An Evaluation of Incentive Regulation: Corrections and Extensions

by

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Abstract

This note re-estimates our model of the determinants and impacts of cost component incentive regulation using an improved data set which avoids double-counting firm observations. It also tests alternative specifications of the relationships. While cost component incentive regulation improves engineering efficiency (heat rates), it does not improve economic efficiency. Thus, our earlier findings are not altered by the smaller data set or by model respecification.

1. Introduction

The Energy Policy Act of 1992 requires that states consider new PURPA standards related to integrated resource planning--for the promotion of efficiency. The new PURPA standards [Sec. 11(d)(9)] mandate that commissions consider the efficiency impacts of incentives associated with existing rate-making procedures. Consequently, it is important that policy-makers be aware of the empirical tests of past state incentive plans. Our earlier analysis (Berg-Jeong 1991, 45-55) of the causes and effects of cost component incentive regulation contained data problems.[1] Some double

[1]Paul Joskow pointed out problems with the original data set; rather than publishing a comment, he encouraged us to re-estimate the model. Dana Aberwald assisted in eliminating holding companies from the final sample. In addition, Bill Taylor and David Sappington provided helpful comments on model specification and interpretation. This note attempts to address their concerns and presents some new results. Each co-author blames the other for any remaining deficiencies.

counting occurred because holding companies and the operating companies were both included in the sample. Although our earlier conclusions are unaffected by re-estimation, the relative importance of some factors is altered. Going beyond our earlier analysis, we also test whether cost component incentives at least improve heat rates--which are targeted by some of the incentive plans. These new results are reported in the concluding section. Furthermore, we take this opportunity to clarify the construction of the data base used for estimating the simultaneous model. We conclude that cost component incentive regulation did not reduce overall costs (as measured by managerial slack). To facilitate comparisons with the 1991 analysis, an identical equation numbering scheme is utilized here.

2. Results for Operating Companies

To obtain a proxy for managerial slack, we estimated a cost function

$$C_i = \beta_0 + \beta_1 GEN_i + \beta_2 GEN_i^2 + \beta_3 GEN_i^3 + \beta_4 RESCAP_i + \beta_5 LOADF_i + \beta_6 HYR_i + \beta_7 NUCR_i + \beta_8 YEAR_i + V_i \quad (3)$$

where

C_i = log operating cost of the firm

GEN_i = log total generation

$RESCAP_i$ = reserve capacity of firm i

HYR_i = log % electricity produced by hydroelectric

$NUCR_i$ = log % electricity produced by nuclear plants

$YEAR_i$ = time variable (year), 1973-1985

The original and the new results for the cost function are shown in table 1. The coefficients of the generation variables change slightly, but they generally remain significant. Changes for HYR and NUCR occur, but overall explanatory power of the cost equation is basically unchanged.

The managerial slack variable (S_i) was defined as

$$S_i \equiv \frac{C_i - C_i^*}{Q_t} \quad (1)$$

Table 1

Estimated Cost Function: Equation (4)

Variables	Original Results	Without Holding Co.
Constant	17.22 (5.85)**	5.59 (1.12)
GEN	-5.59 (-5.35)**	-3.69 (-2.01)*
GEN^2	0.68 (5.58)**	0.45 (2.02)*
GEN^3	-0.02 (-5.19)**	-0.02 (-1.75)
RESCAP	0.41 (1.80)	0.07 (0.21)
LOADF	0.32 (1.26)	0.38 (0.71)
HYR	0.009 (0.938)	0.05 (2.70)**
NUCR	-0.02 (-4.80)**	0.02 (0.60)
YEAR	0.09 (19.86)**	0.09 (14.99)**
Adj. R^2	0.81	0.78
N	490	296

* 5% significance level
** 1% significance level

where C_i^* is the predicted value of log operating cost. A Probit MLE model was estimated:

$$I_i = \alpha_0 + \alpha_1 S_i + \alpha_2 H_i + \alpha_3 MAR_i + \alpha_4 LOADF_i + \alpha_5 GEN_i + U_i \quad (2)$$

where I_i = 1 when firm i is under incentive regulation

S_i = managerial slack of firm i (based on 3 years)

H_i = heat rate of firm i

MAR_i = (Total Revenue - Total Cost)/Total Cost = firm i's margin

$LOADF_i$ = Total Generation/(System Capacity * 8760) = load factor firm i

GEN_i = log of total generation of firm i

As noted in Berg-Jeong (1991, 51), S_i is endogenous because the onset of incentive regulation (IR) might reduce managerial slack. Thus, for firms subject to IR, observations are used only for the three years prior to adoption. Observations for firms not subjected to IR are deleted after 1980 since IR is expected to lower industry average cost--resulting in higher measured managerial slack.

