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Identification of Key Drivers for Municipal Utility Performance

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This report explores the various performance indicators for municipal electric utilities and the greatest impact financial investments can make for improving these indicators. A literature search provided key detail about performing an analysis that would prove useful to utilities. The analysis identifies key performance indicators that allowed for the most prudent of investments. Data mining techniques and statistical analyses were performed on data sets concerning the 51 North Carolina municipal electric utilities to identify several key ratios and performance indicators that have the greatest impact on cost of service, system reliability, and customer satisfaction. Statistical analyses were used to determine which investments optimized these outcomes. No other studies on the statistical significance of municipal electric utility performance indicators were identified in our literature search.

1 Introduction

Performance indicator data provides a useful measure of the municipality's financial health over a period of time.[i] A study using statistical modeling to identify performance indicators for municipal electric utilities to make prudent financial investments, as described in this paper, has never before been performed. Regardless of size or customer demand, each municipality aims to meet its revenue requirements, decrease its operating expenditures per fiscal year, and maintain a high level of service to its customers, among other objectives.[ii] However, conclusions to this analysis identify the highest value variables to a municipality's operating expenditures, margins, and overall financial health. This report examines the relationships between the variables that have the greatest impact on key areas of municipal electric utility performance.

2 Literature Review

De, Bandyopadhyay, and Chakraborty's (2011)[iii] investigation presented in the *Journal of Business Studies Quarterly* provided a factor analysis on financial ratios was performed based on the results of a cluster analysis of the Indian cement industry. Initially, 44 variables were grouped into seven categories and selected as possible financial ratios of interest. After the exclusion of low correlation variables, the study conducted a factor analysis, identifying eight key variables to the Indian cement industry. The paper is useful to our analysis for many reasons. The analytical process used by De, et. al. is useful because of the selection of homogeneous companies (or municipalities, in our case), a m ethod which we replicated in our analysis. Additionally, the study recognizes the various aspects of the financial position of each company. This aspect is crucial in understanding and analyzing the municipalities, as they each vary vastly in size, demand, and revenue requirements. Lastly, the study outlines its procedure in determining which financial ratios it deems prudent to the cement industry's investments, which is most important for our study. This selection process was helpful in outlining which financial ratios are important to the municipals.

In *Municipal Benchmarks: Assessing Local Performance and Establishing Community Standards*[iv], David Ammons discusses specific benchmarks that have been collected as prime examples of municipal-run electric services. These performance targets aided our process in defining variables that were key drivers as well as deciding which performance factors to look at in the first place.

Finally, *Applied Multivariate Statistical Analysis*[v] by Richard Johnson and Dean Wichern aided our search for accurate analyses to run with our specific set of data, and what to make of the results when processed. The correlation coefficients and methods of identifying outliers used in our study were drawn from this resource.

3 Objectives of the Study

The objective of this study is to aid municipal electric utilities in either confirming or modifying their financial investments to improve their cost of service, reliability and customer satisfaction using the analysis techniques described herein. These techniques allowed us to select key ratios and performance indicators that made the most impact on the investments of a utility. It is necessary to understand the local economic considerations, financial health, and demographics of each municipality to better understand what kind of prudent investments will benefit it most.

4 Theoretical Analysis

To provide numerical confirmation of specific variables that may be key indicators of financial health, spreadsheet analysis techniques were used to analyze data found from all sources. Municipal electric utility members of ElectriCities of North Carolina, Inc. are required to respond to data requests of governmental organizations, and the North Carolina Department of State Treasurer prepares state-mandated and regulated financial documents each year to remain transparent to constituents and stakeholders. These documents, called Comprehensive Annual Financial Reports

(CAFRs), provided line items detailing the spending, revenues, margins, and overall financial health of the municipality's various city-run services, like electric services, water, gas, cable, sewage, etc.[vi] This study used the electric fund information, usually found in the enterprise portion of each city's CAFR, to conduct its spreadsheet analyses.

Fiscal year 2013 CAFRs were the source of over 80% of the municipal data. In the event that a city had combined water and power funds, or an enterprise fund that could not be separated from the electric fund, the municipality was left out of our study. Several replications of this study were performed to accurately identify the list of performance indicators and key ratios which significantly impact the optimization of capital investments. Municipalities from both North Carolina Municipal Power Agency Number 1 (PA1) and North Carolina Eastern Municipal Power Agency (EA) that provided sufficient financial detail in their respective CAFRs were used for the initial analyses. Added to these 51 cities were non-member North Carolina cities, such as Fayetteville, New River Light and Power, and Kings Mountain, that had accurate data for that fiscal year concerning profits and expenditures. Variables were calculated using the guidelines set by the APPA ratio report.[ii]

Another source of data that was used in this study was electric utility performance indicators. ElectriCities collects performance indicator data, which are calculated ratios, detailing the overall financial health, margins, and reliability of the utility.[vii] These ratios, calculated using utility-submitted data over the course of a year, serve as a benchmark against other municipal utilities' reliability performance and investment. Because the number of in-state reporting municipal electric utilities was limited, several out-of-state municipalities were included in this portion of the analysis, so long as they possessed accurate and complete data. This limitation is expected with smaller municipalities, and reinforces their need to put resources towards management. The out-of-state data set was drawn from APPA.[iii]

