REGULATORY OPPORTUNISM AND INVESTMENT BEHAVIOR: EVIDENCE FROM THE U.S. ELECTRIC UTILITY INDUSTRY*

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Abstract

The traditionally large and sunk nature of utility investments gives rise to the possibility, if not the likelihood, of opportunistic behavior on the part of either regulators or regulated firms. In this paper, we develop a theoretical model to provide insights into this possibility, then employ a novel and comprehensive data set to test for the existence and empirical importance of opportunistic behavior in the electric utility industry. Our empirical analysis focuses on the investment consequences of $19 billion in cost disallowances that were levied on electric utilities in the 1980s. The econometric investigation finds evidence of regulatory opportunism for nuclear technology, but not for other technologies. An owner/operator of a nuclear plant under construction scaled back annual investment by $121 million after regulators disallowed other firms in the same state. However, spillover effects were minor for firms building non-nuclear generating units and for firms that owned a share in a nuclear plant under construction but did not plan to operate it. Overall, we find the reduced investment of the late 1980s was due primarily to the existence of excess capacity and a shift away from capital-intensive nuclear technology. Spillover effects from regulatory disallowances may have actually led to a net increase in investment, due to the positive effects on firms building non-nuclear generating units.

I. INTRODUCTION

Regulated public utilities in the United States alone spend over $75 billion per year on new plant and equipment, much of which cannot readily be shifted to alternative uses. This enormous investment in specialized assets has traditionally been supported by a regulatory system in which “prudently incurred” investments by the regulated monopolist were rewarded with “fair” returns. From a contractual perspective, however, the highly incomplete nature of the regulatory framework means that opportunistic behavior---e.g., inappropriate investment practices by the firm or abuse of pricing discretion by the regulator---has always been a nagging possibility.[1]

The potential for regulatory opportunism is an especially serious concern during the transition to competition occurring throughout the world in electricity, natural gas, and telecommunications. Incumbent monopolists fear regulators will appropriate the as-yet-unrecovered portion of their historical investments, sometimes referred to as “stranded costs.”[2] The stakes are certainly high: in the U.S. electricity industry alone, stranded costs are estimated in the neighborhood of $200 billion. Quasi-rents

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[1] The parallels between regulation and private contracts as institutions for supporting specific investments have been noted by many scholars. The modern analysis of regulation as a form of contract originates with Goldberg (1976) and has been elaborated by Williamson (1985). There is an enormous literature examining the myriad ways regulated firms can take advantage of the regulatory system, including the overinvestment problem emphasized in the Averch-Johnson-style literature, as surveyed by Kaserman and Mayo (1995), as well as the managerial slack and information distortion problems emphasized in the more recent principal-agent literature, ably summarized by Laffont and Tirole (1993). The literature on the abuse of administrative discretion is smaller and relatively recent, and is both summarized and advanced by Levy and Spiller (1996).

[2] Such concerns have also been raised by authors such as Baumol, Joskow and Kahn (1994) and Sidak and Spulber (1997).

of this magnitude are clearly a tempting target for regulators anxious to deliver visible benefits to consumers. Appropriating these quasi-rents, however, has the potential to undermine incentives for future investment in the portions of these industries that remain regulated, though the magnitude of any such "reputational spillovers" remains an open question.

In this paper, we investigate the importance of opportunistic behavior and reputational spillovers during another important recent episode in the U.S. electric utility industry that raised the same set of concerns. In the mid-1980s, public utility commissions disallowed the recovery of roughly $19 billion in electric power plant investments that would otherwise have become part of the utilities' rate bases. In response, industry members and some industry observers alleged that the implicit "regulatory contract" between regulators and regulated firms was violated, with regulators opportunistically reneging on their end of the deal after it was seen---with 20-20 hindsight---that fundamental demand and supply conditions had shifted. As a result of the abrogation of the regulatory contract, so the argument goes, utilities would become reticent, if not openly resistant, to further investment activities and the result would be large-scale supply shortages.[3]

Some support for this industry perspective may be inferred from a small theoretical literature including papers by Lyon (1991), Gal-Or and Spiro (1992), and Gilbert and Newbery (1994). Although each of these papers adopts a somewhat different modelling process, all of them may be construed as suggesting that a sudden conversion by regulators to the use of hindsight reviews will

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[3] Joskow (1989, p. 161) noted that as a consequence of power plant disallowances "[f]ew utilities appear willing to build large base-load facilities, even in areas where additional capacity is needed." For similar comments, see also Navarro (1985), Kahn (1985), Kalt, Lee, and Leonard (1987), Pierce (1991), and Kolbe and Tye (1991).

reduce the investment propensities of regulated firms.[4] Perhaps more importantly, however, this literature shows that the ability to disallow excessive costs can help regulators achieve more efficient levels of investment, e.g. by curbing the incentives for overinvestment that would otherwise be present. Thus, large disallowances *per se* are not evidence that the regulatory contract has broken down. In fact, some industry observers have argued that the emergence of large-scale power plant disallowances was not an abrogation by regulators of the regulatory contract, but rather a reflection of regulators fulfilling their obligations when confronted by some electric utilities that "misbehaved." From this perspective, managers of some specific electric power companies exercised particularly poor judgment in the development of their investment plans with the result that billions of dollars of excessive costs were incurred in investment activities to bring power plants online in the 1980s.[5] Whether the disallowances of the 1980s represent regulatory opportunism or punishment of utility excesses is ultimately an empirical question.

