An Analysis of the Privatization of Drinking Water Facilities in the United States

By

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MP Advisor's Signature

Abstract

The drinking water infrastructure in the United States faces significant underinvestment. The 2009 American Society of Civil Engineers Report Card on America's Infrastructure gave a D minus for the Nation's drinking water infrastructure (ASCE 2010). In a 2007 study, the EPA found a 20-year investment gap of $334.8 billion (EPA 2009). Degrading infrastructure and constrained finances have led cities and municipalities to consider selling, or privatizing, their drinking water services to for-profit companies.

Debate regarding the efficiency of public or private ownership lacks sufficient quantitative analysis to address two major concerns: water prices and infrastructure investment. Previous studies quantifying the impacts of ownership on drinking water utilities are dated or lacking financial analysis. This study uses survey data from 2002-2008 provided by the American Water Works Association and National Association of Water Companies[1]. Quasi-experimental design methods and statistical regression analysis provide a causal link between ownership and employment levels, operating revenue, and infrastructure investment.

Results of this study show ownership to have a significant impact on operating revenues and number of employees at a facility. Specifically, private ownership will increase operating revenues and decrease facility-staffing levels. However, public facilities regulated in a similar manner to private facilities show no statistical difference from private ownership regarding employment numbers. Ownership does not have a significant effect on infrastructure investment as approximated through depreciation expense and planned capital expenditures.

Analysis of the results emphasizes ownership to be neither the savior nor the downfall to issues in U.S water management. This study suggests policy-makers and advocates shift focus away from debate regarding privatization towards the proper management of water infrastructure. Future studies would benefit from analyzing management structures and incentives at drinking water facilities.

[1] I would like to thank both the AWWA and NAWC for graciously providing data for my analysis

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Introduction

"The newest wave for cash-strapped cities seeking money: Tapping their water" (Merrick 2010).

This beginning of a Wall Street Journal article from August of 2010 is referencing the influx of cash cities receive by selling their drinking water and wastewater services to private companies. In July of 2010, Indianapolis sold its facilities for $1.9 billion. The recession has caused cities and municipalities to seek new ways to raise funds and lower costs. Facing stagnated growth and a lower tax base, the pressure for governments to privatize drinking water resources has only increased.

Converting public drinking water facilities to private ownership is not new. Debate regarding the efficiencies of different utilities with regard to ownership has been occurring since the 1970's (Crain and Zardkoohi 1978; Bel and Warner 2008). However, the renewed attention on water ownership has reignited a debate in the United States regarding its efficacy and morality. Environmental groups such as the Food and Water Watch and Sierra Club have rallied against business control of drinking water supplies. Meanwhile, nonpartisan research groups such as the Pacific Institute have begged for caution and review.

Those groups hesitant of private control have a public paralleling their concern. In a September 2008 vote, Akron Ohio residents rejected the sale of their water infrastructure to a private company. Residents were hesitant towards the idea of losing control of their municipal services (FWW 2009). A four to one margin vote in June 2010 by Trenton, New Jersey residents rejected the sale of their city's water services for almost $1 million (Fried 2010).

There exists a growing need to analyze the causal implications of ownership on United States' drinking water infrastructure. The need stems from three facets of the privatization debate:

1. Under-substantiated claims
2. A dearth of contemporary analysis
3. Increased pressures towards privatization

As of 2010, more cities and municipalities are considering privatizing their water infrastructure than ever before (FWW 2010). Part of this debate is motivated by local government financial constraints exacerbated by the recent recession. However, the majority of peer reviewed data informing managers to the efficiency of private ownership in the United States dates back to the 1980's and 1970's (Bel and Warner 2008). Contemporary white papers both for and against privatization suffer interpretation limitations by lacking experimental design. Additionally, one must analyze the conclusions presented by partisan organizations in light of the strategic objectives carried by the groups.

The objective of this paper is to assess the financial, infrastructure, and efficiency implications of water privatization in the United States. I will accomplish this objective by using survey data to compare public and private utilities while controlling for observable characteristics. Through my analysis, I will contribute unbiased and statistically relevant material to the privatization debate. Additionally, I will be able to provide practical policy recommendations for improving and managing drinking water infrastructure.

The paper begins with an overview of the United States' drinking water infrastructure. Here I define "private" and "public" ownership, the relative size of each, and the general incentives encountered by both parties. I then explain the key arguments both for and against drinking water privatization and the academic literature supporting these arguments. A list of hypothesis regarding expected differences between public and private drinking water facilities follows.

With a clear idea of the arguments, I then explain the nature and source of the data I use for my analysis. Information regarding publicly owned drinking water facilities comes from three surveys conducted by the American Water Works Association (AWWA) through 2004 and 2008. I sourced the private ownership data used in the analysis from three financial and operational surveys conducted by the National Association of Water Companies (NAWC).

The analysis section of this paper shows the results of four separate regressions assessing the following attributes: operating revenues, employment, depreciation expense, and capital expenditures. In the analysis section, I justify my methods of analysis and interpret results. This paper concludes with policy recommendations and options for future research. I will argue that despite claims, few significant differences exist between public and private drinking water facilities. Similarly, I will recommend that we shift the policy debate from the benefits of ownership towards the methods of funding the Nation's degrading drinking water infrastructure.

Background Research

State of Water Infrastructure

What is the difference between "private" and "public"?

Before assessing the impact of ownership on the state of US drinking water systems, it is important to explain the definitions of ownership I will be using throughout the paper, the nature of the infrastructure system, and the challenges facing this system. The below table defines public and private ownership:

Table 1: Definitions of Public and Private Drinking Water Facilities

Public Utility	Private Utility
Any not-for-profit owned and controlled drinking water utility including those run by municipalities, cities, nonprofits, homeowner associations, state government, and federal government.	Any for-profit drinking water facility. Ownership equity may be traded either publicly (as in the stock market) or privately.

I define privatization as the "transfer of some or all of the assets or operations of public systems into private hands" (Institute 2005). I do not include forms of public-private partnerships as an indication of privatization or private ownership as the survey data does not make such a distinction. Public-private partnerships often occur when a private company obtains operational responsibility of a utility but does not retain ownership. My analysis only compares ownership.

Size and Percentage Private

The United States' drinking water infrastructure covers 280 million people with 80 million residential connections. There are 49,133 community drinking water (CDW)systems in the United States as of 2006 (EPA 2009). For-profit drinking water facilities operate a little over 10% of all community drinking water systems in the United States (NAP 2002)[2]. This encompasses 15% of the 280 million people served by U.S. drinking water infrastructure using over 38 billion gallons of water per day.

A Capital-intensive Operating Environment

Drinking water infrastructure is the most capital-intensive utility sector in the United States (as based on revenue). In 1998, the ratio of net utility plant[3] to operating revenues for water utilities was 3.52. This is twice as capital-intensive as the next most intensive utility sector of electricity at 1.51 (NAP 2002). The EPA estimates 10-17% of capital expenditures go to meeting compliance (EPA 2009, 2009). Thus, the purpose of the majority of capital expenditures for water utilities is to maintain and expand water distribution infrastructure.

Relative investment in water infrastructure has been decreasing over time. From 1956 to 2008, water supply utilities in the U.S. spent a combined $788.4 billion in 2008 inflation adjusted dollars on capital investments alone (Anderson 2010). For comparison, revenues from water sales in 2006 were $47 billion (EPA 2009). The extreme expense associated with building infrastructure and transporting water drastically limits the possibility of competition in the water utility sector. A utility's investment in capital infrastructure remains an important indicator for the long-term health of the facility. The need for infrastructure investment should only grow over time; 20% of water distribution mains are over 40 years old and will need replacement in the coming years (Anderson 2010).

Degrading Infrastructure

Although drinking water facilities face tremendous pressure to invest in infrastructure, such investment has lagged dramatically. The 2009 American Society of Civil Engineers Report Card on

[2] Of the 49,133 community drinking water systems in the United States, 24,847 are publicly owned. Not all "non-publicly owned" CDWs are owned by for profit companies. A significant portion of utilities is owned by nonprofits and homeowner associations.

[3] Net Utility Plant is the sum of all capital infrastructure for a specific utility minus depreciation. For a drinking water facility, this would include the treatment plant and distribution system. A ratio of 3.52 compared to operating revenues means that water utilities maintain infrastructure valued 3.5 times the amount of their yearly operating revenues.

America's Infrastructure gave a D minus for the Nation's drinking water infrastructure (ASCE 2010). They site an annual investment shortfall of $11 billion.

A 2007 EPA survey finds a more drastic investment need with a 20-year investment gap of $334.8 billion (EPA 2009). The investment gap represents the difference between needed infrastructure investment and actual planned infrastructure investment. This high figure may even be an underestimation of investment needs. The survey only analyzes Drinking Water State Revolving Fund (DWSRF) compatible investments. These investments do not include capital investments for population growth.

The current investment environment for drinking water utilities shows an increased pressure towards drinking water privatization. The sale of a public utility represents a quick influx of cash for municipalities and cities whose tax-base has shrunk with decreased housing values (Starmer 2011; Merrick 2010). For facilities in need of great capital investments, privatization helps transfer the burden of responsibility to the for-profit utility.

Funding a Drinking Water Facility

Essential to the background information regarding U.S. drinking water infrastructure is the ability of utilities to raise funds for capital investment. As stated earlier, water utilities are the most capital-intensive utility of all public services. This study highlights three main sources of funds for drinking water infrastructure investment and the relative accessibility of these funds for both private and public facilities.

REVENUES

The majority of dollars used to fund capital improvements for drinking water facilities in the United States comes directly from revenues associated with water bills (EPA 2009). Public and private utilities have varying degrees of flexibility with regard to raising rates to cover the cost of supplying and investing in drinking water. While most private utilities must file a rate case with a state utility commission, public utilities seek approval through a governing body at the city or municipal level. Later sections of this paper will cover the relative incentives to raise rates for infrastructure investments between public and private utilities.

Municipal Bonds

Public utilities as a whole (including electric, telecommunications and water) encompassed 10% of the $3 trillion municipal bond market in 2009 for all forms of investment (Leurig 2010). Municipal bonds are only available to public drinking water utilities. These bonds are the issuance of debt to cover infrastructure investment. In general, bonds are backed by the revenue generated from drinking water sales (Walter 2009). Some claim municipal bonds to be the largest single federal subsidy for municipal water. Tax-free interest on the bonds allows municipalities to set lower rates than similarly-rated bond issuers (Anderson 2010).

Drinking Water State Revolving Fund (DWSRF)

Created in 1997, the DWSRF provides low interest loans to public drinking water facilities. States provide a 20% match to grants given by the Federal government. States then give the loans to local utilities. The interest from the loans goes back to the revolving fund (ASCE 2010). Eligible projects do not include infrastructure expansion for population growth but do include compliance and public health investments as well as loan repayment assistance. Not all states allow privately owned drinking water utilities to use DWSRF loans.

Peer Reviewed Literature

The privatization-prone state of U.S. water infrastructure makes the topic a prime candidate for academic study. Peer-reviewed literature on drinking water privatization in the United States dates back to the 1970's and 1980's when privatization first became prominent. U.S. studies tend to be location specific (such as only using data from Southern California) with a focus on efficiencies and competition. Water rate data, possibly due to inconsistencies or inaccessibility, does not play a major role in these studies. Contemporary studies tend to focus on international privatization issues. European studies highlight the price implications of privatization. Studies in developing countries focus primarily on the impacts of privatization regarding health and accessibility.

I have organized the peer review literature into four sections: efficiency, compliance, incentives and international. The first three sections analyze literature studying only U.S. water facilities.

Efficiency

One supporting argument for advocates of drinking water privatization rests on efficiency. The profit motive creates an incentive for private utilities to reduce cost. Previous research stands inconclusive with regard to this argument. A 1987 article by Teeples et al. analyzed the cost of delivering water for a number of drinking water systems located in southern California. The study found private ownership in this location to have no significant impact on the cost of delivering water (Teeples and Glyer 1987).

A 1995 paper by Bhattacharyya et al. argues that size combined with ownership does influence efficiencies. The study uses 1992 American Water Works Association (AWWA) survey data that includes 190 public and 31 private facilities[4]. Results of the paper state that small private utilities are comparatively more efficient than their public counterparts in delivering water. However, large private utilities are comparatively less efficient than large public utilities. The authors estimate production

[4] Note: the same data source is used in the analysis for this paper

efficiency using the stochastic frontier methodology. On average, the cost-inefficiency levels of private firms are higher than that of public firms (Bhattacharyya et al. 1995).

Academic studies analyzing ownership and efficiency do not exclusively compare costs. A 1986 study by Byrnes et al. compares ownership based on production. The authors define technical efficiency as output per unit of input. Generally, this involves analyzing the amount of water lost in a system. Measured output was millions of gallons of water delivered in 1976. Measured inputs included ground water, surface water, purchased water, miles of pipeline, part-time labor, full-time labor, and storage capacity. This study found no differences with regard to operational efficiency (Byrnes, Grosskopf, and Hayes 1986)

Compliance

A 2008 study by Wallston and Kosec use fixed-effects and panel data to discern the impacts of ownership on the number of Safe Drinking Water Act (SDWA) health and reporting violations. The analysis controls for income, share of population that is urban, ownership concentration, system size, water source, and year fixed effects. Results of the study shows ownership to have no significant impact on health violations (Wallsten and Kosec 2008).