Our goal in using data mining methods to accumulate this information was to identify financial ratios that could be manipulated to help municipals find monies. Our broader aim is that these ratios will be applied for the improvement of the municipal system. This was primarily accomplished by obtaining a statistically significant pool of data and performing relevant analysis. In our data mining attempt, usable data was identified for all 51 North Carolina member cities serviced by ElectriCities. However, as the pool was widened to non-participants and out-of-state municipal electric utilities, the data became less available and unusable. For example, several performance indicators were calculated differently in the state of California, while some municipalities combined their electricity and water services, not allowing for us to separate their profits for our use. Some statistical analyses were deemed unusable or insufficient due to the smaller pool of data, thus requiring us to attempt widen the pool with accurate data. For example, ratios using miles of line were essentially not included for non-member cities due to data unavailability. Because of the limitations of the data caused by differentiating reporting methods, lack of reporting, and sheer unavailability, the reliability of our pool of data was limited to the accurate data provided by the 51 member cities in North Carolina.[iv]

We hoped to analyze the performance of customer service, system reliability, cost of service, safety, and overall financial health. However, due to a lack of available data, only cost of service, system reliability, and financial health could be studied. From the variables studied, customer service was deemed to be the most difficult to analyze. Smaller municipalities generally do not measure customer service, and there was no numerical measure of customer service from the municipalities that was readily available for this study. After selecting variables, procuring data for these variables proved to be a challenge. Not every municipality reported data, nor did they report data using the same parameters, so missing and or flawed data was frequently encountered during the data mining procedure. As stated earlier, only accurate and complete data were used in the data pool. Any inaccurate, incomplete or vague data was discarded from our analysis.

5 Variable Selection

Variables were selected from reliability ratios, performance indicators, and financial health indicators compiled by ElectriCities of North Carolina. Additionally, several variables were added from the APPA ratio report, to help account for ratios that are less likely to be calculated by the municipality in the CAFRs. By combining all these variables into one spreadsheet, a correlation matrix was constructed to determine which variables had the highest correlation with municipal performance. The following table was used to determine the validity of a variable.[v]

Possible Correlation Coefficients	
1	Perfect positive relationship
0	No relationship
0<x<1	Indicates positive correlation
-1>x>0	Indicates negative correlation
-1	Perfect negative (inverse) relationship
x>|.5|	Variable chosen as a strong key factor
x<|.5|	Variable thrown out as a weak key factor

Table 1

Possible Correlation Coefficients, as defined by Applied Multivariate Statistical Analysis

After choosing several variables from the initial correlation matrix, which only used data from member cities of ElectriCities of North Carolina, several other analyses were run to further identify key factors that could drive municipal utility investments. Variables with the highest correlation were graphed. In an attempt to identify nonlinear relationships, independent variables were graphed normally, squared, to the 0.5 power, and as a natural log. The identification of nonlinear relationships was deemed important as it would point to monotonic trends in the data as well as help us understand the relationships between variables better. From these graphs, the dependent variables were graphed regularly, and each graph contained a linear and exponential trendline. However, this graphing exercise suggested that that all relationships were primarily linear. Additionally, different performance indicators were compiled by developing normalized ratios. This new set of indicators tracked spending habits of municipalities per kWh sold and the OSHA (Occupational Safety and Health Administration) incidence rate of municipalities, and were added in order to further investigate variables that may enhance municipality performance. Using ratios in this manner helped to normalize the indicators over a range of sizes for municipal electric systems.

A regression analysis was performed, where the multiple R was analyzed to determine the significance of the correlation between the independent and dependent variable in each case. Correlations setting the normalized ratios against each other were run in order to go through the possibility of all variables, providing some insight into the variables that may most affect municipality performance. These aforementioned matrices were again correlated and were compiled using these variables to ensure that no additional variables were missed. A regression analysis was performed for each of the graphed variables. In this analysis, we were interested in the correlation of Net Income per Distribution Cost and Net Income per Power Supply Cost versus O&M per Retail Customer. The absolute value of the natural log and square root of both Net Income per Distribution Cost and Net Income per Power Supply Cost were plotted against O&M per Retail Customer. Distribution Cost is calculated as expenditures less power supply cost. Total revenue less power supply cost was thrown out due to data limitations. The most interesting graph format of the variables was the natural log of the independent variable versus the dependent variable, as it was an excellent way to see where cities stand in terms of financial health. Municipalities closer to the point at which ln(x) approaches infinity are effectively maximizing their return and net profit. However, those municipalities approaching 0 in Figure 3 should investigate their spending and investments.

