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Article

Assessment of profitability and inventory management in the Nigerian power generation asset companies

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Abstract: In Nigeria's electricity sector, there are numerous energy generation firms (GenCos). These companies are responsible for the generation of electricity for millions of clients around the country. These companies often face significant inventory management issues despite the high electricity demand. These inefficiencies can result in both financial losses and operational disruptions, which negatively impact these businesses' overall profitability. Additionally, this study will look into how inventory management affects revenue generation, operational costs, and overall financial sustainability. Three generation firms were selected to represent Nigeria's energy industry in the dataset. Mainstream Energy Solutions Limited, Transcorp Power Limited, and Egbin Power PLC are some of the companies. Important elements needed to assess inventory management practices and their impact on profitability in Nigeria's oil industry are contained in the dataset. The following variables are used: year, city, location, cash flow, revenue, capital cost, and operating cost. Regression analysis, sensitivity analysis, and Data Envelope Analysis (DEA) were used to examine inventory management and its impact on profitability in the Nigerian energy sector. According to the analysis, there is a lot of pressure on businesses in Nigeria's energy sector to efficiently control costs to stay profitable.

Keywords: distribution; generation; power; electricity; inventory management

1. Introduction

An essential component of any country's economic growth is the energy sector. It's the same in Nigeria. The foundation of the nation's industrialization, economic expansion, and social well-being is made up of the power distribution subsectors. Inventory management is one of the main areas influencing financial performance, but the industry has faced many obstacles in guaranteeing profitable and effective energy delivery.

Inventory management is a crucial aspect of the operations of any industry, but its importance is even more pronounced in the energy sector, where it directly impacts supply chain efficiency, cost control, and overall profitability. In power generation and distribution companies, inventory includes the materials, equipment, and spare parts necessary for generating and distributing electricity. This inventory is essential for the smooth operation of the energy infrastructure, ensuring that plants are operational and that distribution networks function without disruptions.

The Nigerian power sector is comprised of numerous electricity distribution companies (DisCos). These companies are responsible for distributing electricity to millions of consumers across the country. Despite the immense demand for power, these companies often face significant obstacles related to inventory management. These challenges include poor stock control, inefficient procurement practices, inadequate storage facilities, and lack of real-time data to track inventory levels. Such inefficiencies can result in both financial losses and operational disruptions, negatively impacting the overall profitability of these firms.

The Nigerian power sector has undergone various reforms, especially since the privatization of the electricity distribution and generation companies in 2013. The aim of these reforms was to improve the operational efficiency of the sector and make it more attractive to private investors. However, despite these efforts, the sector continues to struggle with persistent inefficiencies and challenges. These include inadequate infrastructure, a growing demand for electricity, financial instability, poor technical capabilities, and weak regulatory frameworks.

Several studies have focused on the financial performance of Nigerian power companies, but few have specifically addressed the relationship between inventory management practices and profitability in this sector. The energy industry is unique because of its capital-intensive nature, where companies must maintain large inventories of spare parts, fuel, and other materials that are essential for both routine and emergency operations. As a result, effective inventory management can lead to reduced costs, better service delivery, and ultimately improved financial performance.

As reported by African Energy and Mineral Corporation (AEMC) [1], the Power Holding Company of Nigeria (PHCN) operated in a maintenance-like environment that was primarily concerned with providing continuous support for the operations of a single unit, plant, or fleet or group of components, as well as ensuring that operational requirements were met. Inventory control was clearly a critical component of maintenance activities that necessitated the use of spare parts demand forecasts, as was evident. The result was that both capital and operational spare parts had to be kept on hand in order to protect the operations from unwelcome, and sometimes costly, stockouts. In the majority of situations, the inability to obtain spare parts resulted from a lack of a good maintenance culture or from unanticipated outages, which prolonged the downtime of the equipment. The cause of irregular power supply outages may be due to deteriorating infrastructure or failures in power-generating plants, but it has been highlighted that inadequate inventory management is a significant contributor to the problem due to the rising fluctuation of demand. This will result in the need for greater safety stock and insurance spares in order to maintain a minimum needed service level, necessitating the use of a well-planned, reliability-centered inventory.

For the purpose of checking the stochastic demand for spare parts and inventory optimization in order to determine the average number of backorders, a decision support simulation model has been constructed. In order to develop a general simulation life cycle, which included the Intelligence Phase, the Managerial Phase, the Development Phase, the Quality Assurance Phase, the Implementation Phase, and the Operation/Maintenance/Archival Phase, it was necessary to first define what a simulation life cycle was. It is critical that a Reliability Centered Maintenance Strategy be implemented, which includes tools such as Failure Mode, Effects and Criticality Analysis (FMECA), optimization studies, Reliability/Availability and maintainability studies, Root Cause Analysis, and other similar techniques, in order to determine the need for consumables, capital, and operational spare parts inventory management and stock levels.

According to Ayansola et al. [2], who looked at how inventory management techniques affected the business operations of flour milling companies in Nigeria, "there have been cases of materials overstocking, which eventually became expired or out of date, understocking, a lack of stock-taking, theft of materials by workers, and a delay in the delivery of materials into the organizations, among other things". It found that working capital, which includes inventories, accounts for approximately 50% of the total assets of a majority of manufacturing firms [3–5]. When such a large amount of working capital is invested in inventory, it has a negative impact on the company's operational performance and profitability. For Capital Cost, Cash Flow, Revenue, and Operational Cost are reported solely as absolute numbers without error descriptions. that some business managers lack the necessary skill sets or technical knowledge to ensure efficient inventory management. There is a requirement for organizations to maintain minimum, ordering, hastening, and maximum stock levels at their facilities [6,7]. According to Kaitafi [8], the majority of Nigerian manufacturing enterprises were still relying on outdated methods of inventory control and valuation, which were deemed ineffective and unsophisticated.

When it comes to inventory carrying costs in the electric and gas utility industry, Scott Madden Management Consulting believes that management's responsibility includes optimizing actual shareholder return on assets (ROA) and ensuring that such regulated revenue is not earned on unnecessary or obsolete assets. Also confirmed is that inventory in excess of that required to meet a defined "level of service" is "surplus" inventory and should be deleted because holding such inventory diminishes actual revenue. For a number of reasons, such as establishing economic order quantities (EOQs), figuring out lot sizes, conducting price break analysis, deciding whether to manufacture to order or produce to stock, analyzing lifetime buys, assessing supplier promotional offers, assessing vendor-managed inventory (VMI) opportunities, conducting inventory risk analysis, and calculating inventory carrying costs, it is crucial to create a calculation of inventory carrying costs.

The goal of inventory replenishment is to guarantee that there is enough product on hand to fulfill predicted demand while maintaining a defined level of service. The level of service specifies the minimum amount of inventory availability that must be maintained. In most cases, this is expressed as a percentage of the time the part is available for usage when it is required. Inventory is said to be optimized when it is kept on hand at all times to the extent that it is only necessary to meet the defined service level requirements. As a result of this viewpoint, inventory reduction is not a desirable goal in and of itself. Inventory optimization, on the other hand, is important.