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[4] Teisberg (1993) shows that when firms are uncertain about future regulatory behavior, hindsight review could in principle *increase* utility investment in the short run if firms rush to complete building programs before regulators become even harsher. We present a simple model incorporating uncertainty about regulatory behavior in section II.

[5] See Blank and Pomerance (1992) for an argument along these lines. In addition, Zimmerman (1988) argues that recent regulatory treatment of cancelled nuclear power plants has been similar to that afforded manufactured natural gas plants that were abandoned in the 1950s, with regulators typically allowing recovery of but not a return on the investment, and with amortization typically occurring over a 10-year period. This suggests at least the possibility that incumbent electric utilities would have already accounted for the potential of partial cost disallowances, and that, accordingly, the realization of such disallowances in the 1980s would have no effect on realized investment propensities.

We are aware of two previous empirical papers that study the determinants of regulatory cost disallowances. While both agree that cost overruns have been an important factor in disallowance decisions, they disagree on the importance of political variables to these decisions. Dismukes (1995) studies a set of 87 nuclear plants completed between 1971 and 1988, 23 of which experienced regulatory disallowances. He estimates a logit model that predicts the probability that a given plant will be disallowed. Disallowances were more likely for larger plants, plants with more severe cost overruns or schedule delays, and plants that had to comply with a larger number of new Nuclear Regulatory Commission construction guidelines during construction. Dismukes finds that the majority political orientation of the state Public Utility Commission (Democrat vs. Republican) did not have a significant effect on disallowance decisions. Ryan (1993), in an approach complementary to that of Dismukes, studies a set of 26 nuclear power plants that experienced disallowances during the 1983-1988 period. She finds that the percentage of costs disallowed was higher for plants that had more significant cost overruns. In addition, she finds that political variables matter. Utilities with a higher share of sales going to industrial customers suffered larger disallowances, suggesting that these customers wield considerable influence with regulators. Furthermore, disallowances were more extensive in states that restrict regulatory commissioners' ability to find employment with a utility after they leave public office. Taken together, these papers suggest that the decision to disallow is based on a utility's performance in managing the construction of its new plants, but that once regulators decide to disallow full recovery, political variables have some effect on the extent of the disallowance.

In this paper, we take an approach quite different from previous empirical papers on disallowances. We focus on the investment behavior of electric utilities and how it changed in the wake of regulatory cost disallowances. This approach has three advantages. First, it allows us to assess empirically the predictions of several recent theoretical models of investment under regulation. Second, it provides a check on previous empirical work by offering an alternative way to estimate the extent of regulatory opportunism. Third, and perhaps most important, it allows us to evaluate the practical importance of regulatory opportunism by identifying the extent to which utility investment has been undermined by regulatory decision-making.

While the extant theoretical literature provides some guidance for structuring our empirical model, its usefulness is limited because it neglects some important features of the regulated environment. For example, it does not allow for firm heterogeneity, i.e. it does not distinguish between firms that are engaged in efficient investment activities and those that are over-investing. Moreover, the literature does not incorporate the fact that regulators typically deal with multiple firms that may have different expectations regarding future demand growth or the likelihood of *ex post* cost disallowances. Nor does it allow for different regulatory treatment of these different types of firms. Thus, while these models provide considerable insight into the potential effects of a shift in regulatory policy, they do not provide enough structure for assessing when or whether, in fact, such a shift has occurred.

In this paper, we present a simple model of regulator-firm interaction that allows for firm heterogeneity. In particular, we allow for multiple regulated firms that have potentially different expectations regarding the prospects that regulators will punish the firm through *ex post* cost disallowances should the firm's base capacity deviate substantially from realized demand levels. Firms may also differ in their expectations of future demand levels. Additionally, we allow firms to update their beliefs about regulator type through observations of regulatory decisions that apply to other regulated firms. The results point toward an empirical model that is capable of distinguishing between the "violation of the regulatory contract" proposition that has been advanced by the industry and the "bad managerial judgment" proposition that has been alternatively suggested.

Building on our simple theoretical framework, we construct an empirical model of electric utility investment decisions for the 1970-1991 period.[6] Using a new and unique panel dataset involving 156 electric utilities, we first examine the general investment tendencies of these firms; then we turn to a regression-based model of utility investment. The results indicate that a utility that suffers a regulatory cost disallowance does indeed subsequently reduce its propensity to invest. Whether other utilities in the same state also show a statistically significant change in their investment behavior depends on the type of generating units they have under construction. In particular, non-nuclear firms did not alter their investment behavior in response to adverse regulatory actions taken against other regulated firms in the same jurisdiction. Additionally, we find no reduced investment propensity on the part of other same-state firms who owned shares in nuclear power plants under construction but who did not have responsibility for operating those plants. Only in one type of situation do we find that regulatory cost disallowances had any "reputational spillover" on other utilities operating in the same regulatory jurisdiction. Specifically, utilities that were to serve as operators of nuclear power plants reacted negatively when other utilities within the same state were subjected to a cost disallowance. Overall, we find that while utilities that faced cost disallowances reduced their investment propensities, other same-

