http://clevelandfed.org/research/review/
Best available copy

The Effect of Regulation on Ohio Electric Utilities

by Philip Israilevich
and K.J. Kowalewski

Philip Israilevich is an economist at the Federal Reserve Bank of Chicago. K.J. Kowalewski is an economist at the Federal Reserve Bank of Cleveland. This article was completed while Mr. Israilevich was an economist at the Federal Reserve Bank of Cleveland.

Introduction

During the pioneering days of the electric utility industry, it was believed that utilities were natural monopolies, meaning that one utility could service a geographic area more cheaply than any combination of smaller utilities. More recently, the economic viability of transferring or wheeling electricity over long distances, the development of small-scale generators and efficient windmill and solar power, and the increased use of cogeneration have undermined the view of electric utilities as natural monopolies. Nevertheless, electric utilities continue to be monopolies because regulatory agencies, such as the Public Utilities Commission of Ohio (PUCO), give them exclusive rights to produce and distribute electricity in designated markets.

These regulatory agencies also attempt to impose profit ceilings on electric utilities in order to push the price and consumption of electricity away from monopolistic levels and toward competitive levels. This is accomplished by regulating the rate of return on capital of electric utilities. The regulator determines a "fair" rate of return that is sufficient to allow a utility to cover its capital costs. With production costs and the demand for electricity, this "fair" rate determines the price of electricity.

The impact of this type of regulation on the production decisions of regulated utilities was first described by Averch and Johnson (1962). They argued that this regulation gives utilities the incentive to overcapitalize, that is, to employ a capital-labor ratio that is larger than one that minimizes costs for a given output level.[1] Thus, utilities operating under this constraint are not producing electricity as cheaply as they could. Virtually all empirical tests of regulatory bias to date have adopted the Averch and Johnson (A-J) model, and most have found an overcapitalization bias.[2]

The major challenge to the A-J model concerns the nature of the regulatory environment. Implicit in the A-J model is a regulator that constantly monitors capital returns and adjusts electricity prices to keep capital returns at "fair" levels. Joskow (1974) argues that regulators are more concerned with nominal electricity prices than with the rate of return on capital. As long as nominal electricity prices do not increase, regulators will not actively enforce the rate-of-return constraint, thereby eliminating the source of the A-J bias. Moreover, utilities face additional constraints, such as fuel-cost-adjustment clauses, environmental regulations, strict rules about what capital is allowed in the rate base, and the requirement to meet all demand at given electricity prices. When these additional constraints are taken into account, the net impact on a utility's production decisions is not clear.

Atkinson and Halvorsen (1984) developed a generalized cost model that allows for the impact of additional regulatory constraints and found empirical evidence of their impact on

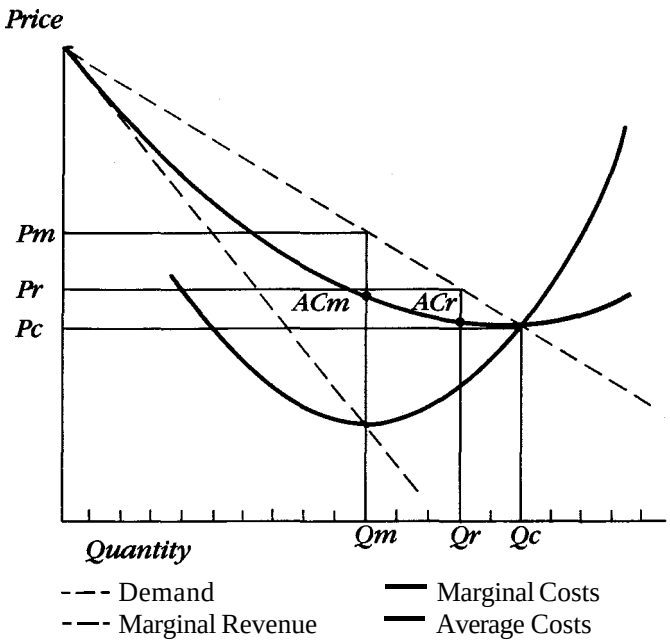
1 This interpretation of the A-J result is attributed to Baumol and Klevorick (1970).

2 Courville (1974), Spann (1974), Petersen (1975), Cowing (1978), and Nelson and Wohar (1983), for example, test only for an overcapitalization bias against an alternative hypothesis of no bias. Of these papers, only Nelson and Wohar do not find an overcapitalization bias.

http://clevelandfed.org/research/review/
Best available copy

utility production decisions. However, no one has formally tested the implications of Joskow's view. The purpose of this paper is to fill this gap by estimating a modified version of Atkinson and Halvorsen's model. The modifications are of two sorts. The first allows for different regulatory impacts over time as argued by Joskow. The second permits the use of panel data and the estimation of total factor productivity and its components to evaluate more accurately the impact of regulation on the technical change implemented by utilities.

The Short-Run Effect of Regulation on Utility Prices



SOURCE: Authors.

