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A Comparison of Public and Private Electric Distribution Utilities in Pennsylvania



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by

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I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College as a whole.

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Abstract

Electric distribution utilities can be organized in multiple ways, the two most common are public local government ownership or private investor ownership. This provides a topic of debate in economics: which ownership structure is better? A public owner has an advantage at determining how to benefit the citizens over a third party regulator. A private utility is able to take advantage of economies of scale by growing to a large size. Public firms have denser populations that they service, making the utility need to lay fewer power lines. All of these contribute to which ownership structure is better. Pennsylvania has both of these ownership structures in existence, providing a state to analyze electric distribution utilities in.

1. Introduction

The electricity distribution grid is a crucial part of many aspects of modern life, but is easily overlooked. People may overlook the electricity distribution grid because, for most people, electricity is just there for them and the thought of how it gets there does not occur to them. This industry is made up of a few different types of utility. One type of utility is privately owned utilities, or IOUs, whose main focuses are keeping profits high for the shareholders, distributing electricity to its customers, and obeying the regulations set for them by an overseeing regulating agency. Another type is publicly owned utilities, or munis, whose main concern is providing electricity to its customers; they are run by the local government and are regulated differently than IOUs, without a regulating agency, such that IOUs have. A third organizational structure of an electric distribution utility is a rural cooperative, which is different than both private and publicly owned utilities. The first two organizations will be looked at more in depth in the following chapters.

This study is interesting to me because I grew up in a small town, Pitcairn, that I always knew had its own electricity and cable company, which I always thought was interesting. When my father started working for Pitcairn a few years ago, I learned about other boroughs that also distributed their own electricity, which intrigued me further. Upon further research, I came to realize that in Pennsylvania alone, there are 33 municipalities that have their own electric distribution utility. This made me wonder why so many towns, many of which are not isolated or far from privately owned electric distribution utilities, such as Pitcairn, have their own electric distribution utilities when they could easily sell all of their infrastructure and customer accounts to the nearby IOUs rural cooperatives. For example, Pitcairn neighbors Monroeville, a town whose electricity is serviced by Duquesne Light, an IOU, but Pitcairn has its own electric

distribution utility. Why does Pitcairn continue to provide electricity to its citizens if the local government thought Duquesne Light could provide it at a lower price to the citizens of Pitcairn? This prompted the idea to conduct this research project.

This study is to determine if there is a cost advantage to the type of ownership of local electric distribution in Pennsylvania. In Pennsylvania there are 11 privately owned electric distribution utilities and 33 publicly owned electric distribution utilities. All of these electric distribution utilities purchase electricity from power generating companies and then sell the electricity to the customers that live in the region that the utility services. For a muni, this area is the municipality or borough that the government runs. These outnumber the IOUs in number of utilities, but are individually smaller because of the borders of their municipality or borough. IOUs are larger and distribute electricity over a larger area than munis and to many more customers than each muni. These electric distribution grids are generally responsible for any blackouts that their customers experience. These could be caused by nature, such as a storm that knocks down a power line or damages a transformer, or caused by the utility not purchasing enough power to cover peak usage by the consumers. The following chapters discuss how the study was conducted in more detail.

In chapter two, the relevant literature to this study is reviewed. Among this literature were two important articles by Kwoka (2005a, 2005b). Kwoka (2005a, 2005b) helped in providing the theory presented in chapter three and the structure of data in chapter four. Among the other articles was Farrell (1957), Yatchew (2000), and Burns and Weyman-Jones (1996). The reason Kwoka's were more helpful is because the articles were written more recently and used a larger data set than the other studies.

Chapter three explains the theory behind completing this research project. There are four different theories presented. The first is that electric distribution utilities are examples of natural monopolies. The second is from Kwoka (2005a) stating that a public utility might have an advantage in producing a product or service whose quality is hard to specifiy a priori. The third theory is also presented by Kwoka (2005a, 623) arguing that "public 'owners' may be better able to secure information necessary to monitor enterprise behaviour for consistency with social objectives" when compared with regulators. The fourth and final theory presented in chapter three is about economies of scale and why IOUs are able to realize these while munis are not.

Chapter four presents the data, the regression results, and graphs to explain the data set in a visual manner. The first regression, testing for the comparison of price to customers for public and private ownership structures, presents a model of how the study would have been completed if more data had been collected. The second regression explains the difference between the two means of munis and IOUs. Section three presents the differences between the two organizational structures visually. Chapter four found that, in the sample, IOUs had a lower price to the customer than munis did, but munis still had advantages in certain areas that are predicted to decrease the end price to the customer.

2. Literature Review

This section reviews the literature on local electric distribution and empirical techniques to determine productive efficiency. Kwoka (2005a) looks specifically at the comparative advantage of public ownership in local electric distribution. Kwoka (2005b) looked at the restructuring of the distribution of electricity in The United States. In these two articles, public ownership had a statistically significant cost advantage over private ownership. However, the studies also found that there is an economies of scale effect on local electric distribution, which at larger outputs overcomes the disadvantage of private ownership. Looking at this literature, which establishes advantages that existed in local electric distribution, allows for an estimate of what to expect from an analysis of the industry in Pennsylvania today.

Kwoka (2005a) states he conducted the study because of the lack of symmetric, or similar, conclusions from other articles written on the subject of public versus private ownership. He states his main reason for completing the study as testing "the relative advantages of public vs private enterprises in producing outputs with more specifiable and less specifiable quality" (Kwoka, 2005a, p. 624). He wrote the study using local electric distribution utilities because "this industry had structural characteristics that made it nearly ideal for such a study" (Kwoka, 2005a, p. 624). He continues to explain the make-up of the electric distribution industry in the United States by stating the existence IOUs (investor owned utilities), public, rural cooperatives, or coops, and federal power projects. He does not use the coops or federal power projects in his study, but instead focuses on IOUs and munis. He also explains that some IOUs generate some of their own electricity, however, most munis rely on IOUs or federal power projects for electricity generation. The data set he utilized for his empirical study consisted of 147 IOUs and

396 munis. His empirical model is helpful for giving me ideas on variables to include in my empirical analysis involving a Pennsylvania data set. In his empirical analysis, he finds an advantage in cost savings for munis. In his conclusion, he clarifies that "This research finds that both public and private enterprises have a comparative advantage in different facets of the U.S. electric power industry" (Kwoka, 2005a, p. 638).

