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Comparison of operational energy requirements in publicly and privately owned U.S. water utilities

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ABSTRACT

One question in the ongoing discussion about privatization in the water industry is whether publicly or privately owned water utilities are more efficient. This study examines the question from an energy perspective using new data from water systems in the United States. Economic theory predicts that privately owned water utilities should use less energy relative to output than their public counterparts. However, no statistically significant difference was found between the two types of systems. This finding aligns with others indicating that privately owned water utilities do not necessarily perform better than publicly owned water utilities and suggests that energy management policies and practices should regard both types similarly.

1. Introduction

One point of interest in utilities policy and management research is the comparison of efficiency between publicly and privately owned utilities, particularly in the water industry. In the United States, most community water systems are publicly owned (e.g., by a municipal government), while privately owned water utilities (e.g., those owned or operated by a private company) serve about 17% of the population (EPA, 2018). While drinking water standards apply to both types, private systems are also subject to economic regulation by state public utilities commissions.

An organization's economic efficiency is determined by the amount of output produced by a given level of input (Renzetti and Dupont, 2003). Economic theory, specifically the theory of the firm, predicts that private ownership will yield greater efficiency than public ownership (Renzetti and Dupont, 2003; Megginson and Netter, 2001; Brubaker, 1998; Millward, 1982; Crain and Zardkoohi, 1978). These claims assume that private utilities are better managed, have more advanced technology, can access more capital, focus on a single activity, and receive more pressure from shareholders to perform well. Further, a private utility's for-profit mission would motivate measures to reduce costs and improve efficiency (Romano and Guerrini, 2014), assuming effective economic regulatory mechanisms and incentives as applicable.

While economic theory predicts that privately owned utilities will outperform publicly owned ones (in terms of economic efficiency, lower costs, etc.), the literature finds little consensus on this point for the water sector. Testing the theory that private firms will seek, more than public entities, to maximize their property rights (e.g., the right to use, profit from, or transfer resources), Morgan (1977) analyzed a sample of water utilities and determined that the privately owned ones have lower costs. In their economic analysis, Raffiee et al. (1993) found that privately owned water utilities have lower costs and more closely match theoretical cost-minimizing behavior. A meta-regression analysis of several previous studies (Carvalho et al., 2012) found that privately owned water utilities enjoy economies of scale and scope.

On the contrary, Pescatrice and Trapani (1980) found that publicly owned water utilities have lower costs than private ones. Bhattacharyya et al. (1994), using a cost function approach, likewise concluded that publicly owned water utilities are more efficient, though the spread is greater. Lehto (1997), citing the results of a meta-analysis of some 50 studies, observed that public ownership in the water sector (among other sectors) results in better performance. Kallis et al. (2010) surveyed several California water utilities and found that the publicly owned ones are more proactive in their water conservation programs.

Still other studies are inconclusive or found no relationship between economic efficiency and ownership (Seppälä et al., 2001). Renzetti and Dupont (2003) reviewed empirical evidence from the United States, the United Kingdom, and France, and concluded that there is no compelling evidence of superior performance by the private sector. Utilizing a data envelopment analysis of Portuguese water utilities, Marques (2008) concluded that privately owned water utilities are not necessarily more efficient. A meta-regression analysis of econometric studies (Bel et al., 2010) found no systematic support for cost savings resulting from private ownership of water utilities and instead attributed the differences to time periods, service characteristics, and policy environments. Peda

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et al. (2013) studied 43 Estonian water utilities using data envelopment analysis and found no effect of ownership on performance. With such mixed results, the debate over the superiority of public or private ownership in the water sector continues.

The quantity of resources that water utilities consume directly impacts the economic efficiency of these entities and the critical services they provide. Water utilities' consumption of one resource in particular – energy – has not been analyzed in detail until recently. Water services require substantial amounts of energy – about 0.07–3.0 kWh/m^3 – to extract, treat, pump, and deliver water to end users, transforming natural waters that would otherwise be unsuitable for human consumption into a reliable, high-quality product (Twomey and Webber, 2011; Sowby and Burian, 2017a; Chini and Stillwell, 2018). In California, the water sector consumes 19% of the state's electricity and 30% of its natural gas (Klein, 2005). Water utilities' energy footprints carry financial, environmental, and social impacts that need to be understood and managed sustainably.

Among the ongoing discussions about the benefits and drawbacks of privatization in the water industry, the question then arises as to whether there is any difference in energy use between publicly and privately owned water utilities. If the same theories and assumptions that predict greater economic efficiency in private enterprises apply to their energy use, one would expect privately owned water utilities to use less energy than their public counterparts. Further, with energy being one of the larger operational expenses in water supply (EPA, 2017), privately owned water utilities might naturally seek cost savings through strategic energy management and therefore utilize less energy than their publicly owned counterparts.

Using recent data from the United States, this study compares the operational energy use of publicly and privately owned water utilities to determine if a statistically significant difference exists, even after accounting for water utility size, water source type, and climate conditions.