Inventory holding costs differ significantly from industry to industry. Estimates for median carrying costs ranged from 21.8% to 12.3% of total inventory value, with the average carrying cost estimated at 12.3%. Scott Madden's extensive experience working with utilities, as well as its comprehensive understanding of the main performance levers in the supply chain, provides us with a clear lens through which to examine efficiency and effectiveness. Carrying costs in the range of 10% to 15% are more prevalent in the utility industry, according to our experience. My belief is that a number of issues are contributing contributors to the increase in inventory. Inventory Complexity, Warehouse Space and Staffing, Turnover Rate, and a slew of other intriguing topics will be considered in this analysis.

The impact of the multi-year tariff order (MYTO) Tariff Review on the flow of private investment into the Nigerian electricity supply industry was examined by Ahmed [9]. The study looks at how MYTO affects the flow of private capital to NESI. Data from a sample of respondents was gathered using questionnaires. The study made use of primary data. The study employed simple regression analysis.

Ado and Landi [10] looked into the evaluation of Nigeria's private sector funding of electrical infrastructure. The study aimed to identify the causes of the industry's sluggish private sector investment flow. The study generated data for analysis by distributing Likert scale structured questionnaires to top management of privately licensed companies. For data analysis, several regressions were employed. Khonjelwayo and Nthakheni [11] looked into the function of regulation in South Africa's capital infrastructure investment in electricity distribution. Both primary and secondary data are used in the investigation. 16 Energy Regulator officials who are in charge of evaluating and approving applications for electricity distributor tariffs were interviewed in order to gather primary data for the study. Using a sample of 112 South African energy distributors, secondary data was gathered and examined. The study used correlation analysis to examine the relationship among the variables. Stenner et al. [12] Investigated Australian consumers likely response to cost-reflective electricity pricing. The logic of research techniques was used by the researchers. A sample and survey procedure was used to collect the primary data.

Samuel [13] investigates cost-reflective pricing and governance in the energy sector in West Africa. The descriptive statistical method was employed. The regulator (NERC) provided the secondary data that was used. There is no need to estimate parameters or use inferential statistical techniques to test the hypothesis because this methodology is deemed appropriate based on actual electricity supply costs and income data from the Nigerian Electricity Supply Industry (NESI). The marginal cost of delivering one kWh of energy to end customers is known as the unit cost of electricity provision. In the Nigerian electricity supply industry, this cost varies by region and for each DisCo. The study used a descriptive statistical technique. Ayansola et al. [14] investigated the liberalization models and electric power pricing in developing nations. To estimate the effect of the liberalization model on the price of electric power, he employed an instrumental variable technique. The simultaneity bias issues between the chosen liberalization models and the price of electricity were resolved by this method. Panel data from 78 nations across four regions—developed countries, Asian developing countries, the former Soviet Union and Eastern Europe, and Latin America—during the years 1985–2003 were used to create these econometric models.

Beaufils and Pineau [15] carried out a study on assessing the impact of residential load profile changes on electricity distribution utility revenues under alternative rate structures. The researcher used a descriptive analysis technique. Secondary data were employed for the study. Using data from a comparative example in the electricity industry, Bonis et al. [16] investigates the disparate effects of revenue increases and cost reductions on investors' assessment of growth prospects. In order to accomplish this goal, they examine how stock prices are affected in a comparative instance of direct foreign investment that involves the purchase of two distinct growth alternatives, the value of which has previously been thoroughly examined in earlier research. The investigator employed descriptive methods.

Chindarkar and Goyal [17] carried out research on one price not fitting all. An analysis of the variations in home electricity pricing elasticity in India. The Ministry of Statistics and Program Implementation's National Sample Survey Office (NSSO) conducted household consumer spending surveys that the researcher used, for data on electricity use and the household characteristics. The NSS are nationally representative surveys based on a multi-stage, stratified sampling design in which villages or urban blocks are systematically sampled from census enumeration areas. Anosike et al. [18] carried out research on the analysis of the Nigerian Electricity Generation (MYTO) Pricing Model. To supplement the limited information on power plant performance and operation in Nigeria, thermodynamic modeling and simulation of an open cycle gas turbine (OCGT) were conducted. A probabilistic approach based on Monte Carlo simulation (MCS) performed in commercial software was used to do sensitivity analysis. The analysis was conducted using secondary data.

In South Africa, Maphosa and Mabuza [19] investigated the trade-offs between cost-reflective and pro-poor tariffs. One important point that the study aims to address is how the electrical industry can effectively draw in both domestic and global investors without necessarily compromising governmental goals like universal access to electricity. The study employed descriptive analysis. The study made use of both primary and secondary data.

Research was done by Passey et al. [20] on creating demand-charged power network rates that are more cost-reflective. The first step in their analysis is a visual evaluation of the cost-reflectiveness of a certain demand charge network tariff. In terms of matching customer bills with their contribution to network peak demand, they find it to have low cost-reflectivity when applied to a typical demand charge network tariff proposal within the Australian National Electricity Market and actual consumption data from 3876 households in Sydney.

Ohiare [21] looked at cost analysis and spatial planning for extending access to power for everyone in Nigeria. This study presents cost estimates for attaining universal energy access in Nigeria by 2030 and determines the most cost-effective electrification supply option (grid, mini-grid, and/or off-grid) using a spatial power planning model known as the "Network Planner (NP)".

Furthermore, this study will focus on the case of selected Nigerian power generation, examining their inventory management practices and how these practices contribute to or detract from their profitability. By analyzing these companies, the study will contribute to the existing literature [22–28] on inventory management in the energy sector and provide recommendations for improving inventory practices within the Nigerian power sector.

In conclusion, this study is timely and essential, given the significant role that the energy sector plays in the economic development of Nigeria. As the country seeks to improve its electricity generation capabilities, understanding the role of inventory management in financial performance is crucial. By exploring how inventory management practices impact profitability in the Nigerian power generation sector, this study aims to contribute to the ongoing efforts to enhance the efficiency, sustainability, and profitability of the sector.

2. Material and method

2.1. Data

The dataset includes three companies (three power generation companies) selected to represent the Nigerian energy sector. The dataset underwent rigorous cleaning and validation processes to ensure accuracy, consistency, and reliability.

The data used for this study were collected from secondary sources, including publicly available financial reports, industry publications, and databases relevant to the Nigerian power generation sector. These sources provided comprehensive information on the operational and financial performance of three power generation companies over the period from 2017 to 2022. The dataset comprises key variables necessary for assessing inventory management practices and their impact on profitability within the Nigerian energy sector. The variables used are year, city, Capital Cost, Cash Flow, Revenue, Operational Cost, and location. The comprehensive dataset forms the foundation for the exploratory data analysis, modeling, and interpretation of results in this study, enabling a detailed examination of the relationship between inventory management practices and profitability in the Nigerian energy sector.