Another article from Kwoka (2005b) reaches the same conclusion as this, although the study looked at a slightly different aspect of local electric distribution. Kwoka (2005b) looked at the restructuring of and mergers in the industry and the effect that had on economies of scale. He completed this study because of the lack of merger activity prior to 1995 and the activity since then. This study utilized "a multiproduct framework that represents output in…megawatt hours...number of customers and miles of distribution network" (Kwoka, 2005b, p. 2374). To analyze costs, he looked at overall costs and "wires and supply" (Kwoka, 2005b, p. 2374) costs. In his article he mentions earlier studies from the mid to late 1970s and reports them as having limited confidence, or a potential lack of accuracy, due to "their typically small sample sizes, their lack of adequate control variables, and the relatively crude empirical specifications" (Kwoka, 2005b, p. 2374). He also reviews later studies, from the mid to late 1980s, and explains how they were completed in a more complete way than the earlier studies. In his third section, he explains the specification model he uses for the empirical analysis. He starts his specification off simply using C^D, total distribution costs, as a function of Q^D, distribution output, P^D, factor prices, and X^D, exogenous factors. He proceeds through more functions, where C is always the dependent variable and Q gets split into Q^G and Q^T, the generation and transmission outputs (Kwoka 2005b). He then proceeds to break C into different functions, such as C^I, cost interaction, $C^{G,T}$, cost of generation plus transmission and C^D (Kwoka 2005b). This all leads to

his final function $AC(Q^D) = \gamma_0/Q^D+\gamma_1+\gamma_2Q^D+\gamma_3(Q^D)^2+\gamma_4N+\gamma_5N^2+\gamma_6M+\gamma_7M^2+\gamma_8P+\gamma_9X+\varepsilon$ (Kwoka 2005b). In this function γ are the coefficient terms, ε is the error term, N is the number of customers and M is miles of distribution line. The data set utilized information from 1989 with 182 IOUs and 484 munis in it, but he had to add variables to make a full analysis; after adding these, he was left with 436 total observations, of which 117 are IOUs and 319 are munis. In his results, he found that munis had lower costs than IOUs, which was more of a factor of the supply side of costs than it was from the wires side. This is important because it confirms his other study and provides a hypothesis that munis have an advantage over IOUs. He also confirms that scale economies exist and affect IOUs more than munis, meaning IOUs are more efficient at large levels of output, but munis are more efficient at small levels of output. Kwoka (2005b) states that munis are able to experience economies of scale but tend not to because of the lack of area they can grow to. In other words, munis are restricted by borders of boroughs and IOUs are not, so IOUs take advantage of scale economies more often than munis.

Yatchew (2000) conducts a similar study to Kwoka (2005a, 2005b), but uses data from utilities located in Ontario, Canada instead of utilities in the U.S. His analysis uses a semiparametric analysis, which means some aspects use parametric variables and other variables are nonparametric. Parametric variables make assumptions about the probability distribution and nonparametric variables do not make any such assumptions. His data set is more recent than that used by Kwoka, although there are significantly fewer observations. Yatchew (2000) uses data from 1993-1995, but only has 81 observations. The reason for his use of the 81 utilities he chose is because the size varied greatly inside his data set and "very few are involved in self-generation or ownership of transmission facilities" (Yatchew, 2000, p. 188). In his data set he notes that the cost of power is by far the largest factor in determining costs of distribution, so even a small

error in its measurement can create large errors in the results. The main goal of Yatchew's research is to find whether there are economies of scale in local electric distribution. Yatchew's empirical analysis included many variables to control for different factors, such as wage or the price of capital. Another variable, which is not mentioned in other studies, is LIFE, or the "remaining lifetime of assets…to allow for vintage effects" (Yatchew, 2000, p.189). This is added for the possibility that older capital may require more maintenance. His findings note that there are economies of scale that reach the "minimum efficient scale in Ontario" at "about 20000 customers" (Yatchew, 2000, p. 202). Yatchew (2000) also finds that utilities that participated in other services, such as water or sewage, had lower levels of cost. This suggests the existence of economies of scope in the industry.

Burns and Weyman-Jones (1996) aimed "to quantify the cost drivers of electricity distribution" which will benefit this study by providing more insight into variables for the empirical analysis. Their research covered the 12 regional distributors of England and Wales. The costs of distribution are "the costs of building and maintaining the system of mains, service lines…and transformers" (Burns and Weyman-Jones, 1996, p. 46). They proceed to break these down in to a list of nine determinants of cost:

(a) The maximum demand on the system…
(b) The total number of customers served…
(c) The type of consumer…
(d) The dispersion of the customers across the distribution region…
(e) The size of the distribution area…
(f) The total kWh sold…
(g) The value placed upon system security;
(h) The length of distribution line…
(i) Transformer capacity…

These nine determinants of cost all affect a specific aspect of the cost to the distribution system. It is not simple to determine what the best measure of output from an electricity distribution utility is, so it must be specified by the researchers (Burns and Weyman-Jones, 1996). When the output is defined, the independent variables must be defined and justified. For their single-output model, they chose the number of customers serviced as the output of local electric distribution utilities. They find a change in efficiency rankings of utilities when switching from cross-section to panel estimation. Their research led them to find "that the number of customers, maximum demand and factor prices are the significant cost drivers" (Burns and Weyman-Jones, 1996, p.62).

Farrell (1957) provides a study of measure of productive efficiency which eliminates problems of using more than one input cost and includes a theory for why one utility may be more efficient than another utility. Prior to Farrell's paper, many studies failed to truly capture productive efficiency in their studies (Farrell, 1957). According to Farrell, this was due to a "pure neglect of the theoretical side of the problem" (Farrell, 1957, p. 11). Prior to his research, it was "considered adequate to measure the average productivity of labor" (Farrell, 1957, p. 11). This was the norm in studying efficiency. This did not account for multiple input variables, just that of labor. When studies would include more than one input variable, they would run in to "the usual index number problems" (Farrell, 1957, p.11). This problem refers to the difficulties in setting indices when both price and quantity change over time. Farrell set out to provide a method of measuring productive efficiency that included multiple input variables and avoided index number problems. He completed this study so that the method of only using labor input would not create problems for economic policy makers. This study is referenced by Sengupta (1998) when he looks at the U.S. electric utility industry.

Sengupta (1998) presents a study to look at the methods presented by Farrell (1957) in U.S. electric utilities. He utilizes a data set from Greene (1990) to complete this research. He explains that in a competitive market, cost estimation of efficiency is simpler than a production frontier. This is due to the fact that costs can be broken down or lumped together easily. To measure the existence of economies of scale, a Cobb-Douglas function is used. This can be used with a production or a cost frontier. Sengupta (1998) concludes that the Farrell method of measuring efficiency was enhanced by Sengupta in the scope of modern applications of efficiency measurement.