Incentives

A 2002 paper by Timmins attempts to recreate the utility function of a municipal water manager in California. Each public utility acts like a private enterprise where shareholders are not owners of “stock”, but residents served by the water system. Municipal managers do not necessarily attempt to maximize profit (as we would expect a private facility to do) or net social surplus. They have an incentive to both lower the tax burden and earn profits. This potentially limits the incentive of managers to invest in infrastructure.

Lacking from this analysis is a study of relative preference to competing interests: do customers react more strongly to higher tax bills or higher water bills? If customers react more strongly to higher tax bills, we would expect to see higher water bills to cover costs and earn profit. If the reverse is true, we would expect water bills to not even cover the cost of operation (Timmins 2002).

A similar study conducted almost 30 years earlier analyzes the incentives of public drinking water facilities compared to private as based on the transferability of property rights (Crain and Zardkoohi 1978). The authors distinguish the characteristics of the owners for public and private drinking water utilities. In a public utility, the owners are the taxpaying citizens. These individuals have minimal power to actually sell their ownership stake or transfer their property rights to someone else. Thus, the individual citizen has less incentive than a shareholder of a privately traded company to ensure efficient operation.

If one were to consider politicians as the true shareholders of a public utility, it becomes important to consider the tenure of the political office. Politicians have an incentive to maximize the net benefits accrued during their tenure. Such motivation could drastically hinder the efficient operation of a public utility. The authors analyze 23 private firms and 88 public firms between 1965 and 1970. Using a Cobb-Douglass production function, the authors show that private firms require fewer employees to obtain an equal increase in output than publicly owned facilities.

Lessons regarding the power of ownership may be expanded to a discussion on competition. For public utilities, competition does not exist in the traditional sense. Citizens have limited ability to switch water suppliers if unhappy with the service. Benchmark competition could exist with utility managers in a proximate region. Wallsten and Kosec's 2008 article described above found benchmark competition to have a significant impact on SDWA violations. Greater competition led to fewer violations (Wallsten and Kosec 2008).

Competition also has the ability to create political pressure to benchmark rates to those of neighboring water systems. A 2009 study in North Carolina found water rates to be positively and significantly correlated with those in neighboring regions (Thorsten, Eskaf, and Hughes 2009). Since

State utility commissions often regulate private utility rates, it remains unclear if this correlation would follow for private ownership.

International

The majority of international studies focus on health or price (Olmstead 2010). One exception is a study for the World Bank in Asia regarding water utility ownership. A study by Estache and Rossi uses 1995 data from 50 water companies in 29 Asian and Pacific countries and attempts to discern the relative utility of ownership. The analysis confirms older U.S. studies showing no significant difference in efficiencies as based upon ownership (Estache and Rossi 2002).

Studies in Europe tend to focus on prices and productivity. One study in England shows no increase in productivity as a result of the privatization of the water industry in that country (Saal and Parker 2001). A study analyzing the privatization of water in Spain shows a positive and significant effect on prices (Martinez-Espineira, Garcia-Valinas, and Gonzalez-Gomez 2009).

Health benefits appear to be the greatest supporting factor for the privatization of drinking water facilities in developing countries (Olmstead 2010). Galiani et al. use a difference-in-differences model to depict the causal impact of municipalities privatizing drinking water services in Argentina in the 1990's. The model suggests an increased reduction in childhood mortality of 8% for municipalities that privatized. In low-income areas, the results are more drastic: a 26% decline in child mortality.

A separate study conducted in Argentina, Bolivia, and Brazil surveyed households before and after water privatization in their communities (Clarke, Kosec, and Wallsten 2009). The authors find scant evidence to prove privatization controls any impact on the amount of service or quality provided to residence. Their results do suggest, however, the possibility that private competition could provide a benchmark for public utilities to in-turn increase performance standards.

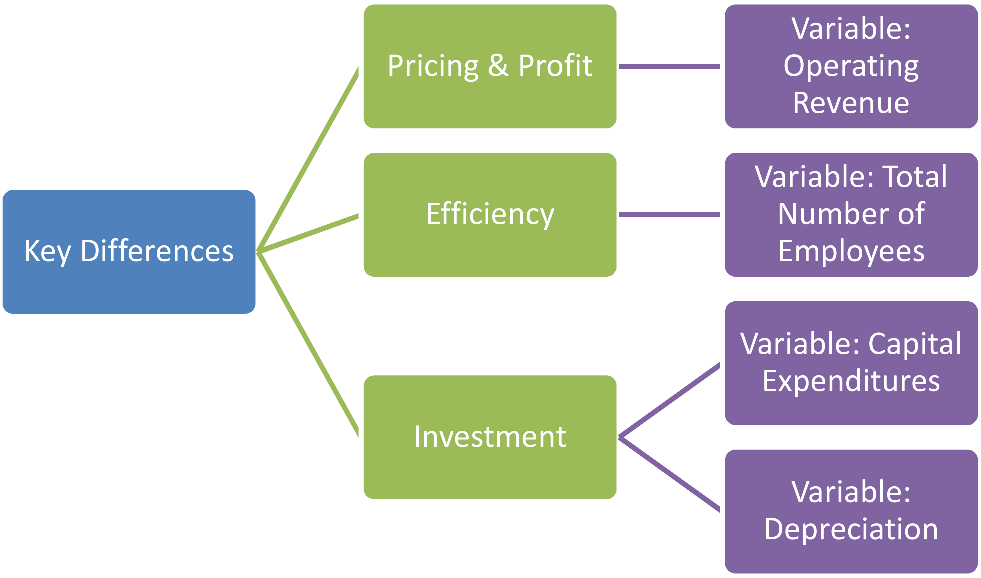
Overall, the academic literature makes important inroads in the privatization debate. Literature on U.S. systems shows that while incentives between ownership styles may differ, impacts on efficiency and compliance remain inconclusive. Internationally, privatization has been shown to increase prices in Spain and possibly decrease childhood mortality in South America.

Renewed interest in the privatization debate provides this study the opportunity to make a contemporary contribution to the existent pool of literature. Only one U.S. study that compared private and public ownership used data from the 21st century. This study used SDWA violations as a method of comparison (Wallsten and Kosec 2008). Concern over privatization, however, moves beyond compliance issues towards concerns of price and infrastructure investment. This paper contributes to the academic literature not only by providing a contemporary analysis of the ownership debate, but though its analysis of ownership's impact on prices and investment.

Hypotheses

I have hypothesized three key differences between public and private drinking water facilities. The following diagram summarizes these differences:

Figure 1: Key Hypothesized Differences as Based Upon Ownership



Hypothesis on Pricing and Profit

Higher Operating Revenues for Private Ownership

Much of the privatization debate in the public sphere rests on the appropriateness of private entities profiting from a fundamental human need, water. Authors note the moral complications municipalities face when deciding to allow a private company to earn revenue on a historically municipal-controlled service (Starmer 2011; FWW 2009). However, scant peer-reviewed research has analyzed revenue in relation to ownership.

Pricing and profit differs for public and private drinking water facilities due to both regulation and incentive. While a state public utility commission usually designates the rates and profit allowed for a private utility, a local governing body will often determine public utility rates. While private utilities operate on incentives governed by contracts and shareholders, public utilities operate on incentives governed by the tax-base and elected officials. These incentives and regulations provide the foundation by which operating revenues at a facility may differ due to the ownership of that facility.

According to the EPA, operating revenue can cover both direct water sales and indirect water related revenue. Water-related revenue can include connection fees, service fees, and fines. Public systems obtain approximately 15% of their revenue from water-related sources. Private facilities obtain less than one tenth of one percent.

My analysis uses operating revenue data for public and private facilities to approximate the supply price of water system services. Although public utilities obtain a greater proportion of revenue from water fees, we still can benefit from an analysis of operating revenue as a proxy for water prices. Holding the amount of water sold equal, we can determine approximately how much a utility receives per unit of water sold (including fixed fees)[5].

The operating revenue variable does not face the same complications as an income variable due to its uncomplicated correlation with water sold. Income may be correlated with various, unobservable, expenses related to the utility. We may expect public and private utilities to differ regarding these costs. Indeed, we would not expect a perfectly healthy and profitable facility to be as readily sold to a private utility as an under-maintained facility.

Some literature leads us to expect higher revenues in private facilities. A study by the Food and Water Watch shows private water facilities, at face value, to have higher prices than their public counterparts (FWW 2009). Two obvious reasons to see higher prices relate to taxes and profit motive (Institute 2005; Teeples and Glyer 1987). Unlike public municipalities, private investments are not tax exempt in their ability to issue debt. This raises the cost of developing infrastructure and may mandate higher rates (and thus revenues).

[5] Due to fixed fees, any significant and positive effect private ownership has on operating revenue will be a conservative estimate with regard to the water rates.

Private facilities face a profit motive that may incentivize increased prices and revenue. Although often regulated by state-wide utility commissions, private drinking water facilities are allowed a level of profit (NCUC 2009). Public utilities may encounter a similar profit motive if municipalities use the facility to fund ancillary public services. However, this motivation must outweigh the incentive to keep resident tax burdens low. Considering the above information, it appears rational to believe private drinking water facilities in the United States should maintain a higher level of revenue.

Hypothesis on Efficiency

Lower Employment Levels for Private Ownership

While testing operating revenue helps compare ownership based on price, testing employees helps analyze efficiency. The bulk of the historical peer reviewed literature focuses on efficiencies as they relate to ownership. In a 1986 paper, Byrne et al. measure water output as based on a variety of inputs including full and part time labor (Byrnes, Grosskopf, and Hayes 1986). While the study uncovers no difference in operating efficiencies as based on ownership, it does raise questions regarding the nature of hiring and firing practices in public facilities. Generally, we expect private utilities to have greater flexibility in determining the level of employment at a plant.

Policy memos and peer reviewed papers support the concept that publicly owned facilities retain higher levels of employees holding all else equal (Institute 2005; FWW 2010). Two case studies reported by Crane and Zardkoohi find productivity per employee to drop when a private facility became publicly owned and rise when a separate public facility became privately owned (Crain and Zardkoohi 1978). Though these case studies are limited in their scale of interpretation, the findings reflect expectations regarding employee productivity.

The Pacific Institute notes that public facilities should be more prone to inefficient staffing situations due to the government's limited ability to hire and fire staff. In this situation, we expect public facilities to carry more employees per measured unit of output than their private counterparts carry. However, incentives for municipal managers of water utilities to keep tax burdens low may create a more frugal system of hiring (Timmins 2002). This paper's analysis of employment levels will attempt to determine the relative weights of these competing incentives.

For privately owned facilities, rate-of-return regulation may entice lower employment levels. In many cases, private utilities may only make profit on equity investment for capital expenditures. Therefore, the utility has incentive to invest in capital, not labor, intensive projects. This incentive combined with the government's limited encouragement to change employment levels leads to an expectation that privately own facilities will maintain lower levels of employment.

Hypothesis on Investment

No Difference in Planned Capital Expenditures

In 2007, the EPA issued its findings from a Drinking Water Needs Survey. This survey describes the capital investment needed to maintain the country's drinking water infrastructure. The paper pegged the 20-year infrastructure investment need at $334.8 billion (EPA 2009). Large community water systems (the bulk of the survey data used in this analysis with over 100,000 customers) require$116 billion in additional investment. Only 16% of costs actually involve meeting drinking water regulations. The majority of investment required encompasses water transport infrastructure needs (EPA 2009).

Relative to operation and maintenance expenses, capital expenditures have decreased over time (Anderson 2010). Historical financial data support this claim for public utilities. In the 1950's through the 1980's, the majority of expenditures for U.S. water infrastructure involved capital outlay. This was predominately due to the Federal government's construction grant program that subsidized investment in water infrastructure in local communities. In 2008, operating and maintenance expense accounted for 58% of municipal spending compared to just 37.5% in 1956.

Since the construction grant program's closure, the primary methods for subsidizing water infrastructure investment involve the Safe Drinking Water State Revolving Fund (DWSRF) and the Federal Treasury. The DWSRF provides low interest loans to municipalities. Interest accrued from loans flows back into the fund. Congress has provided approximately $10 billion in assistance through this program though it only relates to 4% of capital expenditures in municipalities. The Treasury subsidizes capital expenditures in allowing returns from municipal bonds to be tax-free. This provides municipalities the opportunity to offer lower interest rates(Anderson 2010).

Similar government incentives for capital investments do not exist in for-profit facilities. Any financial incentive for infrastructure investment comes from rate cases. Public utility commissions generally do not allow private facilities to profit from debt services or operating costs. However, utilities may earn a rate of return from equity investment. With typical debt structures involving 50% bonds and 50% equity, an average utility may profit from half of capital expenditures (Sugarman 2011).

It should be noted that such allowed profit does not stem from "planned" capital expenditures. Equity investment in a rate case only counts for projects already in the ground. Private utilities do not have an incentive to overinflate expected capital expenditures. Private utilities *do* have an incentive to invest in infrastructure. This is the private utility's only allowed method of profit. If the private facility has a form of rate regulation different then a rate of return system, incentives may shift towards underinvestment and cost cutting. For example, a fixed-fee increase system where fees increase only with inflation would incentivize cost cutting for increased profit margins (Institute 2005).

