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The Role of Competition in Natural Monopoly: Costs, Public Ownership, and Regulation

JOHN E. KWOKA*
Department of Economics, Northeastern University, 301 Lake Hall, Boston, MA 02115, USA

Abstract. Conventional policy for industries with very high economies of scale is to permit monopoly but to subject it to regulation or public ownership. Since the latter may not result in cost minimization, however, it is possible that competition, by forcing firms to operate at the cost frontier, may be less costly despite sacrificing some scale economies. The paper sets out the relevant analytical considerations, estimates a cost function for electric distribution utilities in the U.S., and tests for the relative costs of monopoly and duopoly utilities. Among other notable findings, it concludes that competition does indeed lower net costs.

Key words: Benchmark competition, electric utilities, public ownership, regulation.

I. Introduction

Although the relationship between competition and price receives more attention, the effect of competition on costs may be at least as important. By some measures the efficiencies gained from the latter exceed allocative improvements due to price competition (Scherer and Ross, 1990, p. 672), and in any event, cost reductions are one reason for price declines. All this makes cost competition seem universally advantageous, but where production technology is characterized by significant economies of scale, classical competition involving multiple firms would seem to be an unpromising approach: Competition may force firms to minimize cost for a given output and thus operate at the cost frontier, but each firm produces less output, fails to achieve minimum efficient scale, and suffers excess unit cost. For this reason, the preservation of multiple firms of suboptimal scale is scarcely ever endorsed as good policy.

That conclusion may be too facile, however, for two reasons. First, the trade-off between a closer approximation to the cost frontier and the

*Author for correspondence: Tel.: 617-373-2252; Fax: 617-373-3640; E-mail: j.kwoka@neu.edu

sacrifice of scale economies is an empirical question, and not one that necessarily favors the full-scale monopoly firm with its excess costs. Second, the monopoly that results from realization of all economies is usually accompanied by public ownership or regulation, each of which has its own well-known limitations with respect to cost minimization. Thus, in a world of second (and perhaps third) best choices, the possibility that competition might have a role even in the face of persistent scale economies cannot be ruled out.

The empirical analysis at the heart of this paper focuses on competition in the traditional distribution sector of the U.S. electric power industry. While the vast majority of jurisdictions in the U.S. have always been served by monopoly distribution entities, a nontrivial number have two distribution systems within their boundaries. These experiences allow an evaluation of the benefits of cost competition versus the costs of diminished realization of scale economies. In some instances the utilities are true duopolists, with duplicative facilities and direct competition for customers on an on-going basis. This represents the most obvious and straightforward type of competition in these markets. In other cases, the two utilities' service territories, while in the same city or county, are fixed and exclusive so that direct competition for customers does not occur. But since the utilities' operations are more readily observed and compared, their regulators or overseers have better information about true minimum costs, alleviating the usual information asymmetry that favors regulated firms and thereby permitting tighter control over costs and prices than otherwise would be the case. Note that in contrast to actual competition, this so-called "benchmark competition" does not sacrifice scale economies since no second firm actually operates in the same market and no facilities duplication occurs. How close it approximates the cost discipline of direct competition is an empirical question.

It should also be noted that most distribution duopolies consist of two quite different types of enterprises. One utility in each pair is typically privately owned and regulated, while the other is a publicly owned system. Although the relative costs of public vs. private ownership is itself an interesting (and well researched) question, the relevance of this question to the present study is limited to the need to control for ownership effects in order to isolate the incremental effect of competition. Moreover, it is entirely possible that direct competition has a different effect on costs in the case of a publicly owned system than for a private system, and hence our analysis must permit the two to differ.

We proceed as follows: We begin by estimating a standard cost function for the distribution sector of the U.S. electric power industry, allowing for the presence of competition in either form. Consistent with expectations, we find that competition lowers overall costs for the average utility, and does so by reducing operating costs sufficiently to offset the higher fixed costs of operation. The overall average cost reduction from competition is 1.7 percent, which may therefore be interpreted as a measure of the cost inefficiency of the typical regulated monopoly. Next we distinguish direct vs. benchmark competition and find that both reduce costs, with fixed cost differences now important only in the case of direct competition—precisely the case where duplication actually occurs. Remarkably in these results, quantitatively similar overall effects on costs arise from both types of competition—direct and benchmark.

Finally, distinguishing regulated private utilities and publicly owned systems produces the striking result that competition reduces costs only for the former. The reason is that costs are found to be equally low for a publicly owned monopoly as for a publicly owned utility facing competition. But since the competitive entity achieves true minimum cost, this implies that public ownership even without competition achieves cost efficiency. By contrast, costs under regulation are significantly higher without competition. Taken together, these results strongly suggest that the imperfections of the regulatory process exceed the imperfections of public ownership. Public ownership by itself appears to impose strong cost discipline on natural monopoly.

This paper is structured as follows. The next section focuses on the relevant theory regarding the effect of competition on costs.[1] Section III describes the U.S. electricity sector, with its publicly owned and regulated enterprises, and with particular attention to cases of competitive utilities. Section IV reports the results of estimating a cost function that measures the effects of competition on utility costs, drawing distinctions between direct and benchmark competition and between publicly owned and private firms. Section V offers some brief conclusions and further implications of these results for policy.

