

A Comparison of Costs in Privately-Owned  
and Publicly-Owned Electric Utilities:  
The Role of Scale\*

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## I. INTRODUCTION

At a time when many governmental activities are being privatized around the world, a large number of publicly-owned utilities continue to produce electricity in the U.S. Table 1 shows that these utilities tend to produce much less electricity than do the privately-owned utilities. Why do both types of ownership persist? Is it because publicly-owned utilities are more efficient at low levels of output and privately-owned utilities are more efficient at high output?

The answer may be found in the different costs of monitoring the two types of firms. While we recognize that single-factor explanations of complex behavior are fraught with difficulty, monitoring performance appears to play an important role in determining optimal organizational forms.<sup>1</sup> In the public sector, the electorate is faced with monitoring the actions of its elected officials and rewarding (reelecting) those who do well and punishing (not reelecting) those who are bad agents and who provide ineffective oversight of utility managers. As is well known, constituents have little economic incentive to vote, much less to make an informed voting decision. There is evidence, nevertheless, that elected officials are rewarded for good economic performance and for casting votes preferred by their constituencies.<sup>2</sup> Numerous theoretical models of voting predict voting turnout to be lower in larger jurisdictions, either because the probability of being a decisive voter

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<sup>1</sup>Demsetz and Lehn (1985) argue that regulation leaves managers with fewer decisions, and thus the managers of regulated firms require less monitoring from their stockholders. Consistent with this reasoning, they find stock ownership to be less concentrated in regulated privately-owned firms than in comparable non-regulated firms.

<sup>2</sup>Peltzman (1990) summarizes the literature on how economic performance is rewarded. Johannes and McAdams (1981), Wright (1993), and Schmidt, Kenny, and Morton (forthcoming) show that incumbents whose voting record is far from that predicted for them are less likely to be reelected.

is smaller or because free riding is more of a problem.<sup>3</sup> And this prediction is supported by the empirical evidence.<sup>4</sup>

The drop in the voter turnout rate in local elections as jurisdictions get larger undoubtedly reflects reduced political participation in general. Since there is less political involvement in large cities, citizen monitoring of officials' performance should be less effective in large cities. Hansen, Palfrey, and Rosenthal (1987) conclude that "budget-maximizing agents are more likely to arise in large jurisdictions." Less effective monitoring should lead to higher electricity generation costs for large publicly-owned firms. Thus, as output rises, publicly-owned utilities become more expensive relative to privately-owned utilities, for which monitoring costs are relatively unaffected by changes in scale.

In the small literature that has compared the costs of electricity generation for these two forms of ownership, the evidence is far from conclusive on which form of ownership yields lower costs. Meyer (1975) estimated a quadratic cost function without taking into account differences in input prices or in technology; he concluded that publicly-owned electric utilities have lower costs than privately-owned utilities. It is difficult to interpret his results, since publicly-owned utilities face lower interest rates and many of the publicly-owned utilities in his sample relied on cheaper hydroelectric power.

Due to the limited availability of data on publicly-owned firms,

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<sup>3</sup>See, for example, Palfrey and Rosenthal (1985).

<sup>4</sup>Filer and Kenny (1980), Hansen, Palfrey, and Rosenthal (1987), and Darvish and Rosenberg (1988) have found a strong negative empirical relationship between voter turnout and the size of the jurisdiction in city-county consolidation elections, school district budget referenda, and Israeli municipal elections, respectively. The estimates of the elasticity of the turnout rate with respect to the number of registered voters range from -.1 to -.2.

most of the studies in this area have been based on small samples of publicly-owned firms, which makes it difficult to draw strong inferences from the data. For example, the results reported in the studies described below are based on no more than 30 public utilities. Yunker (1975) also estimated a simple quadratic cost function and found no significant differences in average operating and maintenance expenditures. Färe, Grosskopf and Logan (1985) employed a nonparametric, linear programming technique and found no significant differences in overall cost efficiency. Both Pescatrice and Trapani (1980) and Atkinson and Halvorsen (1986) considered the effects of regulation and estimated a generalized translog cost function. But their studies differ in how they handled the effects of regulation. Pescatrice and Trapani (1980) allowed for effects of regulation--that is, use of shadow input prices rather than market input prices--on the privately-owned utilities only and found that publicly-owned utilities are 33% more cost efficient. Atkinson and Halvorsen (1986), however, allowed regulation to affect both types of utilities, and found that there is no significant difference in allocative efficiency between publicly-owned and privately-owned electric utilities and the two types of enterprises are equally cost inefficient.