[6] Peck (1974) presents a pioneering estimation of the investment function for electric utilities, but for a much earlier time period with fewer demand and cost shocks, less dramatic regulatory action, and more rapid plant construction. As a result of the different economic environment during our sample period, Peck's methodology is not directly appropriate for our purposes.

jurisdiction utilities revealed a slightly increased propensity to invest as a consequence of regulatory cost disallowances. The isolated nature of the spillover effects is a striking result, and suggests that even opportunistic disallowances of "stranded" generating costs may not have big effects on future investment in transmission and distribution facilities.

The paper is organized as follows. In Section II, we provide a conceptual framework for our analysis by first identifying the nature of regulatory cost disallowances and the extant theoretical research regarding those disallowances. Next, we construct a simple model of utility investment decisions that permits the regulated utility to chose between investment and purchased power in a regulatory environment where investment costs may be disallowed. Several potentially important determinants of electric utility investment arise from this model. Then, in Section III, we turn to an empirical analysis of electric utility investment decisions for the 1970-1991 period. Using panel data involving 156 electric utilities, we first examine the general investment tendencies of these firms; then we turn to a regression-based model of utility investment. Section III also reports the results of our empirical analysis. Finally, Section IV concludes the paper.

II. CONCEPTUAL FRAMEWORK

A. The Structure of the Regulatory Process. The traditional regulatory process determines utility revenues in a series of three steps. First, regulators determine what operating costs are to be recovered in rates.[7] Most operating costs are passed directly into rates, though some categories such as advertising or purchases from affiliated subsidiaries may receive special treatment. Second, the

[7] These include such items as wages, salaries, fuel costs, maintenance, advertising, research, depreciation and taxes.

capital stock or “rate base” (non-depreciated value of tangible and intangible property) is ascertained. The rate base includes only investments that are “prudently incurred” and that are “used and useful” in providing a particular utility’s services. Third, the allowed rate-of-return on capital is determined. This rate must be commensurate with that earned by unregulated entities of comparable risk, and must preserve the utility’s access to capital markets. The net revenue requirement is then the sum of operating costs plus the product of the rate base times the allowed rate of return.[8]

The cost disallowances discussed in the preceding section have typically been part of the second step mentioned above, the determination of the utility’s rate base. From 1980 through 1991, roughly $19 billion was disallowed from various utilities’ rate bases. The bulk of these disallowances were for management imprudence, but major disallowances have also been made on the basis of excess capacity (which is not used and useful), and of economic value (in retrospect, alternative sources of power would have been cheaper). It is worth noting that an investment can be “prudent” *ex ante* (based on the information held by managers at the time the investment was made) but not “used and useful” or of maximum “economic value” *ex post* (given the economic circumstances when the project is completed). Regulators clearly have discretion over the criteria to which they will hold a given investment, giving a vivid example of the incompleteness of the so-called “regulatory contract.”

In practice, it is the application of the retrospective criteria which has been most controversial. Both the used and useful test and the economic value test have been examined in the theoretical literature on regulation. The analyses of these rules generally start from the observation that overinvestment would tend to occur if the regulator were required to provide the firm a fair rate of

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8 For a more detailed discussion of rate-of-return regulation in theory and practice, see Kaserman and Mayo (1995).

return on all investment, regardless of its value in use. Gal-Or and Spiro (1992) consider a static setting with two utilities facing uncertain demands, each of which can sell power to the other if it has a capacity surplus. While the use of rate-of-return (ROR) regulation gives incentives to overinvest, each firm also has an incentive to free-ride on the other's costly capacity. On balance, the ROR effects dominate the free-riding effects, and without the threat of disallowances, the firms overinvest. Used and useful requirements help reduce, but cannot in general eliminate, the propensity of regulated firms to invest excessively.

The “economic value” criterion has been modeled by Lyon (1991), who presents a static model where the regulator allows the firm to recover no more than the lowest “avoided cost” for an alternative plant, as judged *ex post* with perfect hindsight. The firm chooses between a “safe” project with known costs, or a “risky” project with uncertain costs; demand is known with certainty. Without the possibility of disallowances, the firm may have incentives to overinvest in the risky project. When the firm anticipates the application of the economic value criterion, it shifts to smaller, less risky projects. As long as the expected cost of the risky project is no less than that of the safe project, underinvestment does not occur.[9]

Gilbert and Newbery (1994) examine “used and useful rate-of-return regulation” (UUROR) in a repeated game where demand moves randomly over time. An equilibrium with efficient investment requires that the regulator develop a reputation for allowing a high rate of return when all capacity is used and useful, in order to compensate for the low rate of return earned in demand states where not all

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[9] Lyon (1995) shows that if the risky project has lower expected costs than the safe project---as might be expected for process innovations---then underinvestment may occur.

capacity is used and useful. If alternative sources of power are cheap, however, the regulator may have incentives to severely disallow excess capacity, despite the fact that such an action induces the utility to retaliate by underinvesting in all subsequent periods. The model thus predicts that an "opportunistic" disallowance will be followed by underinvestment, but an "efficient" disallowance will not.