II. The Effect of Competition on Costs

This section sets out the simple analytics describing the relationship between competition and costs. We first examine duopoly competition in the context of pervasive economies of scale, and then the case of benchmark competition where comparable firms are used to impose cost discipline on monopoly sellers subject to regulatory oversight or public ownership.

[1] The issues with respect to regulation and public ownership are well-known and do not need further explication here. See, for example, Viscusi et al. (2000).

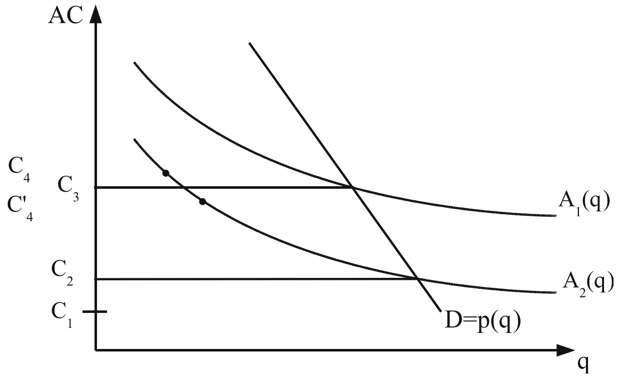

Figure I. The trade-off between inefficient monopoly and suboptimal scale duopoly

1. DIRECT COMPETITION AND THE COST TRADE-OFF

Consider a jurisdiction that might be served either (a) by a single publicly owned or regulated utility that incurs excess costs, or alternatively (b) by a duopoly that achieves lower costs at any output level due to competition. Assume further a single-product firm and a subadditive cost function. In Figure I, $A_1(q)$ represents average incurred costs—that is, including any excess costs—for the monopoly utility, while $A_2(q)$ is unit costs under duopoly structure. Cost competition under duopoly implies that $A_2(q) < A_1(q)$ for all q. The difference between the two cost curves is a measure of cost inefficiency from the regulated or publicly owned monopoly at each output q.

Given market demand $q(p)$, first-best price equals marginal cost, which is indicated by some c_1. Average cost c_2 represents the second-best price, i.e., that which minimizes allocative inefficiency subject to breakeven operation by the utility. But with only one utility, the cost locus A_2 is not attained. Rather, A_1 holds and the operative price is some third-best cost and price c_3—that which arises from monopoly production subject to both the breakeven constraint *and* cost inefficiency. The alternative duopoly structure involves operation along A_2 but at less than full scale. If, plausibly, each duopolist operates at half scale for the size of the market, each will realize some unit cost denoted c_4. Clearly, depending on the exact shape of A_2, unit cost under duopoly may be greater than or less than that of the inefficient but full-scale monopoly c_3.

This trade-off can be formalized as follows: Let minimum total costs be given by

$$C(q) = F + cq \tag{1}$$

where F denotes fixed and sunk costs, and c is constant marginal cost. Actual incurred costs under monopoly exceed $C(q)$ and are given by

$$D_1(q) = (1+\alpha)C(q) \tag{2}$$

where α is the percentage excess cost.[2] Total incurred costs under duopoly are given by

$$D_2(q) = C(x) + C(q-x) \tag{3a}$$

where x and $q-x$ denote the duopolists' respective outputs. For the present case of constant marginal cost, total costs are invariant to the distribution of output between the firms. Hence this expression becomes simply

$$D_2(q) = 2F + cq, \tag{3b}$$

We now wish to know, for given q, which production vector is more efficient—that based on a duopoly, or that under a non-cost-minimizing monopoly? Comparison of equations (2) and (3b) indicates that despite duplicative costs, duopoly is the lesser cost alternative so long as

$$2F + cq < (1+\alpha)(F+cq) \tag{4}$$

or

$$\alpha > F/(F+cq) \tag{5}$$

That is, duopoly is more efficient whenever the percent of excess costs under monopoly exceeds the ratio of fixed to total costs. Thus, greater monopoly inefficiency and smaller fixed costs favor duopoly provision, and are more likely to do so as output itself increases. The reverse set of circumstances favors monopoly.

2. BENCHMARK COMPETITION AND INFORMATION ASYMMETRY

The alternative mechanism by which competition may operate is benchmark competition—where similar firms operate subject to regulation in different markets. The effect of such competition may be portrayed as follows: Assume initially that the firms are identical and that each is a regulated monopoly seeking to maximize its profits:

$$\pi_i = (p_i - c^*)q(p_i) \tag{6}$$

[2] Excess cost may differ between fixed and variable costs, of course. The present model is easily modified to accommodate this possibility. By fixed costs, we mean any indivisible costs associated with production.

Here p_i denotes the price set by firm i's regulator, $q(p_i)$ is the firm's demand curve (assumed identical across firms), and c^* is the minimum unit cost of production. Stated in terms of Figure I, c^* is represented by the intersection of demand and $A_2(q)$, that is, c_2. This is common to all firms, known to them, but is not known to the regulator or public overseer. This latter fact would seem to preclude the regulator/overseer from enforcing c_2. Rather, there would seem to be informational rents conferred on the firm.

Note that in this stylized example, cost-of-service regulation is of little help. Under that technique, the regulator/overseer sets price at each firm's c_3, its incurred level of cost. The firm realizes no gain from cost conservation, incurs no loss from excess costs, and simply allows costs to rise.