FIGURE 1

The data are a panel sample of the seven major electric utilities in Ohio over the period 1965 to 1982.[3] Ohio utility data were used because of general interest to most residents of the Fourth Federal Reserve District. Also, because these utilities are all privately owned, coal-burning plants that are subject to the same regulator, their technologies should be fairly similar. Thus, the estimation of a common cost structure for these utilities should yield a smaller potential for specification bias than is true of all previous studies of electric utilities, whose samples include utilities that employ varying technologies and/or face different regulators.

We find considerable circumstantial evidence consistent with Joskow's more general regulatory mechanism. However, the estimation results suggest that the impact of regulation in Ohio does not completely square with Joskow's expectation. In opposition to Joskow's view, we find that these utilities produce electricity with their prevailing technologies more efficiently during the years when Joskow expects regulatory constraints to be more binding. In Joskow's favor, we find that regulation retards the rate of technical change implemented by these utilities to a greater extent during the years when Joskow expects tighter regulatory constraints. To our knowledge, this is the first paper to explicitly estimate a regulatory impact on technical change in the electric utility industry.[4] Moreover, this type of inefficiency is surprisingly large in magnitude. Thus, the emphasis regulators and economists place on efficient production using a given capital stock appears to be misplaced; the retardation of technical change implemented by these utilities appears to be an important source of bias.

The first part of this paper reviews the regulatory process and contrasts the A-J and Joskow views. Next, the rate hearing experience in Ohio during the 1965 to 1982 period is discussed and is found to correspond quite well with Joskow's view of the regulatory mechanism. The third section describes the empirical results.

I. The Regulatory Process

It is useful to view the regulatory process in two parts: 1) the ***mechanics*** of setting a utility's electricity price structure, and 2) the ***events*** that initiate a rate hearing or a review of a utility's electricity price structure. There is little disagreement among economists about the first part. Simply put, a regulatory agency such as PUCO attempts to maintain a competitive price for electricity by regulating the rate of return on a utility's capital. It establishes a "fair" rate of return (r), taking into account all of a utility's production costs and the demand for its electricity, that is consistent with a "fair" level of profit and that is slightly higher than the utility's cost of capital. The "fair" return or profit on capital is then

$$\pi_r = Br,$$

where B is the rate base or the book value of the utility's net capital stock. The basis for a rate change and, hence, a change in the price of electricity, is the difference between this "fair" return on capital and the utility's accounting return on

3 The seven major electric utilities in Ohio are Ohio Power; Cincinnati Gas and Electric; Cleveland Electric Illuminating; Columbus and Southern Ohio Electric; Dayton Power and Light; Ohio Edison; and Toledo Edison. Over the 1965 to 1982 period, they accounted for about 90 percent of electric power sales in Ohio.

4 Nelson and Wohar (1983) estimated the impact of a rate-of-return constraint on *TFP* and calculated its impact on technical change as a residual. Israilevich and Kowalewski (1987) argue that this residual is an incorrect estimate of the regulatory impact on technical change.

http://clevelandfed.org/research/review/
Best available copy

capital (π), which is the difference between the utility's operating revenues (R) and its operating costs (OC):[5]

$$\pi = R - OC.$$

Electricity prices are set by the regulator to equate π with π_r on the date of the hearing. If π is less than π_r, electricity prices are raised, while if π is greater than π_r, electricity prices are decreased.

This mechanism is shown in figure 1, assuming there is only one utility serving the market for electricity. If there were no regulation, the utility would maximize profits (or minimize costs) by equating marginal revenues with marginal costs, producing quantity Q_m and charging a price P_m. Its profits would be $Q_m(P_m - AC_m)$. If the utility was acting like a perfectly competitive firm, it would maximize profits (and minimize social costs) by equating the market price, P_c, to its marginal costs and to its average costs and would produce the quantity Q_c. In this case, its profits would be zero. Note, however, that at both P_m and P_c, production is efficient in the sense that input-factor marginal products are equated to their market prices. A regulator picks some price P_r that is less than P_m but greater than P_c, giving the utility a "fair" profit of $Q_r(P_r - AC_r)$ to cover capital costs. At this point, production is inefficient.

This is a general description of the price-adjustment mechanism of an electric utility regulator. What brings a utility to a rate hearing and what motivates a regulator are questions debated by economists. The predominant answers to these questions were influenced by Averch and Johnson. They investigated the optimal response of a cost-minimizing utility in static equilibrium to a "fair" rate of return on capital regulatory constraint. They showed that when the rate of return on capital constraint is binding, and when the "fair" rate of return is larger than the cost of capital, a utility has the incentive to overcapitalize; that is, to employ a capital-labor ratio that is larger than the one that minimizes costs for the chosen output level.[6] This is called the *A-J* bias.

Implicit in the A-J model is the assumption that the motivating factor behind regulatory action is the rate of return on capital. In the A-J model, the constraint on a utility's profit-maximization actions is that the actual rate of return on capital earned by a utility is no greater than the "fair" rate. Another assumption is that an active regulator continually monitors utility returns and pounds on a utility with a "visible hand" to maintain the equality of a utility's profits with its "fair" profits. When a utility's profits are less than its "fair" level of profits, the regulator calls a rate hearing to raise r and, hence, the utility's price of electricity. When a utility's profits are above the "fair" level, the regulator calls a rate hearing to lower rand the price of electricity.

