Incentives for Accruing Costs and Efficiency in Regulated Monopolies Subject to ROE Constraint

A. Rashad Abdel-Khalik*

1. Introduction

Incentive problems arise in the electric utilities industry as a consequence of the institutional and legal arrangements of the cost-plus pricing regime under which natural and statutory monopolies operate. In the United States, such monopolies operate under a cost recovery system that gives the firm a mechanism by which it can shift all or part of the cost of moral hazard risk to consumers, who then become the residual claimants (Sherman [1980]). In this setting, expense accruals have a more direct link to the firm's cash flows than is the case in unregulated industries. In particular, pricing a monopolist's output at cost-plus means that accruing expenses generates sales revenues for utilities. Consequently, agency cost can be included in the allowable cost passed on to consumers. The result is that the residual loss is shared between the consumers and shareholders with two competing consequences: (1) it would be in the best interest of shareholders to provide managers with incentives to shift all costs to the consumer; and, by the same token, (2)

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it would be in the consumers' interest to persuade regulators to challenge the cost assumptions underlying the firms' requests for revenue requirements.

Much of the work on incentives in regulated companies has considered the link between the regulator and the firm (e.g., Holthausen [1979]). This paper considers the link between shareholders and managers (see Hirschy and Pappas [1981] and Carroll and Ciscel [1982]). Incentive problems arise between the two parties because failure to pass all accrued costs on to consumers would result in erosion of the maximum profit limit allowed by the regulator. Given this orientation, this paper should be viewed as a descriptive analysis of the institutional aspects of executive compensation in an industry subject to regulatory constraints, not as a test of the analytic theory of agency.

The question arises whether shareholders of public utilities reward managers (1) for efforts that are consistent with making consumers the primary residual claimants and (2) for operating as efficiently as implied by the allowed rate of return on equity. However, the institutional setting places constraints on the owners' ability to publicly disclose the details of such incentive systems. While owners would want the regulator and consumers to know that operating efficiency is an important element of managers' incentive schemes, they cannot explicitly acknowledge taking steps to shift the cost of moral hazard to consumers, since doing so would alert regulators to disallow suspected padded costs from inclusion in the required revenues. Indeed, even in recent years, proxy statements of electric utilities do not include information on the ways in which incentive bonus awards are determined; some regulatory commissions disallow the inclusion of bonus awards in the required revenues. In this paper I assume that some aspects of top executives' incentive structure would have to be in the form of implicit contracts, resulting in the utility firms' building a reputation for rewarding certain managerial actions.

Outcome indicators of unobservable effort are generated from both accounting information and the investment bankers' quality rating of managers. Managers are not expected to state that they are operating inefficiently; if they do, it would be imprudent for regulatory commissions to allow the related cost in the required revenues unless they are convinced the events are not under managers' control. Data for 1981 and 1982 are used for analysis because these years precede the recent shift in consumers' willingness to bear some costs. Specifically, consumers have become more reluctant to bear the cost of decisions made with respect to nuclear power plants, implying that the quality of those decisions was under management control and consumers need not pay for bad decisions. The Indiana Supreme Court recently ruled in favor of a consumers' advocacy group and reversed a decision by the Indiana Commission to recover from consumers (through rate-base increase) a loss of over $190 million on the nuclear plant unit of Northern Indiana Public Service Company (Smartt [1986]). This follows an earlier ruling in Ohio to bar the cost recovery of a canceled plant. Also, in 1986, the New York Public Service Commission found that $1.35 billion of the Long Island Lighting Company's Shoreham plant cost (totaling over $5.3 billion) was the result of mismanagement (Manzi [1986]). These recent developments imply that the type of analysis carried out in this paper may not apply for current periods.
regulatory climate. They include (1) two specific measures of the expense-preference of utility firms: the effort to pass on to consumers the cost resulting from overinvestment in plants (e.g., overcapitalization, or the Averch-Johnson (A-J) bias) and accruing operating costs beyond industry standards required for actual output; (2) two measures of operating efficiency: the deviation of the realized from the allowed rate of return on equity and the energy input/output ratio; and (3) the quality of regulatory climate as an indicator of the lobbying effort required for success with regulatory commissions.

These measures are developed for a sample of investor-owned electric utilities operating under 45 different regulatory jurisdictions for the three-year period 1981–83. The sample size varies between 44 and 52 firms due to data availability.2 The simultaneity of production and operating budget functions constructed here led to using the two-stage least squares (2SLS) method in generating expense-preference measures. The other explanatory variables are generated from publicly available sources. These measures are then used in an ordinary least squares (OLS) regression as explanatory variables of executive compensation. Compensation data were collected from proxy statements of 1981–83 for each of the three top executives of the sample firms.

The choice of the test period is predicated on the assumption that 1983 constitutes a pivotal period in the evolution of incentive programs in electric utilities. In particular, the Resources Consulting Group (RCG) issued, in July 1983, its recommendations to improve incentive regulation in the electric utility industry. While the report of RCG acknowledges that “there should be a relationship between compensation and performance quality and that there is a need to compensate management for their efforts” (Edison Electric Institute [1987, p. 41]), incentive regulation programs were then either nonexistent or ineffective. Indeed, several of those programs were canceled, and most of the existing incentive regulation programs are targeted toward a particular plant or cost component (Edison Electric Institute [1987]). Although the specific recommendations of RCG, including the exclusion of CEOs from participating in some known incentive schemes, have not been implemented, its 1983 report has signaled the need to change incentive structures in electric utilities.

The empirical analysis was performed for both the levels and annual changes in compensation for the period 1981–83. The results can be summarized as follows: (1) The estimated production and operating budget functions are stable over the three years. (2) Firm size and

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2 Complete data were obtained for 52 companies for 1982, 44 companies for 1981, and 45 for 1983. These constitute the majority of investor-owned electric utilities and include several holding companies that operate multiple electric utilities across state (regulators) lines. All firms were single-product firms in the period studied. A list of the sample is in Appendix B.
operating slack (the deviation of actual operating costs from the estimated industry-wide operating budget) were significant determinants of the levels of CEOs’ compensation for each of the three years, 1981–83. Significant results for capital utilization efficiency (e.g., overcapitalization) and ROE deficiency were obtained for two of the three years. With respect to annual changes in compensation, operating slack, firm size, and ROE deficiency were all significant for 1981–82, but not for 1982–83. (3) The same type of results were obtained for the second and third executives, except for operating slack, which was significant in 1981 and 1982, but not in 1983.

A discussion of the relevant aspects of the regulatory environment is presented in the next section. In section 3 the nature of the problem and objectives of the research are outlined. Section 4 consists of the methodology developed for generating various measures of outcome indicators of effort. These measures are used as regressors in testing specific hypotheses about incentives and compensation, which are provided in section 5. The sample selection, empirical estimation, and analyses are presented in section 6. The last section provides concluding remarks and discussion of limitations.

2. The Regulatory Environment

Electric utilities are regulated (mostly) by the Federal Energy Regulatory Commission (FERC) and the regulatory commissions of the states in which the utilities provide service. Each regulatory commission (RC) periodically determines the price of electricity to be paid by its constituents. Since RC is a political body with an observable product, its objectives are assumed to be minimizing consumer dissatisfaction with electricity prices and maintaining high quality of service. Because electricity is a nonstorable commodity (in large volumes), the quality of service consists of two components: (1) satisfying spot demand of consumers at all times and (2) providing uninterrupted service (e.g., infrequent brownouts). Since these two measures of quality are observed by all parties, pricing may be the most complex aspect of regulating electric companies. In this cost-plus environment, accounting methods and accruals play a significant role, since a regulatory commission’s ruling essentially translates accrued costs into real cash inflows to the extent that the costs are included in the required revenues.

Under the guidelines of the U.S. Supreme Court decision in the 1944 Hope Natural Gas case (Sherman [1980; 1983]), electric utility pricing

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3 There are 50 such regulatory (public service) commissions whose memberships vary from fully elected (such as in Louisiana, which has five elected Democrats on the 1986 commission) to fully appointed (such as in Illinois, which has four Republicans and three Democrats on the 1986 commission).

4 The existence of regulatory lags and the commission’s ability to disallow costs render the pricing system an imperfect cost-plus regime (Joskow and Schmalensee [1986]).
must be set at kWh average of required revenues, which is the sum of three components: (i) accrued operating costs, (ii) the actual cost of servicing debt and preferred stock, and (iii) "normal" profits computed as the product of a "fair" rate of return times the book value of common equity. A fair rate of return on equity (ROE) is one which the commission judges to be (1) "comparable" to those earned by similar risk firms and (2) adequate to "attract" capital to the industry (Sherman [1983]). Other than specific clauses for automatic fuel adjustments (which began with the significant fluctuations of oil prices post-1973), electricity is priced at the regulated rate until the commission issues a revision. Due to the intervening regulatory lags and to the regulator's authority to disallow certain costs, electric utility pricing is not a pure cost-plus regime. The departure from the pure case has been narrowed in recent years, however, because price and rate revisions have been made with frequency varying from every six months to every year.\footnote{For practical purposes, most rates are revised in intervals shorter than a year; the average regulatory lag for the firms in this study was nine months. This shortening has been brought about by inflationary pressures on costs and is said to have a negative impact on the ability of managers to innovate and cut costs so as to benefit from the de facto price freeze during regulatory lags; see Kafoglis [1983].}

While regulatory commissions allow stockholders to earn a "fair" expected ROE, they do not guarantee its realization.\footnote{Other discussions of regulatory problems are in Hagerman and Ratchford [1978], Bowen [1981], Stober [1985], and Olsen [1985].} In negotiating with regulatory commissions, the firms' managers are likely to focus on (1) measures concerning the accuracy of predicting demand for electricity (the denominator of pricing); (2) the validity of the assumptions underlying the accuracy and efficiency of predicting operating costs (a component of the numerator of pricing); and (3) the level of ROE that would be considered "fair" (another component of the numerator). These issues are regularly and frequently debated in public hearings where each side draws on considerable skills and resources to persuade the other side of its position.