In its simplest form, benchmark regulation addresses this incentive problem by setting each firm's price in accordance with the following rule:

$$p_i = \sum_{j \neq i} c_j/(n-1) \tag{7}$$

That is, a firm's price is now determined by the average of the *other* firms' realizations on c. This severs the dependence of a firm's price on its own costs and instead creates an incentive to reduce its own costs. Shleifer (1985) has shown that the unique Nash equilibrium cost choice for such a firm is the minimum cost c^*. The reason is straightforward: Since each firm earns profit to the extent that it achieves costs below the average of others, each has an incentive to lower its costs and ultimately all costs are "competed" down to their minimum level.

For this benchmark competition to be effective in practice, several issues must be resolved: The regulator/overseer must credibly commit to these rules. Firm accounting practices must be sufficiently comparable, or at least any differences allowed for. And very importantly, heterogeneity among firms' production processes, input costs, and demand conditions must be addressed. One proposed remedy for this last issue would identify characteristics that cause heterogeneity and then use regression techniques to purge firms' c_j's of such differences. In the limit, however, if firm heterogeneity dominates common characteristics, the utility of "benchmark" firms may be more as a source of some cost information, rather than as the basis for a specific pricing formula.

Note, of course, that while direct competition would seem to create stronger cost incentives than benchmark competition, the latter has the distinct advantage of not compromising the realization of scale economies. That implies that either mode of competition might in principle result in greater cost efficiency.[3] That relative effect, the comparison of such costs

[3] A similar implication is developed by Auriol and Laffont (1992), who emphasize the precise nature of the informational asymmetry between the firm and regulator.

under simple monopoly, and the further incremental effect of public ownership vs. regulation are the key questions addressed below.

III. Competitive Electric Utilities: Public vs. Regulated

Electric utilities in the U.S. are very numerous and diverse. The differ in size, structure, ownership, and competition. Here we focus primarily on competition—both direct and benchmark—in local distribution in the period prior to the restructuring of the late 1990s.[4]

While infrequent, competition between U.S. electric distribution utilities is by no means unknown. Hellman (1972, p. 51) and Primeaux (1986, pp. 187–188) report that direct competition existed in 85 communities in 1939, declining to 49 cities in 1966 and to 27 by 1981. Two Department of Energy publications—*Typical Electric Bills* and *Electric Sales, Revenue, and Bills*–contain lists of jurisdictions with multiple electric service providers. The latter source, for example, reports fully 110 cases where two (or in a few instances three) local distribution utilities operate in the same city or town. Out of 3000 electric utilities in the U.S., these numbers are relatively small but nonetheless constitute a usable set of experiences for analysis.

The initial list of possible competitive utilities was complied from several sources—Hellman, Primeaux, and the DOE publications dating from 1976 into the early 1990s. All listings required updating and confirmation to determine whether competition still existed as of 1989, the year of this study, and, if competition did exist, whether it took the form of "direct" or "benchmark." Moreover, in the case of true duopoly utilities, additional information on their operations was sought. Since public information was not entirely adequate, a survey was sent to both utilities in 40 cities and towns where direct competition was known to exist or where doubt remained as to its possibility. Initial responses plus follow-up contacts yielded a total of 46 completed questionnaires, with one (or more) from each of the 40 jurisdictions. Based on these returns together with public source information, 17 cities and towns were in fact determined to have direct distribution competition in the early 1990s. Other jurisdictions which had two utilities but lacked direct competition were categorized as having benchmark competition.

The 17 jurisdictions supporting direct competition—"duopoly utilities"—are listed in Table I. In all cases one utility was publicly owned and the other a private regulated enterprise. As indicated there, in twelve cases

[4] The competition here described and analyzed involves entire distribution utilities as traditionally constituted, that is, including both wires services and marketing. Current restructuring often separates the two functions in the belief that they are subject to different scale properties. Here and throughout, "distribution" is distinguished from generation and transmission.

existing customers could freely switch between electric power distributors on an on-going basis, while in five others such choice was limited to new residential and industrial users. Where switching was possible, customers were obliged in seven cases to notify their terminated supplier, and to wait from one to thirty days for the switch to be consummated. Apart from two with refundable deposits, no utility imposed a switching fee and only two had minimum stay requirements.

These provisions suggest relatively easy switching for customers in these cities and towns. It might seem surprisingly, therefore, that the median percentage of residential customers that actually do so in any year was only 0.5 percent, varying from near zero in Columbus, Ohio, to a maximum of just over six percent in Floydada, Texas.[5] One explanation, of course, is that one equilibrium to this interaction involves little or no customer switching since as the cost and price of rival sellers converge, the very reason for switching is eliminated. A more mundane possibility is suggested by survey responses indicating that some utilities' competitive efforts at attracting customers were stymied by regulatory or municipal boards that closely controlled pricing and related activities.

The survey also asked duopoly utilities about the operations side of their relationship with each other. Several utilities indicated that they had actual duplicate facilities—poles and wires—in their competitive areas. Perhaps the best known examples of such direct competition is Cleveland, Ohio. At the other extreme, five utilities indicated that they share poles, most on some contractual basis, although one professed to rely on a "gentlemen's agreement." Two of the five utilities sharing poles also reported that they also shared wires, while none did so with respect to drop lines to individual residences. In all but two cases utilities participated in some arrangement to buy and sell power between themselves, and in one case they jointly provided emergency services to customers affected by outages on either system.