Publicly owned facilities do not share the same incentives for infrastructure investment. Although tax-free municipal bonds and the DWSRF supports infrastructure investment, pressure to keep tax burdens low and limits on debt levels may reduce the ability of public facilities to engage in infrastructure development. Public utilities issue high levels of debt; in 2009 public utilities comprised "10% of the nearly $3 trillion municipal bond market in daily trading volume" (Leurig 2010). Both public and private drinking water facilities retain access to DWSRF loan monies. However, such monies retain much greater significance for public utilities. In 2006, DWSRF loans accounted for only 2% of capital investments for privately-owned drinking water utilities; meanwhile for public utilities it accounted for over 14% of monies invested (EPA 2009).

In times of high property values, it may be easier for municipal managers to receive tax revenue for capital improvements. However, an annual debt service coverage ratio (ADS) limits the ability of municipal facilities to take out debt. The ADS is a ratio of revenue compared to principal and interest payments. For many utilities, an ADS may not fall below a ratio of 1.1-1.3 (Leurig 2010). With the rise in property values between 2000 and 2006, public utilities saw an increase in capital expenditures. During this time, the percentage of public utilities that invested in capital projects went up. For private utilities, it actually went down (EPA 2009).

The capital expenditure variable in this analysis is *planned* capital expenditures. As this represents prospective and not actual investment, we may expect reporting biases to limit the interpretation of our material. How reporting biases may influence public and private facilities depends on hypothetical incentives for utility managers. Public utilities seeking federal funds through the DWSRF may have an incentive to overestimate infrastructure investment needs. Higher needs reflect a higher access to funding sources at least at the macro state level. As private utilities cannot profit from "prospective" capital investments, we would not expect an upward bias in estimation.

Table 2: Summary of Expected Biases Regarding Capital Expenditures

Category	Publicly Owned	Privately Owned
Actual Capital Expenditures	*Incentives for investment:* Equity investment by facility allowed to earn rate of return *Incentives against investment*: In a fixed-fee increase system, incentives focus on cost cutting	*Incentives against investment*: Municipal managers may be constrained by the amount of debt they may take out for the facility. Pressure to keep tax burden low may incentivize underinvestment as well. *Incentives for investment*: Government support structure including Treasury and DWSRF
Planned Capital Expenditures	*Incentives for over-estimation:* None	*Incentives for over-estimation*: Higher estimates of capital expenditures may increase access to funds.

Table 2 summarizes the conclusion that no single overriding incentive should cause ownership to have a significant impact on capital expenditures. While private utilities may have a greater incentive to invest in infrastructure for profit, public utilities have stronger incentive for higher levels of planned investment. While the government subsidizes capital investments for publicly owned facilities, no such incentive exists for private utilities. With no concept regarding the relative weight of these competing incentives, one may conclude that ownership should have no significant impact on investment.

Higher Levels of Depreciation Expense for Private Ownership

Another method for discerning infrastructure investment involves analysis of depreciation expense. Depreciation is an expense used to delineate an asset's useful life. As used in this analysis, depreciation provides a useful approximation of a utility's intention to invest in capital projects. The term acts as a key component for signaling the actual cost of operating a drinking water facility. Higher depreciation costs require more revenue from water sales so facilities may later invest in plant upgrades.

Through indicating the true-cost of operation, depreciation places pressure on utility managers to invest and upgrade infrastructure. Depreciation may therefor create pressure for increased rates to customers in order to pay for upgrades. This paper analyzes depreciation for its importance in assessing the true infrastructure-related health of a utility. Higher depreciation levels indicate more capital investments in a facility. Where planned capital expenditures estimates future investment in a utility, depreciation helps estimate past investment and future need for investment.

Depreciation expense may differ by ownership due to the separate reporting requirements faced by public and private drinking water facilities. Municipalities are generally exempt from Securities and Exchange Commission (SEC) reporting regulations while issuing bonds. This includes bond issuances for drinking water facilities (Leurig 2010). In a 1975 ruling known as the "Tower" amendment, Congress prohibited the SEC from forcing municipalities to disclose specific financial data or follow general accounting principles (Walter 2009).

The "Tower" amendment provides publicly owned utilities the leeway to alter reporting of depreciation expense. If utility managers have an incentive to keep the public's tax burden low, then managers will likely underreport depreciation. Lower depreciation values artificially increase balance sheet assets and allow, for book purposes, the deferment of plant upgrades. A study in North Carolina showed a direct correlation between cost and pressure to increase revenue through rate increases. The political unpopularity of rate increases further discourages true depreciation accounting (Thorsten, Eskaf, and Hughes 2009). Higher depreciation expense for private utilities in the analysis should account for this reporting discrepancy.

Data Management and Exploration

I have gathered survey data from two industry sources: the American Water Works Association (AWWA) and the National Association of Water Companies (NAWC). This section describes the nature and purpose of these organizations as well as a background on the data received from both entities.

American Water Works Association

The American Water Works Association is an industry association for water and wastewater professionals. By holding conferences, issuing studies, and gathering data, the organization seeks to advance knowledge on water management[6]. The AWWA accomplishes this goal by tapping the field of knowledge generated by its 60,000 worldwide members. Part of the knowledge sharing process includes a bi-annual water and wastewater rate survey called "Water:\Stats".

Although the AWWA has conducted this survey since 1996, the Association revised and improved the survey in 2002. The AWWA compiles and makes available the data through a Microsoft Access format. This format simplifies an individual utility's ability to benchmark its performance against similar plants. Data acquired by the water survey includes financial, operational, size, and rate data. The majority of these data are of little value or too specific for the purposes of this study.

National Association of Water Companies

The NAWC is an industry association representing for-profit water companies[7]. While the main mission of the organization stands to advance the interests of the private water industry, the NAWC also conducts benchmarking analysis. Every year the organization issues a "Financial and Operations" (F&O) survey for member companies. Annual survey data exist from the mid 1990's through the present.

Data submitted to the F&O survey include general accounting and size variables. All information is collected and distributed in a Microsoft Excel file. Unlike the AWWA survey that predominately

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[6] More information regarding the organization may be found online at www.awwa.org (Visited 24 February 2011)
[7] Further information regarding the National Association of Water Companies may be found at www.nawc.org

focuses on operational metrics such as meter size and rate structures, the F&O maintains a focus on financial solvency and the balance sheet.

Since the AWWA and NAWC surveys utilized separate file formats, the data formatting process was extensive. The data cleaning and sorting process may be found in the appendices of this paper.

Data Exploration

Table 3: Variables by Category

Category	Variables	Description
Time	Balance Year	Year relating to financial information
Ownership Type	Public (including: Government Water District, Homeowner's Association, City or Municipality, and County) and Private	Type of ownership. Public variable includes all forms of nonprofit ownership such as government district, county ownership, and city ownership
Facility Size[8]	Population Served, Total Customers Daily Production Capacity, Maximum Daily Water Delivered to System, Number of Employees	Describes size of the population served by the utility and the facility size needed to serve the population
Water Production	Total Water Sold (year), Wholesale Water Sold (year), water source (ground, surface, purchased)	Amount of water delivered to the system in a year and the source of this water by percentage. Does not include water loss.
Financial	Operating Revenues, Operation and Maintenance Expense, Non-Operating Income, Net Income, Total Assets, Current Liabilities, Long Term Debt, Equity, Capital Expenditures, Depreciation	Available financial descriptions of the facilities.

The above table shows the categories of variables, including descriptions, to be used in the analysis. I divided the variables by ownership, size, production, and finances. Generally, the variable descriptions are straightforward. A problem occurs, however, when attempting to determine the proper way to compare capital expenditures for public and private facilities. Both the AWWA and NAWC surveys project Gross Capital Expenditure (GCE) entries between 4 and 5 years into the future.

[8] All references to water consumption is in Millions of Gallons (MG)

Analyzing each year appears unnecessary. Instead, this analysis compares GCE over two formats: closest year approximation and projected sum. The below table explains these formats:

Table 4: Gross Capital Expenditure Format Explanations

Format	Explanation	Method
Closest Year Approximation	Analyzes ownership based on the closest gross capital expenditure entry to the survey year in question. For example, the 2002 survey in this dataset has the nearest GCE entry at the year 2004. Analysis for the 2002 survey will be at this entry. The purpose of this test is to compare ownership to the closest approximation to actual capital expenditures at the year of the survey.	A new variable is created that includes only the closest GCE for each survey year.
Projected Sum	Analyzes ownership based on the summation of GCE across all years in the survey projection. For example, the 2004 survey will include the years 2005-2009. The purpose of the "projected sum" stands to analyze the scale of future capital planning for a utility.	A new variable is created that includes the sum of planned GCE for the relevant survey year.

Table 5: Mean Values and Standard Deviation for Dependent Variables in Analysis

Ownership	Operating Revenues	Employees	Depreciation Expense	Gross Capital Expenditures Closest Year Approximation	Gross Capital Expenditures Sum
Public	58,700,000	199	10,500,000	31,600,000	134,000,00
Std Deviation	125,000,00	344	28,900,000	97,200,000	384,000,000
Private	69,700,000	172	8,710,038	23,300,000	110,000,000
Std Deviation	98,100,000	217	12,800,000	37,800,000	184,000,000
Total	60,700,000	195	10,200,000	30,300,000	130,000,000
Std Deviation	120,000,000	326	27,000,000	90,300,000	360,000,000

For space economy, I have not included descriptions of all variables in the dataset. Detailed descriptions of all the variables may be found in the appendix section of the paper. Additionally, the appendix contains summary data divided by survey year and survey source (AWWA or NAWC) for operating revenue, employment, depreciation, and capital expenditure variables. I have also included summary data for all variables in the analysis.

The table shows the type of survey respondent to be bias towards larger facilities relative to the national composition of drinking water utilities. According to the EPA, 82% of facilities serve 3,300 persons or fewer. None of the 887 facilities in the dataset serves a population less than 3,300 individuals. The summarized data also reveals significant variation in all dependent variables. This is unsurprising since the size of a drinking water facility in the U.S. will vary drastically by population.

Exploring Relationships in the Data

It is useful to explore the behavior of the data as they relate to variables in the dataset. Unusual relationships may reveal inconsistencies in the data collected by the two surveys and limit our ability to compare public and private utilities for this study. Here I explore three relationships: how ownership relates to community variables, how finance variables relate with water sold, and how facility size relates to population served.

I define community variables as those that describe the physical environment in which the facility operates and through which the facility has little input in determining. For example, a facility has little choice with regard to the population size of the community it serves. If these variables differ by ownership in unexpected ways, we may worry that there is something different about the survey respondents from the total population of facilities. The following tables show these expected relationships and the results from testing this relationship. I tested these relationships by running a correlation test through STATA. The correlation table confirms all hypotheses at a 0.5% significance level.

Table 6: Hypothesized Relationships between Ownership and Size Variables

Variable	Relationship	Explanation
Population Served	None	Although the majority of privately held facilities serve less than 10,000 residents, few responses for either survey contain small population sizes. With large-population respondents, there should not be a difference between ownership and population served
Total Water Sold	None	Facilities cannot "advertise" water. Although utilities may have marginal control regarding incentives for water use, this difference should not prove significant
% Groundwater	Positive for private facilities	The EPA notes in its community water system survey from 2006 that private facilities source more water from the ground relative to public facilities.
% Residential Customers	None	Facilities tend to have a higher percentage of residential customers at smaller sizes. Without a size difference, we should not expect a difference between ownership and this variable.

Table 7: Calculated Correlation Coefficients for Size Variables

Variable	Correlation Coefficients with Private Ownership	P-value
Population Served	-0.035	0.2995
Total Water Sold	-0.0246	0.4728
% Groundwater	0.1459	0
% Residential Customers	0.042	0.2124

Financial variables should relate positively with the amount of water sold in a system. Increasing water sales indicate increasing revenue, expenses, and necessary capital investment. Similarly, higher population levels should indicate greater facility size to meet the needs of the population. Running the same test as above shows all financial variables in the dataset to correlate positively with total water sold and all size variables to positively correlate with population size with a p-value equal to 0.000. This test, alongside a series of graphs representing this positive relationship may be found in the appendix of this paper. The two graphs provide extended confidence that the data used for this analysis are well behaved and generally vary linearly with outcomes of interest.

Analysis

The following sections of this paper use the previously explained data to discern differences between public and private drinking water facilities across revenue, employment, expenditure, and depreciation variables. To accomplish such a comparison, this analysis uses ordinary least squares (OLS) regression as a quasi-experimental design technique. The reason I use quasi-experimental design lies in the desire to analyze ownership on a single outcome of choice without confounding by other observable variables.

In an ideal design, we would observe the same facility at the same time under different ownership conditions. The ideal experiment would randomize ownership. We would then know that any difference in mean outcomes between the two ownership groups would be due solely to ownership. In such a world, we retain that treatment is ignorable; absent any difference in ownership, the potential outcomes of our two groups is the same. Neither is feasible. Since this cannot happen, we must use principles of quasi-experimental design to generate a scenario that is as good as random assignment.

In order to make a defensible comparison between ownership types, we must control for observable variables such that treatment (in this case ownership) is once again ignorable. These observable variables should be predetermined with respect to ownership; meaning the value does not depend on ownership. For example, we may believe that the size of the population served varies based on ownership simply because larger municipalities are more apt to sell their drinking water facilities to private companies. However, ownership does not directly determine population served. If we were to compare total revenue by ownership type without taking into account population size, we would have an invalid estimate.

Ideally, the analysis in this study would be controlling for both observable and unobservable characteristics of drinking water facilities. Unobservable characteristics are non-measurable aspects of a utility that influences both ownership and an outcome of interest. Indeed, we may believe that municipalities and cities *only* sell their drinking water facilities to private industry due to specific, unobservable, conditions. A common method for controlling for unobservable characteristics involves the creation of fixed, time invariant, effects for facilities; thereby measuring only those variables that change over time (Galiani, Gertler, and Schargrodsky 2005). Unfortunately, the data available for this study does not contain the consistent entries necessary for such an analysis[9].