With minor amendments, this view of regulatory behavior predominates in the economics literature, especially in empirical studies of electric utility behavior, with the exception of Joskow (1974).[7] Joskow agrees that rate-of-return regulation will give a utility the incentive to employ an inefficient mix of input factors, but he argues that the A-J bias may not always occur. In Joskow's view, regulators are political institutions whose objective is to minimize "conflict and criticism," not to keep the rate of return on capital equal to the "fair" rate.

One important source of conflict and criticism is an increase in the nominal price of electricity. Consumers will agitate against increases in electricity prices because they typically view these increases as price-gouging. If electricity prices are not increasing, and especially if they are falling, consumers are indifferent to the profits earned by a utility. Thus, Joskow argues that if utilities are able to adjust their production and investment decisions to raise their earned rates of return without raising electricity prices, they will not be thwarted by the regulator. In this case, there may be little A-J bias. On the other hand, Joskow argues that regulators do not initiate any actions to raise the rate of return on a utility's capital when it is below the "fair" rate unless requested to do so by the utility. Before a rate increase is granted, the utility will earn a return on capital below the "fair" return. In this case, an A-J bias may appear.

Thus, in contrast to the active A-J regulator, the Joskow regulator is passive, adjusting the rate of return on a utility's capital only when requested to do so by a utility or by a consumer advocate. As time passes, earned profits may deviate from "fair" profits if input prices, electricity demand, and other factors change, but the regulator does not initiate a price change to re-equate earned profits with "fair" profits until the next rate hearing. In the meantime, a utility can alter its production and investment decisions in ways opposite to those predicted by the A-J model. The "fair" rate of return is a means to an end (uncontroversial electricity prices), not an end in itself, in Joskow's view. After reviewing the regulatory experience across the U.S. between the 1950s and early 1970s, Joskow concludes that:

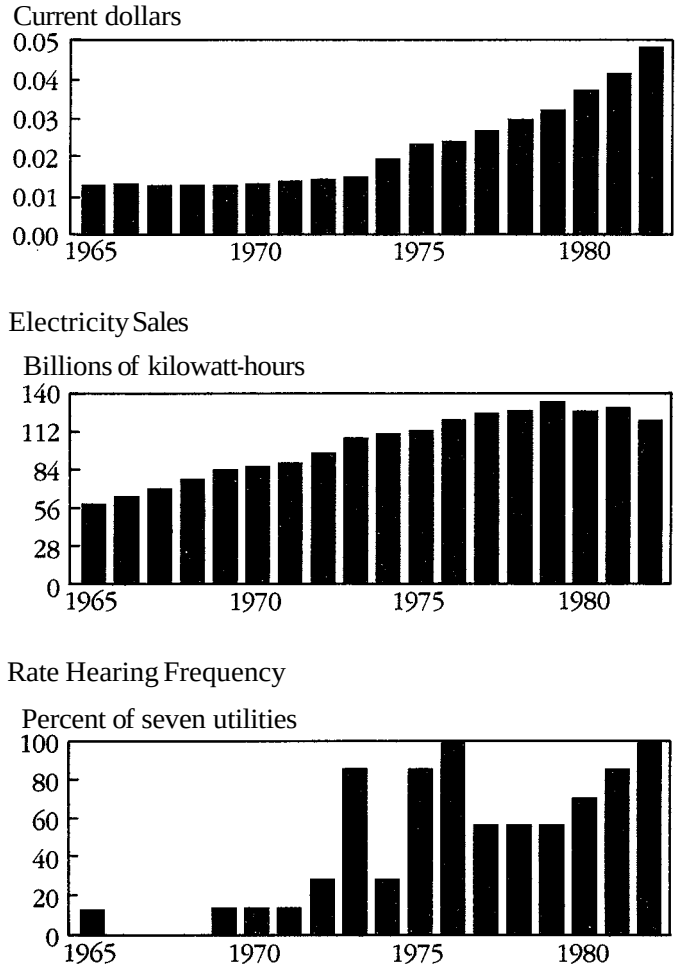
Contrary to the popular view, it ***does not*** ap-

5 Operating costs include all noncapital costs of production.

6 Actually, Baumol and Klevorick (1970) argue that Averch and Johnson did not prove this as a general result. Note that if there are additional production factors, then the amount of capital relative to these other inputs also will be higher than for the cost-minimizing firm.

7 A slight modification to the A-J regulatory process was the introduction of a "regulatory lag"; see, for example, Bailey and Coleman (1971) and Baumol and Klevorick (1970).

http://clevelandfed.org/research/review/
Best available copy



SOURCE: Public Utilities Commission of Ohio and Standard and Poor's Cornpustat Services, Inc., **Utility** *Compustat II.*

FIGURE 2

pear that regulatory agencies have been concerned with regulating rates of return per se. The primary concern of regulatory commissions has been to keep ***nominal prices from increasing.*** Firms which ***can*** increase their earned rates of return without raising prices or by lowering prices (depending on changing cost and demand characteristics) have been permitted to earn virtually any rate of return that they can. ***Formal regulatoy action in the form of rate of return review is primarily triggered by firms attempting to raise the level of their rates or to make major changes in the structure of their rates.*** The rate of return is then used to establish a new set of ceiling prices which the firm must live with until another regulatory hearing is triggered. General price ***reductions*** do not trigger regulatory review, but are routinely approved without formal rate of return review.