These studies thus yield inconclusive evidence on the relative efficiency of publicly-owned and privately-owned electric utilities. Furthermore, they do not suggest that any differences in costs may be related to output levels. Additional evidence would help to resolve these issues. Our model follows Atkinson and Halvorsen's (1986) logic of allowing for the effects of regulation on both types of ownership and also allows market structure to affect cost. To obtain more precise estimates, our sample includes over twice as many publicly-owned utilities as other studies.

As predicted, we find that publicly-owned utilities become less efficient relative to privately-owned utilities as output rises. In particular, we find that publicly-owned utilities have lower costs than privately-owned utilities at low output levels and have higher costs at high output levels. Much of the advantage that publicly-owned utilities have at low output levels seems attributable to the subsidy granted by tax exemption on municipal bonds. Our results offer an explanation for the different distributions of output for these two forms of ownership. Interestingly, 83 percent of the utilities in our sample are estimated to have chosen the cheaper form of ownership.<sup>5</sup>

## II. THE MODEL

Our model, building on Atkinson and Halvorsen (1986), examines the relative cost efficiency of publicly-owned and privately-owned electric utilities, taking into account the effects of ownership, regulation and market structure. It takes advantage of the fact that the behavior of a utility maximizing regulated firm is in effect equivalent to cost minimization subject to shadow input prices, which reflects the effects of regulation as well as market input prices.

Electricity ( $Q$ ) is assumed to be produced with three inputs: labor, capital, and fuel. The shadow price for input  $i$  ( $p_i^*$ ), differs from the market price for input  $i$ ,  $p_i$ , because it is reflecting the effect of government's regulation as well as the company's utility maximizing behavior. Following Atkinson and Halvorsen (1984), the shadow price may be related to the market price through a factor of proportionality  $k_i^i$ ,

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<sup>5</sup>A simultaneous model could be developed which incorporates the self-selection process. Given the data limitations, we follow the literature in taking ownership type to be exogenous. The key point is that we establish an economic rationale for the empirical observations.

which is input specific and depends on the type of ownership.

$$(1) \quad p_i^{j*} = k_i^j p_i^j$$

The factor of proportionality is allowed to vary across ownership types. Using this shadow price approach, Atkinson and Halvorson derive a generalized translog actual cost function,  $C^A$ , that allows for departures from cost minimization.

$$(2) \quad \begin{aligned} \ln C^A = & \alpha_0 + \sum_{i=1}^3 \alpha_i \ln(k_i p_i) + \alpha_Q \ln Q \\ & + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \beta_{ij} \ln(k_i p_i) \ln(k_j p_j) \\ & + \frac{1}{2} \beta_{QQ} (\ln Q)^2 + \sum_{i=1}^3 \beta_{iQ} \ln(k_i p_i) \ln Q \\ & + \ln \left\{ \sum_{i=1}^3 k_i^{-1} \left[ \alpha_i + \sum_{j=1}^3 \beta_{ij} \ln(k_j p_j) \right. \right. \\ & \left. \left. + \beta_{iQ} \ln Q \right] \right\} \end{aligned}$$

The usual symmetry restrictions are assumed and standard parameter restrictions are applied so that the shadow cost function is homogeneous of degree one in shadow prices.

As Atkinson and Halvorsen (1984) note, additional degrees of freedom can be obtained by estimating the firm's actual cost share equations together with its total actual cost function.