The survey conducted by Megginson and Netter (2001) of state owned and privately owned utilities provides a look at what the overall most efficient method of management is. They state that "it is tempting to point to the spread of privatization programs around the world during the past two decades and conclude that the debate on the economics and political merits of government versus private ownership has been decided" (Megginson and Netter, 2001, p. 321). They also point out that this conclusion can be incorrect because prior to 20 years ago, proponents of government ownership could have claimed the opposite due to the state of the global economy then. Their goal is "to assess the findings of empirical research on the effects of privatization as a policy" (Megginson and Netter, 2001, p. 321). This paper is a survey of the literature on privatization and "describe some of its lessons on the promise and perils of selling state-owned assets" (Megginson and Netter, 2001, p. 322). Megginson and Netter conclude with eight points on privatization, only one of which is relevant to my research. It is as follows: "Research now supports the proposition that privately owned utilities are more efficient and more profitable than otherwise-comparable state owned firms" (Megginson and Netter, 2001, p. 380).

Boardman and Vining (1989) completed a study comparing different forms of ownership in competitive industries. These ownership forms are private, mixed, and state owned utilities. While this article compares ownership forms, it does so in competitive industries. The local electric distribution industry is noncompetitive due to natural monopolies, so electric distribution utilities do not experience competition like the utilities Boardman and Vining (1989) studied. Boardman and Vining (1989) completed this study because previous research on ownership forms was done on industries with a natural monopoly or a regulated duopoly in existence, such as local electric distribution. This research presents a different view of private and public utilities because it presents a comparison in an industry type that had not formerly been researched upon. With this in mind, local electric distribution is a natural monopoly industry, therefore this paper does not provide too much theory for analysis.

Christensen and Greene (1976) provide a study on a different area of the electric utility industry. Instead of focusing on local electric distribution, they completed a study on economies of scale in the U.S. electric power generation. This is still important to analyze because while looking at the local electric distribution, where the electricity comes from may play a role in input costs to the distribution utilities. This study looked at the economies of scale in order to determine if a reorganization of the industry would benefit or harm the economy. They utilized two separate data sets from 15 years apart. This was so that they could control for technological advancements in those 15 years. The two data sets they chose were 1955 and 1970. Christensen and Greene (1976) found that more utilities were exhibiting constant returns to scale in 1970 than in 1955, that is, more utilities were in the "flat" portion of the average cost curve in 1970 than in 1955. Christensen and Greene (1976) provide a look at a different area of the electric industry and provide insights into potentially vertically integrated utilities I may have to analyze.

Hughes (1962) utilized the fact that the New England electric industry seemed like a model of the entire nation's electric industry. This allowed him to analyze the efficiencies in New England and make generalized statements about the industry as a whole. Another reason for using New England utilities as his data set was that it allowed for a hypothetical utility to easily be set up for analysis. Hughes (1962) looks at the organization of the industry and how interfirm coordination could lead to greater efficiency. Hughes (1962) helps with my research because it allows me to see the organization, albeit outdated, of the electric industry and the short-run efficiencies that existed. The overview and efficiencies shown in the article may directly relate to my findings in Pennsylvania, proving Hughes' point that New England was a good base as a model of the U.S. electric industry.

These studies are on either the subject of public versus private enterprises or on the electric distribution sector of different economies. Kwoka (2005a, 2005b) researched local electric distribution utilities to find out whether private or public ownership has a cost advantage and as a way to understand the mergers and restructuring that began occurring in the industry during the mid-1990s. He found that at small levels of output, publicly owned utilities had a cost advantage over privately owned utilities; however, at larger levels of output, the cost advantage began disappearing and privately owned utilities began to have a cost advantage. Yatchew (2000) completed a similar study with a data set from Ontario, Canada. He found that economies of scale exist. His study uses more recent data, but had a smaller data set than Kwoka (2005a, 2005b), making his analysis less complete. The largest inconsistency that arose in the research is that publicly owned utilities have a cost advantage at small levels of output that disappears at larger levels of output. This raises a few questions: why do IOUs operate more efficiently at large levels of output, but not at small levels of output? Do the data not have enough large munis

to show an existence of economies of scale? Do IOUs exhibit a greater effect from economies of scale? What makes a muni more efficient at small levels of output and less efficient at large levels of output than IOUs?

3. Theories of Natural Monopoly, A Priori, and Economies of Scale

This section explains why electric distribution utilities are used as textbook examples of natural monopolies and why that may create a difference between IOUs, and munis. The reason for calling publicly owned electric distribution utilities munis is that they are run by the municipality that they service. IOUs are referred to as such because the letters stand for investor owned utilities. In addition to exploring natural monopoly theory, this section also provides a theory about IOUs and munis with a service that is "difficult to specify a priori" presented by Kwoka (2005a, Abstract). In addition, this section will look at why munis do not experience the same economies of scale that IOUs are achieve and why it is important for IOUs to keep their costs low to maintain high profit levels. After exploring the theory on economies of scale, this chapter moves to explore the theory that is based on regulators versus public owners (Kwoka 2005a).

I. Natural Monopoly

A natural monopoly is defined as "an industry in which the most efficient way of organizing production is through a single firm" (Ulbrich 1991, 179). This definition is quite similar to that presented by McConnell in his textbook from 1987 (Ulbrich 1991). Natural monopolies are most likely to exist where fixed costs are extremely high (Ulbrich 1991). Although these definitions are common among introductory textbooks for economics, Ulbrich (1991) argues that they are not truly accurate. Ulbrich (1991) argues that "fewer textbooks add the essential qualifier that these cost curves [average total and marginal] decline continuously *throughout the range of demand*" (Ulbrich 1991, 180). This explains why a natural monopoly is seen as having infinitely decreasing average and marginal cost curves (Ulbrich 1991). In

addition to the complaints of natural monopoly definitions, Ulbrich (1991, p. 181) argues that "A natural monopoly produces a product with few close substitutes, and the costs of entry and exit are very high; the bulk of the costs are fixed rather than variable in the short run, and the short run is a very long time period." Public utilities tend to be organized as local natural monopolies because of the reasons presented above. This paper focuses on local electric distribution, so more detail on that sector of the public utilities industry will follow.

Local electric distribution is a natural monopoly because it makes more economic sense to have one utility run all of the lines instead of having two utilities run competitive lines side by side and compete for customers. This is because electric distribution requires a lot of power lines to be laid, which is a large up front fixed cost. These initial costs are the barriers to entry that cause it to make more economic sense to organize as one firm. Due to this, electric distribution utilities have become textbook examples of natural monopolies along with gas utilities and formerly, before the large increase in cell phone owners, telephone utilities. These natural monopolies are either regulated by the government or, in the case of munis, run by the local government.