The design of this study uses OLS as the estimator of choice. Using OLS raises two important assumptions: the causal response of the treatment is linear and the only meaningful differences between public and private utilities are observable. Unobserved impacts on the dependent variable will be found in the error term of our estimates. The error term in the equation estimated by this study cannot be correlated with ownership type.

Hypothesis 1: Operating Revenues

Equation and Test

Testing the impact of ownership on revenue requires running a simple OLS regression with revenue as the dependent variable and a string of observables, including ownership, as the independent variables. The following table shows the list of independent variables and the expected association with revenue. I include this table next to the regression analysis for ease of comparison.

[9] The data averages approximately 1.3 entries per pool, which is not much of a panel at all

Table 8: Expected relationships between variables and operating revenue

Independent Variable	Category	Association	Justification
Private Ownership	Ownership	Positive	See above material
Population Served	Size	Positive	Higher amount of water sold
% Residential Customers	Size	Positive	Signifies less wholesale water sales and more residential water sales which may lead to more revenue
Daily Production Capacity	Size	Positive	Signifies greater need for water
Total Water Sold	Size	Positive	Higher sales signify higher revenues
Water Source	Source	Mixed	Groundwater, if more expensive to pump, could lead to higher water prices and thus higher revenue. Purchased water should lead to higher revenue as costs should be higher
Time Variable Dummies	Time	Higher at higher values	Prices should increase over time and would be unlikely to decrease

Table 9: Regression of Operating Revenue[10]

	Coefficient Estimate	Standard Error		
Privately Owned	24,100,000***	4,531,726	Number of Observations	743
Population Served	104.4264***	20.30754	F(9, 733)	19.83
% Residential Customers	98,300,000***	2.76E+07	Prob > F	0
Daily Production Capacity	785.0257	2944.922	R-squared	0.753
Total Water Sold	569.0809*	313.8211	Root MSE	5.80E+07
% Groundwater	(-7,380,080)*	4,242,126		
% Purchased	9,860,546**	4,794,004		
2007	25,800,000***	5,875,076		
2004	6,830,616	4,246,877		
Constant	(-97,600,000)***	3.29E+07		

[10] For all tables explaining regression analysis: All standard errors are robust for heteroskedasticity. Asterisks denote significance: ***=0.01; **=0.05; *=0.1

Analysis of Regression

Table 9 shows the results of a regression analysis using yearly operating revenue as the dependent variable. A dummy variable signifies private ownership with a value of one equal to private ownership and zero equal to all other forms of ownership. Private ownership shows a positive and highly significant correlation with operating revenue; in this case, a transition from public to private ownership can anticipate a $24 million increase in operating revenues.

All coefficients except groundwater-sourced waters follow the hypothesis mentioned above. Such a discrepancy may be due to unobserved relationships between water source and price or data entry errors. Importantly, purchased water shows a significantly positive correlation (at a 5% significance level) with operating revenue. Such a relationship makes intuitive sense, as the higher price of purchased water must relate to higher water prices for consumers.

Some concern may exist to over-defining and losing significance of common variables. Both total water sold and population served have a positive and significant correlation though total water sold is only significant at the 10% level. One can justify leaving both variables in the regression despite the potential for multicoliniarity. Both may affect operating revenues in different ways. For example, higher population centers may relate to lower (or higher) prices due to infrastructure costs. However, higher levels of water sold can also relate to lower price pressures and relatively smaller revenues. If the regression is run again sans the population variable, total water sold becomes significant

Private ownership shows significance with a p-value less than 0.000. This tentatively confirms observations within the environmental advocacy community concerning higher prices coinciding with private ownership. Analysis is limited, however, to confirming higher prices. A dearth of location information in this dataset limits our ability to determine affordability as it relates to ownership. From a social perspective, we may be more concerned about affordability than revenue. The ethical nature of higher prices for drinking water sources becomes limited without affordability data[11]. If utilities offer affordable water prices for a community, higher water prices could lead to lower rates of water consumption or increased monies for investment in water infrastructure.

Additional Tests

Ownership data provided by the AWWA specifies ownership beyond simple public and private terms. We may be interested in defining the impacts of a variety of forms of public ownership. Teeples found that specifying forms of ownership lowered the relative importance of ownership in their cost equation (Teeples and Glyer 1987). Specified forms include city/municipality, county, government district and homeowner's association.

Table 10: Regression of Operating Revenues while specifying Ownership

	Coefficient Estimate	Standard Error		
Private Ownership	25,700,000***	4,981,791	Number of Obs	743
Homeowner's Association	(dropped)		F(12, 756)	17.62
County	-(17,000,000)	10,600,000	Prob > F	0
Government Water and Waste	15,400,000	13,900,000	R-squared	0.772
Government Water and Waste	-(3,634,321)	5,595,301	Root MSE	5.70E+07
Population Served	109.31***	19.33		
% Residential Customers	105,000,000***	28,200,000		
Daily Production Capacity	1,275.39	3,313.02		
Total Water Sold	611.86**	320.75		
Ground Water	-(6,637,734.00)	4,484,336		
Purchased Water	11,700,000**	5,064,086		
Year 2007	19,800,000***	5,675,217		
Year 2004	5,233,372	4,430,517		
Constant	(101,000,000)***	33,500,000		

[11] This paper does not offer a definition of affordability. However, other papers do. Fitch rating agency considers rates above 2% median household income to be burdensome. See: (Leurig 2010)

The above table runs the same regression as before except it specifies public forms of ownership. I excluded city/municipal ownership from the regression to simplify the analysis. None of the public coefficients are significantly different from zero though the private coefficient retains significance. As expected, the private forms of ownership show a positive impact on operating revenues.

POTENTIAL BIAS

For both regressions, bias may occur if our error term varies along both privatization and operating revenues. We would be concerned about the explanatory capacity of our findings if unobserved factors impact both the likelihood of ownership being private and the size of operating revenues. Situations exist where this may be true.

This dataset does not contain information regarding current or past pricing structures. Price, both historical and current, would influence current operating revenues. We may believe that private facilities are more apt to purchase public utilities with historically higher rates or with the capability to have higher rates. Although ultimately the public utility commission defines fair rate practices for private companies, historical rating systems could influence operating revenue.

Hypothesis 2: Total Number of Employees

Equation and Test

Table 11: Expected relationships between employment levels and independent variables

Independent Variable	Category	Association	Justification
Private Ownership	Ownership	Negative	See above material. Profit motives and public hiring practices may lead to this result.
Daily Production Capacity	Size	Positive	This has implications on facility size which relate to necessary employment
Maximum Daily Water Delivered to System	Size	Positive	Relates to peak demand. Higher peak demand needs may relate to greater personnel needs
Total Water Sold	Size	Positive	Relates to yearly demand. Higher demand may necessitate greater staffing.
Water Source Purchased	Source	Negative for Purchased Water	Purchased water implies that the facility relies less on their water sources. This may reduce personnel need.
Total Current Liabilities	Finance	Positive	Current liabilities define a company's debt obligations for a given year. This can included salary obligations.

Table 11 shows a list of independent variables and their expected association with total number of employees at a utility. It should be noted that I have not included year dummy variables in this table. Intuitively, there is no reason to believe that a specific year, in and of itself, could lead to higher levels of employment outside of a change in the amount of water sold. Since I have included total water sold in the analysis, year dummy variables become unnecessary. One may argue that recessions and resultant tax shortfalls could force utilities to reduce employment levels. However, the data for this analysis comes before the major financial crisis[12].

[12] It should be noted that running a regression using year dummy variables changes none of the conclusions from the following test. The year dummy variables are insignificant in the regression and no variables change significance.

Running a regression on the above independent variables yields the following results:

Table 12: Regression of Total Number of Employees

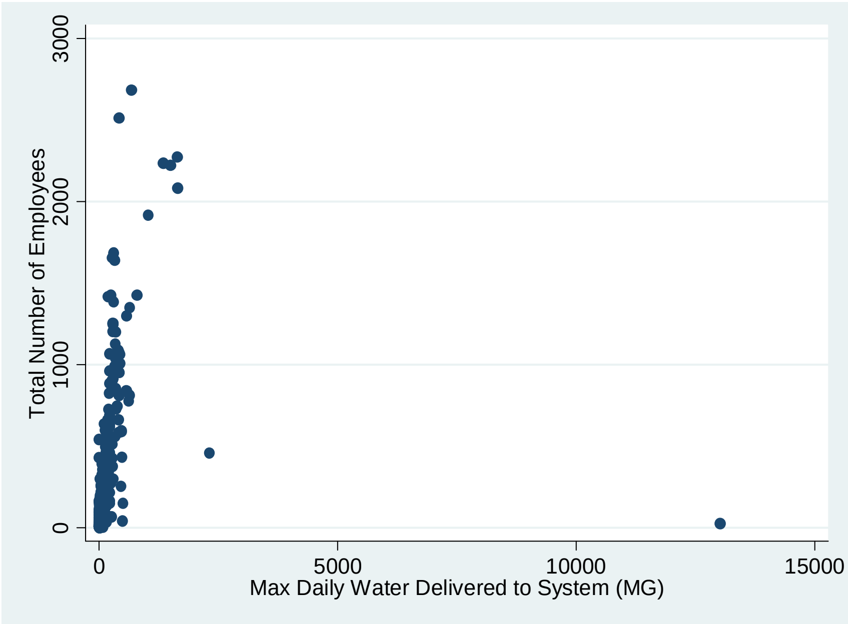
	Coefficient Estimate	Standard Error		
Private Ownership	-17.522*	10.74677	Number of Obs	705
Daily Production Capacity	0.633296**	0.29409	F(6, 698)	19.92
Max Daily Water Delivered to the System	-0.71221**	0.340936	Prob > F	0
Total Water Sold	0.005012***	0.000778	R-squared	0.712
% Water Purchased	-26.5476	18.3205	Root MSE	174.27
Total Current Liabilities	1.50E-06***	5.79E-07		
Constant	63.55145***	11.36135		

Analysis of Regression

All variables except “Max Daily Water Delivered to the System” follow the hypothesis mentioned in the above table. Private ownership has a negative impact on employment levels and is significant at the 10% level. Daily production capacity, total water sold, and total current liabilities all have a positive and significant impact on the number of employees in a specified facility. “% Water Purchased” showed a negative but not-significant correlation with total number of employees. Future studies using these same methods may find purchased water to be significant in the regression. Indeed, the 2006 EPA community water system survey revealed increased reliance on purchased water over the past decade (EPA 2009).

It is difficult to determine an empirical reason why maximum water delivery shows a negative correlation with total number of employees. Indeed, this implies that greater daily delivery needs correlate with lower necessary employment. One reason could be the nonlinear relationship between employees and maximum water delivery. Economies of scale could reduce the need for employees as water delivery increases.

Figure 2: Scatterplot Matrix of Employees and Maximum Daily Water Delivered



The above figure shows an increasing trend of employees and water delivery except a sole outlier. This value may be a result of a mistake in data entry. The value may also indicate a failure by the facility to convert its water delivery data to millions of gallons from some other metric. Indeed, the water delivery value is almost 10,000 million gallons higher than the next highest value. Further statistics show the scale of this difference:

Table 13: Outlier Mean Values for Maximum Daily Water Delivered to System

Maximum Daily Water Delivered to System	Value	Standard Deviation
Value of Outlier	13,021	
Mean with Outlier	102	478
Mean without Outlier	86	175
Employment Level	**Value**	**Standard Deviation**
Value of Outlier	24	
Mean with Outlier	194	326
Mean Without Outlier	194	326
Correlation of Max. Daily Water and Employment	**Correlation Coefficient**	**P-value**
…with outlier	0.25	0
…without outlier	0.75	0

Table 14: Regression of Employees on Independent Variables sans Water Delivery Outlier

	Coefficient Estimate	Standard Error		
Private Ownership	-23.6802**	10.0985	Number of Obs	704
Daily Production Capacity	0.927818***	0.237955	F(6, 698)	40.14
Max Daily Water Delivered to the System	-0.41371	0.286806	Prob > F	0
Total Water Sold	0.002628***	0.001043	R-squared	0.7424
% Water Purchased	-6.59191	17.47247	Root MSE	164.9
Total Current Liabilities	1.37E-06***	4.88E-07		
Constant	47.35008	8.761449		

After eliminating the outlier, private ownership is now significant with a p-value less than .02 and the daily water delivery coefficient loses significance. Holding other variables constant, private ownership can be expected to reduce employment levels at a utility by approximately 24 persons. As stated previously, two conflicting pressures face public utility managers regarding employment. First, public managers face pressure to lower tax burdens through reduced cost. This may be shown through lowered investment in infrastructure or lower operating costs including employment. Public managers also may face difficulty in firing employees and restructuring management systems to reduce staffing.

The above regression shows management pressures that encourage increased employment outweigh pressures for lower employment in public facilities. As with the analysis of operating revenues, the relative utility of higher or lower employment levels stands unclear in this paper. All else equal, lower employment levels equate to higher levels of efficiency in a utility. Public utilities require more personnel for the same level of service.