3. Problem and Objectives

The extent to which stockholders motivate managers to exert greater effort in bargaining with regulators so as to pass as much of the accrued costs as possible on to the consumer is one aspect of incentives in regulated industries. The complexity of incentive regulation is described by Joskow and Schmalensee [1986, p. 24]. The relation between the management of the utility (MU) and the regulatory commission (RC) can be outlined as follows.

MU is the agent of stockholders, whereas RC is the agent of consumers.
RC and MU negotiate on behalf of their respective principals.\(^7\) RC has the statutory power to set prices for MU's product, to disallow cost items with which the regulator disagrees, and to change the allowed ROE to the level that would be considered "fair" in accordance with the guides of the U.S. Supreme Court ruling in the Hope Natural Gas case. This power could place RC as the second principal of MU, which complicates the structure considerably. RC is compensated at a fixed fee and is likely to be concerned with the satisfaction of the constituents in connection with prices and service quality. In the meantime, RC is under a statutory mandate to provide the stockholders of the firm a "fair" rate of return on their equity (generally measured at book value). This dual role requires RC to monitor the types of costs MU is accruing and attempting to pass on to the consumer. However, RC's monitoring of MU is imperfect, since MU knows more than RC about the technology of the firm, the cost structure of production, and the extent to which "gold-plating" or inefficiency is included in the cost information supplied to RC.

Moreover, RC does not have the resources to audit the accuracy of the information provided by MU or his operating efficiency.\(^8\) Instead, RC attempts to motivate MU to be efficient and to reveal accurate cost information by three politically acceptable mechanisms: (1) requiring MU to submit disaggregated cost information in accordance with a prescribed data categorization, (2) requiring MU to defend requested revenues in public hearings, and (3) comparing the requested revenue components and ROE levels with other utilities.

It is not known if these public hearings result in optimum (marginal cost) pricing, or if they eliminate MU's ability to pass inefficiency on to consumers in the form of inflated allowable costs. They do, however, generate consensus on a level of prices and allowed ROE that RC considers adequate for reducing consumers' dissatisfaction. Because the periodic negotiation between MU and RC is public, a greater amount of effort may be required of MU if RC is considered hostile to business interests—i.e., a bad regulatory climate.

In this environment, adversarial relationships exist between the two agents. Stockholders' concerns take two levels. At the rate negotiation stage, stockholders would want MU to convince RC (1) to allow in the

\(^7\) Sappington and Stiglitz [1987] formulate the problem by assuming that the regulator is the principal and the manager is the agent. They acknowledge that anticipation of "reactions" allows the regulator and the firm to engage in strategic behavior, and that the setting consists of repeated games. Some specific single-period models are in Sappington [1983] and Baron and Besanko [1984]. The difficulties in developing analytical solutions for multiple agencies in repeated games are alluded to by Sappington and Stiglitz [1987] as well as by Joskow and Schmalensee [1986].

\(^8\) The information asymmetry (and adverse selection) between managers of electric utilities and regulators is recognized by many authors on regulation; see, for example, Joskow and Schmalensee [1986, pp. 12-13] and Holthausen [1979].
rate base a projected level of operating costs that corresponds to what
**MU** would accrue, including the costs related to capital investments
already made, the cost of consumption at the workplace, and other
inefficiency costs and (2) to allow the highest feasible **ROE**. After **RC**'s
decision is made, stockholders would want **MU** to operate at an efficiency
level that is at least as high as that allowed for in the pricing schedule
approved by **RC** so that the realized **ROE** would approach the allowed.

After the price per kwh is determined, the portion of accrued costs
attributable to errors in assumptions cannot be passed on (at least in the
current period) to consumers, and such costs would be borne by the
stockholders by the realization of below-allowed **ROE**. For example,
regulators guard against the tendency of managers to underpredict de-
mand, for this will result in a higher unit price and abnormal profits.
Overpredicting demand, in contrast, means that required revenues are to
be allocated to a larger number of kwh, resulting in too low a price to
recover costs fully and provide for the allowed **ROE**. That is, the shortfall
in demand is a cost that will reduce realized **ROE** below the maximum
level accepted by **RC**.

Similarly, stockholders' allowed share of total revenues would be eroded
by **MU**'s underestimation of labor or maintenance costs (which are large
cost items in electric utilities), by failure to persuade **RC** to include
certain costs in the rate base, by operating at an efficiency level below
that projected by the rate base, and by increasing consumption at the
workplace (e.g., shirking and perquisites) beyond the level built in the
revenue requirements. Absorbing these costs by stockholders could be
temporary, lasting only through the next rate hearing. Given the appro-
propriate incentives for **MU**, an effort will be made to correct errors in
assumptions and inaccuracies when the rate is revised.

Cost-padding and passing the cost of inefficiency on to consumers in
an environment of cost-plus pricing are not new issues (see Arrow
[1962], Holthausen [1979], Selten [1986], Stiglitz [1986], and references
therein). Of more recent interest, however, is the structure of incentive
contracts for managers of electric utilities. Like **RC**, stockholders have
imperfect information about the technology and the cost structure of a
utility's operations, but, unlike **RC**, they can provide monetary rewards
to managers who exert greater effort in passing all costs on to consumers
and operating as efficiently as projected by allowed levels of revenues.
Although tying income to indicators of effort has existed since the piece-
rate wages (Lazear [1984]), recent literature has provided significant
refinements.\(^9\) Whereas the extant empirical literature has used account-

\(^9\) See, for example, Sappington [1983], Baron and Besanko [1984], Nalebuff and Stiglitz
[1983], Lazear [1984], Sappington and Stiglitz [1987], Stiglitz [1986], Antle and Smith
ing profits and stock prices as outcome indicators of unobservable effort, indicators of effort specific to public utilities need to be generated due to the displacement of competitive markets by a single decision maker, RC. This is the subject of the next section.

4. Specific Outcome Indicators

4.1 OBJECTS OF EXPENSE-PREFERENCE

Managers' preference for incurring certain types of expenses has been posited (for citations, see Smirlock and Marshall [1983]) as the growth strategy adopted by monopolists operating under regulatory constraints on profits. Pursuing expense-preference instead of profit maximization can take place by a combination of increasing investment in plant and equipment, and increasing staff, operating, and recurrent costs. The first component is consistent with the A-J bias, about which there is extensive evidence (Berg and Tschirhart [1988]); the second component reflects the recently developed hypothesis of preference for staffing and padding operating costs (e.g., Crew and Kleindorfer [1979]).

The evidence on using operating costs to examine expense-preference has been obtained largely from commercial banks, which operate in more competitive markets than electric utilities. The evidence is mixed (see Edwards [1977], Hannan and Mavinga [1980], and Smirlock and Marshall [1983]). For electric utilities, the focus has long been on overcapitalization (the A-J bias). However, the other form of expense-preference is supported by Crew and Kleindorfer [1979] but contradicted by Awh and Primeaux [1985]. Whether the firm's manager prefers spending on utility plants or investing in staff and padding operating costs, the cost of shirking and consumption at the workplace would be transferable to consumers so long as the statutory or natural monopolist operates under

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10 The empirical literature has used accounting income and sales (e.g., Abdel-khalik [1985], Abdel-khalik, Chi, and Ghicas [1987], and Healy, Kang, and Palepu [1987]) as well as accounting and market rates of return (e.g., Murphy [1985], Antle and Smith [1986], and Lambert and Larcker [1987]). They all provide evidence suggesting that accounting-based measures play a role in executive compensation. This evidence may not apply to regulated industries since income numbers of regulated firms are jointly determined by effort, the cost-plus system, and other factors.

11 Hirschey and Pappas [1981] found a negative association between accounting profits and compensation of CEOs, a result that was contested by Crew and Kleindorfer [1983]. Also, Carroll and Ciscel [1982] estimated regressions similar to those reported by Hirschey and Pappas and concluded that, "Cost-plus regulation of utility corporations results in a reduction in compensation for the cost-conscious chief executive" [1982, p. 509]. The regression models used in these studies, however, might be misspecified since sales are determined by cost-plus profit.

12 Regressing sales revenues on cost components to infer managers' expense-preferences confounds the dependent and independent variables in that revenues of an electric utility are the result of an administered price equal to the sum of its costs plus normal profits.
a cost recovery pricing regime, even with a constraint on the maximum allowed ROE.

The extent to which a utility manager adopts a particular strategy for expense-preference can be evaluated only relative to industry standards and to the technology mix employed by the firm. The firm’s choice of expense-preference reflects managerial strategies, efforts, and degrees of stickiness (i.e., inclusion in the required revenues in one period implies inclusion in future periods). Since allowable operating costs are renegotiated every time the rate is revised, passing costs of inefficiency on to consumers by padding these costs is less likely to be a sticky component of the required revenues than the cost of using equipment. By allowing depreciation in the required revenues, the regulator effectively signals the legitimacy of the underlying investment, and what is likely to be periodically renegotiated is the amount charged as the cost of using and maintaining plant and equipment. Preference for overinvesting in utility plant has long been the focus in the literature (the A-J bias). Although the empirical evidence about the A-J bias is mixed, recent decisions on nuclear power plants show that regulators appear to be giving capital investment greater scrutiny.

The choice of an overall expense-preference strategy by utility managers generates different expectations about managers’ ability to pass the cost on to consumers in the revenue requirements. Managers of firms with preference for overcapitalization are expected to exert greater effort in lobbying for cost recovery of these investments, which results in exerting effort periodically to convince the regulatory commission to allow a certain rate of cost recovery. Due to the length of time required to plan and construct utility plants, the executives who are expected to negotiate the investment cost recovery might not be the ones who made the overcapitalization commitment. Thus, rewarding managers for their efforts at speeding cost recovery of plants does not necessarily imply rewarding the act of overcapitalization itself. Similarly, the periodicity of incurring operating costs demands recurring negotiation for the inclusion of the cost in the revenue requirements, which generates higher uncertainty about including or disallowing certain operating cost components in the required revenues.