The fact that local electric utilities are examples of natural monopolies may help in explaining why there may be a difference between IOUs and munis. An IOU is run by investors and must profit enough to pay its shareholders, which is an added cost to the customers of that utility. On the other hand, munis are run by the local government of the customers they service and therefore do not have to pay dividends to shareholders because a muni does not have shareholders and does not operate for profit. In addition to this, a muni does not receive regulation from a regulatory agency like the IOUs do. In Pennsylvania this agency is the Pennsylvania Utility Commission, or PUC. PUC regulates the IOUs in Pennsylvania because the

IOUs are natural monopolies and could, theoretically, charge whatever price they wanted for electricity if they were not regulated. Munis, however, are not regulated in the same way as IOUs because they are run by the government, giving them internal regulation, eliminating the need for an external third party to regulate them. Another reason for PUC not regulating munis is that the governments running the munis do not have to keep shareholders happy and therefore are not concerned about profits, but merely covering costs. While munis do not have an incentive to raise the price to the customer beyond that of covering their costs, IOUs have an incentive to decrease costs in order to increase profits without changing the price to customers. If munis are run by a competent government, the price to the customer should remain low because the muni is concerned about covering costs, not earning a profit. On the other hand, if an IOU were not regulated, it would increase the price to the customer to increase its own profits. This leads to regulation from an outside agency that causes the IOU to operate the way it does.

II. A Priori

Kwoka (2005a) provides another theory to analyze. He "draws on theory suggesting that public enterprises may have an advantage in producing goods and services whose quality attributes are difficult to specify a priori" (Kwoka 2005a, Abstract). A priori means that the quality is easier to guess from theoretical deduction rather than through observation. Therefore, Kwoka is stating that public enterprises could have an advantage producing goods that need to be observed to determine quality. Electricity has virtually no quality because it all powers the same devices; the quality in electric distribution is the customer service that a company provides. Customer service of electric distribution is most notable in the quantity and length of power outages. This quality of customer service cannot be determined from knowledge about other

customer service, but must be experienced, through living in an area serviced by a different electric provider.

Kwoka's main findings were that "public systems generally have an advantage in the end-user-oriented distribution function" (2005a, Abstract). Kwoka's (2005a) theory is based on the many theories on public vs private ownership that came up from the late 1980s to the early 2000s. Although there were a lot of theories on the matter, many disagreed with each other. He notes that the reason for the differences in these conclusions is because the authors reviewed "different bodies of literature – a fact that should…temper their conclusions" (Kwoka 2005a, 623). This statement shows that no matter how many studies are done on public versus private enterprises, the answer may never be set in stone. Regardless, Kwoka (2005a) used data to test his theory from the U.S. electric industry from 1989. He cites this reason as being "this industry had structural characteristics that made it nearly ideal for such a study" (Kwoka 2005a, 624). This gave him a starting point to test the theory that "public enterprises may have an advantage in producing goods and services whose quality attributes are difficult to specify a priori" (Kwoka 2005a, Abstract).

People may tend to think privately owned utilities must be better than publicly owned utilities because "privately owned utilities… [are] individually larger, vertically integrated, and responsible for more than three-quarters of all electric power produced and sold" (Kwoka 2005a, 625). While they are responsible for the vast majority of electricity produced and sold, IOUs are not necessarily the best organizational structure for electric distribution utilities. This was more apparent in the early 1900s when IOUs were slow to provide electricity to small cities, towns and rural areas (Kwoka 2005a). It was at this point that munis began to arise as substitutes to IOUs to provide electricity to people that were not being serviced by IOUs (Kwoka 2005s). In 1989,

the year of Kwoka's data, munis were responsible for distributing 15 percent of total electricity in America. (Kwoka 2005a). In addition to munis, there are also federal power projects and rural cooperative, which were excluded in Kwoka's study.

The main theory of Kwoka's paper is that public enterprises have an advantage in producing goods or services that cannot be determined by hypothesizing about the quality (2005a). This idea that a good or service cannot be determined by hypothesizing is true in the electric distribution industry because the quality of electricity is based on power outages and customer service, which must be experienced. In Pennsylvania, the munis provide electricity over a much smaller area than the IOUs. This smaller area may be a factor in helping munis have an advantage in providing better service to their customers than IOUs are capable of. Kwoka's eventual conclusion is that more research and rethinking must be completed to determine when, and if, privatization should be an implemented policy in the electric distribution industry (Kwoka 2005a). He found that "there are identifiable circumstances in which public enterprise is an appropriate, if not perfect, policy prescription" (Kwoka 2005a, 639). This means that while the study did not find a conclusive result, it did determine that previous studies that may have found such a result may have been incorrect. It also means that further research is necessary to determine if there is a totally conclusive result that can be reached or if the public versus private debate is a never ending debate with the best organization being determined in a case by case basis.

III. Economies of Scale

One reason that IOUs are larger is because of the way that munis are set up. Munis are set up to provide electricity to a small municipality or borough, whereas an IOU is set up to provide electricity to customers across its area, which is not limited by the borders of a town. An

IOU is then able to take advantage of economies of scale more than a muni is. If a muni were to attempt to be as large as an IOU it would fail because a muni is limited by the borders of the municipality or borough that it services. Another reason, related to the border issue facing munis that want to experience economies of scale is, because of the border limitation, a lack of customers. In the data set I collected, the two IOUs that responded have many more customers than the munis do. For these two reasons, munis are not capable of experiencing economies of scale like an IOU can.

IV. Public Owners versus Regulators

Kwoka's alternate theory of why public enterprises may have an advantage over IOUs is "that compared with regulators, public 'owners' may be better able to secure the information necessary to monitor enterprise behaviour…" (Kwoka 2005a, 623). This theory provides another aspect of the industry to look at. The theory suggests that perhaps when an industry, such as electric distribution, is regulated due to the existence of natural monopolies, it is better to organize it with public ownership instead of IOUs. The reason for this is that it allows the public employees operating the utility to run the system for the good of the public citizens and not the good of stockholding investors. This essentially cuts out the middle man for the public citizens. Instead of having an IOU deciding what it wishes to do, then have regulators tell the IOU to do something else, eventually reaching a middle ground that satisfies the regulators and the investors, a muni could just operate for the benefit of the citizens. By allowing the government to run the utility and thus not requiring the utility to be regulated, may provide benefits to the public citizens serviced by the utility.

Utilizing Pennsylvania's local electric distribution utilities, this section laid out the theories surrounding the idea that public ownership may have an advantage in servicing its

customers over private ownership. Electric utilities are examples of natural monopolies, which are a reason to look at the ownership structure, since they face no competition in the area they provide electricity for. In addition, when providing services that are "difficult to specify a priori" (Kwoka 2005a, Abstract) public enterprises may have an advantage over similar private enterprises. Also, IOUs are able to experience greater scale economies because they are not bounded by borders of certain towns like munis are. Finally, when looking at the industry from an outside perspective, regulations must be looked at and it is important to note that operators of public enterprises may be able to provide and understand the information about what is beneficial to the constituents of the utility than a third party regulatory agency (Kwoka 2005a). These theories will be analyzed farther at the end of the next chapter after the data is thoroughly explained, collected and analyzed in a regression.

