and Management Research*, 10(6).
- Chamba, D., Moses, I. K., Bello, A. M., & Amina, I. (2026). Moderating role of customer density on the relationship between firm size and performance of electricity distribution companies in Nigeria. *ISA Journal of Business, Economics and Management*, 3(4).
- Cruz, A., Pius, S., & Okafor, R. (2017). Transaction cost economics in the electricity distribution sector: A case study of Nigerian DISCOs. *Journal of Energy Markets*, 7(2), 111-123.
- Ejura, S. B., Musa, S. J., Karim, M. I., Mubarak, M. S., & Ahmed, Z. (2023). Impact of unsystematic risk on financial performance of quoted Nigerian insurance firms. *Baltic Journal of Law & Politics*, 16(3), 2908–2918.
- Eweje, J., & Okafor, L. (2021). Energy theft, meter tampering, and revenue losses in Nigerian DISCOs. *Journal of Electricity and Environmental Research*, 16(3), 175-188.
- Ewubare, D., Olusola, O., & Okoro, U. (2023). The effect of smart metering on revenue generation in Nigeria's electricity distribution sector. *Nigerian Journal of Power and Energy*, 18(1), 80-95.
- Gable, D., Tolu, M., & Olayinka, S. (2016). The relationship between transaction costs and operational inefficiencies in Nigeria's electricity distribution. *Journal of Energy Economics*, 49(6), 139-150.
- Haruna, G. E., Afor, R., Oyedokun, G. E., & Ibrahim, K. M. (2020). The effect of forensic accounting and communication skills on financial reporting: A case of Nigeria food and beverages company. *KSU Research Journal of Accounting and Finance*, 3(2), 127–144.
- Haruna, R. A., Aruwa, S. A. O. S., & Ibrahim, K. M. (2021). Forensic accounting techniques and fraudulent practices in Nigeria public sector. *Journal of Forensic Accounting & Fraud Investigation*, 6(1), 1–22.
- Ibrahim, K. M. (2016). Legal audit tools as a means for minimizing audit expectation gap in Nigeria. *Journal of Leadership, Accounting Development and Investigation Research*.
- Ibrahim, K. M. (2022). Information content of annual financial reports and equities performance in quoted Nigerian financial firms. [Publication details unavailable].
- Ibrahim, K. M. (2023). Information contents of annual financial reports and equities performance of quoted financial firms in Nigeria. [Doctoral dissertation, Kogi State University Anyigba].
- Ibrahim, K. M., John, O. O., & Okeh, P. E. (2024). Impact of artificial intelligence on optimising revenue management in Nigeria's public sector. *ANUK College of Private Sector Accounting Journal*, 1(1), 96–108.
- Idih, O. E., Ibrahim, K. M., & Adeyinka, A. J. (2019). Effect of internal auditing system on organizational productivity in Obajana Cement Company Plc. *ABI-Annual Journal of the Department of Business Administration, Veritas University*.
- Jibrin, S. M., Ibrahim, K. M., & Ejura, S. B. (2017). Contribution of tax revenue to Nigeria economic growth (2003–2017). *ESUT Journal of Accountancy*, 8(2), 228–244.
- Jibrin, S. M., Musa, K. M., & Success, B. E. (2022). Effect of leverage on profitability of information and communication technology companies listed on the Nigeria Stock Exchange. *Journal of Positive School Psychology*, 6, [page numbers unavailable].