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12 Courville [1974], Spann [1974], and Petersen [1975] used modified Cobb-Douglas production functions with multiple variables to test the A-J bias utilizing a variation of the relationship between input productivity and prices (for steam plants). While they provided evidence consistent with the A-J bias, others did not. Berg and Tschirhart [1988, chap. 9] provide a good summary of the contrasting evidence and conclude, “Tests for the A-J effect have yielded mixed results.” For an analytical elaboration on the A-J hypothesis, see Baumol and Klevorick [1970] and Bailey and Malone [1970].

13 To add a recent decision on the cost of constructing nuclear power plants, in May 1988, the New York Public Service Commission agreed to purchase the Shoreham plant (cost over $5.3 billion) for one dollar, then shut it down. In exchange, Long Island Lighting Company will be allowed to pass along the cost of the Shoreham plant in future electric prices (Paul [1988]).
4.1.1. Production and Operating Budget Functions. Management's expense-preference can be evaluated for a given firm by comparison with managers of other firms in the same industry. This task is more manageable for a single-product industry producing a homogeneous product such as electricity. The method developed here begins by assuming an industry-wide Cobb-Douglas production function:

\[ P = AK^\alpha C^\gamma \epsilon \] (1)

where \( P \) is the output in megakwh; \( K \) is the utility firm's plant and equipment; \( C \) stands for other (operating) input factors; \( A \) is the technical efficiency parameter; \( \alpha \) and \( \gamma \) are the technological coefficients showing the factor shares of capital and other inputs, respectively; and \( \epsilon \) is an error term (plus one). Both \( K \) and \( C \) are measured in units of current costs. While this production function provides a convenient empirical description of the industry-wide output, it is different from Spann [1974] and Courville [1974] in that \( C \) is an aggregate of production factors other than capital. The choice of this construction is related to the design of this study, where operating slack (i.e., the relative unexpected operating costs) is generated as the difference between actual and expected measures of \( C \). Technological factors related to electricity generation (e.g., load factor, capacity reserve, percentage of nuclear plants) and the level of output are used to generate expected values of \( C \), the operating budget using industry-wide measures. The level of output, \( P \), is one of those determinants since the costs of fuel and, to a lesser extent, maintenance vary with production level. The jointness of production and operating budget functions leads (after taking the log of (1)) to the following system of structural equations:

\[
\log P_t = \alpha_0 + \alpha_1 \log K_t + \gamma \log C_t + \epsilon_{\log P_t}\] (2)

\[
\log C_t = c_0 + c_1 \log P_t + Z_t \beta + \epsilon_{\log C_t}\] (3)

It is often argued that the form of the Cobb-Douglas production function stated in (1) assumes constant returns to scale if the coefficients are restricted to sum to unity. Simon [1979], however, points out that summing to unity (or close to it) is due to parsimonious statistical properties and has no particular implications for returns to scale. Thus, imposing a restriction may not be warranted.

\^\textsuperscript{14} Estimates of current cost of utility plant and equipment were generated from the 10-K reports, which included only current cost of plants net of depreciation (CCN) and the current cost of depreciation. Since SFAS No. 33 required that current cost depreciation be determined on the same basis and period as historical cost depreciation, the ratio of CCN to book value net-of-depreciation was used as a proxy for the relation between the two valuation bases. The current cost of gross plant was estimated as the product of this ratio times historical cost of gross plant. The current cost numbers used for \( C \) were net of income tax (which is an operating cost item in utilities) and net of depreciation because a separate production factor is used for capital. Using current cost for \( C \) provides both a conversion of different generation technologies into a common unit of measure and a correction for differences in historical costs that are due to differences in acquisition dates.
where \( P, K, C, \alpha, \) and \( \gamma \) are as before; \( \alpha_0 \) is \( \log A \); \( u_i \) is \( \log e \); \( Z_i \) is the \( i \)th row (firm) in a \( n \times j \) matrix of \( j \) input determinants, \( \beta \) is a \( j \times 1 \) vector of parameters of the cost determinants, \( u_1 \) and \( u_2 \) are error terms, and \( i \) stands for the firm. In addition to output level, the \( j \) variables constituting the \( Z \) matrix consist of (1) proportions of different production technology (fossil, hydro, nuclear), (2) technological age of the plant, (3) reserve capacity, (4) operating load factor, (5) and regulatory lag. More discussion of these factors is presented in Appendix A.

While each production function has a dual cost function, the operating budget estimated here is not the same as that dual cost function because the objective is to generate an empirical operating budget rather than to price individual production factors. The Cobb-Douglas production function described by (2) is homogeneous but makes no assumptions about returns to scale. It differs from the common formulation of Cobb-Douglas production functions in three respects.

(a) The use of \( C \) to represent labor and input factors other than capital. The aggregation of several production factors into one requires a suitable transformation by a common index. The common index used is the current-cost dollars of these inputs. For electric utilities, these input factors include labor, fuel, and maintenance. However, for the purpose of this study the benefits arising from using three separate factors instead of \( C \) are not clear.

(b) The production function (2) assumes that the only product of electric utilities is electricity. Because electricity is nonstorable and requires highly specialized means of transporting, it is often argued that electric utilities produce at least two different products: "generation" and "transmission." The number of product lines increases even further if one considers price differentiation for time-of-day or for different customers (industrial vs. residential) to represent different product lines.

(c) A different feature of this Cobb-Douglas production function is estimating it in simultaneous equations. Simultaneity arises from the fact that \( C \) is both a determinant and a function of the level of output \( P \), as shown in the structural equations (2) and (3). \( P \) and \( C \) are endogenous.

\[
\alpha(q\log K) + \gamma(q\log C) = q(\alpha\log K + \gamma\log C).
\]

Other classes of CES production functions are cumbersome to estimate and the parsimonious feature of the usual Cobb-Douglas renders it useful for the type of analysis done here (Bosworth [1976] and Simon [1979]).

Using current cost to estimate production functions is not a new issue. See, for example, Murti and Sastry [1957].

Some authors consider the electricity sold to industry a different product from that sold to residential customers. In addition, time-of-day pricing might also be considered to price different products. For the purpose of this paper, electricity is considered a single product with discriminatory pricing in different markets.
variables, while $K$ and the $j$ variables constituting $Z$ are exogenous variables. The exogenous variables and the error terms are assumed to be independently distributed. But the error terms in the structural models (2) and (3) are correlated with the endogenous variables, $\log P$ and $\log C$. Accordingly, use of OLS to estimate (2) and (3) as single, unrelated equations will result in inconsistent estimates. Thus, a procedure for estimating simultaneous equations that satisfy the necessary identification conditions is required.\(^\text{19}\) Because one of the structural equations is overidentified, an appropriate method of estimation is 2SLS.

In 2SLS, the first stage consists of estimating the reduced form linear equations (RFL) in which each of the endogenous variables is expressed as a function of all the exogenous variables. That is:

$$\log P = k_0 + k_1 \log K + Z_i\pi + \nu_1, \quad (RFL1)$$

$$\log C = \chi_0 + \chi_1 \log K + Z_i\beta + \nu_2, \quad (RFL2)$$

where $k$, $\chi$, and $\pi$ are parameter estimates, and $\nu_1$ and $\nu_2$ are residuals such that $P^* = (\log P - \nu_1)$, and $C^* = (\log C - \nu_2)$.

In the second stage, the structural equations (2) and (3) are then estimated using OLS with $P^*$ instead of $\log P$ and $C^*$ instead of $\log C$. The resulting estimates are as follows:

$$P^{**} = \alpha_0 + \alpha \log K + \gamma C^*, \quad (2s)$$

$$C^{**} = \omega_0 + \omega \log P + Z_i\beta, \quad (3s)$$

Then the error terms are estimated as:

$$(P^* - P^{**}) = \eta_1 = (u_1 + \gamma v_2),$$

and:

$$(C^* - C^{**}) = \eta_2 = (u_2 + c_1 v_1),$$

where $\eta_1$ is asymptotically uncorrelated with $C^*$, and $\eta_2$ is also asymptotically independent of $P^*$. However, the residual variances obtained by applying OLS to the structural equations (2s) and (3s) are invalid estimates of the residual variances of $u_1$ and $u_2$ and must be corrected before making statistical inferences.\(^\text{20}\)

\(^{19}\) To estimate simultaneous equations, each equation must be either exactly identified or overidentified. Estimation of an underidentified function can be carried out by OLS, but it will result in inconsistent estimates and nonunique results. The conditions of identification for each equation are $(J - j) > (g - 1)$, where $J$ is the total number of exogenous (predetermined) variables, $j$ is the number of exogenous parameters included in the specific equation, and $g$ is the number of endogenous variables included in the function (Kmenta [1986, p. 664]). Therefore, equation (2) is overidentified, while equation 3 is exactly identified. For an overidentified function, 2SLS provides one solution and is often recommended.

\(^{20}\) The required correction is to multiply the standard errors obtained from estimating the second stage (3s) by the factors $(S_{uu}/S_{uu})$ and $(S_{u2}/S_{u2})$, respectively, where the numerator is obtained from estimating the structural equations (2) and (3), and the denominator is obtained from estimating the second-stage structural equations (2s) and (3s) as explained in Maddala [1977, p. 239]. Established computer programs often provide 2SLS estimation with the standard errors of the second stage already adjusted. This paper used the SAS-Econometrics program and SYSTAT Package.
4.1.2. Operating Slack. The above relations are used to develop two measures for the relative expense-preference of utility managers. The first is the relative (managerial) operating slack (Selten [1986]), indicating the degree of accruing operating costs, \( C \), at levels higher or lower than the operating budget (the expected operating costs relative to industry-wide estimates conditional on the different mix of technology reflected in \( Z \)). Operating slack is measured as follows:

\[
s_i = \frac{\log C_i - C_i^{**}}{\log C_i}
\]

where \( s \) is for operating slack, \( C \) is actual (accrued) operating costs, \( C^{**} \) is expected log operating costs obtained from the second-stage estimate (3s), and \( i \) is for the \( i \)th firm. Thus, for a given firm, a positive \( s_i \) indicates relatively higher than industry-wide operating slack, and vice versa. Estimated in this fashion, \( s_i \) can be viewed as a cost variance measured by the percentage deviation of accrued cost from an empirical estimate of operating budget, where the latter is the product of a fitted function using firm-specific technology mix and output and industry-wide determinants.