This regulatory process is therefore extremely passive. Regulators take no action regarding prices unless major increases or structural changes are ***initiated*** by the firms under its jurisdiction. In short, it is the firms themselves which trigger a regulatory rate of return review. There is no "allowed" rate of return that regulatory commissions are continually monitoring and at some specified point enforcing. (p. 298)

Because they work in a political environment, public utility commissions face other sources of conflict and criticism, which have resulted in two additional constraints on utility behavior. First, when energy costs increased rapidly in the mid-1970s, utilities requested rate hearings in greater numbers than in the past. This increased caseload put a large burden on regulatory agencies, who were accustomed to only a few hearings per year. The time lag between the request for a rate hearing and a change in electricity prices increased, and many utilities were forced to request another rate hearing immediately after their previous hearing. In order to shorten this lag and to appease utilities, regulators instituted fuel-cost-adjustment clauses that permitted utilities to pass on higher fuel costs to consumers without the need for a formal rate hearing.

Second, the fossil-fuel generators operating before the mid-1970s emitted a considerable amount of pollution into the atmosphere. Successful agitation by environmental advocates forced public utility commissions to establish limits on the amount of pollution that utilities could emit. These additional constraints complicate the analysis of the impact of a rate-of-return constraint on utility behavior.

II. Rate Hearings and Average Costs of Ohio Utilities: 1965 to 1982

Some evidence consistent with Joskow's view of the regulatory mechanism is found in the history of rate hearings in Ohio between 1965 and 1982. To put this evidence into perspective, first consider the behavior of the average price per kilowatt-hour of electricity charged, and the quantity of kilowatt-hours sold, by the seven major Ohio electric utilities (figure 2).

For the purposes of this discussion, three distinct periods of different electricity price and consumption behavior can be seen: 1965 to 1968, 1969 to 1975, and 1976 to 1982.[8] Within

[8] Note that the average price shown in figure 2 is not the regulated price, but the ratio of average total revenue for the seven utilities to their average total sales. In general, different consumers face different regulated price schedules, and utilities serving different geographic markets may be allowed to charge different prices for the same category of consumer.

http://clevelandfed.org/research/review/
Best available copy

each period, the directions of change in price and quantity were the same for each utility in the sample. During the 1965 to 1968 period, the average price of electricity changed very little and electricity sales rose considerably. During the 1969 to 1975 period, the average annual growth rate of electricity sales slowed, while that of prices increased greatly. Between 1976 and 1982, the electricity sales declined for the first time in Ohio's history, while prices increased at their fastest average annual percentage rate.

It is important to note that the average price shown in figure 2 is also the average cost of electricity. All regulators, including the PUCO, define the price of capital to be π divided by B, hence equating operating revenues with operating costs. The neoclassical economist's measure of average cost uses a market price of capital and, hence, the neoclassical measure of average costs can differ from the PUCO's definition. Bemdt and Fuss (1986) argue that a capital price measure such as that used by the PUCO is more appropriate because it is a rental price or user cost of capital and because it controls for changes in capacity utilization. For these reasons, and because it is the measure the PUCO uses and to which utilities respond, the rental price of capital is employed in this paper.

Figure 2 also shows the percentage of the seven utilities requesting rate hearings in each year. In the first period, utilities rarely requested rate hearings, and their average costs were falling. This behavior corresponds with Joskow's first proposition: "During periods of falling average cost we expect to observe virtually no regulatory rate of return reviews" (p. 299). The average price of electricity was also falling during this period, consistent with Joskow's second proposition: "During periods of falling average costs we expect to observe constant or falling prices charged by regulated firms" (p. 299). Given that there were few rate hearings in this period, it is plausible that utility returns on capital were greater than or equal to the "fair" returns the PUCO would have defined had they been requested to do so.[9] According to Joskow, if actual returns were lower than the "fair" return, then the utilities would have asked for price increases. Hence Joskow's third proposition: "During periods of falling average costs we expect to observe rising or constant (profit maximizing) rates of return" (p. 299).

During the 1969 to 1975 period, average costs increased slightly, triggering a modest increase in the frequency of hearings, while during the 1976 to 1982 period, average costs increased tremendously. Production costs increased in the late 1960s because of inflation stimulated by economic policies; they increased very quickly and unexpectedly in the mid-1970s because of inflation engendered by worldwide food shortages and by the Arab oil embargo. For a given electricity price, such increases in operating costs drove utility profits below their "fair" levels. Utilities promptly responded to these cost increases by requesting electricity price increases that, in most cases, were granted by the PUCO. The frequency of hearings increased sharply as utilities had trouble keeping up with the effects of the rapid rise in costs. Viewing the 1969 to 1975 period as a transition from a period of falling average costs to one of rising average costs, the modest increase in rate hearings during this period is consistent with Joskow's fifth proposition:

> The transition from a period of falling average costs to one of rising average costs for a particular regulated industry will at first yield no observable increase in the number of rate of return reviews filed by the regulatory agency, but as cost increases continue more and more rate of return reviews are triggered as firms seek price increases to keep their earned rates of return at least at the level that they expect the commission will allow in a formal regulatory hearing. (p. 300)