Additional Tests

One limit of the above test is that it fails to analyze time trends as it relates to ownership and employment. As stated earlier, it stands difficult to determine a reason why we would believe employment to vary significantly with time in a water utility. Absent a new technology, a drastically shifting market, or changes in compliance, the employment levels at a facility should stand relatively constant. The nature of the dataset used for this analysis cannot analyze technological or compliance factors at a local level.

However, we may believe that overall trends in employment for water utilities differ by ownership. Overtime, it would be easier for private utilities to shed unnecessary jobs than public facilities. Interacting ownership with time variable dummies in a regression would explain any variation in trends. Running this regression shows no time or time-interaction coefficients to have significance. However, coefficient signs are as expected. Unlike the previous regression, ownership no longer holds significance. Results of this regression may be found in the Appendix section of this paper.

Potential Sources of Bias

Similar to the analysis of operating revenue, bias regarding the test of employment levels centers around whether the error term correlates with both the dependent and independent variable of interest. Does an unobservable factor affect decisions on ownership and employment? If we assume that private water companies do not have complete control of employment decisions during a contracting process, then it is possible that companies would be bias to select water utilities where employment levels could be lower than the status quo. However, it seems unreasonable to believe this to be an overriding consideration in a privatization bidding process.

Hypothesis 3: Gross Capital Expenditures

Equation and Test

Before conducting the regression analysis, it is helpful to externally validate the sample data by using the statistic reported by the U.S. Conference of Mayors in 2008 that operation and maintenance expense for water and wastewater facilities equated to approximately 60% of total spending (with the remaining 40% being capital investment) (Anderson 2010). If the drinking water facilities represented by the survey data approximate the same total spending ratios, we may have more confidence that the hypothetical capital expenditure data represents the overall water population.

To conduct the test, I added planned gross capital expenditures (GCE) for the year 2005 with survey-year 2004 total operation and maintenance (O&M) data. I then divided this new variable by the original O&M data to achieve a percentage. I chose the year 2005 for the GCE test as it represents the closest year to the 2008 data point with the closest GCE measure to the survey year[13].

Table 15: Capital Expenditure Ratio

Variable	Obs	Mean	Std. Dev.	Min	Max
2004 Expenditures % O&M	534	0.618495	0.2082924	0	1

The above results show the O&M expenditure ratio to be relatively close to the mean discerned by the U.S. Conference of Mayors and not significantly different. The following table shows a list independent variables and their expected association with gross capital expenditures for both formats.

[13] Year 2007 survey data contains GCE data stating at 2009 instead of 2008. If we assume that investment predictions for the future decrease in accuracy over time, we wish to use a year as close to the balance year as possible (2004 vs. 2005). I cannot account for this discrepancy

Table 16: Expected Independent Variable Relationships for Gross Capital Expenditures

Independent Variable	Category	Association	Justification
Ownership	Ownership	No significant correlation	Incentives for infrastructure investment remain mixed. Municipal and city utilities may inexpensively issue bonds though private facilities may profit from equity investment. Publicly owned facilities may have more incentive to overinflate GCE that may be seen in the "Projected Sum" Regression.
Population Served	Size	Positive	Large population served equates to higher costs and greater infrastructure.
% Residential Customers	Size	Positive	Higher % residential population may signify a greater number of connections and thus higher infrastructure costs.
Daily Production Capacity	Size	Positive	High daily production capacity indicates an extensive system that may require capital investment
Total Water Sold	Size	Positive	Similar to daily production capacity though total water sold indicates potential wear on the system.
% Water Purchased	Source	Negative	If the majority of water in a utility comes from a purchased source, the utility has a lower requirement for infrastructure
Year Variables	Time	Positive	Over time, facilities tend to expand and required investments should increase
Long Term Debt	Finance	Negative	Utilities with high debt may be limited in their ability to offer more debt for capital expenses.

Table 17: Regression Results of GCE Closest Year Approximation

Regression on GCE Closest Year Approximation	Coefficient	Standard Error		
Private Ownership	-388.4936	2,568,390	Number of Observations	744
Population Served	71.59552***	19.79978	F(9, 734)	13.24
Percent Residential Customers	4.58E+07*	2.43E+07	Prob > F	0
Daily Production Capacity	-2188.733	2359.536	R-squared	0.7125
Total Water Sold	-54.30366	309.5129	Root MSE	5.2E+07
Percent Water Purchased	-1,888,956	3,726,865		
2004 Survey Year	-353,609.1	4,616,407		
2007 Survey Year	4,934,348	3,668,780		
Long Term Debt	0.060925***	0.0152524		
Constant	-4.76E+07*	2.64E+07		

As expected, ownership does not significantly affect planned capital expenditures in the year closest to survey completion for an individual utility. This is a result of mixed incentives regarding planned and actual infrastructure investment. Both public and private utilities have mixed incentives and disincentives for infrastructure investment. Equally important, both have mixed incentives for hypothesizing infrastructure investment into the future.

"Long Term Debt" is the only significant variable that does not follow our hypothesis. This could be justified when considering the fact that utilities with higher previous infrastructure investments may be more likely to make future infrastructure investments. The result does not necessarily nullify our hypothesis that utilities with greater present-day debt will be limited in their ability to invest in future capital projects since the dependent variable is planned, and not actual, capital expenditures.

Additional Test

The above regression aggregates capital expenditure entries for all three survey years. However, individual survey years may better describe the relationship between ownership and expected capital expenditures because of the availability of data for the specified survey. For example, the 2002 and 2007 survey compares ownership to GCE planned at least two years into the future. The 2004 survey data compares ownership to GCE just one year in advance. If a utility's ability to accurately predict GCE decreases over time, then the ability of the 2002 and 2007 survey to accurately predict GCE compared to the 2004 survey should similarly be lower. Running regressions for each survey separately yields the following results:

Table 18: Ownership impact using individual survey years

	Coefficient Value	Standard Error	t	P>t	[95% Conf. Interval]	
Private Ownership (Survey 2002)	-2,336,171	2,080,310	-1.12	0.262	-6431660	1759318
Private Ownership (Survey 2004)	10,500,000*	5,792,302	1.82	0.070	-881020.8	2.19e+07
Private Ownership (Survey 2007)	-879,311	6,109,741	-0.14	0.886	-1.29e+07	1.02e+07

For space economy, I have only included the results of the ownership coefficient. As expected, ownership more accurately predicts GCE the closer the estimation is to the survey year. The 2004 survey results show private ownership to have a positive, $10.5 million impact on planned gross capital expenditures at a 10% significance level. For scale, the mean approximated gross capital expenditure for the year 2004 is $30.5 million.

One should not consider this overwhelming evidence regarding how ownership decisions effect investment. Rather, the findings as a whole should call to attention the need to gather more accurate financial data from water utilities.

Testing GCE Summation

Table 19: Regression results using the summation approach for Gross Capital Expenditures

GCE Summation	Coefficient	Standard Error		
Private Ownership	1.08E+07	0.1	Number of Obs.	744
Population Served	369.1452***	70.85648	F(9, 734)	15.44
Percent Residential	2.12E+08***	7.20E+07	Prob > F	0
Daily Production Capacity	-3,398.178	6,835.772	R-squared	0.7915
Total Water Sold	1130.922	1017.337	Root MSE	1.80E+08
Purchased Water	-1.48E+07	1.74E+07		
Year 2004	-2.25E+07	1.58E+07		
Year 2007	-8,865,851	1.49E+07		
Long Term Debt	0.0498756	0.080735		
Constant	-2.14E+08***	7.54E+07		

Table 19 shows a list of independent variables and their expected association with total number of employees at a utility. Similar to the previous regression, ownership does not have a significant effect on predicted capital expenditures. Population served and residential population still significantly predicts GCE. However, no other coefficients show significance different from zero.

We may draw two disparate conclusions from the regressions regarding gross capital expenditures. First, ownership has no impact on planned capital investment. Although public and private facilities face separate incentives, these incentives cancel out when considered in the aggregate. Next, predicted gross capital expenditures may be an unreliable source of information for utility managers. By definition, predicted gross capital expenditures relay information regarding planned, not actual, investment. While some utilities may take such predictions extremely seriously, others may see the category as an opportunity to express "need" for investment instead of planned investment. We may therefore question the relevance of the conclusions regarding gross capital expenditures due to the hypothetical nature of the survey response.

Potential Sources of Bias

Potential biases in the regression analysis stem from the above explanation regarding the efficacy of using GCE as an interpretation tool for ownership. The data suffers from the fact that GCE stands as a predicted, and not measured, variable. Utility managers at one facility may prove better at accurately predicting necessary investments than at another facility. Importantly, we have plausible reason to believe that a manager's accuracy in predicting gross capital expenditures may vary by ownership. In such a situation, an unobservable characteristic that determines ownership also determines predicted capital expenditures.

Bias regarding GCE emphasizes the need for both public and private utility industry experts to better record infrastructure investment in annual survey processes. This paper has already explained the importance of capital improvements for the water industry as a whole. Without sufficient data, it becomes extremely difficult to determine the incentives that may drive further investment in water infrastructure.

Hypothesis 4: Depreciation Expense

Equation and Test

In studies conducted by the EPA, the Agency recognizes the limitations of financial data on any form of analysis for water utilities (EPA 2009). The 2006 Community Water Survey discerned that approximately 18.6% of operation and maintenance costs come from depreciation. Unfortunately, how systems account for expenses and how they account for depreciation varies drastically. Calculating the same ratio for this data set yields the following results:

Table 20: Mean Depreciation Expense as a Percentage of Operating Costs

Ownership	Year	Perc. Dep over Operating Costs	Standard Error	95% confidence interval	
Public	Year 2002	0.2053063	0.013128	.1795367	.2310758
Public	Year 2004	0.2275548	0.012723	.2025803	.2525294
Public	Year 2007	0.2486494	0.0165543	.2161543	.2811444
Private	Year 2002	0.2019588	0.0166029	.1693684	.2345493
Private	Year 2004	0.2170774	0.019584	.1786352	.2555196
Private	Year 2007	0.170112	0.0164726	.1377772	.2024467

None of the depreciation expenses matches that estimated by the EPA. However, four of the six estimations retain a confidence interval inclusive of the EPA's estimate (all of the private estimates, one public estimate). If we believe the EPA results to be accurate, the ratios above provide some confidence in our depreciation measure. However, it becomes important to emphasize caution in any interpretation.

Five of the six measured mean depreciation expenses have higher values than the mean value calculated by the EPA. While this may reflect biased responses, it may also be a result of the nature of respondents. Indeed, the AWWA and NAWC survey respondents tend to be larger in size than the EPA respondents for the 2006 community drinking water survey (EPA 2009). Larger systems should face greater infrastructure needs but have economies of scale with regard to operation. Therefore, we would expect higher levels of depreciation for survey respondents.

Analyzing depreciation expense in relation to independent variables offers similar relations as were determined by the above gross capital expenditures examination. The below table highlights these relationships:

Table 21: Relationships between Depreciation Expense and Independent Variables

Independent Variable	Category	Association	Justification
Private Ownership	Ownership	Positive	As mentioned above, municipal facilities may have more incentive to underreport depreciation expense
Population Served	Size	Positive	Associated with larger facility and thus higher levels of capital to depreciate
% Residential Customers	Size	Positive	Associated with more connections. This leads to greater infrastructure needs
Daily Production Capacity	Size	Positive	Higher capacity signifies larger facility size
Total Water Sold	Size	Positive	Signifies wear on the facility and thus potentially higher depreciation needs
% Water Purchased	Source	Negative	Signifies fewer treatment needs and thus lower capital expenses
Year Variables	Time	Positive	If facilities as a whole expand over time, depreciation should expand as well

The below table shows the results of a regression run using the above independent variables with depreciation expense as the dependent variable. The type of depreciation expense used in the test is book depreciation. Book depreciation differs from tax depreciation in their emphasis on the useful life of a piece of equipment. Tax depreciation emphasizes a quick or slow depreciation level based on some desired level of taxation. Book depreciation reduces the value of a piece of equipment based solely on the machine's useful life.

Table 22: Regression of Depreciation Expense

	Coefficient	Standard Error		
Private Ownership	332,592.4	742,427.7	Number of obs	818
Population Served	22.11286***	4.913841	F(8, 809)	7.12
% Residential Customers	20,300,000***	7,277,474	Prob > F	0
Daily Production Capacity	140.8775	582.2455	R-squared	0.6287
Total Water Sold	132.0707*	73.11833	Root MSE	1.60E+07
% Water Purchased	405,381.6	2,213,735		
2004 Survey Year	1,819,679**	923,564.2		
2007 Survey Year	4,928,135***	1,572,386		
_cons	-21,300,000***	8,322,289		

The regression reveals ownership to have no significant impact on depreciation expense at a confidence level of 95%. Private ownership does express a positive relationship with depreciation expense. However, this relationship is not significantly different from zero. Of the variables with coefficients significantly different from zero at a 5% level, all follow the relationship logic expressed in the above table.

One explanation for the lack of significance regarding ownership may stem from the numerous "zero" depreciation responses listed by public facilities. Of the over 783 public utility entries in the dataset, 117 contain entries for depreciation of zero. Realistically a drinking water facility with any infrastructure such as pipes, buildings, and treatment machines must have a certain level of depreciation. Municipal and city owned facilities might list a zero level of depreciation to inflate income and defer necessary repairs for a future date. However, a zero deprecation level may also signal data entry error where the zero entry should be a non-response.