Define the actual cost share of input  $i$  as

$$(3) \quad S_i^A \equiv \frac{p_i X_i}{C^A}$$

It can be shown that

$$(4) \quad S_i^A = \frac{\left[ \alpha_i + \sum_{j=1}^3 \beta_{ij} \ln(k_j P_j) + \beta_{i0} \ln Q \right] k_i^{-1}}{\sum_{i=1}^3 \left[ \alpha_i + \sum_{j=1}^3 \beta_{ij} \ln(k_j P_j) + \beta_{i0} \ln Q \right] k_i^{-1}}$$

The total actual cost equation (2) and the actual cost share equations (4) will be estimated. Since the sum of cost shares is equal to 1, one of the share equations will be dropped in estimating the set of equations.

Are publicly-owned and privately-owned equally efficient in obtaining output from a given set of inputs? Does the pressure of competition result in more efficient production? To test for these effects, the translog intercept ( $\alpha_0$ ) and the linear terms in output ( $\alpha_0$ ) and in the shadow prices ( $\alpha_i$ ,  $i=L, K, F$ ) are made dependent on ownership and on market structure:

$$(5) \quad \begin{aligned} \alpha_0 &= a_0 + b_0 \cdot \text{PUB} + h_0 \cdot \text{MON} \\ \alpha_i &= a_i + b_i \cdot \text{PUB} + h_i \cdot \text{MON} \\ \alpha_0 &= a_0 + b_0 \cdot \text{PUB} + h_0 \cdot \text{MON} + d_0 \cdot \text{PUB} \cdot \text{MON} \end{aligned}$$

where MON equals 1 in a monopolistic environment and 0 in a competitive environment and where PUB equals 1 for publicly-owned utilities and 0 for privately-owned utilities. Note that we also allow the intercept to be affected by interaction between ownership and market structure.

Differences in price efficiency by ownership type are reflected in the  $k_i$  coefficients.

$$(6) \quad k_i = d_i + g_i \cdot \text{PUB}$$

Since the total actual cost equation and the actual cost share equations are homogeneous of degree zero in the  $k_i$ 's, we need to incorporate at least one normalization on the  $k_i$ 's (Diewert, 1974). By setting  $d_L = 1$  and  $g_L = 0$ ,  $k_L$  is normalized to one.

### III. SAMPLE AND VARIABLES USED IN EMPIRICAL ANALYSIS

The provision of electric power can be subdivided into three components -- generation, transmission, and distribution. To keep our data and production processes comparable, we limit our attention to the generation component, and in particular to steam-electric generation. The sample consists of 182 firms--121 privately-owned and 61 publicly-owned--in the year 1986. The publicly-owned electric utilities in our sample include municipals, public power districts, state authorities, irrigation districts, and other state organizations.

Our sample initially consisted of those firms for which there were data on steam-electricity generation in 1986. Missing data on the individual variables reduced this sample still further. Generally, the data for publicly-owned utilities were poorer than for privately-owned. This was a particular problem for data on wages and employment, which were not published for publicly-owned utilities. We sent out questionnaires to obtain the missing labor data; 61 of 91 companies responded, which gives us twice as large a sample of publicly-owned firms as that utilized by others.<sup>6</sup>

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<sup>6</sup>The high response rate may be attributable to sending out a follow-up questionnaire if we did not obtain an initial response.

The data construction, with several exceptions, follows the methods developed by William Greene (Christensen and Greene, 1976) and later used by Atkinson and Halvorsen (1986).<sup>7</sup> Summary statistics for the entire sample and for subsamples based on ownership and market structure are reported in Tables 2 and 3, respectively.

#### Dummy Variable for Market Structure

We sought to examine whether competitive pressures result in lower costs. Until recently, competition in the electric power industry has been limited. Electric utility duopolies are rare, and competition between them is sometimes restricted. Following Primeaux, Filer, Herren, and Hollas (1984), we take advantage of the fact that natural gas and electricity are substitutes for providing heat and hot water and for cooking. A firm is classified as a monopoly if it supplies both gas and electricity and is classified as acting in a competitive environment if it supplies only electricity.<sup>8</sup> On the other hand, this dummy variable may be capturing economies of scope, since the combination firms defined as monopoly produce multiple products.<sup>9</sup> Our data consist of 127 competitive electric utilities, of which 75 are privately-owned. There are very few publicly-owned monopolies in our sample; only 9 of 55 monopolistic electric utilities are publicly-owned.