4.1.3. Relative Expense-Preference for Plant Investment. The concept of overcapitalization in public utilities refers to investing in more plant and equipment than is required for output levels plus a "reasonable" reserve capacity. In this paper, overcapitalization is formulated for each utility as measured by capital utilization efficiency relative to other firms in the industry. To obtain this second measure of expense-preference, the estimate:

\[
\Phi = \frac{\alpha}{\gamma}
\]

measures the ratio of (average) industry shares of production factors \( K \) to \( C \). Let \( \phi_i \) be the corresponding quotient of technological coefficients \( \alpha_i \) and \( \gamma_i \) obtained from estimating (2s) for the full sample less the \( i \)th firm. And, let:

\[
\lambda_i = (\Phi - \phi_i)
\]

be a measure of the sensitivity of production factors shares for the \( i \)th firm relative to the empirical (average) standard for the industry. The process can be repeated until \( \lambda_i \) is computed for each firm in the sample.\(^{21}\)

Since \( \gamma \) is the estimated relative share of other production factors after being purged of managerial slack \( s_i \), the variation in \( \lambda_i \) should be largely attributable to changes in the share of capital measured by \( \alpha - \alpha_k \), which is the change in estimated parameters resulting from the \( i \)th firm inclusion in the industry. Thus, \( \lambda_i \) measures the relative efficiency of capital utilization. The higher the value of \( \lambda_i \), the lower the relative efficiency of capital utilization (i.e., the greater the degree of overcapitalization), and

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\(^{21}\) The sensitivity measures of coefficient changes is the same procedure as for analysis of outliers (Belsley, Kuh, and Welsch [1980]), except that coefficient changes are to be standardized to test for significance.
vice versa. To show that this is the case, a firm with high excess capacity will have a lower coefficient for capital share than another firm with less excess capacity. In this case, \( \lambda \) will be increasing with the increase in the firm’s excess capacity.\(^{22}\)

If all firms in the industry exhibit the A-J bias, \( \lambda \) would be a relatively noisy measure of overcapitalization and would measure only the differential bias among firms. The effect of this noise, however, would operate against the alternative hypotheses tested here since \( \lambda \) is not an index of deviation from an optimal investment behavior. The size of \( \lambda \) is used as an indicator of the effort a manager might need to exert in order to include the accrued cost of overinvesting in the rate base. Effort is assumed to be linearly related to \( \lambda \).

4.2 ROE REALIZATION DEFICIENCY

Both a financial and a physical measure of overall operating efficiency are developed. The measure of ROE realization deficiency is considered the financial indicator of overall efficiency and is estimated by:

\[
\delta_i = \frac{ROE_r - ROE_a}{ROE_r}
\]

where \( ROE_r \) is the realized (accounting) rate of return on equity, \( ROE_a \) is the maximum allowed rate of return on equity, and \( i \) stands for the firm. In this formulation, \( \delta_i \) reflects the extent to which the shareholders of the \( i \)th firm are penalized by errors in assumptions (e.g., inaccurate demand prediction) or by operating less efficiently than projected. The variable \( \delta \) is a measure of unexpected performance since \( ROE_a \) is considered the budget or target.\(^{23}\)

The second measure of operating efficiency is heat rate, \( H \), which measures the energy input (in British Thermal Units) used in producing one kwh output. \( H \) has recently been suggested by a few regulatory commissions as an index for regulation incentives (Landon and Huettner [1985] and Edison Electric Institute [1987]).\(^{24}\)

4.3 REGULATORY CLIMATE

Since electric utility managers negotiate rates and profits with the regulator, the latter’s political disposition and attitudes have significant bearing on the activities of the manager. The attitude of the regulatory

\(^{22}\) Even if \( s \) does not capture all managerial slack such that the effect of the remaining portions introduces measurement error in \( \gamma \), the basic description of \( \lambda \) still holds.

\(^{23}\) The allowed \( ROE \) is in effect a legally sanctioned “target” and prices of output are set to try to achieve it. Thus, it would not be meaningful to set incentives as a function of either the allowed or achieved level of \( ROE \) alone. Instead, the objective of shareholders is to motivate the manager to have a zero \( ROE \)-realization deficiency. In contrast, the levels of actual \( ROE \) in unregulated markets were used as outcome success indicators and determinants of compensation (Antle and Smith [1986] and Lambert and Larcker [1987]).

\(^{24}\) Experimenting with incentive regulation is a relatively recent phenomenon and its success is unknown. In fact, the Edison Electric Institute report [1987] listed more canceled than active incentive regulation programs. See also Landon and Huettner [1985] and Joskow and Schmalensee [1986].
commission (known as regulatory climate) is a function of several factors (Dubin and Navarro [1982, p. 143]): (1) the political makeup of the commission (elected vs. appointed; Democrats vs. Republicans); (2) the allowed accounting methods for depreciation and investment tax credits; (3) the choice of historical or future test year for predicting demand and costs; (4) allowing funds for construction in progress in the rate base; and (5) adoption of an automatic fuel adjustment clause. Some empirical results have pointed to the serious effect of variation in the regulatory climate on the cost of capital and on the market to book values (proxies for Tobin’s q) of public utilities (Trout [1979], Archer [1981], and Dubin and Navarro [1982]). Investment bankers use the factors stated above to rate each commission’s regulatory climate. The ratings provided by Salomon Brothers, Inc. are used in this paper. Salomon Brothers rates each commission on a scale varying from A (best equals 13) to E (worst equals 1) regulatory climate. The more favorable the regulatory climate (high rating), the less effort managers would be expected to exert to achieve certain levels of allowed ROE and total revenue requirement, and vice versa. Consequently, I assume that managerial effort expended in negotiating with regulatory commissions varies with the ratings generated by Salomon Brothers, Q.

5. Hypotheses About Incentives

The main hypothesis this study tests is whether the compensation of executives in electric utilities is consistent with the existence of implicit contracting that rewards managers for their efforts and success in (g1) shifting a larger share of agency costs to the consumer and (g2) operating as efficiently as implied by the allowed ROE. It is necessary that (g1) be implemented by implicit contracts in industries subject to regulatory constraints because the political nature of the regulatory environment would penalize utility firms if such systems were to be explicitly adopted or if the firm consistently earned higher than allowed ROE. While it is difficult to infer causality, evidence consistent with the existence of implicit incentive contracts would be obtained if outcome indicators developed above have the expected signs and explain a significant portion of the variation in the compensation of executives in electric utilities. In addition, two variables are used to connote the differences in managerial skills between firms. The first variable is firm size. The coefficient of regressing log cash compensation on log size is expected to be about +0.30 (Simon [1957]). A positive relation is expected since

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25 The level of effort expected to be induced by regulatory climate is ambiguous. I assume that a relatively poor regulatory climate will require managers to work harder to achieve an objective which could be achieved in a good regulatory climate with less effort. However, it is also possible that a good regulatory climate might be characterized by tougher regulatory audits and more informed regulators. In this case, managers will also have to exert greater effort. This issue is thus an empirical one.
larger firms are more complex and require greater managerial skills. The technology mix determines the second skill-related variable. Utility firms with nuclear generation facilities are expected to require better managerial skills and higher executive pay.

Since stock-price-based compensation schemes are not prevalent in electric utilities, the compensation measures used here are \( w \), salary and bonus, and total compensation \( v \), which is equal to deferred compensation plus \( w \). Because the sample firms (discussed next) were in a single-product industry during the period of study (prior to recent movement to diversify), analysis of the variation in \( w \) or \( v \) is in effect a contemporaneous analysis of compensation relative to others in the same industry. Specific hypotheses are stated for testing the effect of each of these variables on the compensation of the top three executives in each firm in the sample.

For each executive \( m (m = 1, 2, \text{or } 3) \), the relationships are estimated by the following regression:

\[
\log_{10} w_{im} = b_{0m} + b_{1m}s_i + b_{2m}\lambda_i + b_{3m}\delta_i + b_{4m}H_i + b_{5m}Q + b_{6m}DN_i + b_{7m}rz_i + e_{im}
\]

where \( w_{im} \) is the sum of salary and bonus awards for the \( m \)th executive in the \( i \)th firm; \( s_i \) is the measure of managerial slack; \( \lambda_i \) is the relative capital utilization (e.g., overcapitalization) expense-preference of the firm; \( \delta_i \) is \( ROE \) realization deficiency; \( H_i \) is the heat rate measuring physical input/output efficiency; \( Q \) is Salomon Brothers' regulatory climate rating; \( DN \) is a dummy variable (1,0) for nuclear energy; \( rz_i \) is the firm size (measured by log plant capacity in megawatt-hours); \( b_{0m} \) is the intercept for the \( m \)th manager; \( b_q \) are parameter estimates \((q = 1 \text{ to } 7 \text{ and } m = 1 \text{ to } 3)\); and \( e_{im} \) is a residual term with zero expected value and zero correlation with the explanatory variables. (Another function was estimated for total compensation, \( v \), but the similarity of results led to reporting only those related to \( w \).)

Specific hypotheses about parameters are stated as follows:

- **Null** \( H_0 \): \( b_q = 0 \) (for all \( q \)).
- **Alternative** \( H_a \): \( (A) \ b_1 \) and \( b_2 > 0 \) (for effort to pass on accrued operating costs and the cost of overcapitalization).

