A NOTE ON PURCHASED POWER ADJUSTMENT CLAUSES

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I. Introduction

A recent series of papers has examined some of the economic effects of automatic fuel adjustment clauses on the behavior of the regulated firm.[1] For the most part, these papers have analyzed the implications of profit maximization under two alternative regulatory regimes -- one in which the firm's output price is determined by the terms of an adjustment clause formula and one in which it is not.[2] Today, virtually all electric utilities are subject to some sort of fuel cost adjustment mechanism.[3] Since the specific formulas embodied in these mechanisms exhibit considerable variation across regulatory authorities, however, their impacts on the economic incentives of the firms under their jurisdiction are not uniform.[4] At present, efforts are being made to improve the design of adjustment clauses to reduce or eliminate some of the inefficiencies that they may foster.[5] Consequently, information regarding the differential effects of alternative designs is a topic of some current interest. One of the ways in which the design can vary is in the treatment of purchased power.

In this paper, we examine the impact that alternative treatments of purchased power in the adjustment clause formula have on the incentive of the regulated firm to minimize short-run costs through its choice of purchased power versus own-generated power. Where purchased power is included in the automatic pass through formula, the firm is said to have a purchased power adjustment clause in effect. Our theoretical model indicates that excluding purchased power from the formula creates an economic incentive to overutilize the firm's own generating equipment. Empirical support for this conclusion is also provided. This finding has important public policy implications for the optimal design of adjustment clause formulas. Moreover, it partially explains the perceived reluctance of electric utilities to expand their coordination of power generation through pooling agreements.[6]

II. Incentives Provided by Alternative Treatments

We shall focus our attention on a short-run model of the decision to buy power. This will enable us to abstract from the additional constraint provided by rate of return regulation and thereby simplify the analysis considerably. Since this constraint has not provided an effective ceiling (or floor) on utility company earnings over the past decade, such an abstraction appears warranted [see Joskow (1974)].

The firm's profit function (π) is given by

$$\pi = R(q + z) - rc\bar{K} - fF(q) - pz \qquad (1)$$

here q represents the quantity of output generated in the firm's own plants; z is the quantity of output purchased from other firms, $R(\cdot)$ is total revenue from retail sales of output; $rc\bar{K}$ is the total cost of the capital input, which we assume is fixed; $F(q)$ is the quantity of fuel employed in generating power in the firm's own plants; f is the per unit price of the fuel input, which we assume is exogenous; and p is the per unit price of purchased power, which we assume is also exogenous.[7] In this formulation, $z > 0$ represents purchased power and $z < 0$ represents sales of power to other firms. We will assume that the regulated firm attempts to maximize π subject to the constraint provided by the particular regulatory regime under which it operates. This constraint varies according to the regulatory treatment accorded purchased power in the firm's automatic adjustment clause formula. Since some adjustment clauses include purchased power while others do not, an asymmetry in the tariff schedules of individual firms with respect to q and z arises. We investigate the implications of such asymmetry by examining the regulated firm's behavior under the two relevant regulatory regimes.

Purchased Power Included. First, if the firm is subject to an automatic fuel adjustment clause that includes purchased power, the relevant constraint will be given by

$$\frac{R(q + z) - fF(q) - pz}{q + z} = \delta_1, \tag{2}$$

where δ_1 is a constant determined by base year parameters. Equation (2) represents a reasonable approximation of the more complex constraints actually incorporated in utilities' adjustment clause schedules.[8]

This constraint which is binding during the interval of time that elapses between formal rate reviews,[9] is designed to mitigate the adverse effect on earnings of rapidly increasing energy costs so that the firm's realized return on capital will more closely approximate the "fair" return established at prior rate hearings.[10]

The first order conditions for profit maximization under the constraint in (2) imply that

$$(1 - \lambda)R_q - (1 - \lambda)fF_q = -\lambda\delta_1$$

and

$$(1 - \lambda)R_z - (1 - \lambda)p = -\lambda\delta_1$$

where λ is the shadow price attached to the constraint and the subscripts indicate ordinary and partial derivatives. From these conditions, it follows immediately that

$$f/(1/F_q) = p.$$

The left-hand side is the marginal cost of producing power in the firm's own plants. Thus, the firm that has a purchased power adjustment clause will utilize its own generating equipment up to the point at which the marginal cost of internally generated power equals the external price of purchased power. Consequently, this regulatory scheme will lead the firm to employ a cost minimizing combination of generated and purchased power to meet any level of demand.