2.2. Models

The analysis of inventory management and its impact on profitability in the Nigerian energy sector was conducted using a combination of quantitative techniques. These methods provided comprehensive insights into the relationships between variables, efficiency levels, and profitability trends. The following analytical methods were employed:

2.2.1. Regression analysis

Regression analysis is used to examine the relationship between dependent and independent variables. In this study, multiple regression models are employed to analyze the impact of various factors such as revenue, operational cost, and cash flow on capital cost. Specifically, regression analysis helps to determine how changes in these independent variables are likely to affect the capital cost, which is a key measure of profitability for power generation companies. By quantifying these relationships, regression analysis allows for the prediction of capital costs based on changes in key financial indicators.

2.2.2. Sensitivity analysis

Sensitivity analysis is employed to determine how sensitive capital costs are to variations in key financial variables such as Revenue, Operational Costs, and Cash Flow. By adjusting one variable at a time while holding the others constant at their mean, the study evaluates the effect of these fluctuations on capital costs.

For example, when predicting capital costs, the study examines how increasing revenue or cash flow impacts capital expenditures and whether these changes positively or negatively influence financial performance. Sensitivity analysis is particularly useful for understanding the potential risks associated with fluctuations in these variables and provides insights into the stability of capital cost predictions under different scenarios. It enables the identification of critical factors that should be closely monitored for effective inventory management and financial planning.

2.2.3. Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a non-parametric method used to assess the relative efficiency of decision-making units (DMUs) such as companies or departments. DEA compares the performance of multiple companies based on various input and output variables. In this study, DEA is applied to evaluate the efficiency of power generation and distribution companies in managing their inventory. The method uses multiple inputs, such as operational cost and cash flow, to assess the output, which is typically measured in terms of profitability and revenue generation.

DEA calculates an efficiency score for each company, identifying those that are performing optimally and those that may be underperforming. Companies that operate on the "efficient frontier" are considered to be using their resources in the most effective manner, while those that are not on the frontier may have room for improvement in inventory management practices. By identifying inefficient practices, DEA helps in benchmarking the performance of different companies and offers insights into how underperforming companies can optimize their inventory and operational strategies to improve profitability.

3. Results and discussions

Exploratory Data Analysis (EDA) is an essential step in understanding the underlying patterns, relationships, and distributions within a dataset. For this study on the assessment of inventory management for profitability in the Nigerian energy sector, several EDA techniques were employed to gain insights from the data and inform further analysis. The following types of EDA were performed:

3.1. Descriptive statistics

Descriptive statistics were computed for each of the key variables in the dataset. This provided basic insights into the central tendency (mean, median), variability (standard deviation, range), and distribution of the variables. A summary table was created to present these statistics, allowing for a quick understanding of how variables such as revenue, Operational Cost, Capital Cost, and Cash Flow behave across the different companies and years.

The average capital cost for the power-generating companies over the study period is approximately 279.38 billion Naira in **Table 1**, reflecting a high level of investment in capital infrastructure. However, the standard deviation of 153.5 billion Naira indicates significant variability in capital costs, with large fluctuations observed across the years. The median value of 334.2 billion Naira, which is higher than the mean, suggests a left-skewed distribution where a few years with lower capital costs are pulling the mean down. The presence of outliers is further supported by the large difference between the median and mean values.

Table 1. Descriptive statistics for generating companies.

Variables	Mean	Median	St. Dev.	Min	Max
Capital Cost	279,377,611,056.000	334,201,151,500	153,498,033,185.000	60,230,775,000	459,564,000,000
Cash Flow	23,767,420,000.000	18,503,254,000	19,361,961,315.000	952,532,000	68,612,000,000
Revenue	86,467,522,778.000	81,019,550,000	25,240,565,961.000	55,941,016,000	153,822,254,000
Operational Cost	62,173,576,778.000	49,885,508,000	41,062,430,872.000	8,931,910,000	149,108,000,000

The average cash flow of approximately 23.77 billion Naira, with a standard deviation of 19.36 billion Naira, indicates substantial variation in the financial health of the generating companies. This variability highlights fluctuations in the companies' ability to generate cash, which may be influenced by operational factors, market conditions, or external economic factors. The range of cash flow, from a minimum of 952.5 million Naira to a maximum of 68.61 billion Naira, underscores the significant differences in cash generation across the years. The mean and median values being fairly close suggest a relatively symmetrical distribution of cash flow.

Revenue for power generation companies averages 86.47 billion Naira, with a standard deviation of 25.24 billion Naira, indicating moderate fluctuations in revenue over the study period. The median revenue of 81.02 billion Naira, slightly lower than the mean, indicates a left-skewed distribution, where a few years of higher revenue are pulling the mean upward. The wide range from 55.94 billion Naira to 153.82 billion Naira indicates considerable variation in revenue generation across the years.

Operational costs, which average approximately 62.17 billion Naira, with a standard deviation of 41.06 billion Naira, reflect the varying expenses faced by generating companies. The range of operational costs, from 8.93 billion Naira to 149.11 billion Naira, demonstrates significant variation in the operational efficiency and cost management of the companies. The higher median value (49.89 billion Naira) compared to the mean suggests that the distribution is slightly left-skewed, with a few instances of extremely high operational costs influencing the average.

3.2. Trend analysis

The **Figure 1** illustrate the trends in Capital Cost, Cash Flow, Operational Cost, and Revenue for three companies: Mainstream Energy Solutions Limited, Egbin Power PLC, and Transcorp Power Limited from 2017 to 2022. These trends provide valuable insights into their financial performance and operational dynamics over the years.