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<sup>7</sup>Unless otherwise indicated, the data used in the empirical analysis were mainly obtained from Financial Statistics of Selected Electric Utilities 1986 (1988), Electric Power Quarterly (1986, 1987), Cost and Quality of Fuels for Electric Utility Plants 1986 (1987), and Historical Plant Cost and Annual Production Expenses for Selected Electric Plants 1986 (1988).

<sup>8</sup>The list of combination companies is obtained from Electrical World: Directory of Electric Utilities (1986-1987).

<sup>9</sup>Subadditivity captures the cost advantage of multiproduct production over single-product production. It contrasts the cost of producing outputs  $q_1, \dots, q_n$ , all in a single firm, with the total cost of producing each output  $q_i$ ,  $i = 1, \dots, n$ , in separate firms, each specializing in the production of one product (Berg and Tschirhart, 1988).

### Capital cost of production

Capital costs, unlike labor and fuel costs, have to be estimated. In constructing a rough proxy for capital cost, Nerlove (1963), Christensen and Greene (1976), and Atkinson and Halvorsen (1986) summed just interest expenses and depreciation. Then, interest and depreciation charges on the firm's entire production plant were multiplied by the ratio of the firm's book value of steam production plant to the book value of total production plant. Since we were unable to separate depreciation charges from depreciation and amortization charges for publicly-owned utilities, we used the summed interest expenses, depreciation and amortization charges reported by each firm.<sup>10</sup>

### Labor cost of production

Wage and employment data were obtained from published data for privately-owned utilities and from mail questionnaires sent out to publicly-owned utilities.<sup>11</sup> If steam-electric generation was not the only type of generation employed by the firm, the total labor expenditure was multiplied by the ratio of steam production to total production.

### Fuel cost of production

Fuel expenditure was directly calculated by summing the fuel costs of coal, oil, and gas.

### Total Production Cost and Cost Shares

It is assumed that total production cost consists of the annual capital, labor, and fuel costs described above. Each input's share in

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<sup>10</sup>Amortization allows a firm to write off the value of intangible assets such as good will. Our use of depreciation and amortization charges instead of depreciation charges allows some profit, written off as goodwill, to be included in the firm's cost. With regulatory oversight, this is not expected to be an important problem.

<sup>11</sup>Firms provided data for 1986 on total salaries and wages charged to electric operation and maintenance, number of regular full-time employees, and number of part-time and temporary employees.

total cost equals its cost divided by total cost.

### Output

Monthly net steam-electric generation at every plant by each type of fuel, reported in Electric Power Quarterly (1986), were utilized to obtain annual total output. From Table 3, it can be seen that in our sample as well the typical publicly-owned utility produces much less output than does the average privately-owned utility.

### Price of Capital

Measuring the price of capital is nearly as difficult as measuring the cost of capital.<sup>12</sup> To measure the firm's appropriate discount rate, we first found in Moody's Public Utility Manual the long term bond the firm had issued that was closest to July 1986. Since utilities issue long term bonds infrequently and the corresponding interest rates fluctuate over time, this induces undesired variability into the measured price of capital. To rectify this situation, interest rates are adjusted for changes in Treasury long term bonds over time.<sup>13</sup>

The Handy-Whitman Index used in prior work unfortunately includes the construction costs of hydraulic installations and provides only six regional index numbers. For a more detailed measure, we used the Means City Cost Index, which has construction cost index numbers by state.

Following standard practice in the literature, we multiplied these cost index numbers by the interest rates described above. It can be seen in Table 3 that the price of capital is lower to publicly-owned utilities

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<sup>12</sup>Nerlove (1963), Christensen and Greene (1976), and Atkinson and Halvorsen (1986) measured the price of capital as the current yield on the firm's latest issue of long term debt multiplied by the Handy-Whitman Index of Electric Utility Construction Costs.

<sup>13</sup>For example, the Alabama Power Company issued in May 1986 a thirty year bond with a 9.375% yield. The yields of Treasury long term bonds issued in May 1986 and in July 1986 are 8.09% and 7.88%, respectively. The adjusted yield is  $9.165$ , which equals  $9.375 + (7.88 - 8.09)$ .

than to privately-owned utilities, reflecting the favorable tax status given to municipal bonds.