The theory for this paper is adapted from Kwoka (2005a), natural monopoly, and economies of scale theories. Since electric distribution utilities are examples of natural monopolies, it is important to remember that there is no competition for electric distribution utilities. That is unlike electricity generation in Pennsylvania now with the consumer able to choose where the electricity they purchase comes from. The distribution of that electricity, however, is not a choice because of the heavy fixed costs of transmission lines and the other barriers to entry in the industry. The reason Kwoka's theory "suggesting that public enterprises may have an advantage in producing goods and services whose quality attributes are difficult to specify a priori" is included is because the natural monopoly theory is not enough to determine what ownership structure to operate with (Kwoka 2005a, Abstract). Kwoka also presented an alternative theory to the theory "that public enterprises may have an advantage in producing

goods and services whose quality attributes are difficult to specify a priori" (Kwoka 2005a, Abstract).

4. Empirical Study of Pennsylvania Electricity Distribution Utilities

This section explains the empirical method and the data that were used to complete the study: the variables used and why those variables were chosen, how the data was collected, a regression model and graphs comparing the two ownership structures. For this study, Stata was used to create an empirical regression model. A table of summary statistics for the data collected is attached as an appendix to this chapter.

I. Data and Variables

Data were collected by contacting the different electric distribution utilities in Pennsylvania. First, contact was attempted through phone calls to the utilities. Contact information was received from PUC for the IOUs and the Pennsylvania Municipal Electric Association, PMEA, for the munis. Some utilities, such as Citizens' Electric, responded promptly, making the process easier. Other utilities took longer to respond to a phone call, but still responded. Still, some utilities never returned the phone call. Emails were sent as a second attempt at contact if a phone call was not received from the utilities. Some utilities responded to the emails in a timely manner, while others did not reply at all. After the first contact was achieved, a survey was sent to the different utilities via email. Some of these utilities chose not to respond to the survey, while other utilities sent information or websites with information on their company that did not relate to the variables used in the study. Due to this reason, utilities that did not complete the survey were dropped from the already small population size of 43. After the utilities that did not complete the survey were dropped from the data set, the sample size was nine, with only two of the utilities being IOUs. Only two utilities being IOUs is okay

because it is a similar ratio of munis to IOUs in the sample size as in the entire population of utilities in Pennsylvania.

The data and variables used in this regression are modeling the way a regression would be completed if more data were collected. With a sample size of only nine, the regression does not explain much. The main reason for the lack of explanation from the regression is the variance that is caused in the sample mean of the variables. Variance is basically the average deviation from the mean of the sample. This means that for a larger data set, the outliers matter less because there are more data points close to the mean that makes the variance smaller. With a small sample size, there are few degrees of freedom, which increase the variance that is expected in the sample mean. This means that as degrees of freedom increase, the variance expected in a sample decreases. When sample size is increased, the degrees of freedom also increase, which in turn decreases the variance from the population mean, making for a more accurate regression.

The variables that were chosen for this study were based on Kwoka's (2005a, 2005b) variables. Although the variables are based on his study, there are differences and I use fewer variables overall because of a small sample size. The first variable, public, is a dummy variable that is equal to zero if the utility is private and one if the utility is public. The predicted value of public is the main reason for completing this study and can be predicted as negative or positive (Kwoka, 2005b), meaning that, on average, munis are expected to have a lower price to the customers, if it is negative, or higher price to the customers, if it is positive, than IOUs. The predicted sign for public in this study, however, is negative, meaning the munis are predicted to have a lower price to the customers when compared to IOUs. The next variable used is customer density, an interaction term between square miles covered and the number of customers. Kwoka

(2005a, 2005b) used a similar term because he believed that the density of customers can affect overall costs because the more spread out the customers are, the more distribution lines required to cover that ground. The predicted sign for customer density is negative, meaning that the higher the customer density of an IOU or muni, the lower the overall fixed costs to the utility and therefore the end price to the customers. The next set of variables is total expenditures on power, megawatt hours of power purchased and an interaction term, cost of purchased power. These variables are included because the price of power purchased by the utility largely determines the price that customers pay. The expected sign on the cost of purchased power is positive, meaning that the more the power costs the utility to purchase, the higher the end price to the customers. There are then two more dummy variables, self-gen and gas. Self-gen is a predictor of the advantages of vertical monopolization and gas is a predictor of the advantages of horizontal monopolization. Self-gen is a variable that is one if the utility generates any percentage of the power that it distributes. The predicted sign of self-gen is negative, meaning that a utility that generates some of its own power has lower costs and therefore a lower end price to the customers. Unfortunately, in the sample of data collected, there are no utilities that self-generate the power they distribute. Gas is one if the utility also partakes in natural gas distribution and zero if it does not. The predicted sign of gas is negative, meaning that a utility that also distributes natural gas will charge less for electricity because some of the costs to the utility are covered by the sales of natural gas. The next variable, High-Voltage, is the percent of power that the utility distributes that is high voltage, or not stepped down through transformers. This form of electricity is typically distributed to industrial customers who have need for electricity at higher voltages than residential customers. High voltage distribution should tend to lower costs, meaning the predicted sign is negative, because there are fewer transformers needed on the line

to step down the voltage before it gets to the customers (Kwoka 2005b). In addition to the variables above that directly relate to the utilities output or costs, a set of dummy region variables were added. These variables are East, West, and Central; these variables equal one if the utility is located in that region of Pennsylvania and zero otherwise. There are no predicted signs for the regional dummy variables; they are included to control for varying costs across the three main regions of Pennsylvania. Finally, cost to customer is the dependent variable that will help determine what form of ownership, private or public, organization is potentially better for the customers in the Pennsylvania local electric distribution industry.

II. Regressions

The following regression is a model of what the regression would have looked like had more data been able to have been collected. It is important to show the regression analysis to explain how the data would be analyzed if more of the population could have been collected in the sample. As stated in the previous section, the degrees of freedom play a large role in the variance of the sample mean. The more observations collected in a sample, the more degrees of freedom and the less variance of the sample mean. With a small sample size of nine, there are few degrees of freedom which results in a large variance of the sample mean, causing the actual analysis to have inaccuracies in it. This is why the following regression is a model of what the regression would look like if more of the population had been used in the sample.