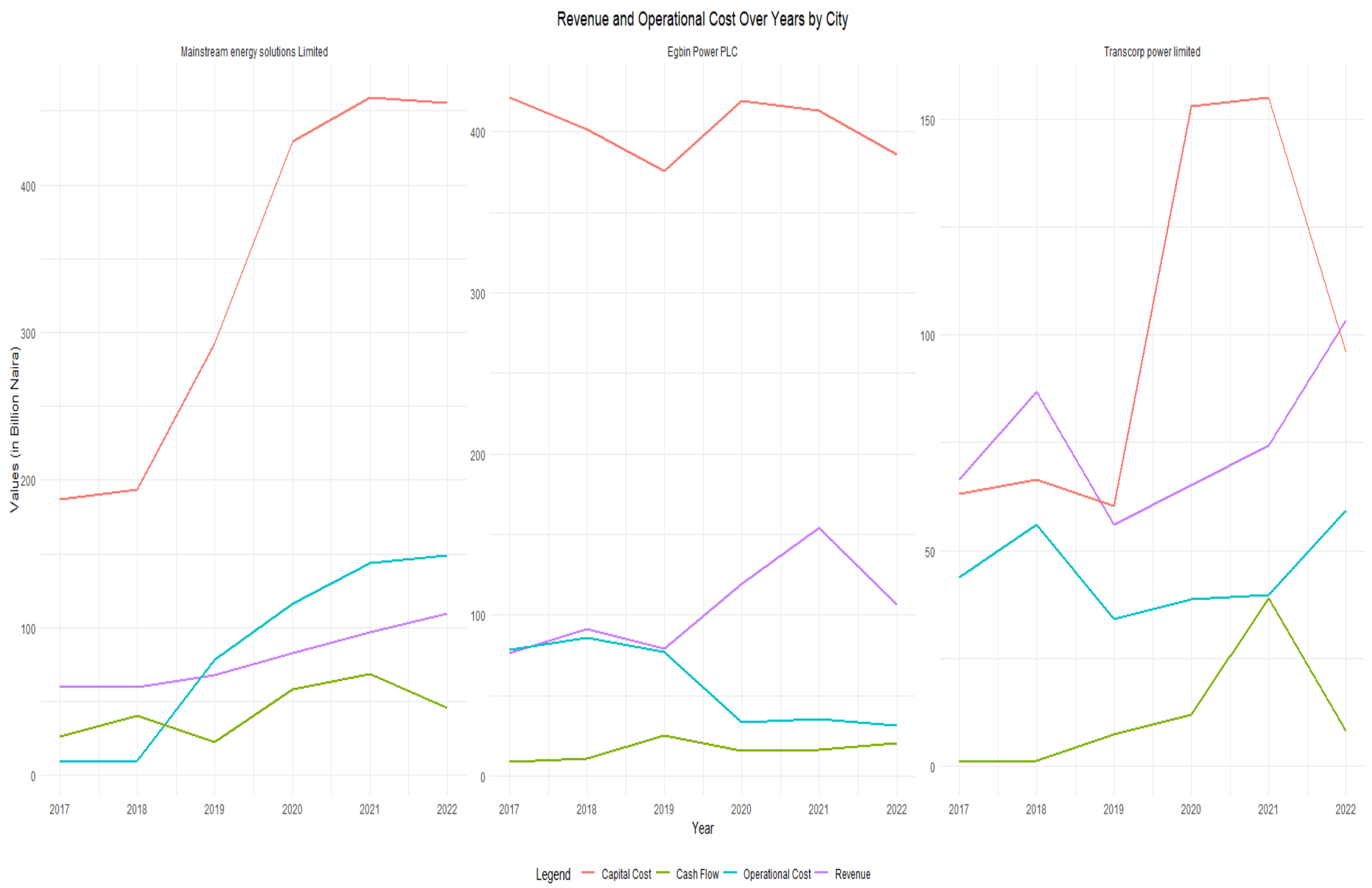

Figure 1. Trend plots for Power generation companies.

3.2.1. Mainstream energy solutions limited

Mainstream Energy Solutions Limited has demonstrated a significant evolution in its financial metrics over the study period. Capital cost exhibited a steep increase between 2017 and 2019, likely reflecting substantial investments during this time. However, from 2019 onward, the capital cost stabilized at approximately 450 billion Naira, suggesting that the company completed major investments and shifted towards a maintenance phase. Cash flow, on the other hand, started at a relatively low level and remained stable with only slight increases observed from 2019 to 2022. This pattern indicates that while the company managed to generate revenue, its liquidity remained constrained. Operational costs showed a gradual upward trajectory throughout the period, with a particularly notable rise between 2019 and 2022, exceeding 100 billion Naira. This increase could be associated with the stabilization of capital investments and the accompanying rise in maintenance and operational activities. Despite these rising costs, revenue maintained a steady upward trend, reflecting consistent income growth likely driven by operational efficiency or market demand.

3.2.2. Egbin Power PLC

Egbin Power PLC exhibited fluctuating financial metrics, indicative of strategic shifts or external market influences. Capital cost experienced a sharp decline from 2017 to 2018, which may suggest the conclusion of major capital projects or reduced investment during this period. This was followed by a peak in 2020, potentially driven by renewed investment activities, and a gradual decrease thereafter. Cash flow remained low and relatively stable throughout the period, with minimal variations, implying limited improvement in liquidity or efficiency in converting revenue into cash. Operational costs increased steadily from 2017, reaching a plateau around 2020, indicating better control or efficiency in managing operational expenditures. Revenue showed a distinctive peak in 2021, which may correspond to strategic market moves or favorable economic conditions, but it slightly declined in 2022. The trend in revenue closely mirrored the fluctuations in operational costs, underscoring the interdependence of these variables.

3.2.3. Transcorp Power Limited

Transcorp Power Limited displayed dynamic changes in its financial performance during the study period. Capital cost sharply increased between 2019 and 2021, peaking at approximately 150 billion Naira. This growth suggests heavy investment in infrastructure or expansion during this period. However, a noticeable decline in capital cost was observed in 2022, possibly indicating a shift towards cost consolidation or a pause in major investments. Cash flow, initially stable, experienced a significant rise from 2020 onward, peaking in 2021 before stabilizing in 2022. This upward trend highlights improved liquidity, potentially driven by increased revenue or better financial management. Operational costs steadily rose over time, reflecting the growing expenses associated with expanded operations or inflationary pressures. Revenue, following a similar pattern, rose sharply between 2019 and 2021, stabilizing thereafter. The concurrent rise in operational costs and revenue suggests that while expenses increased, the company successfully leveraged these costs to generate proportionate income.

This analysis highlights the dynamic interplay of capital investment, operational expenses, and revenue generation across these energy companies. It offers a snapshot of their financial strategies and responses to market conditions from 2017 to 2022.

Overall, the revenue figures reflect the diversity in the financial outcomes of the generating companies, which may be influenced by variations in operational efficiency, scale of production, resource availability, and market dynamics. These insights are crucial for assessing the competitiveness and strategic positioning of these companies within Nigeria’s energy sector.

The correlation matrix for the financial variables of the generating companies reveals several important relationships between Capital Cost, Cash Flow, Revenue, and Operational Cost as shown in **Table 2** and **Figure 2**.

Table 2. Correlation matrix for generating companies.

Variable	Capital Cost	Cash Flow	Revenue	Operational Cost
Capital Cost	1.0000000	0.4987046	0.550798	0.5713060
Cash Flow	0.4987046	1.0000000	0.042433	0.5443319
Revenue	0.5507980	0.042433	1.000000	0.2041906
Operational Cost	0.5713060	0.5443319	0.204191	1.0000000

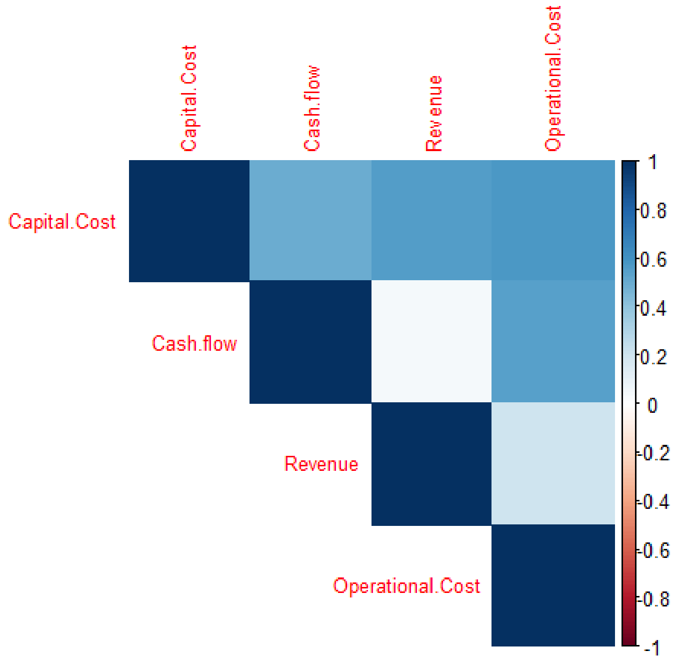

Figure 2. Correlation plot.