26 Stock ownership of top executives in the sample of firms used is small in percentage terms. However, the behavior that maximizes expected gains from holding shares by executives should be consistent with managerial efforts to achieve an \( ROE \) level equal to or slightly greater than allowed, that is, minimizing \( ROE \) deficiency by making consumers the residual claimants. Thus, including executive stock holdings would not have altered the hypotheses tested here. Few firms in the sample offered stock option plans as a means of executive compensation. Exceptions include Tucson Electric, Teco, and Cleveland Electric.

27 Scaling \( w \) by the mean or median does not change the results. Such a scaling would be meaningful in this case because we are dealing with a homogeneous industry having a reasonably defined labor market for executives in that industry.
(B) $b_3 > 0$ and $b_4 < 0$ (to motivate operating efficiency).
(C) $b_5 < 0$ (to reward relative efforts in lobbying regulators).
(D) $b_6 > 0$ (to pay for the higher technical competence required for managing nuclear power plants).
(E) $b_7 > 0$ (for different levels of managerial skill implied by firm size).

6. Empirical Analyses

6.1 DATA

The test period for this study is 1981–83. During that period electric utilities had historically large average ROE realization deficiencies (280 and 220 basis points for 1981 and 1982, respectively) and had not begun to diversify.

Compensation data were collected for each of the top three executives from proxy statements. Operating data (load factor, reserve capacity, output in megakwh, realized and allowed rates of return, etc.) were collected from Electric Power and Light, Utility Compustat, Moody’s, Value Line Investment Survey, and 10-K reports. Data on rates of return, estimates of regulatory lags, and quality rating of electric utilities were collected from Salomon Brothers’ Electric Utility Regulation—Semianual Review. Full data were collected for samples of 52 investor-owned single-product electric utilities for 1982, 44 for 1981, and 45 for 1983.

6.2 ESTIMATION

The 2SLS results of estimating the production function (2s) are reported in table 1. The results are reasonably stable over the three-year period. Using 2SLS without parameter restriction, the capital share coefficient, $\alpha$, is statistically significant at $p < 0.01$, and the coefficient for other factors, $\gamma$, is statistically significant at $p < 0.10$. In addition, the magnitudes of the coefficients $\alpha$ and $\gamma$ are about the same in the three years. The explanatory power of the function (adjusted $R^2$) is about

---

29 Some electric utilities have recently become subsidiaries of holding companies that engage in other types of business such as, for example, paper products or insurance companies. During 1981 and 1982 over 97% of revenues of the sample firms used in this study were generated from generation and sale of electricity. Diversification, however, adds complexity to regulation incentives and factors other than electric utilities in determining executive compensation.
30 Differences in sample size are due to the inability to collect information on either compensation or allowed ROE. Complications in computing the allowed ROE arise for companies that operate electric plants in several states. Since each regulatory commission has a different fair ROE, the allowed ROE for a multistate utility company is estimated as the weighted average of ROE allowed in the states in which the company operates. The weights used are based on ratios of each state’s electric revenues.
31 Estimating the production function as a single equation using OLS (ignoring simultaneity) resulted in significant $\alpha_i (p < 0.01)$ and $\gamma (p < 0.01)$. 
TABLE 1
Regression Estimates of Electric Utility Production Functions*

\[
\log P = \alpha_0 + \alpha_1 \log K + \gamma \log C + u_i
\]

For 1981
\[
\begin{array}{cccccc}
\alpha_0 & \alpha_1 & \gamma & F_{\text{Stat.}} & \text{Adj.} R^2 \\
\hline
0.22 & 0.79 & 0.38 & 133.4^* & 0.86 \\
(t) & (0.76)^* & (3.38)^* & (1.50)^** \\
(N = 44) & & & & \\
\end{array}
\]

For 1982
\[
\begin{array}{cccccc}
\alpha_0 & \alpha_1 & \gamma & F_{\text{Stat.}} & \text{Adj.} R^2 \\
\hline
0.35 & 0.74 & 0.38 & 148.6^* & 0.85 \\
(t) & (1.23) & (2.77)^* & (1.38)^** \\
(N = 52) & & & & \\
\end{array}
\]

For 1983
\[
\begin{array}{cccccc}
\alpha_0 & \alpha_1 & \gamma & F_{\text{Stat.}} & \text{Adj.} R^2 \\
\hline
0.26 & 0.85 & 0.25 & 128.9^* & 0.85 \\
(t) & (0.95) & (3.53)^* & (0.94) \\
(N = 45) & & & & \\
\end{array}
\]

* These are second stage estimates of 2SLS.
* Significant at \( p < 0.01 \) (one-tail).
** Significant at \( p < 0.10 \) (one-tail). The low significance of \( \gamma \) may be due to the high correlation between \( C \) and \( K \), which is 0.84.

\( N \) = number of firms in the sample.

Variables in the Model: \( P \) = electric production in megakwh; \( K \) = current cost of plant and equipment; and \( C \) is current operating costs net of depreciation and income taxes.

0.85 in each year) is consistent with that obtained for estimates of other cross-section production functions (Spann [1974], Courville [1974], and Bosworth [1976]).

Since technical production factors related to electricity generation were used in estimating operating budgets \( (C^{**}) \), the results of estimating the structural equation (3s) are reported in table 5 in Appendix A. As shown, the fit is good: adjusted \( R^2 \) values are over 0.75 in each year. Of the technology mix variables that have been suggested as operating cost determinants, six variables have the expected signs and are statistically significant at conventional levels in either year. However, as measured by the size of \( t \)-statistics,\(^{32}\) output is the major cost determinant. All estimated functions are consistent in terms of the signs and the magnitudes of the coefficients. The industry-wide operating budget, \( C^{**} \), is subsequently used in estimating managerial slack, \( s_i \). (Further discussion of the regression estimates of these functions is in Appendix A.)

6.3 MEASURES OF TEST VARIABLES

Table 2 provides descriptive statistics for the test variables used in examining the existence of implicit incentive contracts. Estimates of firms’ managerial slack \( s_i \) have a small negative average value (-0.003)...

\(^{32}\) The relationship between the magnitude of the \( t \)-statistic for the \( x \), regressor and the incremental explanatory power of adding \( x \) to a regression explaining \( y \) is as follows:

\[
R^2 (y, x | \text{other } x) = R^2 (y | x^2 + n - k - 1),
\]

where \( n \) is the sample size and \( k \) is the number of estimated parameters (see Maddala [1988, p. 107]).
### Table 2
Descriptive Statistics for Electric Utility Executives' Compensation Regressions

<table>
<thead>
<tr>
<th></th>
<th>1983 (N = 45)</th>
<th></th>
<th>1982 (N = 52)</th>
<th></th>
<th>1981 (N = 44)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>SD</td>
<td>Mean</td>
<td>Median</td>
<td>SD</td>
</tr>
<tr>
<td>A. Explanatory variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$s$: managerial slack</td>
<td>-0.002</td>
<td>0.006</td>
<td>0.07</td>
<td>-0.003</td>
<td>-0.003</td>
<td>0.08</td>
</tr>
<tr>
<td>$y$: capital util.</td>
<td>-0.34</td>
<td>-0.04</td>
<td>1.71</td>
<td>-0.182</td>
<td>0.021</td>
<td>1.0</td>
</tr>
<tr>
<td>$\delta$: ROE deficiency$^1$</td>
<td>-0.14</td>
<td>-0.08</td>
<td>0.33</td>
<td>-0.298</td>
<td>-0.15</td>
<td>1.0</td>
</tr>
<tr>
<td>$Q$: regulatory climate</td>
<td>7.3</td>
<td>7</td>
<td>1.81</td>
<td>7.9</td>
<td>8</td>
<td>2.6</td>
</tr>
<tr>
<td>$H$: heat rate</td>
<td>10633</td>
<td>10697</td>
<td>446</td>
<td>10680</td>
<td>10642</td>
<td>480</td>
</tr>
<tr>
<td>$rz$: log$_e$ capacity in mwkh</td>
<td>3.72</td>
<td>3.74</td>
<td>0.45</td>
<td>3.57</td>
<td>3.54</td>
<td>0.43</td>
</tr>
<tr>
<td>B. Dependent variables$^2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$SB_1$: CEO salary and bonus</td>
<td>242</td>
<td>224</td>
<td>96</td>
<td>215</td>
<td>199</td>
<td>76</td>
</tr>
<tr>
<td>$w_1$: log$_{10}$ salary and bonus CEOs</td>
<td>2.35</td>
<td>2.35</td>
<td>0.17</td>
<td>2.31</td>
<td>2.30</td>
<td>0.156</td>
</tr>
<tr>
<td>$SB_2$: 2d executive salary and bonus</td>
<td>163</td>
<td>137</td>
<td>72</td>
<td>146</td>
<td>131</td>
<td>53</td>
</tr>
<tr>
<td>$w_2$: log$_{10}$ salary and bonus, 2d executive</td>
<td>2.17</td>
<td>2.15</td>
<td>0.17</td>
<td>2.13</td>
<td>2.12</td>
<td>0.158</td>
</tr>
<tr>
<td>$SB_3$: 3d executive salary and bonus</td>
<td>139</td>
<td>123</td>
<td>63</td>
<td>123</td>
<td>112</td>
<td>47</td>
</tr>
<tr>
<td>$w_3$: log$_{10}$ salary and bonus, 3d executive</td>
<td>2.11</td>
<td>2.10</td>
<td>0.18</td>
<td>2.06</td>
<td>2.05</td>
<td>0.156</td>
</tr>
</tbody>
</table>

$^1$ In 1981, $\delta$ (Realized ROE - Allowed ROE)/Realized ROE was generally positive. The min $-10.6$ is an outlier; the bottom quartile consists of $\delta = 0$. This outlier did not change statistical results, however. In 1982, $\delta$ was mostly negative.

$^2$ $w$ is log to the base 10 of salary and bonus (in thousands of dollars) and is not distributed differently from normal ($p < 0.13$).