Apart from these 17 cities and towns, approximately 70 other jurisdictions were found to have multiple distribution utilities within their borders where those utilities were constrained to fixed and exclusive territories. This arrangement obviously precludes customer choice, but as previously noted, the coexistence of a second utility operating in the same jurisdiction provides useful cost information to the regulator or public overseer without actually incurring duplicate facilities costs. While we lack direct confirmation that these regulators/overseers employed benchmarking techniques, we

[5] The survey question on which these figures are based appears to have been answered in somewhat different ways. Present data are based on the best reconciliation of responses from one or both utilities together with available outside information.

Table I. Cities with Multiple Electric utilities and Customer Choice

City/Town	Customer Choice		Terms of Switching				Other Features			
	New Only	New & Existing	Advance Notice	Charge	Waiting Time	Minimum Stay	Customer Switching Per Year (%)	Utilities Share: Poles	Utilities Share: Wires	Power Purchase Agreements
Alexander City, AL[1]	X									
Bay City, MI[2]	X									
Bushnell, IL		X	Both	None	2 Days	12 Months	0.84	N	N	Y
Cleveland, OH		X	Both	None	2 Weeks	None	0.66	N	Y	Y
Columbus, OH			Both	None	30 Days	12 Months	0.03	Y	Y	Y
Culpepper, VA		X	Both	None	7–30 Days	None	0.08	Y	N	Y
Dowagiac, MI		X	Both	Deposit	7–30 Days	None	0.10	Y	N	Y
Duncan, OH		X	Both	Deposit	1 Day	None	5.92	N	N	N
Floydada, TX		X	New	None	3 Days	None	6.19	N	N	Y
Greer, SC	X									
Houma, LA	X									
Lubbock, TX		X	New	None	3 Days	None	2.40	N	N	Y
Newton Falls, OH		X	New	None	7–30 Days	None	1.30	N	N	N
Paris, KY		X	New	None	1 Day	None	0.27	Y	N	Y
Piqua, OH		X	Both	None	1–2 Weeks	None	0.11	N	N	Y
Poplar Bluff, MO	X									
Traverse City, MI[3]		X	New	None	3–7 Weeks	None	0.22	Y	N	Y

Notes: [1] Minimum power usage required to switch. Only industrial customers do so.
[2] Only areas contiguous to Bay City; City firm purchased IOU's equipment inside city limits in 1992.
[3] 1994 Agreement between city and IOU effectively ceased competition.

can test whether the proximity and similarity of the distribution utilities had the ultimate effect of disciplining their cost structures.[6] If so, we will infer the existence of significant benchmark effects.

Necessary other data are available for fourteen of the 17 cases of direct competition and for all but one of the cases being tested for benchmark competition. These 83 arguably competitive utilities are the largest and most comprehensive compilation of such cases to be systematically examined for evidence of the trade-off between scale economies and cost competition, as well as for evidence of direct vs. benchmark competition. The entire data set employed in this study consists of 507 utilities accounting for 90 percent of all electric power sold in 1989.[7] Apart from the 83 competitive cases, the remaining 424 utilities are distribution monopolies, 88 of which are privately owned and subject to regulation, the remainder publicly owned. Public ownership entails oversight by an independent agency or a committee of the governing board of the municipality which constitutes its "owner". The stated objective of such systems is in principle similar to that for regulation of privately owned electric utilities—cost efficiency, service quality, and moderate prices. Both regimes also face the problem of informational limitations relative to the utility, which may handicap their ability to ensure these outcomes. Public ownership may not entail the same degree of strategic behavior that characterizes regulation, but it is also less formal and for that reason possibly a weaker form of social control.

The effectiveness of either form of competition, as well as of ownership, in achieving desired cost targets is precisely the empirical question to which we now turn.

IV. The Cost Consequences of Competition and Public Ownership

Several previous studies of competitive electric utilities have already been mentioned. Hellman relied upon case studies to infer that the existence of municipal utilities lowers the price charged by investor owned systems in the same communities. One of several studies by Primeaux (1977) compared costs in a matched sample of duopolies against monopoly utilities. Operating costs for competitive systems were found on average to be 11 percent less, a result interpreted as indicating that monopoly

[6] This concern was emphasized by both reviewers and separately by Catherine Waddams.

[7] This data set is drawn from that developed and described in Kwoka (1996). Essentially all 260 privately owned utilities and the largest 450 publicly owned utilities for which data are collected by the Department of Energy were initially part of the data set. A number of observations were lost due to data incompleteness and inconsistencies that could not be resolved.

cost inefficiency outweighed any reduced realization of scale economies.[8] Nelson and Primeaux (1988) reported that competition reduces average transmission and distribution costs for municipal systems, although elsewhere Nelson (1990) found generation costs to be higher under competitive conditions.

While the data, methodology, and interpretations of these studies have been subject to criticism,[9] the results are nonetheless provocative. The present research pursues these questions using more detailed and reliable data and more sophisticated modeling techniques than in most past studies. Specifically, we estimate a cost function for local power distribution and test for the effects on costs from the various regime alternatives discussed above.