6 Data Analysis

The first step in determining variables for financial health and investments was to accurately capture and calculate all of the possible variables that would be used in the analysis. Below is a summary of each variable included in the study[vi]:

1. *Residential Revenue/ kilo-watt hour*: Revenue from all residential customers per kWh sold
2. *Commercial Revenue/kWh*: Revenue from all commercial customers per kWh sold
3. *Industrial Revenue/kWh*: Revenue from all industrial customers per kWh sold
4. *Total Revenue/ kWh*: Revenue from all customers per kWh sold
5. *Debt to Total Assets*: Ratio of long-term debt, plus current and accrued liabilities, to total assets and debits
6. *Operating Ratio*: Ratio of electric operation and maintenance expenses to total electric operating revenues
7. *Current Ratio*: Ratio of total current and accrued assets to total current and accrued liabilities
8. *Net Income per Revenue Dollar*: Ratio of net electric utility income to total electric operating revenue
9. *Operating and Maintenance Expense per kWh sold (O&M/ kWh sold)*: Electricity utility operation and maintenance expenses, including cost of generated/ purchased power, to total kWh sold (resale/ultimate)
10. *Purchased Power Cost per kWh*: Ratio of total costs of power supply to total kWh purchased
11. *Distribution Costs of O&M per Retail Customer*: Total distribution operation expenses to customers
12. *Distribution Costs of O&M per Circuit Mile*: Ratio of total distribution operation expenses to total number of circuit miles of distribution line
13. *Administrative and General Expenses per Retail Customer*: Ratio of total electric utility administrative and general expenses to the total number of retail customers
14. *OSHA Incidence Rate*: Lost workday cases during year to total worker-hours of exposure/100 employees
15. *Energy Loss Percentage*: Ratio of total energy losses to total sources of energy
16. *System Load Factor*: Average load, total sales plus losses divided by 8760 hours, to system peak demand

Acquiring consistent and useable data proved to be a challenge due to limitations with the data sources. Since CAFRs vary from city to city, it was necessary to calculate A&G and O&M costs outside of the CAFRs, rather than find them as detailed line items on the budget. For example, one city may have had a line item for truck repairs, while another city did not. Additionally, outliers found in the variable graphs and data mining efforts provided exceedingly high correlation between variables that were least likely to be correlated with one another. However, when outliers were removed, correlations returned to their expected normal coefficients, and these unexpected correlations disappeared. For example, one electric worker in Benson fell and was injured for an extensive period of time, making Benson's OSHA incidence rate much greater than it normally would be. Due to this isolated incident, OSHA incidence rate initially had a greater relationship with other variables, but after further examination, it was determined that the variable was no longer significant with the exclusion of outliers.

Secondly, reliability indices were calculated. These indices were included in the study with the intent of helping municipal utilities identify areas in which to invest in their distribution system to improve reliability. Due to the unavailability of reliability data with smaller municipalities served by ElectriCities, out-of-state municipalities were included in order to obtain a statistically significant sample size. Three reliability indices were used, shown below[viii]:

SAIDI (System Average Interruption Duration Index): average outage duration for each customer served, measured in units of time (hours, minutes)

$$\text{SAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

SAIFI (System Average Interruption Frequency Index): average number of interruptions that a customer would experience

$$\text{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

CAIDI (Customer Average Interruption Duration Index): average outage duration that any given customer would experience (can also be average restoration time of power)

$$\text{CAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customer interruptions}}$$

Overall size played a role in the level of technology deployed in the various municipal systems. It was determined that there must be some way to identify the quality, or rating, of the city's system. To address this issue, a municipality's technology level was devised, based on the availability of three technologies for a municipality. A level 1 municipality is characteristic of one with 200-2,500 customers with a considerable amount of outage minutes. Usually, outages last anywhere from 60-210 minutes. However, with level 1 municipalities, outage times are usually over 150 minutes due to the smaller staff and fewer resources. Furthermore, a level 4 municipality usually has over 20,000 customers, and frequent outages, but with short durations. SCADA, or Supervisory Control and Data Acquisition, allows utilities to monitor systems remotely. Some SCADA systems allow the opportunity to open/close breakers and control other devices on their distribution system. GIS, or Geographical Information System, maps the utility equipment and uses a database similar to Google Maps to display the equipment. Mapped equipment includes poles, transformers, meters, etc. GIS serves as an asset management tool, considerably reducing field work necessary due to the viewing capabilities on the mapped display. AMI, or Advanced Metering Infrastructure, allows meters to be read remotely using a communication network between the municipal electric utility and meter, avoiding the need to send an electric worker to a site to read or disconnect a meter. Lastly, OMS, or Outage Management System, utilizes AMI and notifies the utility if a customer has lost power, avoiding the need for a customer to call in an outage.[ix] Advanced AMI systems can also locate a crew nearest to the outage and predict where the outage stems based on the locations of other customers without power. A detailed technology requirement per level is provided in Table 2.

Technology Level	Description
Level 1	No SCADA
Level 2	SCADA only
Level 3	SCADA and GIS
Level 4	SCADA, GIS, OMS (or AMI only)

Table 2

Summary of available technologies per level, as determined by ElectriCities of North Caronlina, Inc.

The technology level helped differentiate the municipalities, but did not entirely solve the issue of missing data. However, the data indicated that smaller cities seemed to only be able to maintain distribution, and had minimal funds to make improvements. The issue of improving a system with continual outages is one these cities encounter and are aware of, but they simply cannot provide capital for the investment.