All three of the above models provide efficiency rationales for the use of *ex post* disallowance criteria. From an empirical perspective, the static models of Gal-Or and Spiro (1992) and Lyon (1991) indicate that a shift in regulatory regime that suddenly allows the use of cost disallowances would be associated with reduced investment by utilities. The dynamic model of Gilbert and Newbery (1994) allows for a more precise distinction between efficient and opportunistic disallowances, though its implications must be adjusted to account for the possibility of overinvestment and for the presence of multiple, heterogeneous, firms under the jurisdiction of a single regulator. We discuss the implications of these additional factors below.

<u>B. A Simple Structural Model</u>. To structure our analysis, we develop a simple long-run model of utility investment decisions that captures the basic elements of disallowance policy discussed above. The utility can invest in generation capacity and/or it can purchase power from third-party generators.[10] Investments deemed allowable by the regulator are placed in the firm's rate base, on which the utility is

[10] We abstract from the complex reality that utilities can also engage in advertising (see Kaserman and Mayo (1985)) or invest directly in conservation (see Marino and Sicilian (1987)), both of which can lower demand and hence reduce the need for investment in generation plant. Data on conservation investments are available from the Energy Information Administration for 1989 and subsequent years, but they do not extend to the earlier periods covered by our dataset.

allowed to earn a return; fuel costs and purchased power, on the other hand, are expenses that are passed through directly into customer rates. At the time investments are made, the utility faces two uncertainties: 1) it is uncertain about future demand, and 2) it is uncertain about future regulatory policy. In particular, it is not sure whether the regulator will adopt a lenient policy of allowing all investment into the rate base, or a tough policy of allowing only investment that is used and useful into the rate base.[11]

We assume perfectly inelastic demand, so that excess capacity is defined unambiguously. We also assume that non-utility power must by law be purchased by the utility, and that the utility has a legal obligation to meet all demand at regulated rates.[12] In states of the world where demand exceeds the utility's own capacity plus its contracted-for levels of non-utility power, the firm can purchase power from other utilities at a per-unit price t. However, since we assume the cost of purchased power is passed through directly into customer rates, this cost does not appear directly in the expressions for expected profits presented below.

We use the following notation:

K = Initial generation capacity

* = Rate at which capital depreciates

I = Investment in new capacity

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[11] Clearly this is a highly simplified account of the actions available to regulators, but it captures in a simple and transparent fashion the regulatory uncertainty faced by utilities. We could add realism to the model by allowing utilities to have heterogeneous expectations about future demand and future construction costs, and allowing the regulator to use a variety of criteria for disallowance, but little additional insight would be gained.

[12] For further discussion of the legal requirements surrounding non-utility power purchases, see footnote 20 and the accompanying text.

x_0 = Initial demand

$x \in [\underline{x}, \bar{x}]$ = Future demand, a random variable

F(x) = Cumulative distribution on x, with corresponding density f(x)

N = Supply of non-utility power, which the utility is required to take

r = Rental cost of capital

s = Allowed rate of return

D = The probability, as assessed by the firm, that the regulator is lenient and allows all investment into the rate base

We begin by examining two polar cases, one where the firm is certain that the regulator is lenient, and the second where the firm is certain that the regulator is tough. In the first of these, the *unrestricted rate base* case, the regulator is assumed to allow full cost recovery on investment so long as $I \leq \bar{x} - (1-\delta)K - N$, i.e. there exists a non-zero probability of the investment being fully utilized; in this case profits are $\pi = (s-r)[(1-\delta)K + I]$. Assuming $s \geq r$, the firm invests to the point where capacity is adequate to meet the maximum possible level of demand, that is, $I^{RB} = \bar{x} - (1-\delta)K - N$.

Our second case depicts *used and useful* regulation, wherein the regulator allows a return on investment only for capacity needed to meet the demand realized *ex post*, that is, for $I \leq x - (1-\delta)K - N$. Any portion of investment beyond this bound is not allowed into the rate base. Now the firm's profits depend on the level of investment relative to observed demand:

$$\pi^{UU} = \begin{cases} s(x-N) - r[(1-\delta)K + I] & \text{if } I > x - N - (1-\delta)K \\ (s-r)[(1-\delta)K + I] & \text{if } I \leq x - N - (1-\delta)K \end{cases}$$

Expected profits are

$$\Pi^{UU} = \int_0^{(1-\delta)K+I+N} \left[s(x-N) - r[(1-\delta)K+I]\right] f(x)dx + \int_{(1-\delta)K+I+N}^{\bar{x}} (s-r)[(1-\delta)K+I]f(x)dx.$$