The re-estimated coefficients for the determinants of IR are shown in table 2, along with the earlier results. We also present the marginal effects--changes in the probability of adoption due to a one unit change in the independent variable. Slack remains a significant determinant of cost component IR, but the size of its impact is less than one-tenth of that found earlier. Since the average slack is lower with the improved data set, the implied elasticity (calculated at mean values) does not drop by a factor of ten. In the original results, a one percent increase in slack increased the probability of IR by .17 percent. Without holding companies, the comparable number is .08 percent.

On the other hand, the impact of margin more than doubles--in terms of the marginal impact and elasticity. As (revenue-cost)/cost rises by one percent, the probability of IR is increased by 1.55 percent. We interpret this as evidence that high prices (relative to average total cost) can also trigger cost component IR since such mechanisms provide a way for sharing cost savings. To continue obtaining such margins, firms will be expected to meet firm-specific targets. The regulatory rationale

Table 2

Adoption of Incentive Regulation: Equation (5)

Variables	Coefficients		Marginal Effects	
	Original Results	**Without Holding Co.**	**Original Results**	**Without Holding Co.**
Constant	-2.84 (-1.14)	-3.21 (-0.86)	-0.78	-1.08
Slack	277.10 (2.42)*	18.49 (3.96)**	75.76	6.23
Heat Rate	-0.14 (-1.11)	-0.22 (-1.41)	-0.04	-0.08
Margin	1.14 (2.85)**	2.72 (3.70)**	0.31	.92
Load Factor	9.39 (3.52)**	14.82 (3.61)**	2.57	4.99
GEN	-0.27 (-1.72)	-0.55 (-2.24)*	-0.07	-0.19
Prediction Rate	0.73	0.76	NA	NA
N	156	90	156	90

* 5% significance level
** 1% significance level

may be that such performance legitimizes the relatively higher margins. Thus, firms may not only accede to such regulations, but promote them as justifying relatively high returns.

We had hypothesized that a large electricity utility (captured by GEN) would be highly visible politically; such firms also offered the potential for larger overall cost savings for a given percentage cost reduction. However, the re-estimated coefficient for GEN was negative and significant at the 10% level (whereas, previously it had also been negative, but was not significant at the 10% level). Thus, size appears to be an important negative factor--suggesting that regulators tend to apply cost component IR to smaller utilities. We do not have an explanation for this result.

Since the correct prediction rate increases from 73% to 76% when the parent (holding) companies are excluded from the sample, the data correction leads to a slightly sharper ability to identify firms which are likely to have cost component regulation imposed on them.

3. Effectiveness of Cost Component Incentive Regulations Re-examined

A simultaneous equations model was used to examine the effectiveness of incentive regulation:

$$S_i = f(D_i, LOADF_i, RESCAP_i, MAR_i, GEN_i) \quad (6)$$

$$D_i = g(S_i, LOADF_i, HEAT_i, MAR_i, GEN_i) \quad (7)$$

where $D_i = 1$ if firm i is under incentive regulation and $= 0$ if it is not. Since D_i is binary, we have a limited dependent simultaneous equation system;[2] two alternative consistent estimation methods were described in Berg-Jeong (1991, 51-52). New results for the reduced form probit model for D_i are shown in table 3. The coefficients and prediction rate were basically unchanged by the use of

[2]Bill Taylor questioned the exclusion of heat rate from equation (6) of the simultaneous model. We consider the heat rate as an alternative measure of utility performance, so it could be an alternative dependent variable of equation (6), but not an explanatory variable. That is, we do not view the heat rate as a major determinant of managerial slack. In addition, if the coefficient for $HEAT_i$ in (7) is restricted to zero *a priori*, equation (6) is not identified, and the IV method would become invalid. Since the decision to adopt incentive regulation captured in equation (7) is a function of performance, including managerial slack, margin, and load factor, heat rate is included in (7); most states use heat rate in formulae for evaluating performance.

Table 3

Reduced Form Probit: Equation (10)

Variables	Coefficients		Marginal Effects	
	Original Results	**Without Holding Co.**	**Original Results**	**Without Holding Co.**
Constant	-6.45 (-3.43)**	-6.06 (-2.57)**	-1.53	-1.66
Heat Rate	-0.12 (-1.32)	-0.13 (-1.08)	-0.03	-0.03
Margin	0.39 (2.26)*	0.14 (0.68)	0.09	0.04
Load Factor	5.70 (3.59)**	3.32 (1.79)	1.35	0.91
RESCAP	1.59 (1.84)	4.81 (3.84)**	0.38	1.31
GEN	0.28 (2.94)	0.36 (3.01)**	0.07	0.10
Prediction Rate	0.82	0.79	NA	NA
N	409	258	409	258