Purchased Power Excluded. The second regulatory regime that we want to investigate excludes purchased power from the automatic fuel adjustment clause formula. The relevant constraint faced by the firm that is subject to this regime is

$$\frac{R(q + z) - fF(q)}{q + z} = \delta_2. \tag{3}$$

Notice that if the firms subject to the two alternative regulatory regimes approximated by equations (2) and (3) are allowed the same rate of return on capital at the formal rate hearing, then $\delta_1 < \delta_2$ will hold. Nonetheless; the firms that are subject to the constraint in (3) are compelled to absorb the cost of any change in the price of purchased power during the interim between hearings.

The first-order conditions for profit maximization subject to the constraint in (3) imply that

$$(1 - \lambda)R_q - (1 - \lambda)fF_q = \lambda\delta_2$$

and

$$(1 - \lambda)R_z - p = -\lambda\delta_2$$

where λ is the shadow price attached to the constraint (3). From these conditions, we find immediately that

$$(1 - \lambda)f/(1/F_q) = p.$$

Since $0 \leqq \lambda < 1$,[11] it follows that

$$f/(1/F_q) > p$$

where the left-hand side is the marginal cost of generating power in the firm's own plants. Thus, profit maximization leads the firm to generate power beyond the point where marginal cost is equal to the price of purchased power. This result indicates that excluding purchased power from the adjustment clause formula leads the firm to overutilize its own generating equipment. For a given quantity of total power supplied, costs will not be minimized.

III. An Empirical Test

To carry out an empirical test of the above hypothesis, we need to specify a model that explains the firms' relative use of purchased power. Ideally, this would be done by solving the firm's first-order conditions for the derived demands for purchased power under the two alternative regulatory regimes considered. This direct approach, however, is prohibited by data limitations. Specifically, the data that are available on purchased power do not separate what are called "economy energy interchanges" from "emergency interchanged." The former are power exchanges that are carried out to the reduce costs of supplying electricity while the latter are due to unforeseen demand surges or equipment failures that lead to temporarily insufficient generating capacity. Our theoretical results apply only to the first of these, but the data reflect both. Consequently, our empirical model must, of necessity, include some factors that do not appear in the optimization problems presented above.

The variables that were selected for inclusion and the corresponding data sources are described in Table 1. The dependent variable is the firm's relative use of purchased power, z/q (where the numerator of this variable is positive for net purchases and negative for net sales). The first independent variable is the purchased power adjustment clause dummy, PPAC. This variable assumes the value of 1 if the firm is subject to a purchased power adjustment clause. The theoretical model presented in the preceding section implies that the coefficient associated with PPAC will be positive.

Next, we include the firm's total assets in service as a measure of firm size. Firm size influences the values of some of the partial derivatives entering the first-order conditions obtained in the model of the preceding section under either regulatory regime. Further, the theoretical work of Tschirhart (1980) indicates that larger firms are more likely to become members of closely coordinated power pools (with central dispatch) which, in turn, results in a lower effective price of purchased power to these firms. Due to both of these considerations, we expect the coefficient of SIZE to be positive.

The final independent variable is a measure of the firm's demand variability, $\bar{q}$/PEAK. Our expectation is that this variable will account

TABLE 1

Variables in the Equation

Variable	Definition	Source
z/q	Relative use of purchased power. Equals the quantity of purchased power in 1000's of KWH (positive for net purchases and negative for net sales) divided by total net generation of the firm in 1,000,000's of KWH.	[1]
PPAC	Dummy variable equal to 1 if the firm has an automatic purchased power adjustment clause and equal to zero otherwise.	[2]
SIZE	Dollar value of the firm's assets in service (in $1,000,000). Used as a measure of firm size.	[1]
$\bar{q}$/PEAK	Total net generation (in 1,000,000's of KWH) divided by peak hourly demand (in megawatts) times 8760, the number of hours in a year. Used as a measure of demand variability (average quantity demanded/peak quantity demanded) to account for emergency interchanges.	[3]

Sources: [1] U.S. Department of Energy (1978a).

[2] National Association of Regulatory Utility Commissioners (1978).

[3] U.S. Department of Energy (1978b).

for the "emergency interchange" component of the dependent variable, and should have a positive coefficient.