After identifying the possible variables to use in the study, the next step of the process was to construct correlation matrices in order to identify potential relationships between the variables. Using the correlation matrix, it was identified that *(System) Load Factor vs.* $\frac{O\&M}{kWh\ sold}$ and $\frac{Debt}{Total\ Assets}$ *vs.* $\frac{Purchased\ Power\ Cost}{kWh}$ had strong correlation coefficients. While relationships between other variables in Figure 1 had higher correlations, such relationships appeared to be intuitively obvious and lacked value in terms of providing a utility with useful information about investments or actions that could improve operating results. Figures 2 and 3 show the respective graphs for the analysis of the independent variables identified in the correlation matrix. These variables were plotted using square root and natural log of the dependent variable. Outliers were identified and discarded from further data analysis if the data behind the outliers was questionable. Additionally, regression analyses were performed on the variable pars, and the multiple R was calculated using Excel regression statistics. The largest multiple R calculated was $\ln(Load\ Factor)$ *vs.* $\frac{O\&M}{kWh\ sold}$. The variable of Load Factor appears to have the greatest impact on operational costs as a result of the correlation matrix. Tables 3 and 4 show the regression statistics of each variable analyzed. Data from the correlation matrx still supports the statement that smaller cities do not have the means to make improvements.

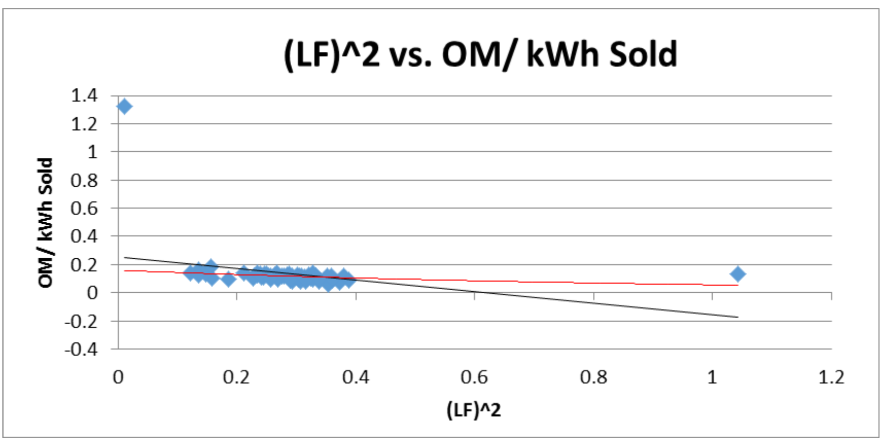

Figure 1

Manipulated Load Factor vs. OM/kWh Sold

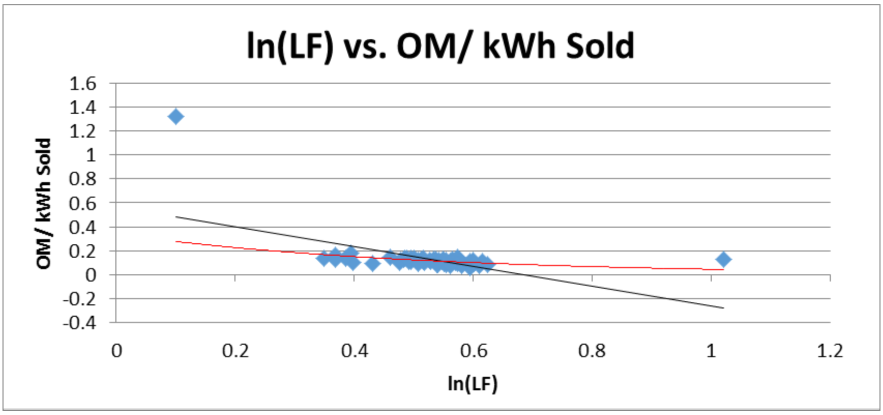

Figure 2
Manipulated Load Factor vs. OM/kWh Sold

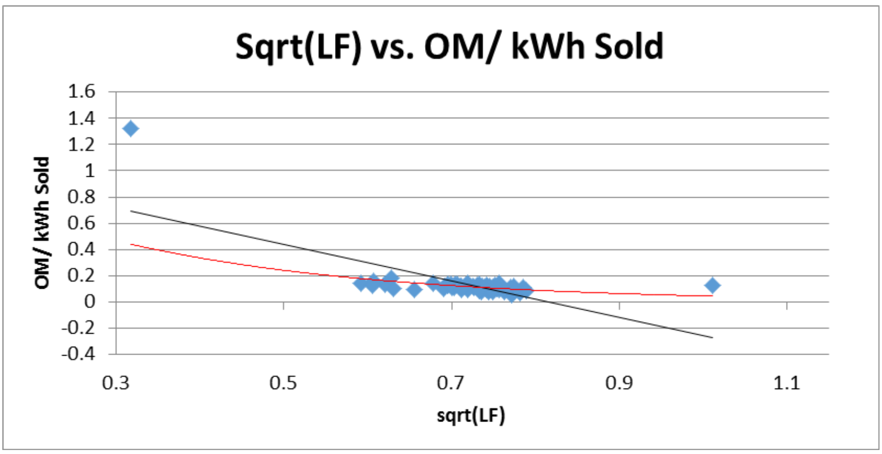

Figure 3
Manipulated Load Factor vs. OM/kWh Sold

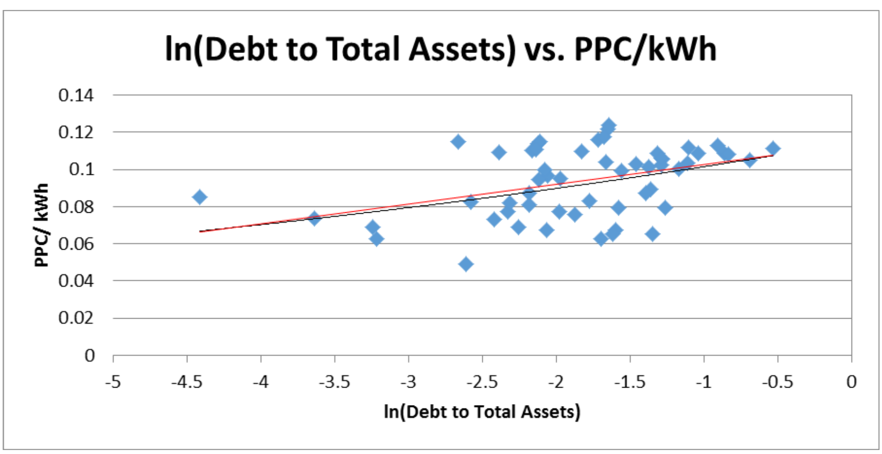

Figure 4
Manipulated Debt to Total Assets Ratio vs. PPC/ kWh

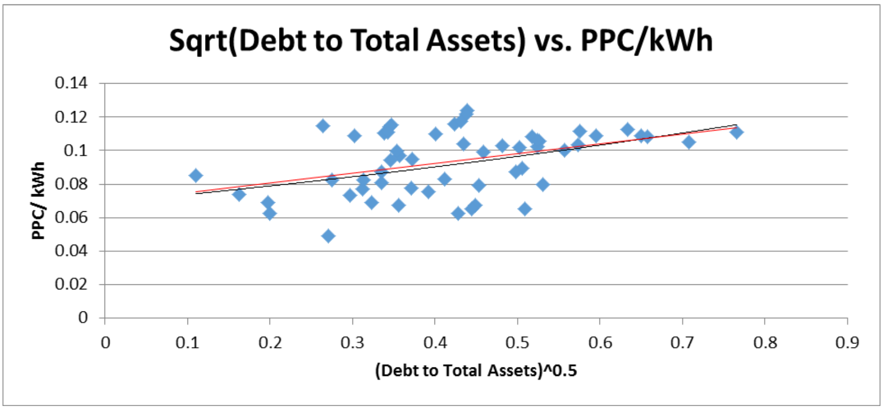

Figure 5