#### Price of Labor

The number of full time equivalent (FTE) employees was found by summing the number of full-time employees and one half the number of part-time employees. The price of labor is then estimated as the ratio of total labor cost to total number of FTE employees. In Table 3, it can be seen that electric utilities in a monopoly environment face a higher price of labor than do utilities in a competitive environment, perhaps because the incentive to fight union wage gains is higher in a competitive environment.

#### Price of Fuel

The prices of coal, gas, and oil were made comparable by defining them as dollars per million BTU. The price of fuel then was calculated as a BTU-weighted-average of the prices of fuels used by each firm.<sup>14</sup>

### IV. EMPIRICAL RESULTS

The total actual cost equation (2) and the actual cost share equations (4) are estimated together with the restrictions associated with linear homogeneity in shadow prices. The equations are estimated by non-linear least squares, with the results reported in Table 4.

Let us begin by discussing the linear shadow price coefficients. As expected, the estimated values for  $\alpha_L$ ,  $\alpha_K$ , and  $\alpha_F$  are all positive. Two of the three base terms ( $a_K$  and  $a_F$ ) but only one of the six interaction terms ( $h_K$ ) are significant. We find no differences between

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<sup>14</sup>We obtained most of the data from Cost and Quality of Fuels for Electric Utility Plants 1986 (1987), but for the five firms for which this was not possible, we used Historical Plant Cost and Annual Production Expenses for Selected Electric Plants 1986 (1988).

privately-owned and publicly-owned utilities in the effect of shadow prices on costs. On the other hand, the positive coefficient on  $h_k$  indicates that capital prices have a greater impact on costs for "monopoly" utilities, which provide both gas and electricity, than for "competitive" utilities providing only electricity. Utilities providing both gas and electricity may spend more on capital due to the lack of competition or because this is warranted to take advantage of economies of scope.<sup>15</sup>

Several of the various trans-log interaction terms involving the shadow prices and output are significant, and a likelihood ratio test rejects the restriction that the production function is Cobb Douglas.

As noted above, the shadow price/market price ratio for labor ( $k_L$ ) has been normalized to be one. We allow the shadow price/market price ratios for capital and fuel to vary by ownership but find no evidence that publicly-owned and privately-owned utilities differ in their distortion of factor prices;  $g_k$  and  $g_f$  are both insignificant. Furthermore, the coefficients  $d_k$  and  $d_f$  not being significantly different from one is consistent with relative price efficiency for privately-owned electrical utilities.

The intercept in the cost function has been interacted with the public ownership dummy (PUB), the monopoly market structure dummy (MON), and the product of the two variables. Of these three interaction variables, only the public ownership dummy ( $b_0$ ) is significant, with a negative coefficient.

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<sup>15</sup> Alternatively, because these multi-product producers set the prices for both electricity and natural gas, they may promote the latter to dampen seasonal and daily electricity peaks. This would give them a higher electricity load factor, enabling them to take greater advantage of base-load capacity. If this happened, multi product suppliers would tend to be relatively more capital-intensive (and less fuel-intensive).

We have hypothesized that publicly-owned utilities become relatively less efficient at higher output levels because voters in larger cities are less attentive monitors. The positive and highly significant coefficient on  $b_0$  provides strong support for this hypothesis. There is, however, no evidence that the effect of output differs by market structure:  $h_0$  is not significant.

To summarize, the negative coefficient on  $b_0$  and the positive coefficient on  $b_1$  imply that publicly-owned firms are more efficient than privately-owned firms at low output levels and are less efficient at high output levels. If both types of firms face the same prices, then

$$\ln C_{\text{PUB}}^A - \ln C_{\text{PRIV}}^A = -2.8694 + .2614 \cdot \ln Q$$

Privately-owned and publicly-owned firms are equally efficient when

$$\ln Q = 2.8694 / .2614 = 10.97705$$

$$Q = 58,516$$

Seven firms in our sample produced less than this output level, and six of these were publicly-owned.