2. Method

Data for this research originated in a survey of 109 U.S. water utilities in 36 states by Sowby and Burian (2017a, 2017b). While water usage and financial data are readily available, water utilities generally do not report or publish details about their energy use. This information is difficult to find, especially for large numbers of water utilities (Chini and Stillwell, 2017, 2018; Sowby and Burian, 2017a; Sowby, 2018a,b). This longstanding data gap is what motivated the Sowby and Burian (2017a, 2017b) survey, as well as similar ones (Chini and Stillwell, 2018; Lam et al., 2017; Kenway et al., 2011; Klein, 2005; Wilkinson, 2000). The dataset characterizes the operational energy uses of drinking water supply from the natural water source to the customer meter. The data include annual energy use and annual water delivery, as well as basic information on each system's water sources and climate setting. In subsequent work, the same researchers developed this information into a validated statistical model that estimates a water utility's operational energy use as a function of these variables (Sowby and Burian, 2018).

In this analysis, complete control over the water system's operation (and therefore its energy use) was deemed important for comparing energy use by ownership type. Of the 109 systems, 10 were excluded from this analysis because they relied on water imported from other water utilities and were therefore not directly responsible for a portion of their energy footprint. Further, the ownership type of the importer and exporter is not always consistent (e.g., a privately owned utility might import water from a publicly owned one), which prohibits comparing their energy use by ownership type. Of the remaining 99 water utilities, 79 were publicly owned and 20 were privately owned.

The relationship between ownership type and energy use was tested through an ordinary least squares (OLS) regression. The regression followed the statistical model developed by Sowby and Burian (2018) that considers the water utility's size (as annual water delivery volume), water source type (as gravity-fed surface water, pumped surface water, or groundwater), average annual precipitation, and average annual air temperature, which were found to explain 94% of the variation in the natural logarithm of the water utilities' energy use and therefore facilitate more equitable comparisons.

An ownership type indicator (1 = private, 0 = public) was added to the model and the regression then expressed the significance of each variable individually. The null hypothesis was that ownership type does not correlate with energy use. A 95% confidence level was selected (significance level $\alpha = 0.05$). If the test statistic's probability, p, for ownership was below 0.05, the null hypothesis would be rejected and the alternative hypothesis would be accepted. In other words, the method computes the probability that the observed energy use value would occur randomly if the ownership type were ignored. A low probability of this random behavior would support a strong relationship between ownership type and energy use. The magnitude and sign of the coefficient, respectively, would indicate how important the relationship is and whether private ownership corresponds to lower energy use (negative) or higher energy use (positive).

3. Results

Fig. 1 shows both groups of water utilities (public and private) plotted according to water delivery and energy use. Table 1 shows the regression results, with a relatively high coefficient of correlation (adjusted $R^2 = 0.94$) that matches the original statistical model by Sowby and Burian (2018).

The regression suggests that privately owned water utilities use less energy than comparable publicly owned ones, but the relationship is not statistically significant. The regression yielded $p = 0.24$ for ownership type, indicating that ownership type is not statistically significant in predicting energy use. (In lay terms, there is a 24% chance that the difference is random.) This is evident in Fig. 1, where there is no clear visual distinction in the vertical direction among publicly and privately owned water utilities of the same size.

The coefficient for policy presence is −0.17, which indicates a negative relationship. However, the 95% confidence interval for this coefficient is −0.45 to 0.12 (of which −0.17 is the mean), meaning that in repeated sampling, the coefficient would fall in this interval 95% of the time. The interval is not strictly negative or positive and the difference cannot be attributed to ownership type alone.

While the result is not statistically significant, it is still interesting to quantify the differences between the two groups, but this requires some interpretation. The statistical model of Table 1 estimates the natural logarithm of energy use rather than energy use, so the result must be exponentiated to obtain energy use. Comparing the two cases where only the ownership indicator differs and all other terms in the exponent

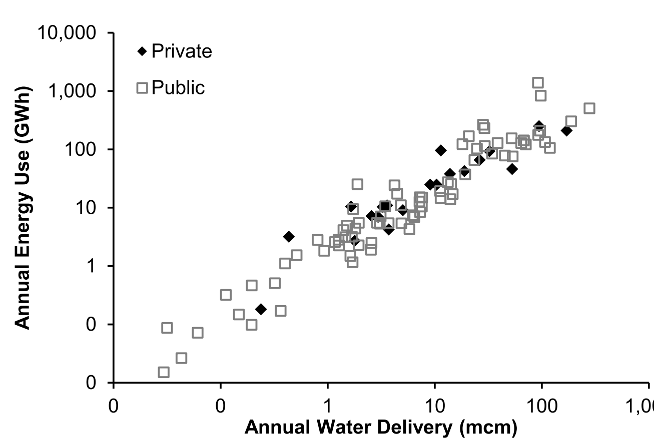

Fig. 1. Energy use of publicly and privately owned water utilities.