The regression has the equation of:

$$costtocustomer = \beta_0 + \beta_1(public) + \beta_2(customerdensity) + \beta_3(purchasedpower) + \beta_4(gas) + \beta_5(highvoltage) + \beta_6(east) + \beta_7(west) + \varepsilon$$

where β_0 is the constant term, the following β terms are the coefficients for the variables, and ε is the error term.

The regression with this data set is shown below:

Table 4.1 Model Regression

Source	SS	df	MS		
Model	31.3479182	7	4.47827402	Number of obs	9
Residual	12.765474	1	12.765474	F(7, 1)	0.35
				Prob > F	0.8648
Total	44.1133922	8	5.51417402	R-squared	0.7106
				Adj R-squared	-1.3150
				Root MSE	3.5729

costtocusto~r	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
public	4.226291	13.37124	0.32	0.805	-165.6714	174.124
customerden~y	-.0062969	.0184362	-0.34	0.790	-.2405508	.2279571
costofpurch~r	-23.51156	37.9626	-0.62	0.647	-505.8721	458.849
gas	-2.286752	10.02928	-0.23	0.857	-129.7209	125.1474
highvoltage	.2094798	.5413947	0.39	0.765	-6.669592	7.088551
east	8.859641	20.09912	0.44	0.736	-246.5238	264.2431
west	17.51099	26.98132	0.65	0.634	-325.3192	360.3412
_cons	38.29886	44.69936	0.86	0.549	-529.6604	606.2581

As expected, none of the variables in this regression are shown to be significant, but their coefficient signs can still be discussed. The main reason for this is the small sample size that was able to be collected. There are not enough observations to complete an accurate regression. Fortunately, with this regression, no variables were omitted due to multicollinearity. Multicollinearity means that an independent variable can, with a reasonable degree of accuracy, be used to predict another independent variable. Some of the predicted signs of the coefficients were correct, while others were incorrect. First, the public variable has a positive coefficient, meaning that, on average, munis have a higher cost to the customer than the IOUs in the study. Customer density's predicted sign was correct because the coefficient is negative, so as the customer density increases in a utilities area, the price to the customer decreases. The cost of purchased power's coefficient's sign is the opposite as expected. This can be explained by the fact that none of the variables are statistically significant due to the small sample size. The sign

on gas's coefficient is negative, as predicted, which means that horizontally monopolized utilities may experience a cost advantage that gets passed along to the customers. The sign associated with high voltage's coefficient is the opposite of predicted. This could be because the sample size is so small that the few that have a high amount of high voltage electricity distributed have higher prices to the customer for a different reason. The signs for east and west were not predicted because they were just control variables to account for any variations in the price to the customers in the different regions of the state. While some of the variables had the predicted signs on the coefficients and others did not, all the coefficients presented in the regression must be looked at with caution because of the small sample size, which results in none of the variables being statistically significant. Due to the small sample size, a normal regression does not provide a lot of information, however, a regression run with just the public dummy variable may provide some information about the means of munis and IOUs prices to the customers.

The equation for this regression is:

$$\boldsymbol{\beta_0 + \beta_1(public) + \varepsilon}$$

Where β_0 is the constant term, which is equal to the mean of the price to customers from IOUs, β_1 is the coefficient on the public variable, which when added to the constant term is equal to the mean of the price to customers from munis, and ε is the error term.

This regression is shown below:

Table 4.2 Difference of Means Test

Source	SS	df	MS	Number of obs =	9
				F(1, 7) =	1.85
Model	9.20695982	1	9.20695982	Prob > F =	0.2164
Residual	34.9064323	7	4.98663319	R-squared =	0.2087
				Adj R-squared =	0.0957
Total	44.1133922	8	5.51417402	Root MSE =	2.2331

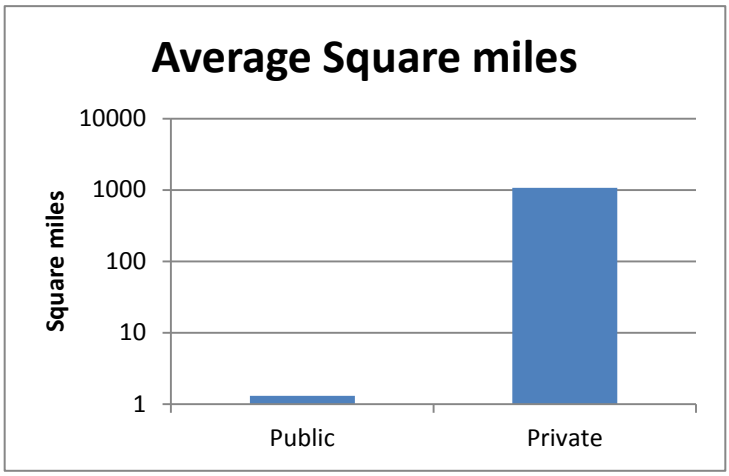
pricetocus~r	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
public	2.43285	1.790445	1.36	0.216	-1.800879	6.666579
_cons	10.55715	1.579024	6.69	0.000	6.823352	14.29095

This regression is useful to compare the two means of IOUs and munis, with the t-stat basically providing a difference of two means t-test. This t-test determines the significance that the difference of the two means has. The constant term in the regression is the mean of the IOUs, at 10.56 cents per kilowatt hour. The mean of the munis is the constant term plus the coefficient, which equals 12.99. The difference of the two means is 2.433, with munis having a higher average price to customers than IOUs, but can only be viewed with 75 percent confidence because the p-value is 0.216. This means that the p-value is so high that this regression cannot be viewed at a normal level of confidence, which would be 90 percent, 95 percent, or 99 percent. Again, the reason for the low confidence level is the small number of utilities that responded to my data collection efforts. With more data from more utilities in Pennsylvania, a study with a higher confidence level and more statistically significant variables could be conducted.

III. Graphs

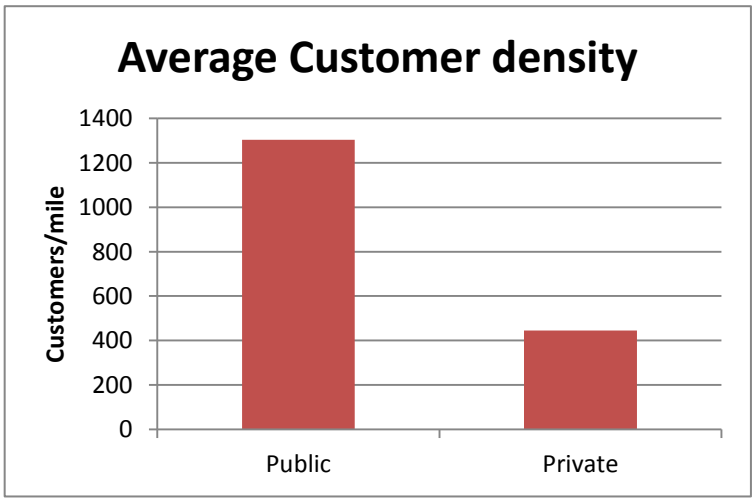
Although the regressions provide information, they must be viewed with caution because of the low level of statistical significance that the variables have. Regardless, the data still show some interesting information about the electric distribution industry in Pennsylvania. This will be shown in the following graphs:

Graph 4.1 Average Square Miles



This graph shows the difference between the average square miles that munis and IOUs cover. There is a considerable difference between the averages of the two different forms of organization. It is important to note that the y-axis is in a log scale to allow for the large difference between the two averages. This is because, as stated in chapter three, munis are limited in size by the borders of the borough or municipality that they service, whereas an IOU is not limited by this factor. While only two IOUs responded properly to the survey, the average is still important when compared to the average of munis. The largest muni, in square miles, is 2.5 square miles large, while the smaller of the two IOUs is 54 square miles, with the other being 2100 square miles. This difference in size comes into play when looking at the averages of customer density for each type of utility.

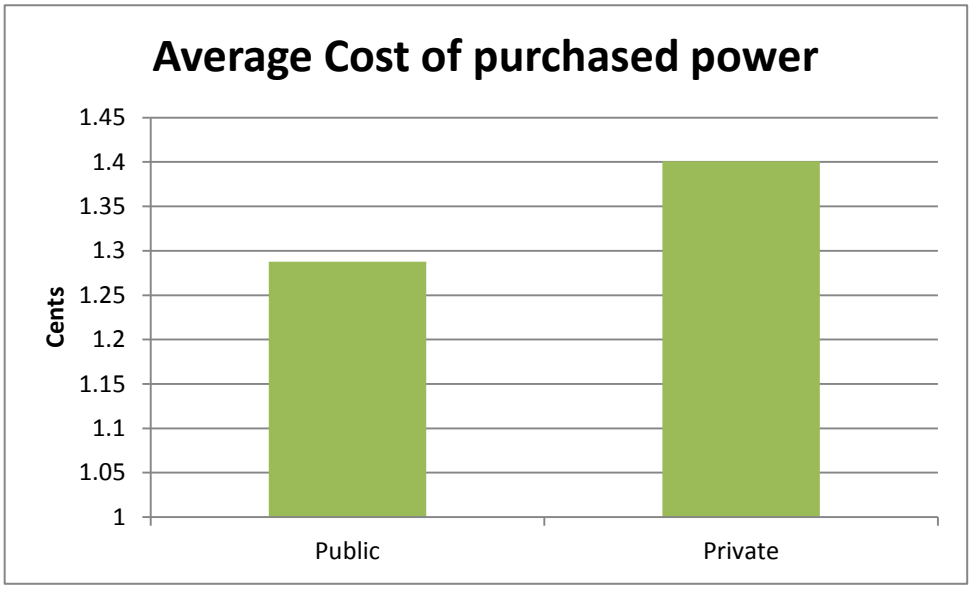
Graph 4.2 Average Customer Density



Graph 4.2 shows the difference between the averages of customer density between the two organizational styles. It shows a large difference, with IOUs having many fewer customers per square mile than munis. While in graph 4.1 IOUs had a much larger square mile coverage area, the small area covered by munis is more densely populated. This is important because customer density is a variable that is predicted to reduce costs to the utility, which can then be

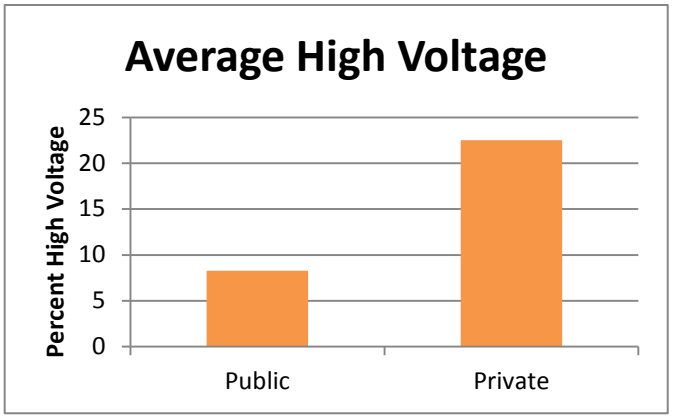
passed along to the consumer in the end price. This may be a reason that a muni may have an advantage in end price to the consumer over IOUs. This graph is interesting to look at because it shows that munis distribute electricity to more populated areas, although much smaller areas. This might be because the larger areas that IOUs cover have towns that are spread out, so they are like multiple muni sized areas tied together with transmission lines, resulting in a smaller customer density in a larger area with more customers.

Graph 4.3 Average Cost of Purchased Power



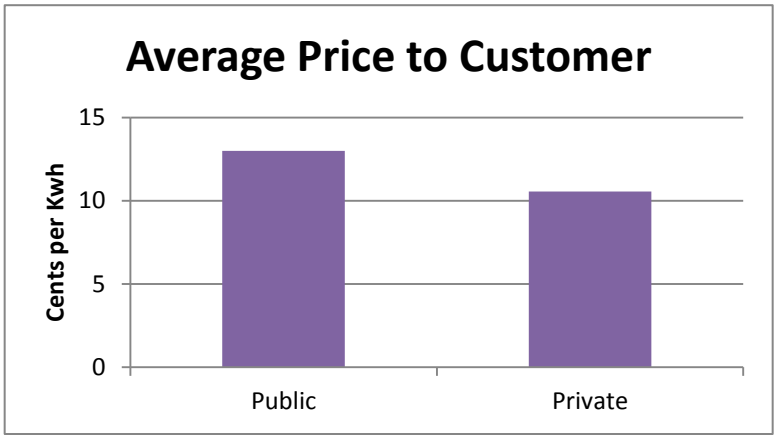
Graph 4.3 shows the difference between munis and IOUs in cost of purchased power. This is important because purchased power is one of the largest determinants of costs to the utilities, which then are passed on to the customers. This is another area that munis in Pennsylvania realize a cost advantage over the IOUs. Another aspect of this graph to note is that the Y-axis is in cents, so the difference between the two is only 0.12 cents, which is not that large, but when applied to the amount of power purchased, where IOUs purchase much more, so that the total expenditures vary greatly between each utility, regardless of organizational structure.