The subsidy to capital given to publicly-owned utilities distorts this comparison. A comparison of the means reported in Table 3 shows that capital is 25-30 percent cheaper for publicly-owned utilities. We recalculate the range of output over which publicly-owned producers are more efficient, taking into account differences in input prices. We substitute the above estimates of parameters and the mean values of input prices into each ownership type's actual total cost function respectively. These costs are equal at an output of 725,106 mwh. Publicly-owned utilities are more efficient than privately-owned utilities at lower output levels and are less efficient at higher output levels. In 1986, fifty four electric utilities generated less than 725,106 mwh electricity. This includes 42 of the 61 publicly-owned

utilities but only 12 of the 121 privately-owned utilities. Thus, if ownership were determined only by these measured costs, 12 of the 121 privately-owned utilities should be publicly-owned and 19 of the 61 publicly-owned utilities should be privately-owned. In total, only 31 of 182 utilities (17 percent of the sample) have chosen an inefficient form of ownership.

Our results differ from those of Färe, Grosskopf and Logan (1985) and Atkinson and Halvorsen (1986), who found no significant difference in efficiency between publicly-owned and privately-owned electric utilities. There are several reasons for the differences. First, our sample included twice as many public-owned utilities. Second, we used better variables for the price of capital and the price of labor. Third, we controlled for market structure, although the variable was generally insignificant.

## V. CONCLUSION

Contrary to our expectations, only one of the five market structure parameters had a significant impact on cost. On the face of it, this evidence suggests that market structure does not affect cost. There is, however, an alternative explanation. As noted earlier, since the combination firms defined as monopoly produce multiple products - electricity and gas - the market structure dummy variable might also reflect economies of scope. If the cost increases associated with monopoly power are offset by the cost decreases due to economies of scope, the coefficients for this variable will be insignificant. Also, the pressures from competition may be diluted in the regulated environment facing utilities.

Nevertheless, the explanatory power of the model is good, and the results are consistent with predictions regarding organizational ownership choice by rate-payers. For low levels of output, publicly-owned electricity suppliers have lower generating costs per KWH than privately (investor)-owned suppliers, and most producers are publicly-owned. Voter rate-payers are in a better position to effectively monitor municipal and other publicly-owned electricity suppliers when there are fewer voters. In large jurisdictions, voter rate-payers are less effective monitors and privately-owned generation is cheaper and correspondingly much more common. It also should be noted that most of the public ownership impact seems attributable to subsidy of capital through municipal bonds since the scale associated with the efficiency cut-over point jumps from 58.5 million MWH to 725.1 million MWH when differences in input prices are taken into account. Based on the sample developed here, the absence of political pressure for further privatization in U.S. electricity may stem from the adoption of appropriate ownership forms by those affected by organizational structure. It remains to be seen whether the 1992 Energy Act's encouragement of open transmission access and increased competition at the generation level will lead to industry restructuring and/or consolidation which changes the potential advantages from systems with larger scale generation capabilities.

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TABLE 1  
 Distribution of Annual Net Electrical Generation  
 for Publicly-Owned and Privately-Owned Producers  
 (Steam, Nuclear, Hydro, and Other)

<u>Output (000s of MWHs)</u>	<u>Privately-Owned</u>	<u>Publicly-Owned</u>
0-60	8	72
60-150	5	32
150-300	9	30
300-450	3	23
450-600	1	7
600-750	2	3
750-1,000	4	5
1,000-1,500	6	8
1,500-2,000	2	7
2,000-3,000	10	10
3,000-4,000	8	3
4,000-5,000	8	3
5,000-7,500	20	9
7,500-10,000	17	3
10,000-15,000	18	4
15,000-20,000	13	1
20,000-25,000	11	1
25,000-30,000	6	0
30,000-40,000	4	1
40,000-50,000	7	0
50,000-80,000	6	0

Source: Financial Statistics of Selected Electrical Utilities 1988

TABLE 2  
Descriptive statistics for the entire sample

Variable	Minimum	Maximum	Mean	Standard Deviation
Total cost (\$)	2,196,917	2,286,818,759	284,323,672	352,962,621
Output (MWH)	16,688	75,450,682	8,178,322	11,082,746
Price of capital	478	1,233	794	151
Price of labor (\$)	14,104	46,393	25,734	5,185
Price of fuel <sup>1</sup> (\$/million BTU)	0.673	4.912	1.895	0.532
Share of capital	0.016	0.793	0.338	0.154
Share of labor	0.031	0.526	0.182	0.091
Share of fuel	0.051 <sup>2</sup>	0.901	0.480	0.182

<sup>1</sup>Since the individual plants of utilities use different types of fuel, the price of fuel might be related to the share of capital in a systematic way.