Manipulated Debt to Total Assets Ratio vs. PPC/ kWh

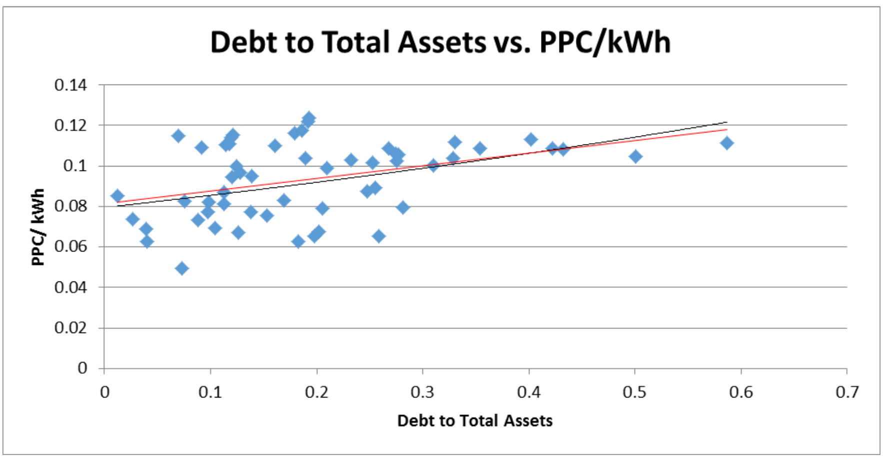

Figure 6

Manipulated Debt to Total Assets Ratio vs. PPC/ kWh

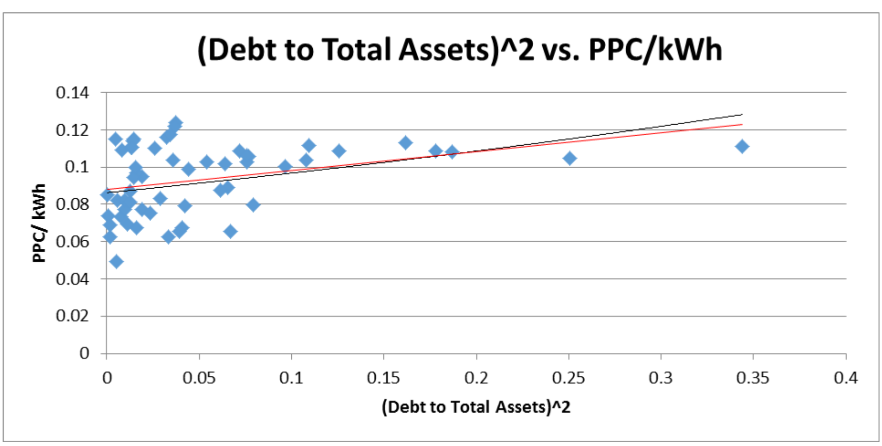

Figure 7

Manipulated Debt to Total Assets Ratio vs. PPC/ kWh

Regression of SLF vs. OM/ kWh sold	
Regression Statistics	
Multiple R	0.5540
R Square	0.3069
Adjusted R Square	0.2940
Standard Error	0.1368
Observations	56
Regression of (SLF)^2 vs. OM/ kWh sold	
Regression Statistics	
Multiple R	0.3183
R Square	0.1013
Adjusted R Square	0.0847
Standard Error	0.1558
Observations	56
Regression of (SLF)^0.5 vs. OM/ kWh sold	
Regression Statistics	
Multiple R	0.6968
R Square	0.4855
Adjusted R Square	0.4760
Standard Error	0.1179
Observations	56
Regression of ln(SLF) vs. OM/ kWh sold	
Regression Statistics	
Multiple R	0.8269
R Square	0.6837
Adjusted R Square	0.6779
Standard Error	0.0924
Observations	56

Table 3

Summary of regression statistics from the System Load Factor vs. OM/kWh Sold

Regression of PPC vs. D2A	
Regression Statistics	
Multiple R	0.4061
R Square	0.1649
Adjusted R Square	0.1495
Standard Error	0.0171
Observations	56
Regression of PPC vs. (D2A)^2	
Regression Statistics	
Multiple R	0.3542
R Square	0.1255
Adjusted R Square	0.1093
Standard Error	0.0175
Observations	56
Regression of PPC vs. sqrt(D2A)	
Regression Statistics	
Multiple R	0.42299
R Square	0.17892
Adjusted R Square	0.16371
Standard Error	0.01695
Observations	56
Regression of PPC vs. ln(D2A)	
Regression Statistics	
Multiple R	0.41362
R Square	0.17108
Adjusted R Square	0.15573
Standard Error	0.01703
Observations	56

Table 4

Summary of regression statistics from the purchased power cost/kWh sold vs. debt to total assets

The multiple R was calculated using Excel regression statistics. The largest multiple R calculated was for $\sqrt{\frac{\text{Debt}}{\text{Total Assets}}}$ vs. $\frac{\text{Purchased Power Cost}}{\text{kWh}}$, and this appears to be a linear relationship. We can also conclude from this analysis that Debt to Total Assets is one of the variables that has the greatest impact on operational costs.