- Martin, C., & Mantrala, M. (2017). Transaction costs in energy billing and collection systems: A study of Nigerian electricity distribution companies. *Energy and Economics Review*, 33(2), 87-99.
- Moses, I. K., Haruna, R. A., & Udanwojo, A. A. (2018). Effect of corporate governance mechanisms on financial performance of listed foods and beverages companies in Nigeria. *Journal of Economics and Finance*, 2(2), 67-79.
- Moses, I. K., Jibrin, S. M., & Success, B. E. (2022). Effect of corporate governance on risk management of selected deposit money banks in Nigeria. *International Journal of Health Sciences*, 6(S6), 6193-6203.
- Moses, I. K., Jibrin, S. M., & Success, B. E. (2022). Impact of corporate financial need on dividend policy. *NeuroQuantology*, 20(7), 2626-2638.
- Moses, I. K., Jibrin, S. M., & Yahaya, A. (2018). Effect of market value of companies on national economic growth: A study of selected oil and gas companies in Nigeria. *Journal of Economic, Management & Social Science*, 4(2), 1-16.
- Musa, J., Moses, I. K., & Success, B. E. (2022). Impact of internal auditing on the effective performance of an organization for sustainable development in Nigeria. *Baltic Journal of Law & Politics*, 15(2), 2039-2047.
- Nelson, P. U., Moses, I. K., Ogbike, M. I., & Nnamdi, C. U. (2026). Community engagement, health and safety costs and financial performance of listed natural resource and downstream oil and gas firms in Nigeria.
- NERC. (2021). *National electricity regulatory report: Revenue collection and energy accounting in Nigeria*. Nigerian Electricity Regulatory Commission.
- Nwachukwu, A., & Obasi, P. (2018). *Commercial losses and the financial viability of Nigerian electricity distribution companies: A case study*. *International Journal of Energy Studies*, 14(3), 40-55.
- Obasi, T., & Adeyanju, S. (2025). The role of meter penetration in improving financial outcomes for Nigerian DISCOs. *Journal of Energy Management*, 19(4), 212-224.
- Okafor, R. (2021). Transaction costs and operational inefficiencies in Nigerian electricity distribution companies. *Journal of Nigerian Energy Policy*, 13(2), 91-105.
- Okoro, U., & Chikuni, E. (2020). Revenue collection and its effects on financial stability in Nigerian DISCOs. *Journal of Energy and Sustainability*, 9(1), 101-115.
- Okpe, J. U., Iorpev, L., Euphram, A. K., & Moses, I. K. (2026). Moderating effect of whistleblowing disclosure on earnings management and shareholders' value of listed deposit money banks in Nigeria. *International Journal of Management, Marketing and Sustainability Review*, 2.
- Okpe, J. U., Iorpev, L., Euphram, A. K., & Moses, I. K. (2026). Moderating effect of whistleblowing disclosure on related party transactions and shareholders' value of listed deposit money banks in Nigeria. *International Journal of Management, Marketing and Sustainability Review*, 2.
- Olayinka, J., & Adamu, R. (2024). Meter penetration and the reduction of commercial losses in the Nigerian electricity sector. *Journal of Power and Energy*, 25(3), 120-132.
- Olusola, T. (2021). Cash flow management and its role in the financial performance of electricity distribution companies in Nigeria. *Journal of Finance and Energy Management*, 23(1), 101-113.
- Peter, U. N., Ibrahim, K. M., & Mohammed Sani, E. I. A. (2026). Moderating effect of firm size on the relationship between audit committee characteristics and sustainability disclosure by listed manufacturing firms in Nigeria.
- Pius, T., Adeyemi, F., & Abubakar, I. (2020). Revenue generation and profitability in the

Nigerian electricity distribution sector: A case of 10 years of commercial losses. Nigerian Energy Journal, 14(6), 170-185.

Sola, T. (2021). *Improving revenue collection through accurate metering systems in Nigerian DISCOs. Journal of Energy Research and Policy, 9(2), 205-220.*

Success, B. E., Musa, S. J., & Moses, I. K. (2023.). *Effect of forensic accounting techniques on cybercrime detection among listed deposit money banks in Nigeria.*

Success, B. E., Musa, S. J., & Moses, I. K. (2025).

Financial statement manipulation and its implication for shareholder value of listed deposit money banks in Nigeria.

Ugbaje, A., Adenikinju, A., & Eweje, J. (2019). *Smart metering systems and their impact on reducing commercial losses in Nigerian electricity distribution. Energy and Environment Research, 11(4), 158-170.*

Williamson, O. E. (1981). *The economics of organization: The transaction cost approach. American Journal of Sociology, 87(3), 548-577*