Firstly, the moderate positive correlation of 0.4987 between Capital Cost and Cash Flow indicates that as capital costs rise, cash flow tends to increase as well, although not in a perfectly linear fashion. This suggests that higher investments in capital might lead to improvements in financial liquidity, perhaps due to enhanced production capacity or operational efficiency that generates greater cash inflows.

Similarly, the 0.5508 correlation between Capital Cost and Revenue indicates a moderate positive relationship, which implies that capital investments are likely driving higher revenues. This could reflect the role of capital expenditures in expanding production capabilities or improving operational infrastructure, which, in turn, boosts the company's revenue-generating potential.

Another notable correlation is between Capital Cost and Operational Cost, with a value of 0.5713. This moderate positive relationship implies that increasing capital investments are often accompanied by higher operational expenses. This might be due to the need for additional resources or more complex systems to operate at the larger scale that capital expenditures often support.

The correlation between Cash Flow and Revenue is relatively weak, at 0.0424. This suggests that changes in revenue do not have a significant impact on cash flow for these generating companies. While one might expect cash flow to increase with rising revenues, this weak correlation indicates that other factors, such as cost management or capital expenditures, may play a more substantial role in determining cash flow.

On the other hand, the correlation of 0.5443 between Cash Flow and Operational Cost suggests a moderate positive relationship. This indicates that as operational costs rise, cash flow tends to increase as well. This could be due to the fact that higher operational expenditures may lead to increased production, which boosts revenue and, ultimately, cash flow.

Finally, the correlation between Revenue and Operational Cost, which stands at 0.2042, is relatively weak. This indicates that although there is some positive relationship between operational costs and revenue, it is not particularly strong. It suggests that while operational costs can influence revenue, other factors likely have a more significant impact on revenue generation.

In conclusion, the analysis highlights that Capital Cost is the most influential variable in terms of its relationships with other variables, particularly with Revenue, Operational Cost, and Cash Flow. The moderate to strong correlations suggest that capital investments are driving significant aspects of company performance. However, the weak relationship between Revenue and Cash Flow suggests that cash flow is influenced by more than just revenue, with operational efficiency and capital expenditures likely playing key roles.

Table 3 provides a summary of the average financial metrics for three power generation companies: Mainstream Energy Solutions Limited, Egbin Power PLC, and Transcorp Power Limited. These metrics include average capital cost, average revenue, average cash flow, and average operational cost, highlighting the financial performance and resource utilization of each company.

Table 3. Average financial metrics of power generation companies.

City	Avg_Capital_Cost	Avg_Revenue	Avg_Cash_Flow	Avg_Operational_Cost
Mainstream Energy Solutions Ltd.	336,319,166,667	79,543,969,833	43,492,747,000	84,247,069,000
Egbin Power PLC	402,858,500,000	104,550,432,167	16,345,965,667	56,997,628,667
Transcorp Power Limited	98,955,101,333	75,308,118,333	11,463,547,333	45,276,032,667

Mainstream Energy Solutions Limited reported an average capital cost of ₦336.32 billion, alongside an average revenue of ₦79.54 billion. Despite its substantial capital investments, the company achieved an average cash flow of ₦43.49 billion, which suggests a moderate efficiency in converting capital into liquid assets. Furthermore, the operational costs averaged ₦84.25 billion, which exceeds the company's revenue, indicating potential challenges in covering expenses through revenue generation alone.

Egbin Power PLC had the highest average capital cost at ₦402.86 billion, reflecting significant investment in infrastructure and operations. The company also led in average revenue generation at ₦104.55 billion, supported by an average cash flow of ₦16.35 billion. However, its operational cost of ₦56.99 billion, while relatively lower than the revenue, suggests that operational expenses are carefully managed to maintain financial stability.

Transcorp Power Limited demonstrated the lowest average capital cost among the three companies at ₦98.96 billion. Despite this, its average revenue of ₦75.31 billion was comparable to that of Mainstream Energy Solutions. The company also achieved an average cash flow of ₦11.46 billion and maintained the lowest operational cost at ₦45.28 billion. These figures imply that Transcorp Power Limited operates with a more cost-efficient model compared to the other companies.

3.3. Modelling

3.3.1. Regression analysis

Table 4. Regression analysis for Capital Cost vs. Revenue (generating companies).

Component	Estimate	Std. Error	*t* value	Pr (> |*t*|)
Intercept	-1.03×10^{10}	1.14×10^{11}	−0.09	0.9295
Revenue	3.35	1.27	2.64	0.0178*

Note: * implies 5% significance level.

Table 5. Model summary.

Metric	Value
Residual Standard Error	1.321×10^{11}
Multiple *R*-squared	0.3034
Adjusted *R*-squared	0.2598
F-statistic	6.968
p-value (*F*-statistic)	0.01784

The regression analysis in **Tables 4** and **5** conducted to assess the relationship between Capital Cost and Revenue for generating companies reveals some key insights. The coefficient for Revenue is 3.350, with a *p*-value of 0.0178, which is less than the commonly used significance level of 0.05. This indicates that there is a statistically significant positive relationship between Revenue and Capital Cost. In practical terms, for each unit increase in revenue, the capital cost is expected to increase by approximately 3.35 units. This suggests that revenue is an important driver of capital cost for these companies, meaning that as these companies generate more revenue, they are likely to incur higher capital costs.

The intercept of the regression model is -1.026×10^{10}, though it is not statistically significant (*p*-value = 0.9295). This means that when revenue is zero, the model predicts a very large negative capital cost, which is not a realistic or meaningful result in this context. Therefore, the intercept does not contribute substantially to understanding the relationship between Capital Cost and Revenue.

The *R*-squared value of 0.3034 indicates that approximately 30.34% of the variation in capital costs is explained by changes in revenue. This is a moderate explanatory power, suggesting that while revenue has a significant impact on capital costs, other factors not included in the model also contribute to the variation in capital costs. The Adjusted *R*-squared value of 0.2598 suggests that after accounting for the number of predictors, the model still provides a reasonable explanation of the capital cost variation.