For estimation purposes, the 1965 to 1982 interval was divided into two periods: 1965 to 1973 and 1974 to 1982. Testable hypotheses of the A-J and Joskow views deal with the absolute and relative production inefficiencies of the utilities in these two periods. The near absence of regulatory hearings in the first period would suggest, to both Joskow and A-J, that earned rates of return of these utilities were at least as great as "fair" rates of return. Averch and Johnson would argue that earned rates of return were lower than monopoly rates of return and, hence, that the A-J bias should exist in the first period. On the other hand, Joskow would argue that earned rates of return may have been close to monopoly rates. If this were true, then because monopoly rates are consistent with efficient production, there may have been very little A-J bias in the first period. Indeed, as Joskow argues in his seventh proposition, production may have been very efficient in the first period because reducing costs would have contributed to higher earned rates of return that were not taken away by regulators:

> During periods of falling or constant nominal average costs firms have an incentive to produce efficiently since all profits may be kept as long as prices stay below the level established by the regulatory commission in the last formal rate of return review. (p. 303)

9 It can never be known whether earned returns were greater than "fair" returns because there were no rate hearings for all firms during these years.

http://clevelandfed.org/research/review/
Best available copy

The high frequency of hearings in the 1974 to 1982 period suggests that earned rates of return for these utilities were lower than "fair" rates of return for most of the period; that is, $\pi < \pi_r$. Because these earned rates were even further away from monopolistic rates of return, Joskow would argue that it is more likely there are inefficiencies of the A-J type in the second period. His proposition eight says: "During periods of rising average costs A-J type biases may begin to become important" (p. 304). He does not exclude the possibility that firms may continue to try to be as efficient as they were in the first period in order to earn greater than "fair" rates of return. However, he argues:

> Unless the direction of the cost path can be changed, however, the continuous interaction of firms and regulators in formal regulatory hearings, resulting from the necessity to raise output prices, is exactly the situation for which the A-J type model (with some modifications) would hold. I would therefore expect that it is under this situation of continuously rising output prices, triggering rate of return reviews that the A-J type models and the associated results are most useful. (p. 304)

Thus, Joskow would argue that utilities would try to organize their production more efficiently in the first period than in the second period. His concept of production efficiency includes the static notion of employing currently available production inputs in the least-cost way for any given level of output (that is, employing the least-cost combination of inputs along a given isoquant) and the dynamic notion of investing in more productive capital over time (that is, investing in productive capital to push the family of isoquants toward the origin). Averch and Johnson deal only with the static notion of productive inefficiency because their model analyzes a static equilibrium. They would argue that the amounts of this static inefficiency are the same in both periods because they assume a regulator who maintains the earned rate of return on capital at its "fair" rate.

The distinction between the static and dynamic notions of production efficiency is important. When a public utility commission conducts a rate hearing, it pays attention only to the static notion of production efficiency. Indeed, most models of regulatory impact deal only with the static notion. However, it is conceivable that regulation also affects the rate of technical change implemented by utilities; if regulation biases the amount of capital employed by a utility, it may also bias the type of capital employed. Regulatory impacts on overall inefficiency and on the rate of technical change are estimated below.

III. Empirical Evidence About the A-J and Joskow Views

The A-J and Joskow views are examined using a modified version of the Atkinson and Halvorsen (1984) generalized long-run cost-function approach with capital (K), labor (L), and fuel (F) as inputs.[10] Atkinson and Halvorsen argued that the long-run neoclassical cost-function approach is incorrect for a regulated firm because it assumes the firm is minimizing costs in a perfectly competitive world constrained only to produce a given level of output.[11] When a firm is subject to a number of regulatory constraints, as is generally true today, firms view all input prices differently from their market or rental prices. The exact specification of these nonmarket or "shadow" prices depends on the exact form of the additional constraints. Atkinson and Halvorsen approximated these shadow prices by simple proportional relationships with market prices; that is, the shadow price of input i: $P_i^* = k_i P_i$, where P_i is its market price and k_i is a constant. Thus, the generalized cost function is simply the neoclassical cost function with P_i^* substituted for P_i. Instead of minimizing long-run actual costs, a utility is assumed to minimize long-run *shadow* costs by equating the *shadow* marginal cost of each input with the amount of the input used.

The modifications made to the Atkinson and Halvorsen approach are 1) the inclusion of time variables to accommodate panel data and to permit the estimation of total factor productivity (*TFP*) and its returns to scale and pure technical change components, and 2) the distinction between the 1965 to 1973 and 1974 to 1982 time periods.

TFP is measured as the change in the cost of production not due to changes in input prices, and reflects the overall productivity of all inputs rather than the productivity of a single input such as labor. The neoclassical approach to the measurement of TFP assumes an optimal distribution of production resources in a firm, which is an inappropriate assumption for regulated electric utilities. The generalized-cost-function approach yields an estimate of TFP that is consistent with regulated behavior. The most important variable for examining Joskow's view on productivity behavior is the pure technical change component of TFP Gollop and Roberts (1981), among others, argue that this component is a better measure of productivity than TFP

10 See Israilevich and Kowalewski (1987) for complete details about the data, the specification and estimation of the shadow-cost model, and the results.