A second correlation matrix was compiled using additional variables. The highest non-trivial correlations identified in the second correlation matrix were $\sqrt{\frac{\text{Net Income}}{\text{Power Supply Cost}}}$ vs. $\frac{\text{O\&M}}{\text{customer}}$, $\sqrt{\frac{\text{Net Income}}{\text{Distribution Cost}}}$ vs. $\frac{\text{O\&M}}{\text{customer}}$, $\ln\left(\frac{\text{Net Income}}{\text{Power Supply Cost}}\right)$ vs. $\frac{\text{O\&M}}{\text{customer}}$, and $\ln\left(\frac{\text{Net Income}}{\text{Distribution Cost}}\right)$ vs. $\frac{\text{O\&M}}{\text{customer}}$. Figures 4 and 5 provide scatter plots for these relationships across the dataset. As stated earlier, each graph was fitted with an exponential and linear trend line, to help identify outliers and nonlinear relationships once determined to have a high correlation coefficient using the first correlation matrix. In cases where a municipality was identified as an outlier, the municipality was discarded from the data pool if the underlying quality of data for that municipality was deemed to be inconsistent or in question. From these graphs, we can assume that a reasonably strong linear relationship exists between the net income per power supply cost (a modified ratio made using APPA calculations) and O&M per customer as well as a strong correlation of these two variables with municipality performance. From analyzing the relationships above, there is a strong positive correlation between placing investments to better your load factor. An optimal load factor means power to customers at a reasonable price with less outages and less interruptions. This, in turn, also has a strong positive correlation to the OM/kWh sold, as customers are considered satisfied and will buy and consume more power. This correlation is stronger than the one that exists between the purchased power cost and debt to assets ratio relationship.