The *F*-statistic value of 6.968 with a *p*-value of 0.01784 indicates that the model as a whole is statistically significant, meaning that the relationship between Revenue and Capital Cost is not due to random chance.

In conclusion, the regression results demonstrate that revenue plays a significant role in determining capital costs for generating companies, but other factors also influence capital costs, as indicated by the moderate *R*-squared value. Further investigation into additional factors affecting capital costs may provide a more comprehensive understanding of the financial dynamics within these companies.

Table 6. Linear regression analysis of Capital Cost with Revenue, Operational Cost, and Cash Flow (generating companies).

Call	**lm (formula = CapitalCost ~ Revenue + OperationalCost + CashFlow, data = data)**
Residuals:	
Min	-1.901×10^{11}
1Q	-5.723×10^{10}
Median	4.574×10^{8}
3Q	8.120×10^{10}
Max	1.891×10^{11}

Table 7. Coefficient.

Coefficients	**Estimate**	**Std. Error**	***t* value**	**Pr (> |*t*|)**
(Intercept)	-1.00×10^{11}	9.79×10^{10}	−1.024	0.323
Revenue	2.89	1.07	2.716	0.0167*
Operational Cost	1.14	7.80×10^{-1}	1.457	0.1673
Cash Flow	2.48	1.62	1.533	0.1476

Note: * implies 5% significance level.

Table 8. Model statistics.

Statistic	**Value**
Residual standard error	1.081×10^{11}
Multiple R-squared	0.5916
Adjusted R-squared	0.5041
F-statistic	6.76
p-value (F-statistic)	0.004769

The intercept term of the model is -1.003×10^{11}, which is not statistically significant (p-value = 0.3230), indicating that the capital cost would not be significantly different from zero when revenue, operational cost, and cash flow are all zero, though this is not a realistic scenario as seen in **Tables 6** and **7**. The residual standard error of 1.081×10^{11} suggests the typical deviation between the observed and predicted values of capital cost, providing a measure of the model's prediction accuracy.

Among the independent variables, revenue is the only one with a statistically significant relationship with capital cost, with a coefficient of 2.892 (p-value = 0.0167), suggesting that a 1 Naira increase in revenue is associated with a 2.892 Naira increase in capital cost, holding other factors constant as seen in **Table 7**. This indicates that higher revenues are positively correlated with higher capital costs. On the other hand, operational cost and cash flow do not have statistically significant relationships with capital cost, as their p-values are 0.1673 and 0.1476, respectively, which are both above the common significance threshold of 0.05.

The regression analysis in **Table 8** examines the relationship between capital cost and three key independent variables: revenue, operational cost, and cash flow. The overall model is statistically significant, with an F-statistic of 6.76 (p-value = 0.004769), indicating that the independent variables collectively explain a significant portion of the variation in capital cost. The multiple R-squared value of 0.5916 suggests that approximately 59.16% of the variance in capital cost can be explained by revenue, operational cost, and cash flow combined. The adjusted R-squared value of 0.5041 indicates that after accounting for the number of predictors in the model, the explanatory power of the model remains strong.

Overall, the regression results indicate that revenue plays a significant role in predicting capital costs, while operational cost and cash flow do not significantly influence capital costs in the given dataset.

3.3.2. Sensitivity analysis

The sensitivity analysis is a critical component of this study, as it helps to examine how the changes in key financial variables impact Capital Cost. By holding certain variables constant and varying others, this analysis aims to provide a clearer understanding of the relationships between Capital Cost and other factors such as Revenue, Operational Cost, and Cash Flow. This approach allows for a detailed exploration of how each factor independently influences capital expenditures, providing valuable insights into the financial dynamics within the power generation and distribution sectors.

In this analysis, the variables of interest Revenue, Operational Cost, and Cash Flow are isolated to determine their individual effect on Capital Cost. The results of the sensitivity analysis will be visualized through graphs that show predicted Capital Cost in relation to each independent variable, with all other factors held constant at their mean values. This method enables the identification of the strength and direction of each relationship, helping to quantify how changes in these factors could influence Capital Cost decisions in the companies under study.

Ultimately, the findings of the sensitivity analysis offer a more nuanced understanding of the financial strategies employed by these companies and serve as a foundation for making informed decisions about capital investment and financial planning in the energy sector.

Sensitivity analysis: Capital Cost vs. Revenue

In this section, the relationship between Capital Cost and Revenue is examined. The analysis holds Operational Cost and Cash Flow constant at their mean values while varying Revenue. The resulting graph demonstrates a positive slope, indicating that as Revenue increases, Capital Cost also increases. This suggests a direct relationship between Capital Cost and Revenue, where higher revenues lead to higher investments in capital. This could reflect a business strategy where increased revenue enables more significant capital expenditures, possibly for expansion or reinvestment in infrastructure. This is shown in **Figure 3**.

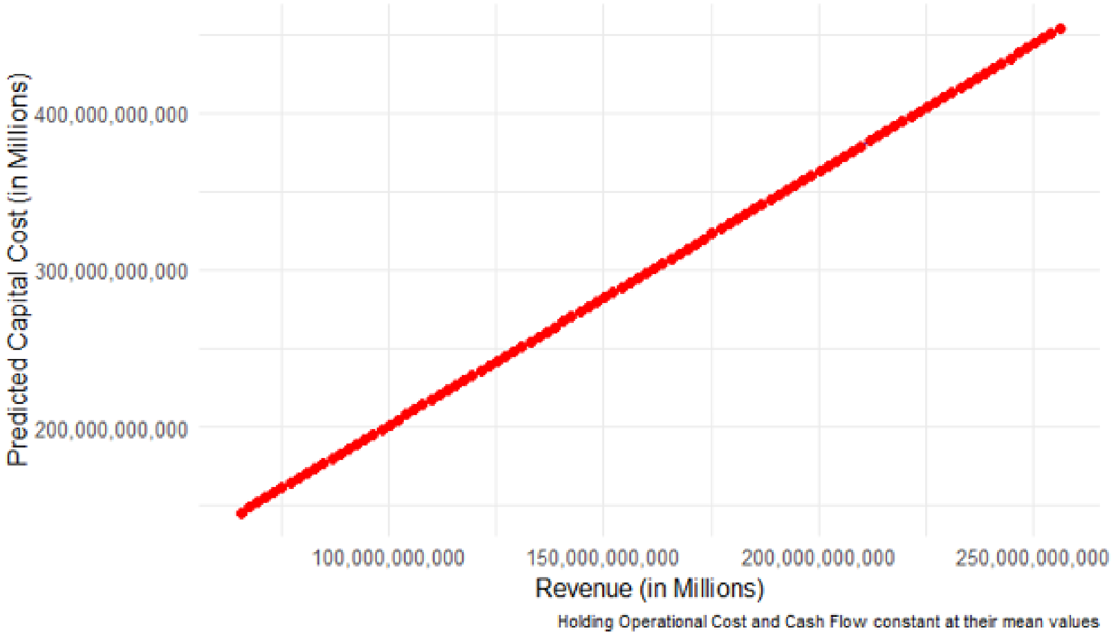

Figure 3. Sensitivity plot of capital cost to revenue.