The initial specification of our empirical model, then, is

$$z/q = \beta_1 + \beta_2(\mathrm{PPAC}) + \beta_3(\mathrm{SIZE}) + \beta_4(\bar{q}/\mathrm{PEAK}) + \mu \ , \qquad (4)$$

where μ is a random disturbance. The theoretical considerations described above imply β_2 β_3, $\beta_4 > 0$.

This specification involves q on both sides of the equation. To eliminate the potential for spurious correlation presented by this specification, we multiply both sides of equation (4) by q. Doing so and adding an intercept term, we obtain our estimating equation:

$$z = \beta_0 + \beta_1(q) + \beta_2(\mathrm{PPAC})(q) + \beta_3(\mathrm{SIZE})(q) + \beta_4(\bar{q}/\mathrm{PEAK})(q) + \mu/(q). \qquad (5)$$

Obviously, the disturbance term of this equation is heteroscedastic. Consequently, we employed weighted least squares with $1/\sqrt{q}$ as weights to estimate the model parameters.[12]

In order to carry out this estimation, we collected data on 113 privately-owned electric utilities in the U.S. for the year 1977. All firms in the sample were subject to an automatic fuel adjustment clause while 82 of the firms were also subject to a purchased power adjustment clause. The sources from which these data are drawn are reported in Table 1.

Applying weighted least squares to equation (5) we obtain the following results:

$$\begin{aligned}\hat{z} = \underset{(3.047)}{47{,}710.344\ \mathrm{E}+02} - \underset{(2.590)}{11{,}112.972\ \mathrm{E}+01}(q) + \underset{(2.183)}{29{,}029.066}(\mathrm{PPAC})(q) \\ + \underset{(4.675)}{19.562}(\mathrm{SIZE})(q) + \underset{(0.443)}{23{,}042.967}(\bar{q}/\mathrm{PEAK})(q)\end{aligned}$$

$R^2 = 0.171$

$n = 113$

where t-statistics are reported in parentheses below their respective coefficient estimates.[13] Several interesting results are evident here.

First, and most important, the results tend to support (at the .05 level of confidence) our conclusion that the absence of a purchased power adjustment clause discourages the firm from using externally produced power. Thus, it appears that current fuel adjustment clauses that exclude purchased power are very likely to lead to an overutilization of the firm's own generating equipment and, thereby, to excessive cost of providing power. As with any other empirical result, this finding must be qualified by the standard caveats that apply to the data, the model specification, and the estimation technique. Here, one of the more important potential sources of bias stems from the possible endogeneity of the purchased power adjustment clause dummy, PPAC. It would seem plausible that utilities that typically purchase relatively large amounts of external power have a greater interest in and, perhaps, greater success in securing purchased power adjustment clauses. If so, β_2 would be biased in the positive direction, increasing the likelihood of a Type I error. Prior research, however, indicates that the firms in this industry had rather limited influence over the regulatory decision to award automatic fuel adjustment clauses in the early 1970s. In fact, Kaserman, Kavanaugh, and Tepel (1983) found that the larger firms in the industry were actually <u>less</u> likely to be successful in obtaining such clauses. They attribute this result to the larger number of customers (voters) served by these firms. If this result carries over to purchased power adjustment clauses as well, the coefficient on PPAC would be biased downward, increasing the likelihood of a Type II error. Since resolution of this issue would require the specification and estimation of a fully simultaneous model, we can only indicate the resulting qualifications here.

Next, we find strong empirical support for the view that larger firms make relatively greater use of power pools. Since participation in a power pool necessitates the commitment of certain fixed costs (e.g., construction of transmission lines between pool members), the ability of larger firms to spread these costs over a greater volume of power interchanges reduces the per unit costs of pooling to these firms [see Tschirhart (1980)].

Finally, the coefficient estimate for the variable $(\bar{q}/PEAK)(q)$ is not statistically significant at any standard level of acceptance, although the sign is as we hypothesized. The insignificance of the $(\bar{q}/PEAK)(q)$ coefficient may be explained by the offsetting effects that increased demand variability may have on the employment of purchased power. The firm experiencing relatively large fluctuations in demand will have an incentive to either purchase power (to meet supply short falls) or sell power (to utilize idle capacity), depending upon its current reserve position. Since purchases may be offset by sales across the firms in our sample, the insignificance of this coefficient could be attributable to our measurement of purchased power on a net basis.