The firm’s first-order condition for investment is then

$$s\left[1 - F((1-\delta)K + I + N)\right] = r.$$

Thus, the firm invests up to the point where the return on another unit of capacity, multiplied by the probability that the additional unit will be needed, is just equal to the marginal cost of capacity. Letting $C = x_0/K$ represent current capacity utilization, we can rewrite the first-order condition as

$$F[x_0 + K(1-\delta-C) + N + I] = 1 - r/s.$$

With these polar cases fixed, we turn to the more general case where the firm places positive probability on both possible regulatory postures. Expected profits become

$$\begin{aligned}\Pi = {} & p(s-r)[(1-\delta)K+I] \\ & + (1-p)\left[\int_0^{(1-\delta)K+I+N} \left[s(x-N) - r[(1-\delta)K+I]\right] f(x)dx + \int_{(1-\delta)K+I+N}^{\bar{x}} (s-r)[(1-\delta)K+I]f(x)dx\right]\end{aligned}$$

The firm’s first-order condition for investment, which is illustrated in Figure 1, is then

$$F[x_0 + K(1-\delta-C) + N + I] = \left(1 - \frac{r}{s}\right)\left(\frac{1}{1-p}\right).$$

Now the firm invests up to the point where the return on another unit of capacity, multiplied by the probability that either the regulator is lenient or the additional unit will be needed, is just equal to the marginal cost of capacity.[13] Totally differentiating the first-order condition, it is easy to derive a number of comparative static hypotheses regarding investment. First, since $\partial I/\partial K = C - (1-\delta)$, investment can either increase or decrease with the size of the current capital stock, depending on whether capacity utilization is greater or less than the fraction of capital that does not depreciate in the next period. Second, since $\partial I/\partial C = K > 0$, investment increases with capacity utilization. Third, since $\partial I/\partial N = -1$, investment decreases with the supply of non-utility power. Fourth, since $\partial I/\partial r = -1/[s(1-p)F'(\cdot)] < 0$, investment decreases with the cost of capital. Finally, because $\partial I/\partial s = r/[s^2 F'(\cdot)(1-p)] > 0$, investment increases with the allowed rate of return. We record these observations as Hypothesis 1.

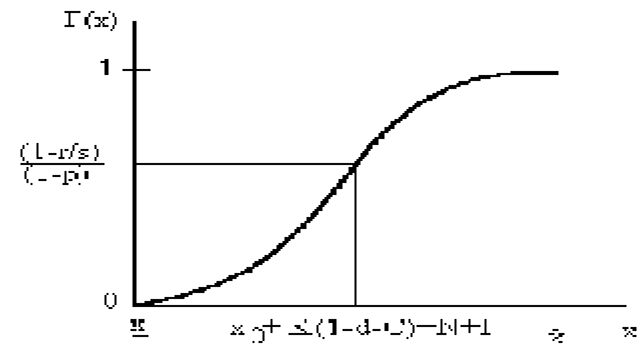

Figure 1: The Firm's Capacity Choice

[13] For simplicity, we abstract from the possibility that the rental cost of capital varies with investors' perceptions regarding the probability of regulatory leniency.

Hypothesis 1: Investment (a) increases with the existing capital stock iff capacity utilization is greater than the fraction of capital that remains undepreciated in the next period, (b) increases with capacity utilization, (c) decreases with the supply of non-utility power, (d) decreases with the cost of capital, (e) increases with the allowed rate of return.

While these basic economic hypotheses help us in structuring an empirical model, our focus lies beyond them: we want to test alternative hypotheses about the nature of the regulatory relationship. We are particularly interested in how firms update their beliefs about the regulatory environment in which they operate. Since $\partial I/\partial \rho = (s - r)/[sF'(\cdot)(1 - \rho)^2] > 0$, investment should increase with the firm's belief that the regulator is likely to allow an unrestricted rate base regime. The firm's beliefs, however, are unobservable. Instead of testing this prediction directly, we use our simple model to distinguish three hypotheses about the effects of regulation on investment, which we refer to as "regulatory opportunism," "bad luck," and "bad judgment."

The "regulatory opportunism" hypothesis reflects the oft-expressed view that the regulatory process went through a structural shift during the 1980s, the character of which was essentially a shift from the unrestricted rate base model to the used and useful model. In a sense, D went from one to zero (or at least decreased greatly) in states across the nation. The implication is that the representative firm's propensity to invest should have fallen over this time period. When a cost disallowance occurs in a given state, this opportunistic act signals a policy shift by that state's regulatory agency, and all firms in the state should reduce investment.[14]

The "bad luck" hypothesis holds that firms knew cost disallowances were a possibility in unfavorable states of the world, and made rational investments in the face of this possibility. The observation of a cost disallowance provides no new information. As a result, a cost disallowance has no impact on the investment propensity of either the firm that was disallowed or any other firm, once excess capacity and future demand growth are accounted for.

The "bad judgment" hypothesis holds that some firms perform better than others, and that good performers may react to regulatory actions in different ways than poor performers. In our model, we can think of firms as differing in their judgment about D. Consider two firms subject to the same regulator, the first of which believes $D = 0$ and the second of which believes $D = 1$. The former would embark on a less aggressive investment program than the latter. If a cost disallowance occurs, the first firm does not change its beliefs or its investment pattern, but the second firm scales back its investment. Combining the above possibilities, we record our second set of predictions.