Sensitivity analysis: Capital Cost vs. Operational Cost

The second part of the sensitivity analysis investigates the effect of Operational Cost on Capital Cost. Here, Revenue and Cash Flow are held constant at their mean values, while Operational Cost is varied. The analysis reveals a negative slope, indicating that as Operational Cost increases, Capital Cost tends to decrease. This inverse relationship could imply that companies might manage operational efficiencies to offset higher operational expenses, potentially leading to reduced capital investments. This could reflect a strategy of controlling operational costs in order to prioritize more sustainable or strategic capital expenditures. This is shown in **Figure 4**.

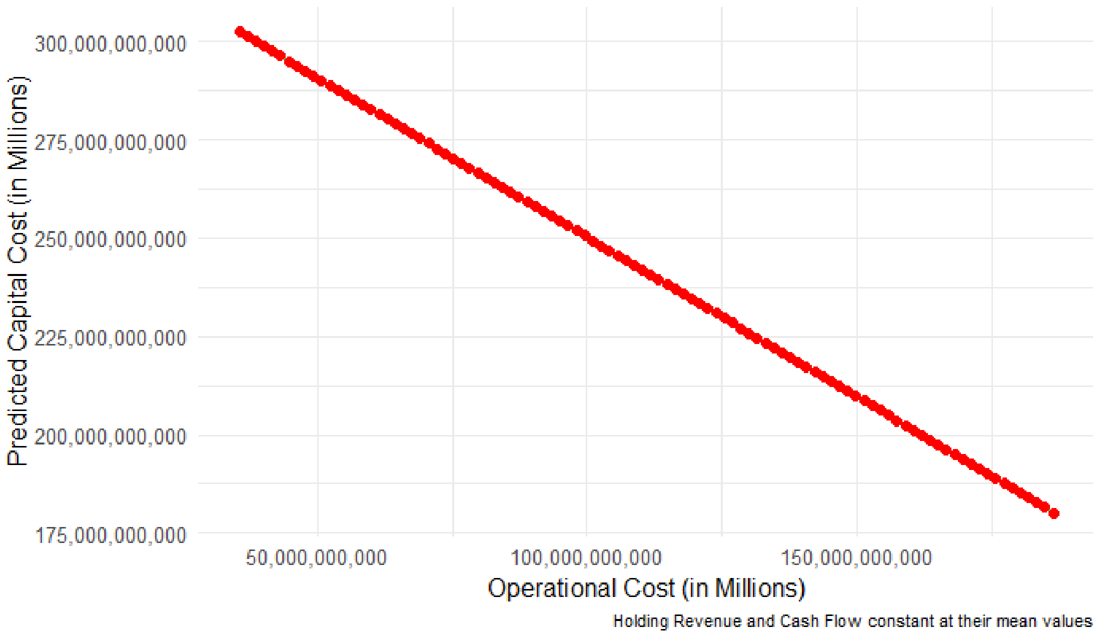

Figure 4. Sensitivity plot of capital cost to operational cost.

Sensitivity analysis: Capital Cost vs. Cash Flow

In the final section, Cash Flow is analyzed in relation to Capital Cost, with Revenue and Operational Cost held constant at their mean values. **Figure 5** produced in this analysis shows a positive slope, indicating that as Cash Flow increases, Capital Cost also increases. This suggests that companies with higher cash flow may have more flexibility and available funds to invest in capital projects, possibly for growth or upgrades to infrastructure. This positive correlation highlights the importance of strong cash flow in supporting capital expenditure decisions.

Figure 5. Sensitivity plot of capital cost to cash flow.

In conclusion, by analyzing these three distinct relationships, the sensitivity analysis provides valuable insights into how changes in key financial factors impact Capital Cost. Understanding these dynamics can help decision-makers in the energy sector make more informed decisions regarding capital investment, financial planning, and resource allocation.

3.3.3. Data Envelopment Analysis (DEA) results

The DEA was applied to a dataset from electricity generation companies, assessing their operational efficiency based on specified inputs and outputs. Efficiency scores were calculated to determine how effectively each firm utilized its resources relative to others in the sample. Firms achieving an efficiency score of 1.0 are considered fully efficient, operating on the efficiency frontier. Those scoring below 1.0 are deemed inefficient, indicating potential for operational optimization.

This section presents a detailed interpretation of the efficiency scores, efficiency ranges, and key takeaways from the DEA results.

The Data Envelopment Analysis (DEA) conducted in **Tables 9–11** using the Variable Returns to Scale (VRS) technology and input-oriented approach reveals insights into the efficiency of 18 firms. Three firms, representing 22.2% of the sample, achieved an efficiency score of 1.0, indicating that they are fully efficient. These firms operate on the efficiency frontier, signifying optimal utilization of inputs to produce outputs. Conversely, the remaining 14 firms (77.8%) exhibit inefficiencies, with scores below 1.0, highlighting areas for improvement in their operations.

Table 9. Efficiency scores of firms.

Firm	Efficiency Score
1	0.7577
2	0.5628
3	1.0000
4	0.8376
5	0.6832
6	0.6446
7	0.6470
8	0.5793
9	0.8512
10	0.6807
11	0.5410
12	0.5432
13	1.0000
14	1.0000
15	1.0000
16	0.6154
17	0.5966
18	0.5631

Table 10. Efficiency summary.

Efficiency Range	Number of Firms	Percentage (%)
$0.5 \leq E < 0.6$	6	33.3
$0.6 \leq E < 0.7$	5	27.8
$0.7 \leq E < 0.8$	1	5.6
$0.8 \leq E < 0.9$	2	11.1
$0.9 \leq E < 1.0$	0	0.0
$E = 1.0$	4	22.2

Table 11. Efficiency statistics.

Metric	Value
Minimum	0.5410
1st Quartile	0.5836
Median	0.6639
Mean	0.7280
3rd Quartile	0.8478
Maximum	1.0000

The efficiency scores range from 0.5410 to 1.0000, with an average score of 0.728. This suggests that, on average, firms are utilizing 72.8% of their potential efficiency, leaving room for a 27.2% improvement in input-output management. A significant proportion of firms (33.3%) fall into the lowest efficiency range of $0.5 \leq E < 0.6$, indicating critical inefficiencies in their operations. Additionally, 27.8% of firms scored within the $0.6 \leq E < 0.7$ range, while only 5.6% reached $0.7 \leq E < 0.8$, and 11.1% achieved $0.8 \leq E < 0.9$. Notably, no firms scored between $0.9 \leq E < 1.0$, emphasizing a considerable gap between the fully efficient firms and the rest.

The efficient firms with a score of 1.0 serve as benchmarks for the inefficient ones. By analyzing the practices of these top performers, inefficient firms can identify specific areas for improvement. For firms in the lowest efficiency range, efforts should focus on optimizing resource allocation, reducing operational costs, or enhancing output levels. Moderately efficient firms can benefit from targeted interventions, such as process improvements or adopting best practices from the benchmark firms.