11 Nevertheless, some authors, for example Gollop and Roberts (1981, 1983), use the neoclassical approach to study electric

http://clevelandfed.org/research/review/
Best available copy

The distinction between the two periods is made by estimating separate coefficients for them. This allows the production decisions, as well as the degree of regulatory constraint, to differ between the two periods.[12]

The k_i coefficients measure the degree to which the neoclassical first-order conditions are not satisfied and, hence, serve to test for production input biases. If all k_i equal one, then shadow prices equal market and rental prices, and regulation does not affect production decisions; actual, not shadow, long-run costs are minimized. If the k_i for all inputs except capital equal one, then there is only an overcapitalization bias. If any other k_i do not equal one, regardless of the k_i value for capital, then the A-J view is rejected.

The results of estimating the model over the 1965 to 1982 period show that both k_K and k_F are separately and jointly statistically different from one at better than a 5 percent significance level in both periods.[13] Thus, production efficiency is rejected, and the neoclassical cost-function approach for regulated firms employed by Gollop and Roberts (1981) and others is inappropriate for this sample. Moreover, these results reject the A-J view over the whole sample; regulation affects the efficient utilization of all production inputs by these utilities.

Another test of the A-J view, and a test of the implications of Joskow's view, is whether production inefficiencies resulting from regulation differ in the 1965 to 1973 and 1974 to 1982 periods. The A-J view is that the inefficiencies should be the same in each period, while the Joskow view is that there should be greater inefficiencies in the second period than in the first. Two approaches are taken here. In the first, the differences in k_K and k_F are examined. The A-J view is not rejected if the difference in k_K between the two periods is insignificantly different from zero and both k_F equal one. If the k_i suggest greater inefficiencies in the second period than in the first, then the Joskow view is not rejected.

The test results show that the A-J view is rejected at better than 0.5 percent, and the differences in the k_K and k_F coefficients between the two periods are significantly different from zero at better than 5 percent. However, the Joskow view is also rejected, because the differences in the k_K and k_F coefficients, second period minus the first, are significantly negative; to not reject Joskow, this difference should have been positive. Unfortunately, due to technical reasons related to the specification of the cost function, the sources of the differences in these coefficients cannot be identified.

The second approach examines estimates of the differences in total and dynamic inefficiency due to regulation between the two periods. The full cost of regulation and, hence, the magnitude of the inefficiencies created by regulation, cannot be estimated because there is no evidence to suggest how the utilities would have organized their production had regulation not existed over the sample period. Of course, it is impossible to know how these utilities would have behaved without regulatory constraints. For example, the activities of production and distribution might have been separated, different amounts of capital might have been employed, and different technologies might have been chosen.[14] Hence, it is impossible to know what these firms' cost functions and associated returns to scale and productivities would have been.

"Instantaneous" inefficiency estimates can be computed, however. A total inefficiency measure compares actual utility costs predicted by the estimated model with the actual costs predicted by the model, but with k_K and k_F set equal to one in both periods. That is, current production costs for actual levels of output, which are generated by current capital, labor, and fuel inputs; production techniques; and regulatory constraints, are compared with the costs generated with the same input levels and production techniques and for the same actual output levels, but without the regulatory constraints. This estimate, also examined by Atkinson and Halvorsen, measures the shift in the cost curve due to regulation.

An estimate of the dynamic notion of inefficiency can be obtained by examining the technical change experienced by these utilities with and without regulation. Technical change is defined here as the negative of the derivative of total costs with respect to time, holding all other factors constant. It is a function of a constant term, shadow input prices, output (returns to scale), and time, and it shifts the position of a firm's average cost curve over time. As above, technical change with regulation is that implied by the estimated model; technical change without regulation is that implied by the estimated model, but with k_F and k_K set equal to one. The difference does not have a real-world coun-

12 A test of similar production behavior in the two periods was convincingly rejected.

13 For technical reasons, only two of the three k_i can be estimated. The k_i coefficient on the price of labor is normalized to one, and only k_K and k_F, for capital and fuel, respectively, are estimated.

14 Under the current regulatory environment, the production and distribution of electricity must be handled by each utility. Moreover, the transferal of electric power across state lines is also impeded.

http://clevelandfed.org/research/review/
Best available copy

terpart or explanation, but it does indicate the direction of regulatory bias.

These inefficiency estimates provide mixed evidence about Joskow's view. The difference in the total inefficiency measure between the two periods is the opposite of Joskow's expectation. Instead of greater total inefficiency in the second period, when Joskow expects regulatory constraints to be binding, our estimates show greater total inefficiency in the first period, when Joskow expects regulatory constraints to be less binding. In the first period, the total inefficiency varies between 26 percent and 49 percent and averages 36 percent. In the second period, it varies between 16 percent and 19 percent and averages 17 percent. This difference in total inefficiency squares with the differences in k_K and k_F between the two periods described earlier.

An interesting feature of these total inefficiency estimates is their large magnitude in the first period. Atkinson and Halvorsen find much smaller inefficiency losses (9.0 percent) in their cross-section sample, which includes two of our firms.[15] However, the Atkinson and Halvorsen result captures only the static portion of total inefficiency costs because the authors do not use time variables in their cost equation. Our estimates include the dynamic inefficiency costs and, hence, are more representative of the total costs of regulation.