Hypothesis 2: Cost disallowances may affect subsequent investment behavior in several different ways. (a) If disallowances reflect a regulatory regime shift, then all firms subject to the same state regulator should reduce investment proportionately after a disallowance in that state. (b)

[14] There may also be informational spillovers to firms in other states that are nearby, but the expected sign of the spillover effect is unclear. On one hand, firms in an adjacent state might decide that their neighboring state's tougher stance portends tougher regulation in their state as well, and therefore reduce investment. On the other hand, such firms might foresee no incipient regional trend in regulatory practice, and reason that reduced investment by their counterparts in the neighboring state creates new opportunities for other firms such as themselves to increase investment.

If disallowances reflect bad luck, e.g. unexpectedly low demand, then they should have no effect on any firm's subsequent propensity to invest. (c) If disallowances are imposed on firms that display bad managerial judgment, e.g. firms that overbuild, then these firms should reduce their propensity to invest after a disallowance, but other firms should show no change in investment propensity.

The above hypotheses regarding investment form the conceptual foundation from which we begin building an empirical model of electric utility investment in the next section.

III. The Empirical Determinants of Electric Utility Investment

In the previous section, we developed a stylized model of utility investment in the context of the incomplete regulatory contract. The theoretical model provides important guidance on the prospective determinants of utility firm investment, but the model is not capable of determining the relative importance of specific determinants. Moreover, the model is devoid of the institutional detail required of an empirical model of a major industry in which important public policy constraints have been modified over time. Accordingly, we now turn to the development of such a model that draws upon both the theoretical insights generated from the previous section and industry-specific institutional factors that are likely to have affected industry investment over the past twenty years.

A. Background and Data. Our empirical analysis covers the period from 1970-1991 and uses a unique new panel dataset. We focus on investment in the form of additions to electric utility plant for a sample of 132 electric utilities that operate in the 48 contiguous states.[15] These firms were selected by beginning with the entire set of 156 investor-owned electric utilities (IOUs) for which continuous investment data were reported in the U.S. Energy Information Administration's Financial Statistics of Selected Electric Utilities. We then eliminated 16 firms with no generating capacity (which we expect to have significantly different investment patterns from firms that engage in generation) and another 8 firms for which data appeared internally inconsistent. The remaining firms in our sample represent 89% of 1991 total sales to final customers by IOUs in the United States and 87% of IOU sales for resale. Figure 2 provides a graph of inflation-adjusted electric utility investment over time. Two features of Figure 2 stand out. First, the total dollar volume of electric utility investment in any given year is quite high. For example, in 1987, the sample firms invested roughly $23.8 billion, or an average of $152.7 million per firm. The extraordinary degree of capital intensity of the industry is further underscored by noting that the total dollar value of electric utility plant in place in 1987 was $475 billion while the value of electricity sales was $139 billion.[16] Second, it is easy to see in Figure 2 that the real dollar volume of electric utility investment peaked in the early 1980s and fell precipitously between 1985 and 1991

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[15] This variable covers all electric plant owned or purchased by the utility, including intangible plant, production plant, transmission plant, distribution plant and general plant. Note that it is *not* a measure of regulatory ratebase treatment of utility plant, but simply measures additions to utility plant as made by the utility company.

[16] See Financial Statistics of Selected Electric Utilities, Energy Information Administration, U.S. Department of Energy, 1987.