1. A COST FUNCTION FOR ELECTRIC POWER DISTRIBUTION

The cost function that we estimate has two important characteristics. Although our focus is on the distribution function, most utilities generate power as well. The chosen cost function must therefore be multiproduct in nature to reflect these two closely related outputs of most utilities in the data base. In addition, we employ a quadratic cost function, since it handles zero values of variables much more easily than does the principle alternative, the translog. Given the number of such zero-value entries in the data, the quadratic has often been adopted in similar contexts, and indeed may be preferred on econometric grounds.[10]

For present purposes, a baseline quadratic model would be specified as follows:

$$\begin{aligned} C = {} & \alpha_0 + \alpha_1 DIS + \alpha_2 COMP + \alpha_3 DIS \cdot COMP \\ & + \alpha_4 GEN + \alpha_5 GENSQ + \alpha_6 DISSQ + \alpha_7 DIS \cdot GEN \\ & + \alpha_8 FCGEN + \alpha_9 PURCH + \alpha_{10} W + \alpha_{11} X \end{aligned} \tag{8}$$

In this model C denotes total utility costs defined as the sum of costs from transmission, distribution, generation, and/or purchase of power, as well as

[8] One specification suggested that the differential is not constant, but rather grows with utility size. Emmons (1993) examines prices, reporting that competition lowered prices charged by private electric utilities but not the prices of their publicly owned rivals in 1930. Competition lowered neither in 1942, a result Emmons attributes to the equalizing effect of yardstick and potential competition.

[9] Joskow and Schmalensee (1985, pp. 61–62), for example, argue that Primeaux's reliance on data only from municipal utilities is misplaced, and also that he fails properly to distinguish direct competition from that involving utilities with adjacent service territories. The present study remedies both of these matters.

[10] See, for example, Roller (1990) and Kaserman and Mayo (1991).

overhead, depreciation, and an imputed capital charge. The imputed charge is calculated as the price of capital multiplied by net electric plant. The price of capital for investor-owned utilities is the weighted average cost of common stock, preferred stock, and long-term debt. In the case of publicly owned utilities, it is the weighted average cost of debt and certain minor capital-like items unique to these systems.[11]

The key output variable is mwh of power distribution *DIS*, that is, sales to final customers and to the resale market.[12] Previous discussion has hypothesized that both direct and benchmark competition strengthen incentives for cost reduction, but noted that direct competition may also result in duplication of costs. To allow for both possibilities, the cost function includes two additional terms—a dummy variable *COMP*, defined as unity for all utilities in competitive environments, zero otherwise, together with its interaction with distribution output, denoted *DIS·COMP*.[13] *COMP* shifts the intercept of the cost curve and should capture the added costs of duplicate facilities. The interaction term, by contrast, permits competition to affect operating costs.

The majority of utilities also generate power, and for them mwh of generation (*GEN*) represents a second output. Both outputs are included in quadratic forms as well (*GENSQ, DISSQ*). This cost function also requires the interaction term between the two outputs (*DIS·GEN*), which conveniently captures any economies or diseconomies of vertical integration between the stages of production (Kwoka, 2002). A variable measuring mwh of purchased power (*PURCH)* is included to control for the costs of *non*-generated power. The fixed effects term *FCGEN* allows for any fixed costs specific to generation. Since all utilities in the data base distribute power, a dummy for fixed costs for distributors cannot be included separately from the constant term. All of these variables together with those represented by a vector of factor costs *W* and a vector of other control variables *X* are identified and data sources provided in Table II.

2. INITIAL RESULTS

The results of estimating the cost function in equation (8) appear in Table III. All specifications achieve a high degree of explanatory power, with R^2s

[11] These are “investment by municipality” and “constructive surplus/deficit,” representing capital and related transfers from municipalities to their publicly owned systems. Consistent with other evidence, the cost of capital is significantly less for publicly owned utilities than for IOUs.

[12] As pointed out by one reviewer, this assumes identical output quality in both regimes. No data are available to confirm or dispute this.

[13] Direct vs. benchmark competitors will be distinguished in later analysis.

Table II. Variable Names, Definitions and Data Sources

NAME	VARIABLE (SOURCE)
Output-related	
DIS	Distribution output in mwh (A, B)
DISSQ	Square of DIS
GEN	Generation output in mwh (A, B)
GENSQ	Square of GEN
DIS · GEN	Product of DIS and GEN
FCGEN	Fixed effects term, equals 1 for utilities with GEN > 0
PURCH	Purchased power in mwh (A, B)
NUCLEAR	Percent capacity that is nuclear (A, B)
HYDRO	Percent capacity that is hydro (A, B)
PEAKING	Percent capacity designed to serve the peak (A, B)
Cost-related	
PRFUEL	Weighted average price of fossil and nuclear fuel in $/mwh (A, B)
GEN · PRFUEL	Product of GEN and PRFUEL
WAGE	Average manufacturing wage in utility's state, $/yr. (C)
DIS · WAGE	Product of DIS and WAGE
PRCAP	Weighted average price of capital, %(A, B)
DIS · PRCAP	Product of DIST and PRCAP
HIVO	Percent of sales represented by high-voltage uses (A, B)
USAGE	Average residential usage of electric power, mwh/customer (A, B)
DENSITY	Number of residential customers divided by miles of distribution lines (A, B)
Competition-related	
COMP	Fixed effects term, equals 1 for a utility facing a competitor (E, F, G)
DIS · COMP	Product of DIS and COMP
DIRECT	Fixed effects term, equals 1 for a utility facing a direct (duopoly) competitor (E, F, G)
DIS · DIRECT	Product of DIS and DIRECT
BENCH	Fixed effects term, equals 1 for a utility facing a competitor in adjacent territory in same jurisdiction (E, F, G)
DIS · BENCH	Product of DIS and BENCH
Ownership-related	
PUBLIC	Fixed effects term, equals 1 for publicly owned utility (B)
PUB · DIS	Product of PUBLIC and DIS