The difference between the Atkinson and Halvorsen result and ours suggests that the dynamic inefficiency may be quite large. Indeed, we find that regulation retarded the growth of technical change, on average, by 0.3 percentage point per year in the first period and by 0.4 percentage point per year in the second. This is an important result, and one that has been neglected by economists and regulators alike. Regulation not only affects the efficient utilization of existing production inputs, but it also affects the implementation of efficient capital and management techniques over time. Unlike our total inefficiency estimates, our dynamic inefficiency estimates support Joskow's view.

The behavior of technical change over time also confirms Joskow's view. Table 1 shows the technical-change estimates over the whole period, averaged over all firms for each year. As Joskow argues, the rate of technical change is lower in the second period, when he expects regulatory constraints to be more binding.

The most notable characteristic about these technical-change estimates is their strong downward trend.[16] Starting at 0.3 percent in 1965, the annual average rate of technical change drops steadily each year to -4.6 percent in 1982. This rather uniform decline, except around 1973 and 1974, when period one ends and period two begins, is due to dominant estimated time trends in each period. That shadow input prices have little influence on technical change is not surprising, because electricity production offers little opportunity for input substitution in the short and medium runs. The time trend captures the effects of pure technical change embodied in the capital investments of these utilities and may be additional evidence in favor of Joskow's seventh proposition. Although this is not conclusive proof of Joskow's seventh proposition, because we do not know the nature of the capital investments made in these and earlier periods, it at least does not contradict it.

Estimated Technical Change

Year	Technical change in percentage points, average over firms
1965	0.3
1966	-0.1
1967	-0.3
1968	-0.6
1969	-1.0
1970	-1.2
1971	-1.4
1972	-1.7
1973	-2.0
1974	-3.4
1975	-3.6
1976	-3.6
1977	-3.8
1978	-3.8
1979	-4.0
1980	-4.2
1981	-4.4
1982	-4.6
Average over year	
1965-1973	-0.9
1974-1982	-3.9

SOURCE: Authors.

TABLE 1

15 It is likely that our estimates are more accurate for Ohio because our sample includes only Ohio firms, which are fairly similar in a number of important respects, as mentioned earlier.

16 A strong downward trend in the rates of technical change experienced by utilities also was found by Nelson and Wohar (1983), Gollop and Roberts (1981), and Gollop and Jorgenson (1980), all of whom used samples that ended in the 1970s. Thus, the results reported here confirm these earlier findings for the late 1970s and early 1980s.

http://clevelandfed.org/research/review/
Best available copy

IV. Summary and Conclusions

Electric utility regulators attempt to maintain a competitive price for electricity by adjusting the rate of return on a utility's capital. At first blush, this price-setting scheme appears sensible. It seems reasonably efficient to allow utilities to pass along operating costs and cover their cost of capital. However, potentially serious problems with this type of regulation relate to consumer reactions to price increases and to the types of incentives given to utilities. First, price increases may lower the consumption of electricity, which may reduce earned rates of return below "fair" rates and trigger a price increase, which in turn may lower consumption and trigger another price increase, and so on. That is, the proper response to falling utility profits because of lower demand may not be to raise prices.

Second, utilities may be able to effect price increases by overcapitalizing, which inflates their rate base. Indeed, rate increases lower the risk of capital investment below the risk level of unregulated industries, clearly giving utilities the incentive to overcapitalize. This potential bias was recognized by Averch and Johnson, and many empirical studies that adopted their model found an overcapitalization bias.

Finally, the ability to pass along operating cost increases that originated from productivity declines suggests that utilities may not have the incentive to raise productivity. This dynamic source of inefficiency was recognized by Joskow, who also argued that the regulatory mechanism is more complicated than that assumed by Averch and Johnson.

This paper is, to our knowledge, the first to test the A-J view against Joskow's more general view. Using a modified version of the generalized long-run cost function derived by Atkinson and Halvorsen (1984) and a sample of the seven major electric utilities in Ohio over the 1965 to 1982 period, substantial evidence is found against the A-J view. However, the evidence is not wholly in agreement with Joskow's view, either. The circumstantial rate hearing evidence is consistent with Joskow's view of the regulatory mechanism, but our estimation results do not wholly confirm the implications Joskow draws fi-om his regulatory mechanism. Two sets of results imply that regulatory constraints were more binding during the years in which Joskow expects them to be less binding. Nevertheless, in accordance with Joskow's view, we find that regulation substantially retards the rate of technical change experienced by these utilities, and the retardation is greater when Joskow expects regulation to be more binding. This is the first demonstration of a regulatory impact on technical change. It clearly suggests that regulators ought to pay closer attention to the incentives they give utilities to innovate.[17]

A reconciliation of these findings is difficult. They may suggest that the circumstantial rate hearing evidence is not closely correlated with the degree of regulatory constraint. Utilities may have been constrained in the 1965 to 1973 period by the possibility or fear of a rate hearing that would eliminate the above "fair" returns they were currently earning. Another possibility is that frequent rate hearings in the 1974 to 1982 period prevented utilities from artificially fattening their rate bases. That is, given the incentive to overcapitalize, utilities were prevented from taking advantage of the regulatory system by frequent and accurate regulatory review. In this case, the price of electricity may have remained close to competitive levels, where production, though different fi-om monopolistic levels, nonetheless is efficient. The poor technical-change performance between 1974 and 1982 may be the primary cause of the greater rate-hearing frequency, and not the reverse.