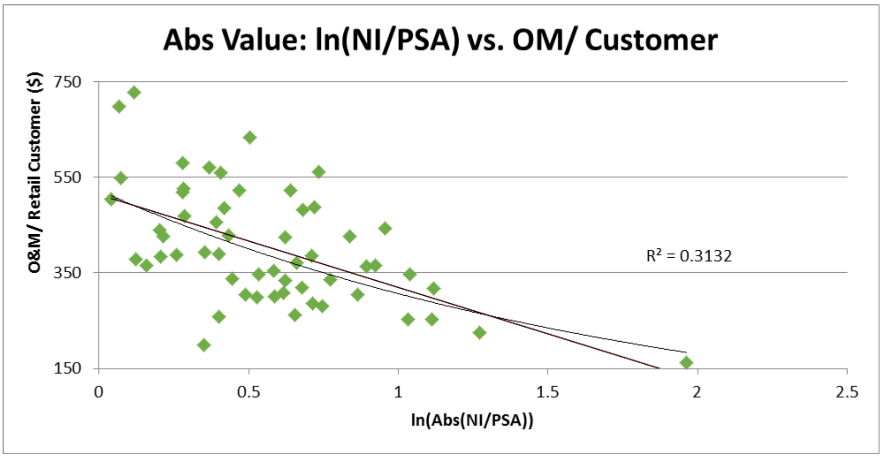

Figure 9

Manipulated Net Income Ratio vs. OM/Customer

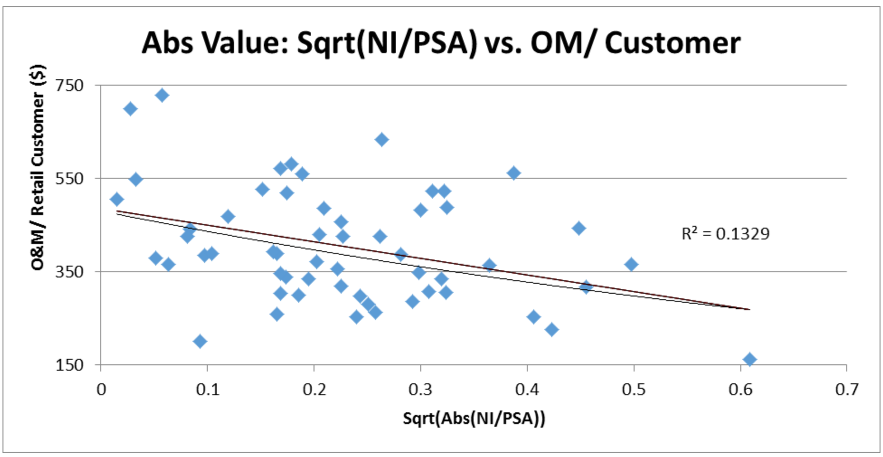

Figure 10

Manipulated Net Income Ratio vs. OM/Customer

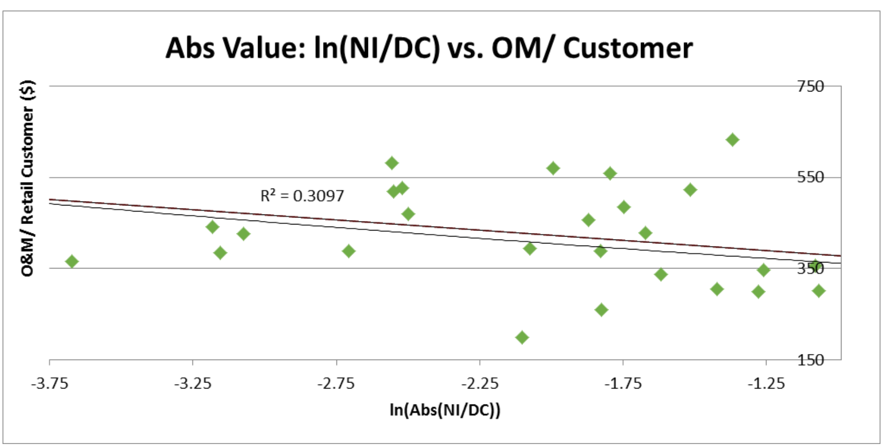

Figure 11

Manipulated Net Income Ratio vs. OM/Customer

Regression of NI/ DC vs. O & M/ Retail Customer	
Regression Statistics	
Multiple R	0.442
R Square	0.196
Adjusted R Square	0.181
Standard Error	110.338
Observations	56
Regression of NI/ DC vs. O & M/ Retail Customer	
Regression Statistics	
Multiple R	0.442
R Square	0.196
Adjusted R Square	0.181
Standard Error	110.338
Observations	56
Regression of (abs(NI/ DC))^0.5 vs. O & M/ Retail Customer	
Regression Statistics	
Multiple R	0.5596
R Square	0.3132
Adjusted R Square	0.3005
Standard Error	101.9521
Observations	56
Regression of ln(abs(NI/ DC)) vs. O & M/ Retail Customer	
Regression Statistics	
Multiple R	0.5565
R Square	0.3097
Adjusted R Square	0.2969
Standard Error	102.2128
Observations	56
Regression of (abs(NI/PSA))^0.5 vs. O&M/ Retail Customer	
Regression Statistics	
Multiple R	0.3645
R Square	0.1329
Adjusted R Square	0.1168
Standard Error	114.5552
Observations	56
Regression of ln(abs(NI/PSA)) vs. O&M/ Retail Customer	
Regression Statistics	
Multiple R	0.3917
R Square	0.1534
Adjusted R Square	0.1378
Standard Error	113.1879
Observations	56