$N$ = number of firms in the sample.
and are not correlated with size. Relative capital utilization efficiency, which is an index of overcapitalization, \( \lambda_i \), has negative mean values with wide ranges. While the mean of \( \lambda_i \) is \(-0.18\) in each of 1981 and 1982, its mean in 1983 is \(-0.34\). The median values of \( \lambda_i \) are \(0.01\) (1981), \(0.02\) (1982), and \(-0.04\) (1983). This change in \( \lambda_i \) over the three years suggests that sample firms used capital relatively more efficiently (e.g., relatively less overcapitalization) in 1983 than in either 1981 or 1982. This is consistent with the statistics about reserve capacity; the means of reserve capacity are \(0.25\) for 1983, \(0.28\) for 1982, and \(0.30\) for 1981. Also, this trend is depicted by the coefficient \(\alpha_i\) in table 1, which should be the complement of reserve capacity. Similar inferences can be drawn from the results about load factor.

Overall efficiency indicators are the ROE realization deficiency \( \delta_i \), which is a financial measure subject to manipulation through accruals and managing other costs, and heat rate, \( H_i \), which is a physical measure of input/output efficiency with less susceptibility to manipulation. The mean values of \( \delta_i \) are \(-0.13\) (1981), \(-0.298\) (1982), and \(-0.14\) (1983); and the median values are \(-0.12\) (1981), \(-0.15\) (1982), and \(-0.077\) (1983). The realized ROE approached allowed ROE for more firms in 1983 than in either of the preceding two years. The mean and median heat rates \( (H_i) \) are about 10,600 BTU per kwh. \( H \) has a narrow range and its standard deviation is about 4% of the mean.

Regulatory climate ratings, \( Q \), are clustered around the middle ratings with a median of 8 (corresponding to a B− on the Salomon Brothers' rating scale). The size measure used is plant capacity; I do not use revenues to measure size because revenues are determined on a cost-plus basis and, as a result, are not independent of the cost measures used to generate expense-preference.

The Pearson correlation coefficients between explanatory variables of the compensation function (8) are all not significantly different from zero (at \( p < 0.05 \)), with the exception of the correlation between \( H \) and \( r_z \) (which has values of \(-0.40\) for 1981, \(-0.36\) for 1982, and \(-0.36\) for 1983). This negative correlation suggests that smaller utility firms are less efficient producers of electricity in terms of BTU/kwh. All other correlation coefficients are small and not statistically significant at

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The reviewer noted that the small variation in heat rate \( (H) \) might be the reason for the lack of statistical significance of its coefficient. From an economic perspective, however, even a small variation in \( H \) can have incentive effects. There is apparently a base heat rate (perhaps slightly over 9,000 BTU/kwh) for the most efficient operation, and significant economies (diseconomies) of operations (fuel consumption, etc.) can be realized with every slight decrease (increase) in \( H \) for several megawatts produced a year. The range of variation in \( H \) has been the focus of several experiments with incentive regulation (see Landon and Huettner [1985] and Edison Electric Institute [1987]).

Since revenues are determined on a cost-plus basis, revenues and costs are structurally dependent. One reason to question the results of Awh and Primeaux [1985] is their use of these two variables as if they are determined by different processes.
conventional levels. As expected, the correlation between \( s_i \) and \( \lambda_i \) is not statistically significant at conventional levels because the \( \lambda_i \) are estimated after partialing out \( s_i \). Furthermore, the correlations between size, \( r_x \), and each of operating slack, \( s_i \), and the index of overcapitalization, \( \lambda_i \), are not statistically significant at conventional levels.

The statistics related to the dependent variable \( \log_{10}w \) are reported at the bottom of table 2. The log transformation was carried out because \( \log w \) is about normally distributed \((p > 0.15)\), which means that the OLS residual errors are more likely to satisfy the assumption of normality. Mean and median \( \log_{10}w \) (for \( w \) in thousands of dollars) take on values from 2.35 for the CEO to 2.03 for the third executive.

6.4 TEST RESULTS—COMPENSATION LEVELS

Two compensation regressions were estimated for each year. The first regression is for the chief executive officers (CEO), and the second is for the other two executives with an added indicator variable \( (D = 1) \) to estimate the intercept shift for the last executive. The results are reported in table 3.

The estimated regressions have statistically significant model F-statistics \((p < 0.001)\) and adjusted \( R^2 \) values ranging from 0.62 to 0.72 for the CEOs’ regressions and from 0.57 to 0.74 for the regressions of compensation for the other two executives. White [1980] heteroscedasticity-consistent estimates were used to estimate consistent standard errors.

(1) Expense-Preference Variables. For the CEOs, operating slack, \( s_i \), is statistically significant \((p < 0.01)\) for each of the three years, and the overcapitalization index, \( \lambda_i \), is statistically significant \((p < 0.01)\) for 1981 and 1982 but not for 1983. For the second-tier executives, both \( s_i \) and \( \lambda_i \) are significant \((p < 0.01)\) for 1981 and 1982 but not for 1983. The \( s_i \) coefficients imply a positive incremental effect of managerial slack on pay. Furthermore, the incremental effect of \( \lambda_i \) (with coefficients ranging between 0.014 and 0.019 for 1981 and 1982, respectively) does not contradict the hypothesis that relative overcapitalization is expected to require greater effort to pass the associated costs on to consumers. The lack of significance of \( \lambda_i \) in 1983 raises questions about this conclusion, however.36

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36 Two factors might shed light on this issue: (1) better capital utilization efficiency in 1983, as has already been noted, and (2) industry-wide concerns for incentives. A relevant question is whether utility management can consistently accrue managerial slack and overcapitalize in a multiperiod world. To address this problem, the temporal behavior of the two variables \((s_i \text{ and } \lambda_i)\) should be examined. In addition, the regulatory commission will be compelled to act if the firm consistently reports abnormal (materially above allowed) ROE; ordering rebates and refunds is an option regulatory commissions have. For example, the Public Service of New Mexico ordered a $14 million refund to rate payers and, in the meantime, disallowed the cost of rebuilding an air pollution control facility; and in December 1982, the Louisiana Public Service Commission ordered Louisiana P&L to refund to rate payers $1.1 billion (Salomon Brothers, Semiannual Summary of Industry: Electric Utilities [February 11, 1983], pp. 7–9).
(2) Operating Efficiency. The financial outcome indicator of overall operating efficiency, \( \delta \), measures the deviations of realized ROE from the targets allowed by regulatory commissions. The coefficient on \( \delta \) shows a statistically significant \((p < 0.01)\) positive relation between \( \delta \) and the compensation of any of the three executives for 1982 only. The insignificant results on this variable for 1981 and 1983 suggest the absence of a systematic connection between incentive systems and ROE deficiency for the period under study. That operating efficiency does not seem to be rewarded is also shown by the lack of significance of the other efficiency measure, heat rate.

(3) Working with the Regulator. The coefficient on regulatory commission rating, \( Q \), is not significant at conventional levels. One explanation of this finding is that stockholders do not encourage managers to work hard with regulators by weighting the required effort implied by different regulatory climates in their compensation. An alternative explanation is that the Salomon Brothers' quality rating does not adequately differentiate among different levels of effort expectations due to varying regulatory climate.

(4) Size. The size variable \( rz \) explains the largest proportion of adjusted \( R^2 \) values of any of the variables for all three years. This is consistent with the assumption that different-sized firms require correspondingly different managerial skills and compensation levels. The value of the \( rz \) coefficient was at about the same level (about 0.30) as that predicted by Simon [1957].

(5) Managerial Skills. Two other variables are used for managerial skills: the rank of the executive in his firm and the adoption of nuclear technology. Comparing the results of panel A and panel B in table 3, we see that the intercept terms of the CEOs' regressions are greater than one (1.367, 1.71, and 1.35), while the intercept terms for the second-tier executives are smaller (0.857, 0.923, and 1.087). In addition, the indicator variable used for the third executive, \( D \), has a statistically significant negative coefficient \((p < 0.01)\), indicating a relatively lower pay for the third executive, as would be expected.

A dummy variable, \( DN \), is set equal to one for firms operating nuclear power plants, and zero otherwise. As indicated earlier, managing nuclear power plants requires having special skills and assuming greater risks for which executives are expected to be compensated. The coefficient of \( DN \) is positive, but significant \((p < 0.05)\) only in 1982 for the CEOs' regression.