Running the same regression as above using public facilities who have listed depreciation above zero provides the following results:

Table 23: Regression on Depreciation Expense Excluding Zero Entries for Depreciation

	Coefficient	Standard Error		
Private Ownership	-618,554.4	760,144.9	Number of Obs	718
Population Served	22.84261***	5.061852	F(8, 709)	5.85
% Residential Customers	22,100,000***	7,694,997	Prob > F	0
Daily Production Capacity	373.388	652.3193	R-squared	0.6382
Total Water Sold	122.2626*	73.54704	Root MSE	1.70E+07
% Water Purchased	478,972.1	2,499,259		
2004 Year Dummy	1,750,182*	1,019,478		
2007 Year Dummy	4,597,786***	1,693,051		
Constant	-21,900,000***	8,803,439		

Although the coefficient for private ownership changes signs from positive to negative, the coefficient still is not significantly different from zero. This rejects the above hypothesis that private ownership signifies higher depreciation expense. One reason for this conclusion may be the unobservable factors contributing to a public utility's decision in recording depreciation expense. Depending on the utility manager's incentives, it is possible that depreciation may be over or under reported. However, the theory that public utilities have an incentive to underreport depreciation expense appears dubious on a national level. While specific public utilities may underreport depreciation expense, as a whole, such underreporting shows no significance from the survey data[14].

The 2007 survey year dummy variable deserves extended analysis for its significance in the previous two regressions. A relatively positive[15] and significant coefficient signifies the importance of facility and service expansion on depreciation expense. Drinking water facilities cannot easily downgrade facilities once it builds infrastructure. If population or service-need declines, infrastructure cannot simply decline in par.

[14]Two other possibilities remain regarding reporting incentives and depreciation expense: the first may be that public utilities indeed underreport but this underreporting shows no significance because private utilities retain fewer assets for depreciation. Secondly, responses for the survey used by the AWWA may be bias towards utilities that conduct standard and fair accounting practices.

[15] \$4.5-\$5 million impact relative to an average depreciation expense for the entire sample of around \$10 million

The above test did not use financial variables in attempting to determine the causal impact of ownership on depreciation expense. One reason for such an omission lies in the feasibly limited correlation between other financial variables and depreciation. Another reason is the ability for observables such as population, infrastructure size, and water sold to explain depreciation expense in the same manner as useful financial variables such as operating revenue. However, it still may be of interest to explore ownership's impact on depreciation with depreciation existing as a percentage or of another financial variable such as Gross Capital Expenditures. In such a situation, depreciation expense being greater than gross capital expenditures would indicate under-investment in the plant.

Potential Sources of Bias

Unfortunately, any analysis of depreciation expense suffers the same potential endogeniety bias as gross capital expenditures. Since public utilities owned by cities and municipalities need not strictly follow SEC guidelines for reporting, stated depreciation expense may vary due to an unobserved factor which also influences ownership.

Exploring Regulation in Public Facilities

Public and private drinking water facilities may differ dramatically in their financial regulation. The previous two tests have detailed the various reporting requirements and biases faced by the two ownership types. Vital in all differences stands the rate regulation process.

State utility commissions overwhelmingly regulate private drinking water facility rates. In the rate regulating process, a commission determines the appropriate level of profit a private facility may garner from equity investment. Demand forecasts help calculate expected revenue, and facilities may only seek compensation for in-ground infrastructure investments[16]. The rate setting process may take upward of a few years(NCUC 2009). Facilities generally seek rate increases as new demand structures or

[16] Sometimes facilities may seek advanced approval to raise rates in order to fund a specified amount of in-ground water transportation infrastructure upgrades.

infrastructure investments erode profitability. Generally, water conservation is not considered during the rate setting process.

Municipal and city-owned utilities retain a higher degree of autonomy in setting rates. In the municipal rate-setting process, politics, not profits, may be the overwhelming catalyst for change. Unlike private utilities, municipal and city-owned plants may decide to raise investment dollars not through rate hikes but through taxes.

Rate regulation stands as one of the overriding differences between public and private utilities. If rate regulation was exactly similar for public and private facilities, differences discovered based on ownership may prove nonexistent. The AWWA survey used for the analysis contains a variable that delineates rate regulation for a public facility. The variable states whether a state utility commission regulates the facility's rates.

The exact nature of the utility commission's oversight regarding rates for specific public utilities may vary depending on the public utility. For a public water utility in Lancaster, Pennsylvania, the utility commission only regulates rates for properties served outside of the city limits (Water 2010). In Columbus, Ohio, the utility commission regulates rates for the city's public water supply by suggesting rate schemes. However, the rating systems must still be approved by the City Council (Vitale 2008).

Despite possible variations in the meaning of utility commission rate regulation, repeating the previous tests using only public facilities regulated by a state utility commission will help inform ongoing discussions regarding the incentive structure of state utility commissions for drinking water. Significant deviations from the above findings will help reveal the importance of commission oversight for revenues and efficiency.

EQUATION AND TEST

Table 24: Regression of Operating Revenue Using PUC Regulated Public Utilities

Variable	Coef.	Std. Error		
Private Ownership	31,900,000***	7,472,989	**Number of Obs**	192
Pop Served	120.1505**	55.58373	**F(9, 182)**	39.6
% Residential	195,000,000****	4.39E+07	**Prob > F**	0
Daily Prod. Capacity	-614.625	1021.167	**R-squared**	0.8231
Total Water Sold	1,197.306	1,159.37	**Root MSE**	3.90E+07
% Water Ground	-9,029,162	6,743,143		
% Water Surface	-7,097,593	1.01E+07		
2007 Year	18,600,000***	6,119,755		
2004 Year	-1,157,945	5,499,811		
Constant	-194,000,000***	4.04E+07		

Table 25: Regression of Employees Using PUC Regulated Public Utilities

Variable	Coef.	Std. Error		
Private Ownership	0.684412	11.16902	**Number of Obs**	179
Daily Production Capacity	0.480573***	0.169385	**F(9, 182)**	81.94
Max Daily Water Delivered	-0.29816***	0.114293	**Prob > F**	0
Total Water Sold	3.98E-03***	1.22E-03	**R-squared**	0.8782
% Purchased	-1.36E+01	1.64E+01	**Root MSE**	72.28
Total Current Liabilities	2.12E-06***	5.06E-07		
Constant	21.98594***	6.574903		

Despite sharing a similar regulatory structure, operating revenues still differ significantly by ownership. The impact of private ownership is higher for this regression by $10 million from the original analysis. It remains unclear how this difference propagates in the regulatory process. However, the results show diverging incentives for public and private utilities; one to lower financial burdens on the voting population, the other to retain profit. While a utility commission may grant similar leeway for profitability through equity investment, publicly owned plants may be less apt to raise rates.

In contrast to the results regarding revenue, total number of employees loses significance when comparing only commission-regulated facilities. A potential reason and bias for such a finding may deal with the nature of commission-regulated facilities. If we believe that such facilities share unique, unobservable, traits that correspond with fewer staffing needs, then the regression has no association with regulation. However, it would seem unlikely that such utilities universally share this attribute. Instead, we may believe that state utility commission oversight imparts some incentive to reducing overhead costs. Further research regarding the incentives granted by public utility commissions is needed.

Conclusions

The above tests help shed light on the public-private water debate within the United States. Operating revenues and employment levels prove the only measurable differences between public and private utilities. However, conclusions go beyond these tests towards the general state of information sharing within the water industry and the need to look beyond ownership to meet the United States' 21st century water infrastructure demands.

Operating revenue and employment

Ownership only proved a significant factor for operating revenue and total number of employees in this study. These findings reflect the common-held belief that private utilities generally charge more for water services and are more efficient in their hiring practices. Simply understanding that these differences exist does little to further the policy debate. We must also consider how these variations reflect the utility gained and lost from private ownership

Regarding higher prices, three major concerns in the privatization debate include affordability, investment, and consumption. Sources define drinking water services as "affordable" to a community if the average water bill encompasses less than 2% of median household income(EPA 2009; Leurig 2010; Institute 2005). In 2006, average water utility charges comprised less than 1% of median household income. Water rates can double on average and still be affordable.

Unfortunately, these details only provide a portion of the pricing picture. Certain communities, both public and private, may grapple with water bills well above the "affordable" range. Water utilities may offer citizens with unaffordable water bills financial assistance. From a social perspective, we may care most if ownership impacts the ability of citizens to afford basic water payments or seek financial assistance. Data regarding affordability and financial assistance was not available for my analysis. Therefore, I cannot judge if ownership affects affordability.

Setting aside concerns regarding affordability, higher rates have a direct correlation with the ability to invest in infrastructure. The majority of cash used for capital improvements comes from revenues (EPA 2009). As a whole, private utilities should have more capacity to increase infrastructure precisely due to higher rates and this increased access to cash. Despite insignificant findings regarding depreciation and planned capital expenditures, we may infer from operating revenues that private ownership increases the potential for capital investment[17].

Beyond infrastructure and affordability, concern exists regarding the overconsumption of water in the United States (Walton 2010). Some sources disavow the use of higher prices as a tool for decreasing consumption. The essential nature of water for human life leads to a certain inelasticity of demand (Leurig 2010). However, some studies associate higher water prices to lower water demand (UNCEFC 2009). All else equal, higher prices help private utilities conserve more water than public utilities. Higher water prices can also serve as a vital tool for utilities to remain in the black as efficiency levels within a community improve (Walton 2010).

The relative utility of lower employment levels may be less obvious depending on the individual. Lower employment levels help signify greater efficiency in a utility. Publicly owned facilities in municipalities and cities may be wasting scarce resources through over-employment in their drinking water infrastructure. However, for individuals that value high levels of government employment, these numbers do not signify better management.

Of greater interest is the implication that ownership loses significance in defining employment levels when one compares private utilities only with utility-commission-regulated public utilities. This finding suggests that the regulatory process, not ownership, may be having a profound impact on efficiency levels in the U.S. water industry.

[17] A counter argument to this would be that cheaper borrowing costs for public facilities offsets the increased revenue generated by private facilities regarding the capacity to invest in infrastructure. The findings from this paper show that, at the very least, cheaper borrowing costs for public facilities and higher operating revenues for private facilities cancel out; leading to no significant difference in infrastructure investment.

Insufficient Survey Data

While the significant findings of these tests reveal interesting insights into the implications of ownership, the insignificant findings shed light on a absence of accurate and comprehensive data for U.S. drinking water infrastructure. Insufficient infrastructure data and potentially inaccurate financial data may have limited the ability of the previous regressions to tease out differences in infrastructure investment as based on ownership. Both the AWWA and NAWC would benefit from collaboration in their survey methods to ensure that future researchers have the capacity to answer new questions regarding the state of U.S. drinking water.

The NAWC survey data is limited in its lack of specific infrastructure and location data. Items such as infrastructure age, amount of water lost, and rating structures can greatly improve the interpretability of the organization's data. However, what the NAWC survey lacks in breadth, the AWWA survey lacks in completeness and accuracy; especially with regard to financial data.

Based on data covered by the EPA, drinking water utilities that serve a population similar to those who responded to the AWWA and NAWC survey have an average proportion of utilities whose revenue do not cover costs. For public utilities, approximately 27% of utilities serving a population over 100,000 do not cover costs and operate with a negative net income. For private utilities, only 5% of facilities face this problem. However, in the survey data compiled for this analysis, only 15% of public surveys reported a negative income. Meanwhile, 7% of private utilities reported a negative income. Therefore, a reporting bias clearly exists between public and private facilities regarding financial data for the AWWA survey.

The importance of contracts and oversight

According to the Pacific Institute, successful management of a drinking water facility matters less about ownership and more about the following characteristics: efficient staffing, community support for adequate funding, detailed asset management, performance metrics and rewards, and transparency (Institute 2005).

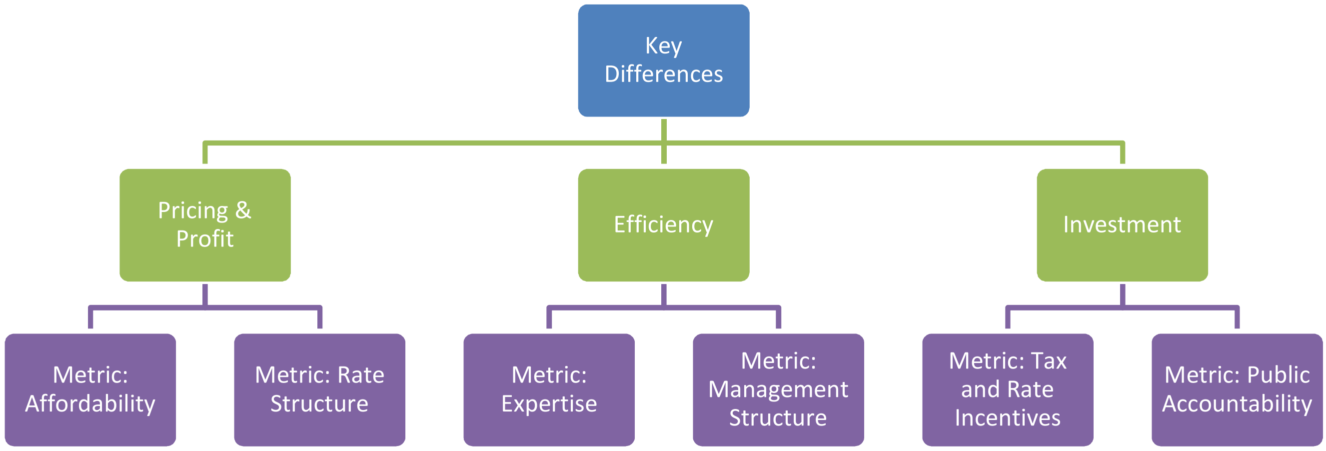
Ownership by itself does not define any of the characteristics. However, one may argue that the current regulatory structure favors private ownership for these drivers of success. Indeed, private utilities, through regulation by a state utility commission, need care less about localized public support for adequate funding. Private facilities may more easily hire and fire staff and may rely on a central entity for management of operationally external issues. The rate-case setting process and SEC regulations require additional levels of transparency in private utilities. Therefore, concerned citizens may benefit in focusing concern on the regulatory and oversight process rather than the ownership type.