Table 5

Summary of the regression statistics from the Net Income/Distribution Cost vs. O&M/Customer and Net Income/ Power Supply Cost analysis

Using the relationships displayed in Figures 4 and 5, a regression was run to determine the largest R^2 value. From the above graphs, the largest R^2 value corresponds with the graph of $\sqrt{\frac{\text{Net Income}}{\text{Distribution Cost}}}$ and ln $(\frac{\text{Net Income}}{\text{Power Supply Cost}})$. Regressions were then run and the multiple R was calculated using Excel regression statistics. The largest multiple R calculated was for $\sqrt{\frac{\text{Net Income}}{\text{Distribution Cost}}}$ vs. $\frac{\text{O\&M}}{\text{customer}}$. We can conclude from this relationship that $\frac{\text{O\&M}}{\text{customer}}$ is an indicator of the effectiveness of a municipal utility investments and can heavily impact investment strategy. Table 5 shows the regression statistics of each variable analyzed.

A third correlation matrix was compiled using the reliability and technology level data. Though some reporting differences were encountered, data were found from the APPA website, which included out-of-state municipalities to widen the pool for a larger availability of data than before. Table 6 shows the third correlation matrix derived from data retrieved from the APPA online reports. With municipalities that had higher technology level scores, they had overall better reliability time and less outage time per customer per outage. However, correlations between financial metrics and the reliability indices were relatively low. Therefore, additional analysis on the reliability indices was not warranted. For future work, it is recommended that the reliability indices be correlated against a wider range of data (if available) to see if there is a reasonable correlation between a financial indicator and a reliability index.

	Debt To Total Assets	Operating Ratio	Current Ratio	Net Income/ Revenue Dollar	O&M/Retail Customer	A&G/# Customers	SAIDI (w/o MED)	SAIFI (w/o MED)
Debt To Total Assets	1.000							
Operating Ratio	-0.127	1.000						
Current Ratio	-0.386	-0.191	1.000					
Net Income/ Revenue Dollar	0.125	-1.000	0.191	1.000				
O&M/Retail Customer	0.420	-0.117	-0.265	0.119	1.000			
A&G/# Customers	-0.066	0.257	-0.126	-0.252	-0.044	1.000		
SAIDI (w/o MED)	0.327	-0.065	-0.166	0.061	0.072	-0.246	1.000	
SAIFI (w/o MED)	0.208	-0.049	-0.235	0.051	-0.049	-0.145	0.606	1.000

Table 6
Correlation matrix of selected variables, using reliability data from APPA.

7 Conclusion

The largest issues in identifying meaningful variables were data relevance, availability, and techniques of calculation. Each municipality may have many of the performance indicators that are mandated to be reported. Differences in customer class, size, and system structure challenge the accuracy and validity of comparative analyses performed and the resulting parallels drawn between different ententies. Additionally, smaller municipalities struggle to place investments towards bettering their distribution systems and cannot be expected to both track particular reliability factors and display line items of their distribution expenditures on their CAFRs. As a result, some essential data is not available to be included for this analysis. This lack of availability made it difficult to identify reliable data, and forced us to widen our pool of municipalities to obtain a data pool of a size sufficient to produce accurate correlations.

Although our study found it difficult to locate all the data necessary for the statistical analyses initially planned for this research, future investigations conducted by institutions such as the APPA and other municipal electric utility organizations could collect accurate data from all municipalities regardless of size or demand. In addition, general financial health ratios not available in the CAFR, such as those specifically calculated for this report, could also be collected. The development of a common rating system for customers to use concerning their experience with customer service representatives, outage crew personnel, and other service entities would be helpful in reintroducing this variable into this study. A rating system focused on customer service, including numerical ratings on friendliness, timeliness, and issue resolution would aid municipalities in assessing the adequacy of the training being provided for representatives. Importantly, it would also indicate whether or not customers are satisfied with the service they are receiving. Those experiencing high numbers of outages may note this in their survey, thus giving the municipality an idea of an area, a line or piece of equipment which may need replacement. This will help future studies of this nature to investigate different variables that may improve municipality financial health, cost of service, reliability and customer service.

The variables that provided the best relationships on the financial health of the municipals were $\frac{\text{Net Income}}{\text{Distribution Cost}}$ and System Load Factor. By providing several methods of statistical analysis to confirm this, we were able to provide an outline for city governments to follow in the future to better track their capital expenditures and investments.

It is important to ensure that customer satisfaction, reliability, and cost of service is up to par with what customers are expecting. The variables that have been isolated through the statistical methods described above form an approach in measuring the reliability of municipal electric system and cost of service per number of customers, or circuit mile. An APPA-led or independent survey effort to further gain data concerning municipalities of all sizes and customer demand classes would be effective for municipalities to compare themselves to similar cities to gain a better understanding of where prudent investments can be made. In the future, further studies concerning prudent investments for municipalities will help develop smaller cities, while also assisting in the maintenance of customers and demand within larger distribution systems.

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Endnotes

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