6.5 TEST RESULTS—FIRST DIFFERENCES

Table 4 includes the results of first-difference regressions. In each of those regressions, the dependent variable is the annual change in salary and bonus \((w_t - w_{t-1})\). The explanatory variables are those used in earlier regressions of year \( t-1 \), that is, the 1981 variables for \( w_{81} - w_{81} \) and 1982 for \( w_{82} - w_{82} \). The observations used for these difference tests are for the utility firms common to each two adjacent periods.
<table>
<thead>
<tr>
<th>Dependent Variable $-\log_{10}\text{w}$</th>
<th>(Expected Sign)</th>
<th>(1981 ( N = 44 ))</th>
<th>1982 ( N = 52 )</th>
<th>1983 ( N = 45 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff. (t)</td>
<td>White's (t^2)</td>
<td>Coeff. (t)</td>
<td>White's (t^2)</td>
</tr>
<tr>
<td>Panel A: For CEOs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.367</td>
<td>2.94$^a$</td>
<td>2.91$^a$</td>
<td>1.71</td>
</tr>
<tr>
<td>(b_1): Slack (s)</td>
<td>(+)</td>
<td>0.365</td>
<td>1.85$^a$</td>
<td>2.92$^a$</td>
</tr>
<tr>
<td>(b_2): Capital Util. ((\lambda))</td>
<td>(+)</td>
<td>0.019</td>
<td>1.42</td>
<td>2.88$^a$</td>
</tr>
<tr>
<td>(b_3): ROE Defic. ((\delta))</td>
<td>(+)</td>
<td>0.002</td>
<td>0.17</td>
<td>0.68</td>
</tr>
<tr>
<td>(b_4): Heat Rate (H)</td>
<td>(-)</td>
<td>-0.00001</td>
<td>-0.46</td>
<td>-0.42</td>
</tr>
<tr>
<td>(b_5): Reg. Climate (Q)</td>
<td>(-)</td>
<td>0.003</td>
<td>0.44</td>
<td>0.43</td>
</tr>
<tr>
<td>(b_6): Dum. Nuke (DN)</td>
<td>(+)</td>
<td>0.037</td>
<td>1.15</td>
<td>1.37</td>
</tr>
<tr>
<td>(b_7): log Cap. ((r_z))</td>
<td>(+)</td>
<td>0.29</td>
<td>6.76$^a$</td>
<td>8.48$^a$</td>
</tr>
<tr>
<td>Model F</td>
<td>12.74</td>
<td>20.04$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(df = (n; \ dn))</td>
<td>(7; 36)</td>
<td>(7; 44)</td>
<td>(7; 37)</td>
<td></td>
</tr>
<tr>
<td>Prob. of Significance</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.66</td>
<td>0.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel B: For Second and Third Executives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.857</td>
<td>2.59$^a$</td>
<td>2.54$^a$</td>
<td>0.923</td>
</tr>
<tr>
<td>(b_1): Slack (s)</td>
<td>(+)</td>
<td>0.168</td>
<td>1.20</td>
<td>1.77$^a$</td>
</tr>
<tr>
<td>(b_2): Capital Util. ((\lambda))</td>
<td>(+)</td>
<td>0.017</td>
<td>1.87$^a$</td>
<td>4.35$^a$</td>
</tr>
<tr>
<td>(b_3): ROE Defic. ((\delta))</td>
<td>(+)</td>
<td>-0.002</td>
<td>-0.40</td>
<td>-1.12</td>
</tr>
<tr>
<td>(b_4): Heat Rate (H)</td>
<td>(-)</td>
<td>0.00001</td>
<td>0.55</td>
<td>0.54</td>
</tr>
<tr>
<td>(b_5): Reg. Climate (Q)</td>
<td>(-)</td>
<td>-0.0003</td>
<td>-0.09</td>
<td>-0.09</td>
</tr>
<tr>
<td>(b_6): Dum. Nuke (DN)</td>
<td>(+)</td>
<td>0.026</td>
<td>1.14</td>
<td>1.11</td>
</tr>
<tr>
<td>(b_7): log Capacity ((r_z))</td>
<td>(+)</td>
<td>0.302</td>
<td>10.08</td>
<td>10.20$^a$</td>
</tr>
<tr>
<td>Model F</td>
<td>22.56</td>
<td>38.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(df = (n; \ dn))</td>
<td>(8; 79)</td>
<td>(8; 96)</td>
<td>(8; 81)</td>
<td></td>
</tr>
<tr>
<td>Prob. of Significance</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.67</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. \(w\) = salary and bonus.
2. \(N\) = number of firms in the sample times two executives.
3. White's \(t\) statistic using standard errors generated from White's [1980] heteroskedastic consistent estimator.
4. An indicator variable, \(D\), is used as an intercept shift for the third executive (\(D\) = 1).
5. \(t\) - statistically significant at \(p < 0.01\) (two-tail).
6. \(-\) - statistically significant at \(p < 0.05\) (one-tail).
### TABLE 4
Regression Results of Annual Change in Salary and Bonus of Electric Utilities’ Top Executives Using the Earlier Period’s Explanatory Variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>t</td>
</tr>
<tr>
<td>Panel A: For CEOs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>3.73</td>
<td>0.33</td>
</tr>
<tr>
<td>$d$: Slack ($s$)</td>
<td>91.5</td>
<td>2.22*</td>
</tr>
<tr>
<td>$d$: Capital Util. ($\lambda$)</td>
<td>-2.23</td>
<td>-0.8</td>
</tr>
<tr>
<td>$d$: ROE Defic. ($\delta$)</td>
<td>3.37</td>
<td>1.83*</td>
</tr>
<tr>
<td>$d$: Heat Rate ($H$)</td>
<td>-0.011</td>
<td>-1.48</td>
</tr>
<tr>
<td>$d$: Reg. Climate ($Q$)</td>
<td>-1.04</td>
<td>-0.87</td>
</tr>
<tr>
<td>$d$: Dum. Nuke ($N$)</td>
<td>4.31</td>
<td>0.62</td>
</tr>
<tr>
<td>$d$: log Cap. ($rz$)</td>
<td>16.67</td>
<td>1.87*</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>3.02</td>
<td></td>
</tr>
<tr>
<td>$d.f. = (n; dn)$</td>
<td>8; 33</td>
<td></td>
</tr>
<tr>
<td>Prob. of Significance</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>White Spec. Statistic</td>
<td>36.8^</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: For Second and Third Executives</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.54</td>
<td>0.01</td>
<td>0.01</td>
<td>-60.0</td>
<td>-0.5</td>
<td>-0.4</td>
</tr>
<tr>
<td>$d$: Slack ($s$)</td>
<td>48.16</td>
<td>2.66*</td>
<td>2.65*</td>
<td>33.8</td>
<td>0.83</td>
<td>1.1</td>
</tr>
<tr>
<td>$d$: Capital Util. ($\lambda$)</td>
<td>-0.60</td>
<td>-0.50</td>
<td>-1.23</td>
<td>0.30</td>
<td>0.10</td>
<td>0.33</td>
</tr>
<tr>
<td>$d$: ROE Defic. ($\delta$)</td>
<td>2.03</td>
<td>2.51*</td>
<td>5.27*</td>
<td>2.12</td>
<td>0.68</td>
<td>0.97</td>
</tr>
<tr>
<td>$d$: Heat Rate ($H$)</td>
<td>-0.006</td>
<td>-1.61</td>
<td>-1.64*</td>
<td>-0.001</td>
<td>-0.18</td>
<td>-0.17</td>
</tr>
<tr>
<td>$d$: Reg. Climate ($Q$)</td>
<td>-0.59</td>
<td>-1.13</td>
<td>-1.70*</td>
<td>-0.97</td>
<td>-0.77</td>
<td>-0.61</td>
</tr>
<tr>
<td>$d$: Dum. Nuke ($N$)</td>
<td>2.14</td>
<td>0.71</td>
<td>0.79</td>
<td>-8.12</td>
<td>-1.01</td>
<td>-1.20</td>
</tr>
<tr>
<td>$d$: log Cap. ($rz$)</td>
<td>9.27</td>
<td>2.36*</td>
<td>2.57*</td>
<td>18.46</td>
<td>1.95*</td>
<td>1.41</td>
</tr>
<tr>
<td>$d$: $D$: 3d Exec.</td>
<td>-4.30</td>
<td>-1.67*</td>
<td>-1.67*</td>
<td>-1.68</td>
<td>-0.27</td>
<td>-0.27</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>4.20</td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>$(d.f.) = (n; dn)$</td>
<td>(8; 75)</td>
<td></td>
<td></td>
<td></td>
<td>(8; 79)</td>
<td></td>
</tr>
<tr>
<td>Prob. of Significance</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
<td></td>
<td>N.S.*</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>White Spec. Statistic</td>
<td>51.9^</td>
<td></td>
<td></td>
<td></td>
<td>76.1^</td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant at $p < 0.01$ (one-tail).

Statistically significant at $p < 0.05$.

Not statistically significant.

Significant results are obtained only for the differences between 1981 and 1982 for all three executives. The adjusted $R^2$ values are 0.26 for the CEOs and 0.24 for the other executives. The coefficients on operational slack, $s$, and size are both significantly positive at $p < 0.01$, consistent with the results obtained for compensation levels. In addition, some evidence is obtained concerning measures of efficiency. First, the coefficient of ROE deficiency, $\delta$, is significantly positive ($p < 0.01$), and the coefficient of heat rate, $H$, is significantly negative ($p < 0.05$). Jointly,
these two results suggest that changes in executives’ salary and bonus from 1981 to 1982 were higher for the relatively more efficient firms. In contrast to these results, the coefficients for the 1982–83 differences are not generally significant and the model as whole has a very poor fit.

While I cannot point to the precise reason for the different results, it is important to note that it was July 1983 when the RCG report (Edison Electric Institute [1987]) was released. As indicated earlier, the RCG group criticized the incentive structure of the electric utilities industries, recommended several new incentive schemes, and stated the following conclusion (Edison Electric Institute [1987, p. 41]): “In order to protect shareholder interests from managerial incentives to hold down the utility's return on equity, the RCG recommends excluding the CEO and selected staff from the incentive bonus system; they would then have the responsibility of representing shareholder interest.”

Thus, it is likely that the 1982–83 changes in compensation were adversely influenced by the report, especially since the final findings of the report were published by FERC and, in addition, 12 large electric utilities as well as Merrill Lynch have participated in an extensive public discussion of these findings. A summary of these concerns is in the Edison Electric Institute publication [1987].

In addition to the effect of the RCG report on the incentive structure of electric utilities’ executives, extending this study to cover more recent periods must be done with care for two reasons: (1) regulators increasingly have been disallowing some nuclear power plant costs in the required revenues; and (2) many electric utilities are becoming members of holding companies seeking diversified investments to generate other sources of income.

7. Concluding Comments

In this paper, I have examined the financial incentives likely to be offered by stockholders to electric utility top managers. Given the (imperfect) cost-plus pricing system mandated by U.S. Supreme Court decisions and by the different statutes regulating public utilities in the 50 states and the District of Columbia, the stockholders would bear smaller residual costs if they motivated the managers to pass all costs on to consumers and to operate as efficiently as implied by the allowed rates of return. In this respect, if the realized rates of return equal the allowed, the consumers, not the stockholders, would be the major residual claimants of operating inefficiency and consumption at the workplace. However, it has been observed that realized rates of return have fallen below the allowed—materially so in 1981 and 1982.