Overall, the DEA results underscore a moderate level of efficiency across the firms, with significant opportunities for performance enhancement as shown in **Figure 6**. The findings suggest that systemic improvements are needed to address inefficiencies, particularly among the least efficient firms. By leveraging the insights from this analysis, managers can implement strategies to enhance operational efficiency, aligning their practices with those of the most efficient firms. These improvements can contribute to better resource utilization, increased productivity, and overall organizational performance.

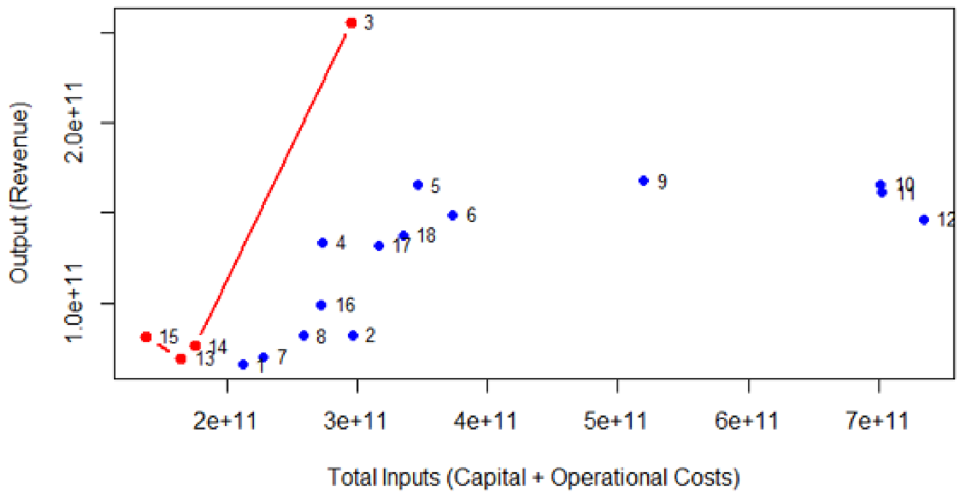

Figure 6. DEA for the generation companies.

3.4. Discussion of results

The analysis conducted in this study aims to provide insights into the relationship between various financial metrics such as revenue, operational costs, cash flow, and capital costs in the context of inventory management for power generation and distribution companies in Nigeria. The following key findings emerge from the statistical models and analyses performed:

The regression analysis reveals a positive relationship between revenue and capital costs. Specifically, the findings indicate that for every unit increase in revenue, capital costs tend to increase as well, with an estimated coefficient of 1.577. This suggests that companies in the Nigerian power sector are likely to incur higher capital expenditures when their revenue increases. While this relationship is statistically significant, with a *p*-value of 0.0551, it falls just outside the traditional threshold of 0.05, suggesting that the relationship is weakly significant.

The implication of this finding is that as power generation and distribution companies experience revenue growth, they are often required to increase their investment in infrastructure, equipment, and other capital expenses. This could be due to the need to expand operations or improve services to meet growing demand. However, since the relationship is only weakly significant, it implies that other factors may also play a significant role in determining capital costs, and revenue alone may not be sufficient to drive substantial changes in capital expenditures.

The relationship between operational costs and capital costs is less straightforward. The regression results show a weak negative relationship between operational costs and capital costs, with an estimated coefficient of −0.8113. This suggests that as operational costs rise, capital costs may decrease slightly. However, this relationship is not statistically significant, with a *p*-value of 0.5541, indicating that operational costs do not have a strong or meaningful impact on capital costs in the dataset used in this study.

This finding may imply that the companies in the study tend to keep capital expenditures stable, even when faced with higher operational costs. It could be that companies prioritize managing their operational costs more effectively or that they do not significantly alter their capital investments in response to fluctuations in day-to-day expenses. This insight points to the importance of differentiating between operational and capital expenditures in financial decision-making, as their relationship may not always be linear or predictable.

The analysis also highlights a positive and statistically significant relationship between cash flow and capital costs. The estimated coefficient for cash flow is 11.78, with a *p*-value of 0.0385, which indicates a strong and significant effect on capital costs. This suggests that as cash flow increases, companies in the power sector tend to invest more in capital projects and infrastructure.

This finding aligns with the expectation that companies with higher cash flow are better positioned to allocate funds towards capital expenditures. Healthy cash flow allows for the financing of large-scale infrastructure projects, technology upgrades, and other capital investments that can help to improve efficiency and expand operations. The positive relationship observed in the study underscores the importance of cash flow management in determining a company's ability to invest in long-term assets, which in turn impacts its profitability and growth prospects.

The sensitivity analysis provides further insights into the relationships between the variables and capital costs. In particular, the results show a positive slope for the predicted capital cost against revenue, with all other variables held constant at their mean. This reinforces the positive relationship observed in the regression analysis, suggesting that as revenue increases, capital costs are expected to rise. This finding supports the notion that revenue growth often leads to increased investments in infrastructure and expansion.

The application of Data Envelopment Analysis (DEA) provided valuable insights into the relative efficiency of different power generation and distribution companies. The DEA scores identified several companies that were operating efficiently in terms of capital utilization, revenue generation, and operational cost management. Conversely, some companies were found to be inefficient, indicating that there is room for improvement in their inventory management and overall operational strategies.

4. Conclusion

The primary aim of this study was to analyze the impact of inventory management practices on the profitability of energy companies in Nigeria, specifically within the power generation and distribution sector. The results of the study provide significant insights into how various financial and operational factors, such as capital costs, cash flow, revenue, and operational costs, influence inventory management practices and overall profitability in the sector.

One of the key findings from the regression analysis is the positive relationship between capital cost and revenue. This indicates that, as revenue increases, capital expenditures tend to increase as well, suggesting that companies often reinvest their profits into expanding their infrastructure, thus increasing their capital costs. The positive relationship is crucial, as it suggests that an increase in financial returns could be used strategically for long-term growth and investments in infrastructure.

Conversely, the relationship between capital cost and operational cost was found to be negative. This implies that energy companies that incur higher operational costs may see diminishing returns in terms of capital expenditures, highlighting the importance of controlling operational expenses.

The analysis indicated that companies in the Nigerian energy sector are under significant pressure to manage costs effectively in order to remain profitable. Given the volatility of energy prices, fluctuations in demand, and regulatory changes, controlling costs is essential for sustaining operations and protecting margins.

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Abbreviations

VMI	Vendor-managed inventory
ROA	Return on Assets
FMECA	Failure Mode, Effects and Criticality Analysis
PHCN	Power Holding Company of Nigeria
OCGT	Open Cycle Gas Turbine
NSSO	National Sample Survey Office

NESI	Nigerian Electricity Supply Industry
MYTO	Multi-year Tariff Order
EOQs	Economic Order Quantities

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