IV. Conclusion

In this paper, we have shown that excluding purchased power from an automatic fuel adjustment clause encourages the regulated firm to overutilize its own generating equipment. In addition, we have provided some empirical support for this result. This finding provides a partial explanation for the perceived reluctance of electric utility companies to expand the coordination of their power generating facilities. It also serves to warn designers of future adjustment formulas about the undesirable consequences of treating power obtained from alternative sources unequally.

FOOTNOTES

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1. See Atkinson and Halvorsen (1980), Baron and DeBondt (1970), Cowing and Stevenson (1979), Gollop and Karlson (1978), Kaserman and Tepel (1982), and Isaac (1982).

2. The study by Gollop and Karlson (1978) is an exception. They create an index that varies directly with the value of the adjustment clause formula to the firm.

3. Fuel adjustment clauses were in effect in 43 states in 1976. See Isaac (1982, p. 159).

4. Existing formulas differ primarily with regard to: (1) the percent of the fuel cost change that is passed through; (2) the length of delay between the cost change and the corresponding rate change; (3) the criteria for measuring fuel cost changes (fuel cost per unit of final output or fuel cost per unit of fuel input in combination with a target heat rate); and (4) inclusion or exclusion of purchased power. See National Association of Regulatory Utility Commissioners (1978).

5. See Kendrick (1975) and Baron and DeBondt (1980).

6. Breyer and MacAvoy (1974, p. 108) view the lack of greater coordination as something of an anomaly. Tschirhart (1980) and Cramer and Tschirhart (1983) explain the existing looseness of pooling agreements in terms of the benefits and costs to the individual utility of increased participation. Evidence presented by Christensen and Greene (1978), however, indicates that the potential cost saving may not be as great as was previously believed.

7. An interesting issue concerns the possible endogeneity of the price of purchased power. If utility companies must engage in costly search activities to obtain the minimum price for externally produced power, then allowing automatic pass through of purchased power costs may encourage the payment of higher prices for this power. We have not resolved this issue empirically, but prior research by Kaserman and Tepel (1982) suggests that this is not a problem. Specifically, their research indicates that the presence or absence of an automatic fuel adjustment clause did not appear to affect fuel price search behavior of the firms in their sample. Thus, to the extent that this result applies to purchased power adjustment clauses, p may be viewed as exogenous. This result may not carry over to the price of purchased power, however, because the markets for fuel are thicker and involve longer term contracts. This makes it easier for the regulators to assess the reasonableness of the prices paid for fuel. The hour-to-hour

economy interchange transactions are much more difficult for the regulators to monitor. Thus, this remains an open empirical question.

8. In effect, these constraints allow the firm's tariff schedule to adjust automatically between rate hearings in response to changes in certain specified cost items. This is done by holding average revenue net of these specified costs equal to a fixed amount (given by δ_1). The essential element of this constraint for our purpose here is that the cost of purchased power is incorporated in the calculation of net revenue.

9. The constraint in (2) differs from the traditional rate-of- return constraint in three respects. (1) it excludes non-fuel variable costs from the numerator (e.g., labor costs); (2) it employs total sales instead of the quantity of the firm's invested capital in the denominator; and (3) it is continuously applied.

10. With the exception of Gollop and Karlson (1978), all of the studies cited in footnote 1 employ an analogous representation of the constraint provided by automatic fuel adjustment clauses.

11. Since $(1 - \lambda)R_z - p = -\lambda\delta_2$, it follows that

$$\lambda = \frac{p - R_z}{\delta_2 - R_z}$$

Therefore, assuming $\delta_2 - R_z > 0$, $\lambda < 1$ if $p < \delta_2$. Also, since $\lambda = \partial\pi/\partial\delta_2$, it is clear that $\lambda \geqq 0$, where the equality holds for $z < 0$.

12. The OLS results are virtually identical with regard to both the signs and significance of the parameter estimates (with a slight reduction in t-values). These results are available from the authors upon request.

13. An additional equation was estimated including the firm's allowed rate of return on equity, ROR, as an independent variable. The rationale for including ROR is due to the theoretical work of Tschirhart (1980). This work implies that firms with higher allowed rates of return will be more inclined to participate in power pools. The coefficient of this variable was insignificant and the remainder of the empirical results were unaffected by its inclusion. This insignificance is probably due to the fact that most utilities were not earning their allowed rate of return in 1977. Consequently, this finding supports our earlier assumption that the rate-of-return constraint was not binding during this period.

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