In general, proxy statements of electric utilities do not discuss the methods of determining salary levels and cash bonus awards for utility managers, as is the case with other industries (see, for example, Antle and Smith [1985], Healy [1985], Watts and Zimmerman [1986], and
Abdel-khalik, Chi, and Ghicas [1987]). In addition, the legal and political nature of the industry would not permit writing incentive contracts that motivate managers to pass the cost of slack and inefficiency on to consumers. Any such schemes would have to be made implicit by creating a reputation in the industry for paying high bonus awards to the managers who succeed in passing accrued costs on to consumers and who operate within the efficiency bounds of the allowed rates. Success in these situations can be proxied by the expected effort levels denoted by managers’ expense-preferences, by overall measures of efficiency, and by working with regulatory commissions.36

Using production and cost functions for electricity generation, a method is provided for measuring utility managers’ expense-preferences for overinvestment in utility plants and for operating slack. Two measures of overall operating efficiency are used: (1) a financial indicator consisting of the divergence between earned and allowed (accounting) rates of return on equity, and (2) a physical indicator for input/output ratio as measured by heat rate (BTUs per kwh). Finally, regulatory climate ratings by Salomon Brothers are used to impute the level of effort required of managers—i.e., high effort is expected to succeed in a poor climate. These variables are then used to examine the existence of implicit incentive contracts for a sample of 44, 52, and 45 investor-owned electric utilities in 1981, 1982, and 1983, respectively. For each firm, the compensation of each of the top three executives is used as a dependent variable. The analysis is carried out relative to empirical benchmarks generated for the industry.

The findings are summarized as follows: (1) The electric utility size (measured by its productive capacity) is the major determinant of executives’ compensation. (2) After controlling for the effect of size, higher compensation for CEOs is partially associated with accruing relatively larger operating slack and capital utilization efficiency, reflecting expense-preference for overcapitalization. Both variables are also significant for the other two executives in the 1981 and 1982 regressions. However, only operating slack was significant for first-difference results between 1981 and 1982. (3) No systematic association between executive compensation and the overall operating efficiency is detected whether efficiency is measured by financial indicators (ROE deficiency) or by input/output ratios (heat rate). (4) The managers’ effort implied by the rating of regulatory climate appears to be unrelated to compensation.

These findings suggest that the connection between top executive compensation and each of operating slack and capital utilization efficiency is not random, especially since operating slack is found to be consistently associated with CEOs’ compensation during the three-year period under study.

36 Paris and Beauchamp [1988] describe the efforts and rewards of the CEO at Southern California Edison that characterize a situation which parallels the hypotheses tested in this paper.
Interpretation of these results is complicated by two considerations: (1) the cost of inefficiency is likely to be shifted to the consumer in the form of future rate adjustments; and (2) the observed inefficiencies could not be solely due to errors in demand predictions and in the underlying cost assumptions; both the management and the regulatory commission meet frequently to discuss rates and adjust prediction errors of weather and demand. Consequently, it is possible that managers of electric utilities either fail to convince regulators to include certain costs in the required revenues or do in fact increase operating costs and consumption at the workplace beyond what can be included in the allowable cost. In either case, part of this cost seems to be borne by the investor, as shown by the realization of ROE levels below the allowable targets.

APPENDIX A

Components of the Z Matrix and Operating Budgets

This appendix presents the determinants of the operating budget used in the function (3). While several authors have generated different variables for the cost of electricity (e.g., Spann [1974] and Courville [1974]), the variables used here relied more on Crew and Kleindorfer (in Crew [1980]). They provided a rationale for the use of reserve capacity, load factor, and different technologies of generating electricity. Instead of adding specific variables for fuel costs, I used the level of output as the major determinant of the cost of consumed fuel. Also added is a proxy for technological age (which has been used by other researchers) and regulatory lag. The older the plant, the higher the cost of operation; and the longer the regulatory lag, the greater the flexibility of the firm to benefit by cost reductions and innovations. The Z matrix consists of the following input determinants for operating cost:

(-) \( R \) = reserve capacity measured by \(((\text{capacity} - \text{peak load})/\text{capacity})\).

(+) \( L \) = load factor measured by \([\text{production}/(\text{capacity} \times 8760)]\).

(+) \( T \) = technological age of plant proxied by \((\text{current cost of plant}/\text{historical cost of plant})\).

(-) \( N \) = percentage of electricity produced by nuclear plants.

(?) \( F \) = percentage of electricity produced by fossil fuel.

(-) \( h \) = percentage of electric production from hydraulic generation.

(?) \( I \) = percentage of electric production from internal combustion.

(+) \( G \) = regulatory lag length in months.

The predicted effect of each variable on the cost of operations is shown next to the variable's definition. These are self-explanatory, except for \( F \) and \( I \). The effect of having a larger percentage of fossil fuel cannot be determined in advance because the price of oil was beginning to decrease below the levels anticipated by prior rate cases; and there is a similar problem with \( I \) due to changes in the price of oil and coal. Since the total
INCENTIVES FOR ACCRUING COSTS  171

TABLE 5
Regression Estimates of Operating Budget Determinants of Electric Utilities*

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>1981 (N = 44)</th>
<th>1982 (N = 52)</th>
<th>1983 (N = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef. (t)</td>
<td>Coef. (t)</td>
<td>Coef. (t)</td>
</tr>
<tr>
<td>$c_0$ Intercept</td>
<td>-0.53 (-1.05)</td>
<td>-0.53 (-1.18)</td>
<td>-0.328 (-0.75)</td>
</tr>
<tr>
<td>$c_1$ log Production: $\log P$</td>
<td>0.96 (9.2)*</td>
<td>0.92 (11.0)*</td>
<td>0.98 (9.50)*</td>
</tr>
<tr>
<td>$\gamma_1$ Tech. Age $T$</td>
<td>-0.10 (-1.15)</td>
<td>-0.08 (-0.7)</td>
<td>-0.15 (-1.60)</td>
</tr>
<tr>
<td>$\gamma_2$ Capacity Reserve: $R$</td>
<td>-0.26 (-1.04)</td>
<td>-0.31 (-1.62)**</td>
<td>-0.37 (-1.59)</td>
</tr>
<tr>
<td>$\gamma_3$ Load factor: $L$</td>
<td>1.0 (1.87)**</td>
<td>1.0 (1.97)*</td>
<td>1.75 (3.19)*</td>
</tr>
<tr>
<td>$\gamma_4$ Regulatory Lag: $G$</td>
<td>0.01 (1.5)</td>
<td>0.009 0.91</td>
<td>-0.01 (-0.75)</td>
</tr>
<tr>
<td>$\beta_1$ Nuke Gen.: $N$</td>
<td>-0.14 (-1.7)**</td>
<td>-0.94 -0.15</td>
<td>-1.68 (-2.11)*</td>
</tr>
<tr>
<td>$\beta_2$ Hydro Gen.: $h$</td>
<td>-0.09 (-2.35)*</td>
<td>-1.02 (-2.44)*</td>
<td>-1.81 (-3.07)*</td>
</tr>
<tr>
<td>$\beta_3$ Fossil Gen.: $F$</td>
<td>-1.32 (-2.85)*</td>
<td>-1.06 (-2.03)*</td>
<td>-1.67 (-3.20)*</td>
</tr>
<tr>
<td>Model F-Statistic</td>
<td>20.5* (df = 11; 36)</td>
<td>24.0* (df = 11; 36)</td>
<td>23.1* (df = 11; 36)</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.78</td>
<td>0.78</td>
<td>0.80</td>
</tr>
</tbody>
</table>

* = second-stage estimates of 2SLS.  
$N =$ number of firms in the sample.  
* Significant at $p < 0.01$ (one-tail).  
** Significant at $p < 0.05$ (one-tail).

percentage of all the four sources of generation adds up to unity, $I$ was not used explicitly as a variable.

Results of estimating the operating budget function (3) are presented in table 5. The major determinant of operating costs is the level of production (proxying for fuel and maintenance cost). The variables $F$, $h$, and $N$ show significantly negative coefficients, and $L$ shows a significant positive coefficient. $R$ shows a significant negative coefficient only for 1982. The model fit is good (adjusted $R^2$ values are 0.78 and 0.80).

APPENDIX B

Sample of Utility Companies Used

- Allegheny Power System  
- American Electric Power  
- Atlantic City Electric  
- Boston Edison Co.  
- Carolina Power & Light  
- Central & South West Corp.  
- Central Maine Power Co.  
- Central Vermont Pub. Serv.  
- Cleveland Electric Illum  
- Commonwealth Edison  
- Delmarva Power & Light  
- Detroit Edison Co.  
- Duke Power Co.  
- Duquesne Light Co.  
- Eastern Utilities Assoc.  
- Empire District Electric Co.  
- Florida Power & Light  
- Florida Progress Corp.  
- General Public Utilities  
- Gulf States Utilities Co.  
- Hawaiian Electric Inds.  
- Houston Industries Inc.  
- Idaho Power Co.  
- Indianapolis Power & Light  
- Iowa Resources Inc.  
- Kansas City Power & Light

Kentucky Utilities Co.
Middle South Utilities
Minnesota Power & Light
Nevada Power Co.
New England Electric System
Ohio Edison Co.
Oklahoma Gas & Electric
Otter Tail Power Co.
Pacific P&L
Pennsylvania Power & Light
Portland General Electric Co.
Potomac Electric Power
Public Service Co. of Ind.
Public Service Co. of N.H.

Public Service Co. of N. Mex.
Puget Sound Power & Light
Southern Calif. Edison Co.
Southern Co.
Southwestern Public Serv. Co.
Teco Energy Inc.
Texas Utilities Co.
Toledo Edison Co.
Tucson Electric Power Co.
Union Electric Co.
United Illuminating Co.
Utah Power & Light
Wisconsin Electric Power

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