Graph 4.4 Average Percent High Voltage



Graph 4.4 shows the difference of how much electricity the utilities distribute that is considered high voltage. High voltage is less costly to distribute because it requires fewer transformers on the grid to step down the voltage to the end customer. In addition, most high voltage customers are commercial or industrial buildings that purchase the high voltage in large blocks (Kwoka, 2005b). The reason that the IOUs have a higher percent of total distribution as high voltage is because the munis cover small towns or boroughs, which either have few or no commercial or industrial buildings that require high voltage electricity. While munis have few or no commercial or industrial customers, IOUs can have many that are on the outskirts of towns or in industrial parks that do not fall in a particular towns borders. Due to this, the IOUs distribute more electricity at high voltage, which overall reduces their costs, which can lead to a decreased final price to the customer.

Graph 4.5 Average Price to Customer



Finally, graph 4.5 looks at the average price charged to the customers by the utilities. Here, as in table 4.2, it is shown that the private utilities have a lower price to the customer than munis do. This could be due to many different factors. One of which is shown in graph 4.4 where the average percent of high voltage distributed is shown. Another factor could be the economies of scale that are in play in an industry with heavy fixed costs, such as electricity distribution. The reasons munis and IOUs differ in their ability to realize economies of scale were talked about in more depth in chapter three.

Chapter four explains, using regression model and various bar graphs, the differences in the data set between IOUs and munis. Although the data set was small, it still showed important information because the data set that was able to be collected was proportional to the number of IOUs compared to munis in the entire population. The data presented interesting information about the differences between the two organizational types. Although the regression did not show any statistically significant variables, it still showed the predicted signs on some of the variables. In addition, when looking at the averages of different variables, it was shown that munis had advantages in some areas that were expected to reduce costs. While munis realize a cost advantage from the logic presented in graph 4.2 and 4.3, they have a higher average price to

the customer than IOUs due to other factors, such as the smaller percent of high voltage electricity distributed, as shown in graph 4.4. With a larger data set, which possibly means looking at more than just one state, a more comprehensive study could have been completed with more statistically significant variables in a regression and more accurate averages for the population as a whole.

Chapter 4 Appendix

Appendix Figure 4.1 Public Summary Statistics

N[1]=7	Public	Square Miles	Number of Customers	Customer Density	Expenditures on Power	MWh of Power	Cost of Purchased Power (cents/MWh)	Self-gen	Gas	High Voltage	Price To Customer	East	West	Central
Mean	1	1.467	1821.5	1235.397	2321923.8	28487.128	1.303	0	0.167	3	12.988	0.333	0.333	0.333
Median	1	1	1518	1518	929130	12897.436	1.195	0	0	0	13	0	0	0
Standard Deviation	0	0.783	1309.051	638.256	2175999.284	23567.239	0.295	0	0.378	15.327	2.398	0.488	0.488	0.488

Appendix Figure 4.2 Private Summary Statistics

N[1]=2	Public	Square Miles	Number of Customers	Customer Density	Expenditures on Power	MWh of Power	Cost of Purchased Power (cents/MWh)	Self-gen	Gas	High Voltage	Price To Customer	East	West	Central
Mean	0	1077	803500	445.767	431935240	6189962	1.401	0	0.5	22.5	10.557	0.5	0	0.5
Median	0	1077	803500	445.767	431935240	6189962	1.401	0	0.5	22.5	10.557	0.5	0	0.5
Standard Deviation	0	1446.74	1126421.102	447.086	597552364.4	8572066.004	0.0467	0	0.707	3.536	0.626	0.707	0	0.707

1.) N is the sample size that is public for the first table and private for the second table

5. Conclusion

This paper explains the difference between two different organizational structures of electric distribution utilities and the difference in advantages to the consumers between the two different organizational structures. The paper explains the differences between the different types of ownership structures that these utilities could have in the United States. To reiterate, a muni does not have stockholding investors, but is run by the local government in order to provide electricity to that government's constituents. In contrast, an IOU tends to be larger and has stockholding investors that it tries to keep happy while providing electricity to its customers and obeying regulations set forth for it by a regulating agency. Pennsylvania has three times as many munis as IOUs, although the munis are individually smaller in size.

This study is important because it looks at an industry that has different organizational structures for the utilities. The one organization, private, results in a utility that is large and regulated by a third party organization, such as PUC. One of the other forms of organization is publicly owned, which are small and run by the local government. There are other forms of organization, such as a rural cooperative, but this paper focused on the former two organizational techniques. The reason for completing this study is that I grew up in a town that is a muni.

Growing up in a muni, next to towns serviced by an IOU provided some interesting moments. When I would get home from school, I would occasionally receive a phone call from a friend living in a town serviced by an IOU asking if I was experiencing a power outage. The answer was almost always, "No" because I received my electricity from a muni and did not experience power outages at the same time as my friends living in the neighboring town. This provided me with an interest in why towns would decide to provide electricity to its citizens instead of letting a large private utility provide that service. This study helped me understand the

difference between the two organizational structures and why towns still provide electricity themselves instead of selling their infrastructure and customer accounts to a large IOU.

In the second chapter, the relevant literature was reviewed. Some articles, such as Kwoka (2005a, 2005b) and Yatchew (2000) were reviewed due to their strong relationship to this study. In addition, Kwoka (2005a) was used in developing part of the theories presented in chapter three. In addition to articles being included for their similarity to the study, some were also included for their empirical methods, such as Farrell (1957).

Chapter three set the tone for the empirical research by providing the theories that were tested and analyzed in chapter four. There were four sections to the theory section: natural monopoly, a priori, economies of scale, and public owners' vs regulators. The natural monopoly section set out to define what a natural monopoly is, describe how electric distribution fit in to the natural monopoly definition, and explain how ownership structure could effect a natural monopoly. A priori means that a good or service's quality can be determined by hypothesizing what the quality will be. Kwoka's (2005a) theory was that public enterprises had an advantage when this was not the case. Economies of scale tend to affect IOUs more than munis, possibly for the fact that munis are restricted by local borders to grow in size. Finally, the theory about public owners versus regulators ended the chapter. This part of the theory stated that a private enterprise has to obey rules and regulations set forth by external regulators and a public owner may be able to better secure and understand information for the betterment of the customers instead of the regulator who is not directly involved in the business and does not interact with customers.

Finally, chapter four explains why the variables were chosen, explains the data set, explains the results of the regressions, presents data in a visual manner, and discusses any

problems with the data set, variables, and regression. The results of the first regression were problematic, because the small sample size does not allow for a great deal of confidence in the regression. This regression presents a model of how the regression would be run and analyzed if the data set was more complete. The second regression only included the public dummy variable. This was to show an analysis of the difference of means with a t-test. In section three of chapter four, graphs were presented comparing public and private ownership of different variables. The end conclusion of the data analysis is that IOUs in Pennsylvania charge a smaller amount to the customers than munis do; although munis have advantages in some areas, like customer density, that theoretically reduce the costs that get passed on to the customers. More data is needed to complete an accurate regression on the electric distribution industry in Pennsylvania.

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