Table II. continued

NAME	VARIABLE (SOURCE)
PUB · GEN	Product of PUBLIC and GEN
PUB · DIS · GEN	Product of PUBLIC and DIS · GEN
PUB · DIRECT	Product of PUBLIC and DIRECT
PUB · DIS · DIRECT	Product of PUB and DIS · DIRECT
PUB · BENCH	Product of PUBLIC and BENCH
PUB · DIS · BENCH	Product of PUBLIC and DIS · BENCH

Sources:
A *Financial Statistics of Selected Investor-Owned Electric Utilities 1989*, Department of Energy
B *Financial Statistics of Selected Publicly Owned Electric Utilities 1989*, Department of Energy
C *Statistical Abstract of the United States*, Bureau of the Census
D Department of Energy, Form 861
E *Typical Electric Bills*, Department of Energy
F *Electric Sales, Revenues, and Bills*, Department of Energy
G Author's survey
Unmarked variables are constructed

of nearly .97. Most variables are correctly signed and statistically significant. Before addressing the impact of competition, we will briefly summarize the results on other variables.

First with respect to distribution and generation outputs, all terms but one have the correct sign and are statistically significant.[14] The positive and significant coefficient estimates on *DISSQ* and *GENSQ* confirm the expectation of convexity of the cost function, that is, diseconomies of scale eventually set in for both outputs. The significant and negatively signed interaction term *DIS·GEN* implies cost complementarity between generation and distribution, a key condition for economies of vertical integration.[15] The term representing power purchases is statistically significant, while that for generation-specific fixed costs is not.[16]

The variables denoting the type of generation capacity emerge with the expected signs, although not all coefficients are significant. Relative to conventional steam generation (the omitted category), greater reliance

[14] Although *DIS* is negatively signed, it is insignificantly different from zero. Even if significant, however, the overall effect of output on costs is a function of other terms that are interacted with *DIS*.

[15] Cost complementarity is not by itself a sufficient condition, but economies of vertical integration have been established for these utilities (Gilsdorf, 1994; Kwoka, 2002).

[16] This does not imply that there are no generation-specific fixed costs, since those are also represented in the terms for capacity type and fuel price.

Table III. Regression Results on Utility Costs (t-statistics in parenthesis)

Variable (Scale)	(a)	(b)	(c)
Competition-Related			
COMP (10^6)	27.4 (1.27)		
DIS · COMP	−6.76 (4.39)		
DIRECT (10^6)		52.6 (1.24)	544 (3.83)
DIS · DIRECT		−6.29 (2.55)	−17.9 (3.83)
BENCH (10^6)		22.6 (.95)	72.6 (1.88)
DIS · BENCH		−5.96 (3.76)	−8.19 (4.11)
Ownership-Related			
PUBLIC (10^6)			20.9 (.88)
PUB · DIS			−24.8 (2.91)
PUB · GEN			7.14 (.58)
PUB · DIS · GEN (10^{-6})			1.97 (3.51)
PUB · DIRECT (10^6)			−556 (3.58)
PUB · DIS · DIRECT			39.6 (.39)
PUB · BENCH (10^6)			−72.9 (1.50)
PUB · DIS · BENCH			10.9 (1.34)
Output-Related			
DIS	−12.5 (1.42)	−12.5 (1.34)	−8.77 (.94)
DISSQ (10^{-6})	2.29 (6.45)	2.29 (6.35)	2.03 (5.62)
GEN	21.2 (2.88)	19.8 (2.68)	14.9 (1.88)
GENSQ (10^{-6})	1.73 (4.76)	1.77 (4.81)	1.63 (4.42)
DIS · GEN (10^{-6})	−3.89 (5.45)	−3.92 (5.42)	−3.46 (4.81)
FCGEN (10^6)	−16.5 (.85)	−16.0 (.82)	−8.99 (.46)
PURCH	38.1 (5.52)	37.6 (5.39)	48.9 (6.48)
NUCLEAR (10^6)	428 (7.09)	423 (6.94)	422 (7.22)
HYDRO (10^6)	−25.9 (.84)	−23.3 (.77)	−25.9 (.86)
PEAKING (10^6)	38.6 (1.35)	38.7 (1.35)	31.6 (1.14)
Cost-Related			
PRFUEL (10^6)	.275 (.53)	.285 (.55)	.111 (.22)
GEN · PRFUEL	.835 (5.16)	.855 (5.17)	1.01 (5.83)
WAGE (10^6)	−11.2 (1.15)	−12.3 (1.25)	−8.36 (.88)
DIS · WAGE	2.95 (3.39)	3.00 (3.41)	2.01 (2.21)
PRCAP (10^6)	−60.3 (.36)	−69.9 (.41)	−22.0(.13)
DIS · PRCAP	105 (1.85)	111 (1.79)	118 (1.86)
PCTHIVO (10^6)	−47.6 (1.58)	−47.9 (1.58)	−32.0 (1.09)
USAGE (10^6)	.856 (2.02)	.841 (1.97)	.808 (1.96)
DENSITY (10^4)	6.66 (.80)	6.70 (.80)	8.08 (1.00)
CONSTANT (10^6)	96.4 (1.94)	102 (2.02)	59.0 (1.08)
R^2	.967	.967	.970
No. Utilities	507	507	507

on nuclear power (*NUCLEAR*) and peaking power (*PEAKING*) is associated with higher cost, while greater use of hydro power (*HYDRO*) lowers it. The three input prices–*PRFUEL, WAGE,* and *PRCAP*–are all positively signed and significant (or nearly so) in their interactions with output but not in their linear forms.[17] The coefficients on the variables representing high-voltage power, average customer size, and customer density all confirm expectations: High-voltage production (*HIVOLT*) reduces cost since it requires little or no voltage reduction and involves smaller line losses. Greater average customer usage (*USAGE*) similarly lowers costs, by conserving on administrative and service costs. Finally, higher customer density (*DENSITY*) is associated with cost reduction, confirming earlier discussion about its impact on both facilities costs and operations costs of distribution utilities.