Or Joskow may be correct, and utilities were simply lax about maintaining efficient production in the first period, or they anticipated future regulatory constraints and took actions to fatten their rate bases while they had the opportunity.[18] Clearly, there is much to learn about the impact of regulation on utility performance.

17 The poor technical-change performance also may be due to increased investment in nuclear power plants. Many of these plants were cancelled after the mid-1970s, but they diverted managerial attention and funds away from conventional power-generation capital investments.

18 Joskow can also be defended by arguing that our inefficiency measures are incorrect. As was mentioned earlier, it can never be known how utilities would have behaved without regulation. Without this knowledge, any inefficiency measure can be faulted. Nevertheless, the estimated change in k_F and k_K between the two periods is hard evidence against Joskow's view.

http://clevelandfed.org/research/review/
Best available copy

REFERENCES

Atkinson, Scott E., and Robert Halvorsen. "Parametric Efficiency Tests, Economies of Scale, and Input Demand in U.S. Electric Power Generation," *International Economic Review,* vol. 25, no. 3 (October 1984), pp. 647-62.

Averch, Harvey, and Leland L. Johnson. "Behavior of the Firm under Regulatory Constraint," *American Economic Review,* vol. 52, no. 5 (December 1962), pp. 1052-69.

Bailey, Elizabeth E., and Roger D. Coleman. "The Effect of Iagged Regulation in an Averch-Johnson Model," *The Bell Journal of Economics and Management Science,* vol. 2, no. 1 (Spring 1971), pp. 278-92.

Baumol, William J., and Alvin K. Klevorick. "Input Choices and Rate-of-Return Regulation: An Overview of the Discussion," *The Bell Journal of Economics and Management Science,* vol. 1, no. 2 (Autumn 1970), pp. 162-90.

Berndt, Ernst R., and Melvyn A. Fuss. "Productivity Measurement with Adjustments for Variations in Capacity Utilization and Other Forms of Temporary Equilibrium," *Journal of Econometrics,* vol. 33, no. 1 / 2 (October/November 1986), pp. 7-30.

Christensen, Laurits R., and Dale W. Jorgenson. "U.S. Real Product and Real Factor Input, 1929-1967," *The Review of Income and Wealth,* series 16, no. 1 (March 1970), pp. 19-50.

Courville, Leon. "Regulation and Efficiency in the Electric Utility Industry," *The Bell Journal of Economics and Management Science,* vol. 5, no. 1 (Spring 1974), pp. 53-74.

Cowing, Thomas G. "The Effectiveness of Rate-of-Return Regulation: An Empirical Test Using Profit Functions," in M. Fuss and D. McFadden, Eds., *Production Economics: A Dual Approach to Theoy and Application,* Amsterdam: North Holland Publishing Company, 1978.

Fare, Rolf, and James Logan. "Shephard's Lemma and Rate of Return Regulation," *Economics Letters,* vol. 12 (1983), pp. 121-25.

Gollop, Frank M., and Dale W. Jorgenson. "U.S. Productivity Growth by Industry, 1947-1973," in J.W. Kendrick and B.N. Vaccara, Eds., *Studies in Income and Wealth,* National Bureau of Economic Research, Chicago: University of Chicago Press, 1980.

Gollop, Frank M., and Mark J. Roberts. "Environmental Regulations and Productivity Growth: The Case of Fossil-Fueled Electric Power Generation," *Journal of Political Economy,* vol. 91, no. 4 (August 1983), pp. 654-74.

_____. "The Sources of Economic Growth in the U.S. Electric Power Industry," in T.C. Cowing and R.E. Stevenson, Eds., *Productivity Measurement in Regulated Industries,* New York: Academic Press, 1981.

Israilevich, Philip, and K. J. Kowalewski. "A Test of Two Views of the Regulatory Mechanism: Averch-Johnson and Joskow," Federal Reserve Bank of Cleveland, *Working Paper* (forthcoming).

Joskow, Paul L. "Inflation and Environmental Concern: Structural Change in the Process of Public Utility Price Regulation," *The Journal of Law and Economics,* vol. 17 (October 1974), pp. 291-327.

Nelson, Randy A., and Mark E. Wohar. "Regulation, Scale Economies, and Productivity in Steam-Electric Generation," *International Economic Review,* vol. 24, no. 1 (February 1983), pp. 57-79.

Petersen, H. Craig. "An Empirical Test of Regulatory Effects," *The Bell Journal of Economics and Management Science,* vol. 6, no. 1 (Spring 1975), pp. 111-26.

Spann, R.M. "Rate of Return Regulation and Efficiency in Production: An Empirical Test of the Averch-Johnson Thesis," *The Bell Journal of Economics and Management Science,* vol. 5, no. 1 (Spring 1974), pp. 38-52.