* 5% significance level
** 1% significance level

the revised data set. Note that the original article was unclear about how the data were arranged for testing the simultaneous model. The original data set was an incomplete panel, having 305 missing observations out of 795 potential cells. Due to the large proportion (38%) of missing data, we decided to pool the data, ignoring time variation. However, for the pre-estimation of equation (2) (explaining the adoption of IR), we had deleted some observations to reduce endogeneity bias--as described earlier. Thus, the data set used for equation (2) is different from the data used for the simultaneous model (equations (6) and (7)): the results from equation (5) do not suggest that $\delta_2 = 0$. Turning to the estimation process, the two-step estimation suggested by Maddala-Lee (1976, 525-545) yielded equation (11)--with the results shown in table 4. The adjusted R^2 increases dramatically, from .38 to .55. Again, the IR dummy does not reduce managerial slack.

The alternative IV method yields similar results: the insignificance of the coefficient for D_i in table 5 suggests that cost component IR is not effective in reducing managerial slack.

4. Cost Component Regulation Improves Heat Rates

The heat rate was not a significant determinant of the decision to adopt incentive regulation. However, heat rates are often targeted as aspects of production which regulators are trying to change. The heat rate reflects the engineering efficiency with which fuels are transformed into electricity. Lower heat rates imply more complete transformation of fuel inputs into electricity output (as measured in BTUs).

In the sample periods, only nine states have the heat rate (or fuel efficiency) as the target of their IR: Arkansas, Arizona, California, Connecticut, Massachusetts, New Hampshire ("Energy Cost Recovery Mechanism" program only), New York ("Incentive Fuel Adjustment Clause" program only), Oregon, and Pennsylvania ("Limerick 2 Operational Incentive Program" only). Nine states in the data set (DE, FL, IA, MS, NH, NJ, NY, OH, and PA) had complex combinations of various factors

Table 4

Effect of Incentive Regulation on Slack: Equation (11)

Variables	Original Results	Without Holding Co.
Constant	-0.21 (-1.78)	-0.16 (-1.96)
Dummy	0.002 (0.02)	-0.04 (-0.79)
Margin	-0.19 (-13.21)**	-0.11 (-15.36)**
Load Factor	-0.39 (-3.44)**	-0.10 (-1.44)
RESCAP	0.002 (0.03)	0.06 (0.83)
GEN	0.05 (6.95)**	0.03 (5.73)**
Inverse Mills Ratio	0.02 (0.39)	0.03 (1.08)
Adj. R^2	0.38	0.55
N	409	258

* 5% significance level
** 1% significance level

Table 5

Effect of Incentive Regulation on Slack: Equation (12)

Variables	Original Results	Without Holding Co.
Constant	-0.13 (-1.04)	-0.19 (-1.77)
Dummy	0.08 (0.84)	-0.06 (-0.90)
Margin	-0.20 (-13.31)**	-0.11 (-13.60)**
Load Factor	-0.47 (-3.39)**	-0.08 (-0.92)
RESCAP	-0.02 (-0.26)	0.09 (0.93)
GEN	0.05 (6.15)**	0.03 (4.67)**
Adj. R^2	0.37	0.35
N	409	258

* 5% significance level
** 1% significance level

(Edison Electric Institute 1987, 1-50). The model presented below does not include all the firms in the earlier data set, but only the above nine states which clearly had the heat rate target.

We investigated the impact of cost component regulation on the heat rate:

$$HEAT_i = h(D_i, LOADF_i, RESCAP_i, GEN_i, YEAR, LAGHEAT_i) \quad (13)$$

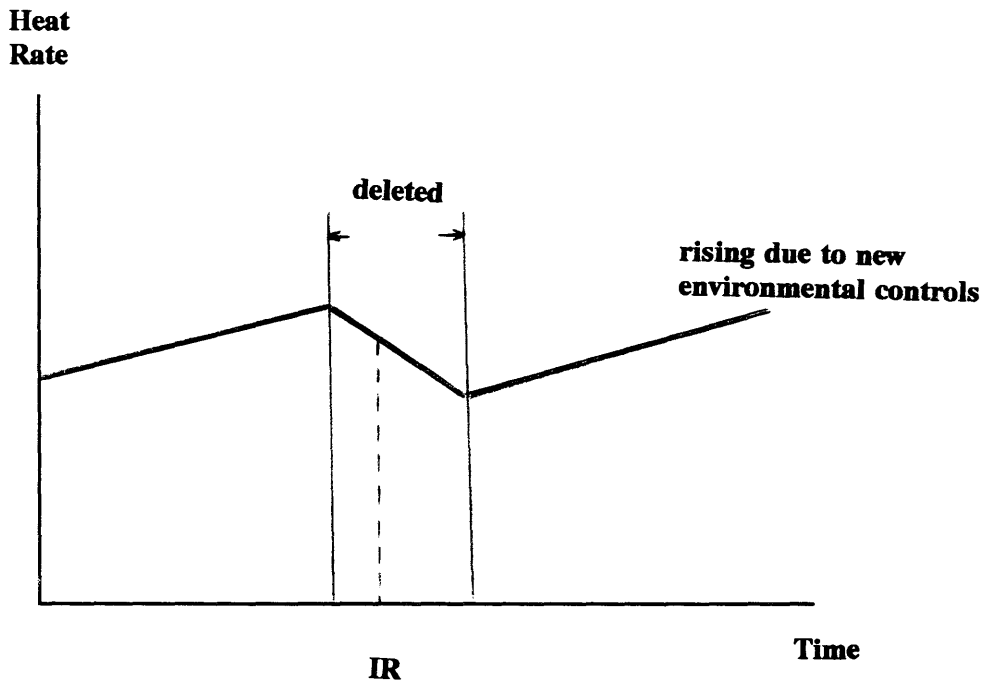
The variables are all as defined earlier, with $LAGHEAT_i$ being the previous period heat rate. Cost component regulation represents a structural break. Since lagged heat rate is a key determinant of current heat rate, a more complicated model would be needed to capture the switch in the relationship. Also, managers could anticipate changes in regulation. Deleted from the sample were observations from the year prior to regulation, the year regulation was initiated, and the first two years after regulation. Figure 1 illustrates why a total of four years around the adoption point are deleted. The time series relationship implied by the inclusion of the trend (YEAR) and the lagged heat rate has the following typical autoregressive form:

$$y_t = ay_{t-1} + bt + u_t \quad (14)$$

Year (t) captures the linear trend, and the variable LAGHEAT (y_{t-1}) captures the autoregressive trend.

We expected D_i (dummy for cost component incentive regulation) to negatively affect the heat rate. All else equal, a greater load factor ($LOADF_i$) implies that fuel-efficient base load units are run relatively more of the time. High reserve capacity also ought to lower the heat rate as the electric utility does not run older generating units. Also, larger firms (reflected in the log of output) have more opportunities to benefit from power pooling and other techniques for efficiently utilizing its generation mix. Rather than capturing technological change by the average age of production capacity, we use the passage of time, so the coefficient on YEAR ought to be negative. The lagged heat rate is included so that the firm-specific generation mix can serve as an anchor on which to base subsequent developments.

Figure 1
Impact of Incentive Regulation on Heat Rate



The new results are presented below:

$$\begin{aligned} HEAT_i = \; & \underset{(2.93)}{4.57} - \underset{(-1.98)}{.239}\, D_i - \underset{(-2.10)}{1.36}\, LOADF_i - \underset{(-0.70)}{.201}\, RESCAP_i - \underset{(2.95)}{.132}\, GEN_i \\ & + \underset{(2.06)}{.025}\, YEAR + \underset{(5.97)}{.584}\, LAGHEAT_i \end{aligned} \tag{15}$$

Adj R^2 = .755, N = 64, F Value = 33.95

The signs and significance of the coefficients are generally as expected. Engineering efficiency, as reflected in the heat rate, is improved by the presence of targeted incentives.

In addition, the results indicate that higher load factors and greater output improve (reduce) heat rates. Running counter to expectations, the coefficient on reserve capacity is negative, but it is not significant. The positive significant impact of time (reflected in the coefficient on YEAR) implies that the heat rate rises over the period, *ceteris paribus*. The trend of worsening heat rates could be explained by environmental regulations which negatively affect the performance of generating units--as when electricity is used to operate pollution control equipment.

We conclude that engineering efficiency (as defined by heat rates) has been enhanced by cost component regulation between 1973 and 1985. However, our earlier conclusions are underscored by the results from the improved data set: we do not find that economic efficiency is improved by narrow cost component regulation.[3] The non-observance of improved cost performance does not necessarily mean that the cost component IR is worthless, just that both the incentives themselves and operating cost savings may be relatively small. When states consider the new PURPA standards, generalized incentive schemes, such as yardstick regulation or price caps, may offer greater promise for promoting cost containment.

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[3]Graniere, Duann, and Hegazy (1993, 1-103) assume that cost component incentive regulation is exogenous, rather than endogenous. They use a recursive system rather than a general simultaneous equations system and conclude that these performance based incentives do reduce operating costs. We performed a Hausman test to test the endogeneity of the incentive dummy and found that it was endogenous--bringing their recursive model into question.

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