When community groups and advocacy organizations express frustration and worry over the privatization of water resources, they may be expressing greater concern over the process rather than the outcome. Successful attempts at privatization almost exclusively require adequate public oversight (Wolff and Palaniappan 2004). However, the real issue is not ownership; the real issue is that citizens receive the adequate services. Instead of debating ownership, the water community should develop rules which insure operating efficiency and response to social needs (Wolff and Palaniappan 2004).

Further Research

This study attempted to inform many of the claims made regarding water privatization. Figure 1 highlighted the three main differences between public and private utilities to be tested: pricing & profit, efficiency, and investment. Future research should parallel these arguments with a focus on management and government incentives as described below:

Figure 3: Key Differences in Relation to Future Research



Additional studies would benefit from a focus on affordability in lieu of rates. High rates have advantages with regard to resource conservation, and thus are difficult to quantify as detrimental to society. Affordability may be of more interest as this reflects the utility's response to public need. An analysis of rate structure would also be preferable to water prices as rate structure helps define incentives such as water conservation.

Although employment levels help dictate the efficiency of a water system, employee and company expertise within a water system may prove a better metric for understanding how well the organization complies with contemporary needs. This is of special concern for communities that have privatized utilities. Privatization of utilities means a local loss in expertise for water management increasing the difficulty of ever switching back to public management (NAP 2002).

Expertise differs by organizational structure for private and public facilities. Where private facilities may have centralized expertise, public utilities may require all expertise to be retained in-house. This leads to divergent management structures. Increasingly complex regulatory systems create incentives for new management structures as well. An ongoing trend among public utilities is to regionalize operations to meet new regulatory measures[18]. The way that ownership influences the organizational structure and knowledge retained by a facility may prove a compelling argument for private or public ownership in the future.

New studies could also inform the privatization debate by analyzing both government infrastructure-investment incentives as well as utility rate case data. Government incentives such as the DWSRF and tax-free bonds help decrease the cost to cities and municipalities for investing in infrastructure. At the same time, the ability of private utilities to profit off investments through equity greatly incentivizes investment in infrastructure. Such dueling incentives have local and national cost implications for the United States. The efficacy of either incentive may vary on a community level.

In addition to investment incentives, pressures towards public accountability vary by ownership though become difficult to characterize by the available data. Key to public accountability for private ownership stands the bidding process. When a local government offers the sale of its water utility, various private water companies compete for ownership and operation. The length of these contracts and the contracting process has a great impact on public accountability. The public-private debate would benefit greatly from an in-depth study of the bidding process.

[18] Regionalization occurs where contiguous systems consolidate. Regionalization has the added benefit of combining expertise to meet new drinking water standards.

Works Cited

Anderson, Richard F. 2010. Trends in Local Government Expenditures on Public Water and Wastewater Services and Infrastructure: Past, Present and Future. Washington: Mayors Water Council.

ASCE. 2011. *Drinking Water Report Card* 2010 [cited 21 February 2011]. Available from http://www.infrastructurereportcard.org/fact-sheet/drinking-water.

Bel, Germà, and Mildred Warner. 2008. Does privatization of solid waste and water services reduce costs? A review of empirical studies. *Resources, Conservation and Recycling* 52 (12):1337-1348.

Bhattacharyya, Arunava, Thomas R. Harris, Rangesan Narayanan, and Kambiz Raffiee. 1995. Specification and estimation of the effect of ownership on the economic efficiency of the water utilities. *Regional Science and Urban Economics* 25 (6):759-784.

Byrnes, Patricia, Shawna Grosskopf, and Kathy Hayes. 1986. Efficiency and Ownership: Further Evidence. *The Review of Economics and Statistics* 68 (2):337-341.

Clarke, G. R. G., K. Kosec, and S. Wallsten. 2009. HAS PRIVATE PARTICIPATION IN WATER AND SEWERAGE IMPROVED COVERAGE? EMPIRICAL EVIDENCE FROM LATIN AMERICA. *JOURNAL OF INTERNATIONAL DEVELOPMENT* 21 (3):327-361.

Crain, W. Mark, and Asghar Zardkoohi. 1978. A Test of the Property-Rights Theory of the Firm: Water Utilities in the United States. *Journal of Law and Economics* 21 (2):395-408.

EPA. 2009. 2006 Community Water System Survey. edited by O. o. Water. Washington, D.C.

———. 2009. Drinking Water Infrastructure Needs Survey and Assessment: Fourth Report to Congress. edited by E. P. Agency. Washington.

Estache, Antonio, and Martín A. Rossi. 2002. How Different Is the Efficiency of Public and Private Water Companies in Asia? *The World Bank Economic Review* 16 (1):139-148.

Fried, Kate. 2011. *Trenton Residents Drown Risky Water Deal* 2010 [cited 18 February 2011 2011]. Available from http://www.foodandwaterwatch.org/pressreleases/trenton-residents-drown-risky-water-deal/.

FWW. 2009. Money Down the Drain. Food & Water Watch.

———. 2010. Trends in Water Privitization. Washington D.C.: Food and Water Watch.

Galiani, Sebastian, Paul Gertler, and Ernesto Schargrodsky. 2005. Water for Life: The Impact of the Privatization of Water Services on Child Mortality. *Journal of Political Economy* 113 (1):83-120.

Institute, Pacific. 2005. Beyond Privatization. Pacific Institute.

Leurig, Sharlene. 2010. The Ripple Effect: Water Risk in the Municipal Bond Market. edited by CERES. Boston: CERES.

Martinez-Espineira, Roberto, Maria A. Garcia-Valinas, and Francisco Gonzalez-Gomez. 2009. Does private management of water supply services really increase prices? An empirical analysis in Spain. Report. *Urban Studies* 46 (4):923.

Merrick, Amy. 2010. Cash Flows in Water Deals. *Wall Street Journal*, 12 August 2010.

NAP. 2002. Privatization of Water Services in the United States: An Assessment of Issues and Experience. edited by N. A. Press. Washington D.C.

NCUC. 2009. Order Granting Partial Rate Increase to Aqua North Carolina. edited by N. C. U. Comission. Raleigh.

Olmstead, S. M. 2010. The Economics of Managing Scarce Water Resources. *REVIEW OF ENVIRONMENTAL ECONOMICS AND POLICY* 4 (2):179-198.

Saal, David S., and David Parker. 2001. Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales. *Journal of Regulatory Economics* 20 (1):61-90.

Starmer, Elanor. 2011. Keep a public hand on water. *High County News*, http://www.hcn.org/wotr/keep-a-public-hand-on-water.

Sugarman, Dan. 2011. Questions Regarding Rate Cases for United Water Private Utility. Washington, 04 February 2011.

Teeples, Ronald, and David Glyer. 1987. Cost of Water Delivery Systems: Specification and Ownership Effects. *The Review of Economics and Statistics* 69 (3):399-408.

Thorsten, Richard E., Shadi Eskaf, and Jeffrey Hughes. 2009. Cost Plus. *Public Works Management & Policy* 13 (3):224-238.

Timmins, Christopher. 2002. Measuring the Dynamic Efficiency Costs of Regulators' Preferences: Municipal Water Utilities in the Arid West. *Econometrica* 70 (2):603-629.

UNCEFC. 2009. Designing Rate Structures that Support Your Objectives: Guidelines for NC Water Systems. Chapel Hill: University of North Carolina Environmental Finance Center.

Vitale, Robert. 2008. Request for 7.1 percent rate hike ends streak of double-digit jumps. *Columbus Dispatch*, 10 November 2008.

Wallsten, Scott, and Katrina Kosec. 2008. The effects of ownership and benchmark competition: An empirical analysis of U.S. water systems. *International Journal of Industrial Organization* 26 (1):186-205.

Walter, Elissa B. 2009. Regulation of the Municipal Securities Market: Investors Are Not Second-Class Citizens. New York, 28 October 2009.

Walton, Brent. 2010. The Price of Water: A Comparison of Water Rates, Usage in 30 U.S. Cities. *Circle of Blue*, http://www.circleofblue.org/waternews/2010/world/the-price-of-water-a-comparison-of-water-rates-usage-in-30-u-s-cities/.

Water, City of Lancaster Bureau of. 2010. Filing of Rate Increase for Water Service to Properties Outside of the City. edited by B. o. Water. Lancaster.

Wolff, Gary H., and Meena Palaniappan. 2004. Public or Private Water Management? Cutting the Gordian Knot. *Journal of Water Resources Planning & Management* 130 (1):1-3.

Appendix

Appendix A: Detailed Variable Explanations

Table 26: Detailed Variable Explanations for entire dataset

Variable	Explanation
Facility Name	Name of the facility
Balance Year	Year corresponding to financial data, not the year the survey was taken
Ownership	Delineates ownership of the facility
Population Served	# of individuals served by the facility. Does not describe the number of connections
Residential Customers	Number of residential customers in the system
Wholesale Customers	Number of wholesale customers in the system. Wholesale customers generally garner lower rates than residential customers. However, these customers represent a more stable demand for water
Total Customers	Total number of customers in a system
Daily Production Capacity	Amount of water (in millions of gallons) that a utility can process and deliver in the system in a given day
Max Daily Water Delivered to System	The highest amount of water (in millions of gallons) that the utility delivered to its customers on a given day during the survey year
Wholesale Water Sold	Amount of water sold to wholesale customers in a given year in millions of gallons
Total Water Sold	Amount of water delivered to the system in millions of gallons for a given year
% Groundwater	The percentage of water delivered that is sourced from groundwater
% Surface water	The percentage of water delivered that is sourced from surface water
% Purchased Water	The percentage of water delivered that is purchased from another utility. Often this is finished water but it can be raw water.
Operating Revenue	Cash received by the facility for operations. Generally includes water rates and water-related fees.
Operation & Maintenance Expense	Cost of delivering water and maintaining the facility. Usually this variable includes depreciation expense, however, this is not the case for these surveys
Total Nonoperating Income	Amount of income received not related to operations.
Net Income	Summation of revenues and expenses for the balance year
Total Assets	Monetary value of the capital infrastructure of a facility
Total Current Liabilities	Liabilities due within the year. Current liabilities often include wages and other accounts payable
Long Term Debt	Financed debt from the facility
Total Liabilities and Equity	Should equal the total assets of a facility. Includes debt and equity investment.
Employees	Total number of full time employees at a facility

Gross Capital Expenditures	The planned amount of money to be invested by the facility into capital projects such as pipe replacement or facility upgrade. It should be noted that these are planned, not actual, expenditures. Contain values for years 2004 through 2012.
Depreciation	Depreciation expense for a facility in the given balance year
Rates Regulated	Dummy variable indicated whether the rates of the facility are regulated by a public utility commission (PUC). The PUC generally determines the level of profit a utility is allowed to make. Most public utilities are not regulated by a PUC
Current Assets	Assets to be realized within the current year. This will not include capital assets.
City/Municipal Ownership	Dummy variable indicating ownership by a city or municipality
County Ownership	Dummy variable indicating ownership by a County
Government Water and Wastewater Ownership	Dummy variable indicating ownership by the federal government. Also indicates the utility operates a wastewater facility
Government Water Ownership	Dummy variable indicating ownership by the federal government.
Co-op Ownership	Dummy variable indicating ownership by a co-op
Other Ownership	Other ownership
Private Ownership	Dummy variable indicating private ownership
Public Ownership	Dummy variable indicating public ownership
2002 Balance Year	Dummy variable indicating that responses come from the 2002 balance year response
2004 Balance Year	Dummy variable indicating that responses come from the 2004 balance year
2007 Balance Year	Dummy variable indicating that responses come from the 2007 balance year
EPA Small Size	Dummy variable indicating if the population served is between 501 and 3,300
EPA Very Small Size	Dummy variable indicating if the population served is less than 500
EPA Medium Size	Dummy variable indicating if the population served is between 3,301-10,000
EPA Large Size	Dummy variable indicating if the population served is between 10,001-100,000
EPA Very Large Size	Dummy variable indicating if the population served is above 100,001

Appendix B: Summary Data

Table 27: AWWA Survey Entries--Mean Values by Balance Year

Survey Balance Year	Total Water Sold (Million Gallons / Year)	Net Income	Population Served	Operating Revenue	Total Unique Entries
2002	7898	2,579,153	150,000	19,878,809	253
2004	7276	1,908,561	150,000	22,663,117	222
2007	6196.5	2,378,493	125,000	24,001,344	275

Table 28: AWWA Survey Entries--Number of Utilities in EPA Size Designations

Survey Balance Year	EPA Small	EPA Medium	EPA Large	EPA Very Large	# in Private Ownership
2002	0	2	91	172	12
2004	0	0	80	147	7
2007	0	3	118	159	4