More to the point, one central issue of this study–that competition matters–is confirmed by these results: The dummy variable *COMP* is positively signed and significant at 10 percent in a one-tail test, implying that competition results in the lesser achievement of scale economies and therefore the duplication of fixed costs. Taken at face value, its magnitude–$27.4 million–represents a 10.5 percent increase in the mean total cost for utilities in the data base. But as hypothesized, competition is associated with a reduction in incurred operating costs. The interaction term *DIS·COMP* is negative and highly significant (t = 4.39). Evaluated at mean output, this represents a $31.9 million cost reduction, or 12.3 percent of total cost, due to competition. Netting increased fixed and reduced operating costs and holding all else constant, the average utility has total costs 1.7 percent less when operating in a competitive setting rather than a monopoly. This is a modest, but certainly nontrivial and plausible, effect.

The fact that competition produces a net cost advantage at sufficiently large output levels corroborates the prediction of the model in Section II(A). There it was also shown that a duopoly competitor is more likely to save costs at larger output by virtue of averaging facilities costs over more units. There is evidence of this effect in the present results as well. The estimated magnitudes of the fixed and variable cost effects permit determination of the "crossover" point–the output at which net cost savings first emerge. That point is at 4.1 million mwh of distribution output (27.4 million mwh, divided by 6.76). Of 83 competitive utilities, 49–or nearly 60 percent–exceed that threshold, compared with only 15 percent of the 424 monopoly utilities in the data base. It seems clear that competition is more

[17] Linear price terms simply shift the intercept of the cost function. Interaction terms with output more plausibly reflect the cost effects of of higher input usage but their inclusion greatly increases collinearity among the variables.

prevalent precisely where the underlying cost structure implies it is viable and advantageous.

It should be noted that some competitive utilities face competition in only a portion of their service territory, whereas others confront it for most of their customers. To determine whether utility costs are affected differently under these circumstances, we incorporate a variable for the percent of each utility's customers that reside in its competitive region. This variable is statistically insignificant, with a t-value of about .20. This suggests a spillover effect of some magnitude: Even a modest degree of competitive contact results in widespread cost reductions.

3. EFFECT OF TYPE OF COMPETITION

The results so far are based on the simple *COMP* variable without distinction between types of competition. That model is now generalized to allow for differences in the cost effects of duopoly competition and benchmark competition, both relative to conventional monopoly. Accordingly, we define fixed effects terms for direct or duopoly competition (*DIRECT*) and for benchmark competition (*BENCH*), together with their respective interaction terms with output.

The results of this estimation are reported in column (b) of Table 3. As is evident, both forms of competition lower costs relative to regimes lacking competition altogether, but the effect of benchmark competition is now rather striking: Presumably by conveying information about cost efficiency, such a firm clearly leads to lower cost of the other firm in the market. Duopoly operating costs are lower than under monopoly, with *DIS·DIRECT* statistically highly significant with a $t = 2.55$. While the term *DIRECT* suggests that fixed costs under duopoly may be higher, this estimate does not achieve true statistical significance ($t = 1.24$). In all important respects, these results mirror those found overall for competitive utilities and broadly confirm our hypothesis that while direct competition may entail higher fixed costs, it conserves on variable costs.

There is a further testable hypothesis in the case of benchmark competition. Since such competition does not entail duplicative facilities costs or otherwise impede the realization of scale economies, its effect, if any, should manifest itself in operating cost reductions. These predictions are confirmed by present evidence. The fixed effects term *BENCH* is positive but clearly statistically insignificant, with a $t = 0.95$. By contrast, the coefficient on *DIS·BENCH* is negative and highly significant ($t = 3.76$). Benchmark competition appears to be quite effective in reducing costs and in particular operating costs.

Remarkably, the magnitudes of cost effects resulting from benchmark competition do not differ greatly from those from facilities duopoly.

The rates of variable cost savings–the coefficients on *DIS·DIRECT* and *DIS·BENCH*–are very similar, and the fixed cost terms, taken at face value, differ only by factor of two. In both cases statistical tests indicate that the effects of direct competition–higher fixed cost and lower variable costs–exceed the effects of benchmark competition. Nonetheless, this evidence clearly supports the proposition that benchmark competition–through the mechanism of superior information to the overseer–serves as a potent, if not quite perfect, substitute for the direct effect from an actual rival in the market. This is an especially important finding since benchmark competition entails none of the scale economy sacrifice that accompanies an actual competitor.