<sup>2</sup>The minimum value of the share of fuel is much smaller than the maximum value. This might be attributable to stockpiling of fuel over time, since the data for fossil fuels used here are the receipts data.

TABLE 3  
Means for Each Variable of the Four Subsamples

<u>Variable</u>	<u>Means</u>			
	<u>Private Competition</u>	<u>Private Monopoly</u>	<u>Public Competition</u>	<u>Public Monopoly</u>
Total cost	428,458,050	333,268,727	68,944,651	77,452,355
Output	13,281,927	8,751,964	1,429,710	1,708,307
Price of capital	867	873	650	610
Price of labor	25,707	25,982	25,367	26,807
Price of fuel	1.891	1.787	2.025	1.731
Share of capital	0.303	0.338	0.375	0.417
Share of labor	0.163	0.181	0.207	0.201
Share of fuel	0.534	0.481	0.418	0.382
<u>Number of observations</u>	75	46	52	9

TABLE 4

INTERCEPT			INTERACTION WITH PUB		INTERACTION WITH MON			
$\alpha_0$	$a_0$	14.9047* (1.4689)	$b_0$	-2.8694* (0.7742)	$h_0$	0.3664 (0.4249)	$d_0$	-0.0244 (0.1356)
SHADOW PRICE COEFFICIENTS								
$\alpha_L$	$a_L$	0.0725 (0.0820)	$b_L$	-0.0356 (0.0652)	$h_L$	-0.0031 (0.0072)		
$\alpha_K$	$a_K$	0.4810* (0.1250)	$b_K$	-0.1024 (0.1220)	$h_K$	0.0297* (0.0177)		
$\alpha_F$	$a_F$	0.4465* (0.1122)	$b_F$	0.1379 (0.1178)	$h_F$	-0.0265 (0.0157)		
$\beta_{KL}$		-0.0234 (0.0414)						
$\beta_{KF}$		-0.1030* (0.0257)						
$\beta_{LF}$		-0.0033 (0.0115)						
$\beta_{LL}$		0.0267 (0.0503)						
$\beta_{KK}$		0.1265* (0.0400)						
$\beta_{FF}$		0.1063* (0.0241)						
SHADOW/MARKET PRICE RATIOS								
$k_L$	$d_L$	1.0000	$g_L$	0.0000				
$k_K$	$d_K$	6.4877 (13.9498)	$g_K$	0.9297 (4.0030)				
$k_F$	$d_F$	0.9423 (1.8697)	$g_F$	4.8413 (9.8914)				

TABLE 4 Cont'd.

OUTPUT COEFFICIENTS			INTERACTION WITH PUB		INTERACTION WITH MON INTERACTION WITH PUB	
$\alpha_Q$	$a_Q$	-0.8006* (0.2138)	$b_Q$	0.2614* (0.0504)	$h_Q$	-0.0288 (0.0274)
$\beta_{QQ}$		0.1165* (0.0131)				
$\beta_{LQ}$		-0.0048 (0.0096)				
$\beta_{KQ}$		-0.0347* (0.0129)				
$\beta_{FQ}$		0.0395* (0.0099)				

Log Likelihood = 333.949

Number of observation = 182

R-square of total actual cost equation = 0.9409

R-square of share of capital = 0.188163

R-square of share of labor = 0.310279

- Notes: 1) Standard Errors are in parentheses.  
 2)  $\alpha_F = 1 - \alpha_K - \alpha_L$   
 3)  $k_L$  is constrained to equal to 1.0.  
 4)  $\beta_{FQ} = -(\beta_{KQ} + \beta_{LQ})$   
 5)  $\beta_{FZ} = -(\beta_{KZ} + \beta_{LZ})$   
 6) \*: significant at the 5% level.