Table 29: NAWC Survey Entries--Mean Values by Balance Year

Survey Balance Year	Total Water Sold (Million Gallons / Year)	Net Income	Population Served	Operating Revenue	Total Unique Entries
2002	5581.5	2333513	163000	23666295	56
2004	5973	1873438	161000	25389717	47
2007	6650	2659698	155261	35383887	34

Table 30: NAWC Survey Entries--Number of Utilities in EPA Size Designations

Survey Balance Year	EPA Small	EPA Medium	EPA Large	EPA Very Large	# in Private Ownership
2002	0	0	22	34	56
2004	0	0	18	29	47
2007	0	0	12	22	34

Table 31: Summary Data of All Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Balance Year	887	2,004.348	2.100563	2,002	2,007
Population Served	879	391,634.3	778,682.7	10,002	9,008,278
Residential Customers	886	75,651.08	104,743	0	753,480
Wholesale Customers	886	140.3318	2,656.145	0	75,629
Total Customers	882	83,694.07	116,702.5	3	828,070
Daily Production Capacity	852	130.662	548.475	0	14,995
Max Daily Water Delivered to System	846	102.1076	478.1037	0	13,021
Wholesale Water Sold	520	7,704.038	64,448.49	0	1,423,447
Total Water Sold	857	17,860.4	36,485.24	0	451,200
% Groundwater	886	0.34167	0.413765	0	1
% Surfacewater	886	0.491693	0.453816	0	1
% Purchased Water	886	0.146512	0.311163	0	1
Operating Revenue	799	6.07E+07	1.20E+08	0	2.13E+09
Operation & Maintenance Expense	799	3.76E+07	7.51E+07	0	1.39E+09
Total Nonoperating Income	799	1,779,811	6,388,168	-5,226,458	9.78E+07
Net Income	799	7,194,711	2.17E+07	-2.12E+08	2.38E+08
Total Assets	801	4.73E+08	1.05E+09	0	1.91E+10
Total Current Liabilities	801	2.63E+07	6.75E+07	0	6.76E+08
Long Term Debt	801	1.88E+08	5.64E+08	0	9.48E+09
Total Liabilities and Equity	801	4.74E+08	1.06E+09	0	1.91E+10
Employees	831	194.7377	326.018	1	2,686
2004 Gross Capital Expenditures	578	1.37E+07	3.65E+07	0	5.26E+08
2005 Gross Capital Expenditures	578	2.59E+07	8.29E+07	0	1.59E+09
2006 Gross Capital Expenditures	578	2.33E+07	6.19E+07	0	9.94E+08
2007 Gross Capital Expenditures	578	2.56E+07	9.85E+07	0	1.88E+09
2008 Gross Capital Expenditures	853	2.55E+07	8.21E+07	0	1.43E+09
2009 Gross Capital Expenditures	578	2.76E+07	7.72E+07	0	1.18E+09
2010 Gross Capital Expenditures	309	3.16E+07	8.64E+07	0	8.38E+08
2011 Gross Capital Expenditures	309	3.00E+07	9.20E+07	0	1.03E+09
2012 Gross Capital Expenditures	309	3.11E+07	8.99E+07	0	8.17E+08
Depreciation	887	1.02E+07	2.70E+07	0	5.36E+08
Current Assets	887	3.97E+07	8.32E+07	-3,951,278	8.29E+08

Appendix C: Data Cleaning and Sorting

The data, as presented by the NAWC and AWWA, cannot be analyzed by the methods used in this study. Three main processes had to occur to resolve the data of formatting and consistency errors. First, I combined each individual survey into a single master spreadsheet for both the AWWA and NAWC. This required noting and resolving any question inconsistencies developed throughout the different propagations of the survey[19].

I then prepared both survey sets for combination into a single master datasheet. The combination process required finding questions from both surveys that were the same. Additionally, I had to determine the corresponding financial balance year to use from the multiple NAWC datasets for the AWWA survey. Although the AWWA issues its survey bi-annually, the financial data it requests does not follow the same pattern[20]. This most probably reflects the period between survey implementation and publication of results. Thus, a survey conducted in 2008 for both the NAWC and AWWA may have data from 2006 in the latter and 2007 in the former. I was able to resolve this issue by combining surveys not by survey year, but by balance year.

Once combined, I scanned the data for entry inconsistencies. Data inconsistencies followed two patterns: complete non-entries and selective entry inconsistencies. Complete non-entries exist where a utility fills out only a specific portion of the survey. For example, a utility may fill out data regarding the amount of water it sells, and leave the rest of the survey blank. Such entries were deleted[21].

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[19] Generally, both surveys changed very little in all years of issuance (with only one or two questions added in a year and no questions ever deleted).

[20] Additionally, the AWWA contains a minimal amount of international water company entries. I deleted these entries as they did not follow this study's focus of U.S. water ownership

[21] This only occurred for two surveys

Selective entry inconsistencies occurred where utilities would enter the number zero for entries where a zero entry is impossible[22]. Such inconsistencies only occurred in the AWWA data and may be a result of the methodology used in converting non-entries. Where reasonable and possible, I converted the "zero" entry to the closest approximation as based on previous entries by the same company. Otherwise, I converted the zero entries to non-responses.

With the data in a combined and coherent format in Microsoft Excel, I exported the data into STATA's statistical software package for analysis. To complete the data cleaning process, I applied appropriate labels to all of the variables and created dummy values where appropriate.

[22] In one example, a utility entered "0" for its daily production capacity although it entered a positive number for the amount of water it serves to a population. A "0" in this case would be impossible. The utility must be able to process water in order to serve water.

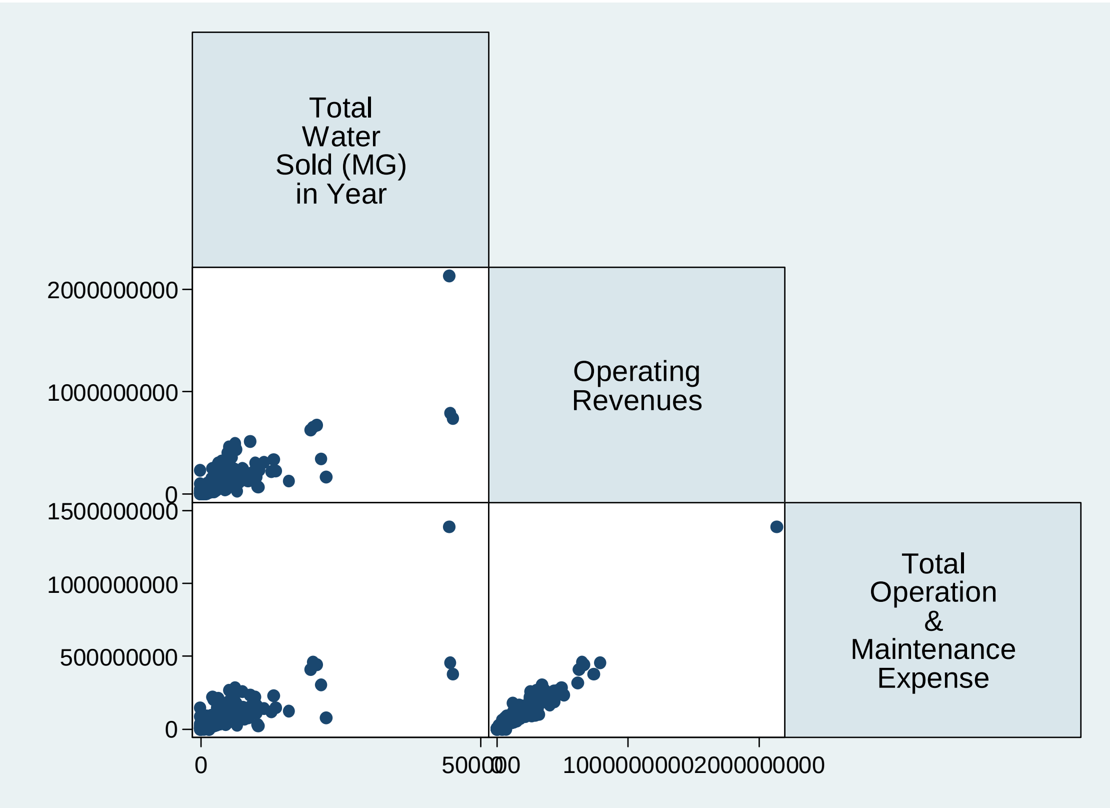
Appendix D: Testing Behavior of Variables

RELATIONSHIP BETWEEN TOTAL WATER SOLD AND FINANCIAL VARIABLES

Table 32: Correlation Coefficients for Finance Variables on Total Water Sold

Variable	Correlation	P-value
Operating Revenue	0.8315	0
Operation and Maintenance Expense	0.8269	0
Total Nonoperating Income	0.266	0
Net Income	0.4983	0
Total Assets	0.826	0
Total Current Liabilities	0.7442	0
Long Term Debt	0.8235	0
Total Liabilities	0.8286	0
Depreciation Expense	0.7545	0

Figure 4: Matrix Graph Depicting Relationship between Total Water Sold and Select Finance Variables

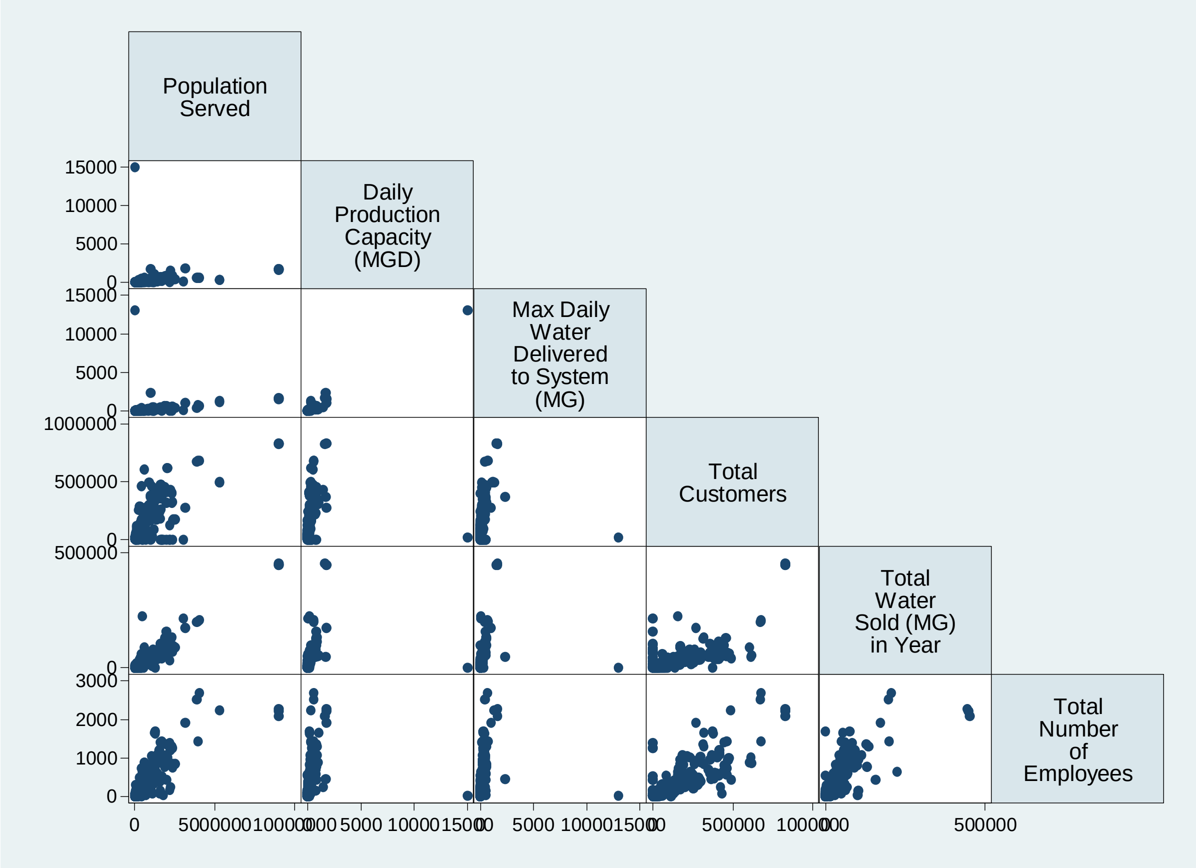


Relationship Between Population Served and utility Size Variables

Table 33: Correlation Coefficients for Size Variables and Population Served

Variable	Correlation	P-value
Daily Production Capacity	0.2688	0
Max Daily Water Delivered to System	0.2943	0
Total Customers	0.7837	0
Total Water Sold	0.945	0
Total Employees	0.8418	0

Figure 5: Matrix Graph Depicting Relationship between Population Served and Size Variables



Appendix E: Additional Regression Tests

EMPLOYMENT AND OWNERSHIP USING TIME TRENDS

	Coefficient	Std Error		
Daily Production Capacity	0.925604***	0.238873	Number of Obs	704
Max Daily Water	-0.40789	0.287846	F(10, 693)	27.41
Total Water Sold	0.002627***	0.001038	Prob > F	0
% Water Purchased	-7.21215	17.64817	R-squared	0.7427
Total Current Liabilities	1.37E-06***	4.90E-07	Root MSE	165.28
2004	-1.12E-01	1.70E+01		
2007	7.77779	16.73357		
Private Ownership	-18.1992	13.13787		
2004/Ownership Interaction	-15.9524	22.7106		
2007/Ownership Interaction	2.17728	24.29153		
Constant	44.93915***	12.29468		