Figure 2: Real Investment by Electric Utilities, 1970-1991
All Firms

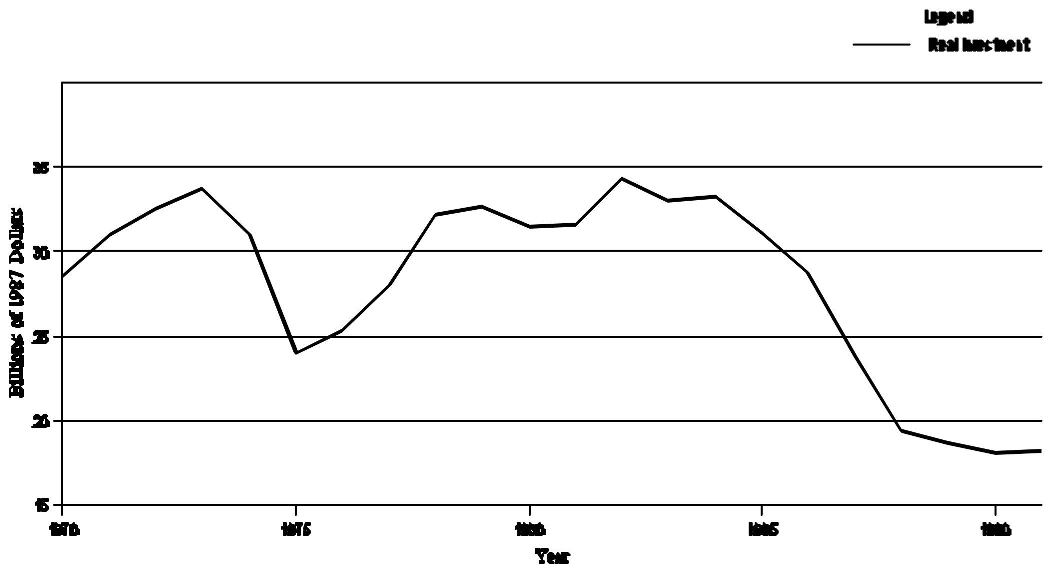
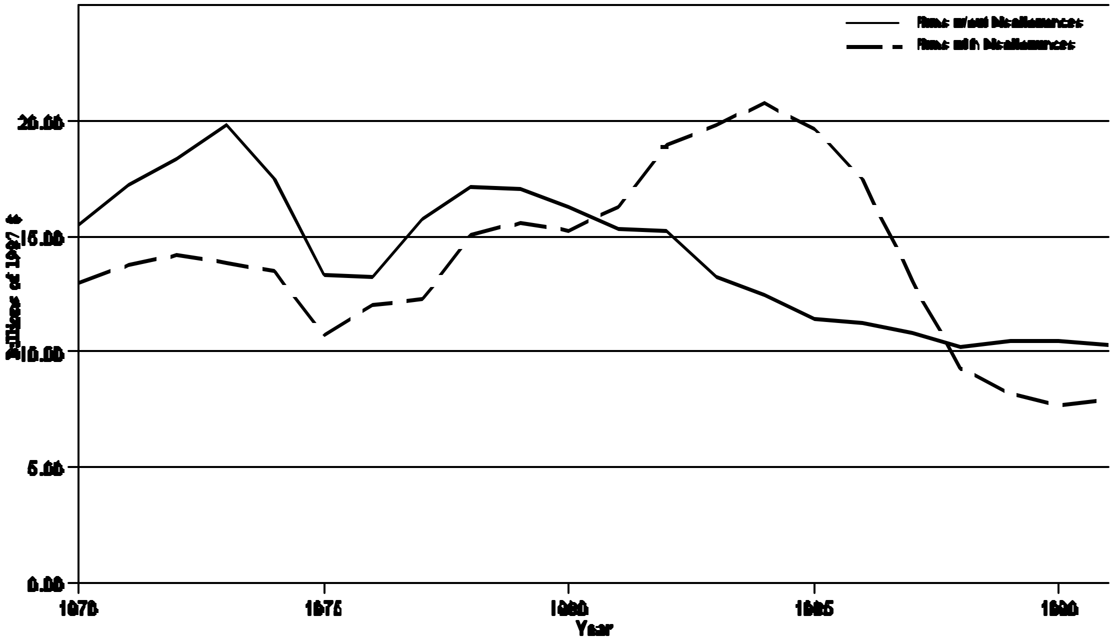


Figure 3 bifurcates the sample firms into those that incurred regulatory cost disallowances and those that did not. Again, the graph is quite revealing. Real investment by electric utilities that ultimately were not penalized with regulatory cost disallowances peaked in 1973 and declined more or less continuously throughout the subsequent period. In contrast, firms that ultimately suffered a cost disallowance are seen to have increased investment markedly from 1975 through 1984, after which investment spending declined sharply.

Figure 3: Real Investment by Electric Utilities, 1970-1991
By Firm Type



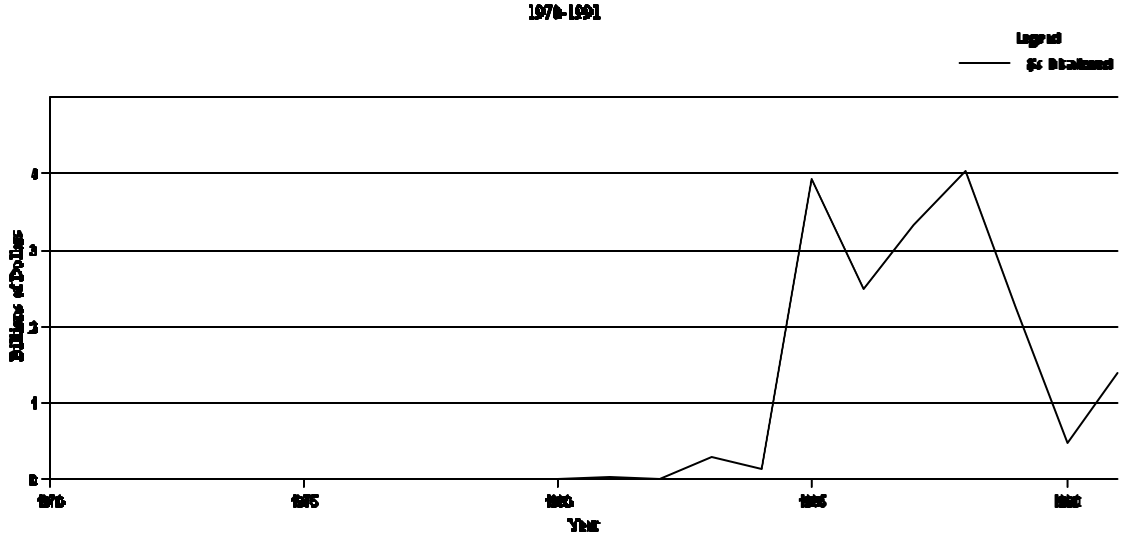
The potential for regulatory cost disallowances is as old as regulation itself.[17] Nevertheless, while some electric utility cost disallowances were observed over the years, it was not until the mid-1980s that significant dollar volumes of cost disallowances began to occur. Typical disallowances during the mid-1980s amounted to hundreds of millions of dollars and in two cases (the Nine Mile Point 2 unit in New York state and the Diablo Canyon plant in California) regulatory cost disallowances were $2 billion or greater. As noted in Section II, these disallowances have generally taken one of several forms. First, under the "prudent investment" rule construction costs deemed to be imprudent are not allowed to be recovered from ratepayers. Second, under the "used and useful" rule regulators have allowed the recovery of costs only for that part of the capital stock that is demonstrated to be used and