4. THE EFFECT OF PUBLIC VS. PRIVATE OWNERSHIP

The 83 "competitive" electric distribution utilities differ in another important respect that needs to be addressed: Fifty-one of them are regulated investor-owned utilities, the remaining 32 publicly owned. Extensive literatures maintain that both public ownership and regulation afford opportunities for non-cost-minimizing behavior, but the magnitude of any inefficiency and the impact of competition on that magnitude need not be identical between the two regimes. In order to avoid imposing such uniformity across ownership mode, we first define a dummy variable to distinguish cases of public ownership from private ownership. Then we create interaction terms between it and the four variables representing duopoly and benchmark competition and also with the output variables themselves. All are included in an augmented cost function that is estimated and reported in column (c) of Table 3.[18]

The impact of competition is shown to differ strikingly between the two types of utilities. The effects of direct and benchmark competition for regulated private systems are captured by the same variables as previously employed: *DIRECT, DIS·DIRECT, BENCH,* and *DIS·BENCH*. The estimated coefficients are somewhat larger and more highly significant than those reported in column (b), but the effects have the same signs and a similar pattern of magnitudes–higher fixed costs and lower variable costs, and both somewhat greater for duopolies than in the case of benchmark competitors.

These same four variables when interacted with *PUB* serve to reflect any differences in the cost effects for publicly owned competitive utilities relative to all other competitive systems. The results in column (c) clearly show that such differences exist and are significant. The coefficients on

[18] As both reviewers note, this procedure assumes that the public-private decision is exogenously determined. While that is not entirely correct, the decision was effectively made long before the demand, operating, and cost experience here examined.

all four variables distinguishing publicly owned utilities are of opposite sign from, and have absolute magnitudes very similar to, the corresponding variables for all direct and benchmark competitors. That is, they negate the effects on cost just reported for privately owned utilities. More specifically, a test of the coefficients on *DIRECT* and *PUB·DIRECT* cannot reject the hypothesis of equality ($t = 3.78$), nor can analogous tests on the coefficients on *BENCH* and *PUB·BENCH* ($t = 1.76$) and on the coefficients on *DIS·BENCH* and *PUB·DIS·BENCH* ($t = 2.15$). Only the coefficients *DIS·DIRECT* and *PUB·DIS·DIRECT* appear to be significantly different ($t = .77$).

These sums indicate that competition has little incremental effect in the case of publicly owned utilities. Rather, all publicly owned systems achieve similar costs whether facing competition or not. It therefore follows that the previously found effect of competition was due to the changed behavior of private utilities only. It is only in the case of privately owned and regulated utilities that competition is necessary in order to fully realize lower costs. Put more positively, cost regulation can be improved by the appropriate introduction of competition, whereas costs are not further lowered by competition in the case of public ownership.

An important question is whether these lower costs for public systems–for *all* public systems, whether subject to competition or not–are equal to the higher costs of private monopoly or to the lower costs achieved by private utilities facing competition. Recalling that the competition variables for publicly owned utilities essentially drop out, we therefore look to other evidence concerning the relative distribution costs of (any and all) publicly owned utilities and privately owned systems. The relevant results are also reported in column (c) of Table 3. Fixed costs for public systems, represented by the fixed effects variable *PUBLIC*, appear somewhat greater, but the statistical significance of the difference ($t = .88$) is doubtful. But variable costs are clearly lower, with the coefficient on *PUB·DIS* having a t-statistic of 2.91.[19]

By themselves, these suggest lower costs for publicly owned utilities, but these comparisons are against the omitted category of utility, namely, privately owned systems subject to regulation but not to competition. To repeat, relative to those, publicly ownership achieves significantly lower costs. Whether those costs are as low as regulated *and competitive* private utilities requires comparison of the coefficient of *PUB·DIS* with the coefficients on *DIS·DIRECT* and *DIS·BENCH*. The latter two coefficients measure the effect of competition in either form in the case of private,

[19] A similar variable cost advantage for publicly owned utilities is reported in Koh et al. (1996). Their interpretation involves size and governance, rather than production, as emphasized here.

regulated utilities. The absolute value of the public ownership effect (24.8) is actually a bit larger—but not significantly so–than either of the two variables measuring the effect of competition on regulation (17.9 and 8.19, respectively). This simple comparison establishes that the costs achieved by public ownership itself are the same as what is achieved by a combination of competition *and* regulation. This conclusion constitutes a potent argument for public ownership in circumstances where perfect competition cannot be attained and where regulation cannot be supplemented by direct or benchmark competition.

V. Conclusions

The proposition that competition affects cost may seem scarcely worth stating, much less proving. But this paper demonstrates four things not previously recognized, or at least not well established empirically: First, cost competition may produce net benefits even when some scale economies are sacrificed. Secondly, competition is beneficial both in the form of benchmark competiton as well as direct rivalry. Third, competition of either type reduces costs even for a utility already subject to regulation as a natural monopoly. And fourth, costs under public ownership are not further reduced by competition, implying that public ownership is by itself an effective method of cost minimization.

From a policy perspective, this study underscores the enormous power of competition to impose cost discipline, even relative to other institutions such as regulation which are directed at the same objective. Direct competition is clearly useful in this regard, but benchmark competition is surprisingly effective as well. Conveniently, the latter does not require multiple sellers and the possible sacrifice of scale economies. A further policy implication concerns public ownership. While often suspected of inferior cost performance, the evidence here shows that publicly owned utilities achieve costs comparable to those under competition. As between those two regimes, public ownership appears more successful by in controlling costs by itself, though regulation buttressed by benchmark competition achieves a similar result.

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