[17] See Kahn (1988) for a thorough historical discussion of the legal and economic issues surrounding regulatory cost disallowances.

useful. The costs associated with excess capacity, however, have not been permitted. Third, in the mid-1980s regulators began to apply a standard of "economic value" to determine whether investment costs incurred by electric utilities would be allowed into the companies' rate bases. Under the economic value standard, regulators have allowed the firm to recover no more than the lowest cost for an alternative plant, as judged with perfect hindsight.

Figure 4 provides the total dollar volume of regulatory cost disallowances for the sample firms from 1970-1991. There we see that virtually all regulatory cost disallowances occurred beginning in the mid-1980s. Cumulatively, over 50 separate disallowances on 37 different generating units were observed in the sample period, with a total dollar volume of disallowances

Figure 4: Dollar Volume of Regulatory Disallowances
1970-1991



of over $19 billion.[18] A complete list of disallowances on a generating unit basis is given in Table 1.[19]

Aside from regulatory cost disallowances, the major public policy change in the electric utility industry during the sample period stemmed from the passage of the Public Utilities Regulatory Policies

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[18] Our data on cost disallowances are drawn from four sources. Oak Ridge National Laboratory (1987) inventories all disallowances in the United States over the period 1980 - 1986, for nuclear, coal, and other types of plants. The study classifies the reason for each disallowance, drawing from five categories: imprudence, excess capacity, economic value, cost caps, or other. U.S. Department of Energy (1989) updates the data through 1988. LeBoeuf, Lamb, Leiby and MacRae (1991) provide an independent accounting of nuclear disallowances that extends from 1980 through 1990. Anderson (1991) gives another list of nuclear plant disallowances.

These four sources sometimes disagree on the dollar amount of disallowances, and in combining them we have generally placed more credence in data gathered more recently and reported in more detail. There are several potential reasons for disagreement about the dollar value of a particular disallowance. First, disallowance cases often drag on for a number of years, and earlier decisions may be altered later. The Oak Ridge study sometimes notes that a particular case is under regulatory review, but can provide no dollar value disallowed. Thus, we use the data from the most recent source in such cases. Second, a particular plant may be jointly owned by several utilities. The Department of Energy study sometimes reports only an aggregate disallowance for the plant, and Anderson sometimes reports only a particular firm's disallowance for a given plant; in these cases we have relied on the LeBoeuf et al. data, which break down disallowances by company ownership. Third, a disallowance may be effected by such means as phasing capacity into the rate base over time or by subjecting the plant to regulatory incentives designed to induce its efficient operation. In such cases, it is difficult to accurately calculate the net present value of the effects of a disallowance decision. In these cases, we have restricted ourselves to recording only the specific dollar amount disallowed from ratebase by the regulator. One exception is the Diablo Canyon plant built by Pacific Gas and Electric, which is being operated under an incentive regulation plan which all parties appear to agree generated a net present value of disallowance of $2 billion at the time the plan was implemented. The total amount disallowed from nuclear plants from 1980 - 1991 was $18.335 billion, while the total disallowed for coal and other plants was $781.915 million.

[19] In cases where a plant is owned by multiple firms, the table reports only the aggregate disallowance for the plant.

Act (PURPA), which was part of the more comprehensive National Energy Act of 1978. The purpose of PURPA, in part, was to encourage the efficient use of fossil fuels through the growth of cogenerated power and the use of renewable resources such as solar, wind, or biomass to generate electricity. A key feature of PURPA is a requirement that electric utilities interconnect with and purchase power from any "qualifying facility."(QF)[20] Moreover, PURPA requires that the incumbent utility buy power from qualifying facilities at the utility's own avoided costs. The combination of mandatory interconnection and the requirement to purchase power from QFs at the utility's avoided costs ensures that these fringe suppliers have a market for their electricity. Because the magnitude of "avoided costs" was initially set by fiat at what many consider to be relatively lucrative rates,[21] rather than through a competitive bidding process, and because QFs are not cost-of-service regulated, the amount of investment in electricity-producing cogeneration and small power producing facilities by non-utilities grew rapidly during the latter part of the 1980s. For our sample, Figure 5 reveals that power supplied by nonutility generators grew from zero to 116.7 million megawatthours in a mere six years. Moreover, this growth in supply from nonutility generators is expected to continue. The Energy Information Administration (EIA) has

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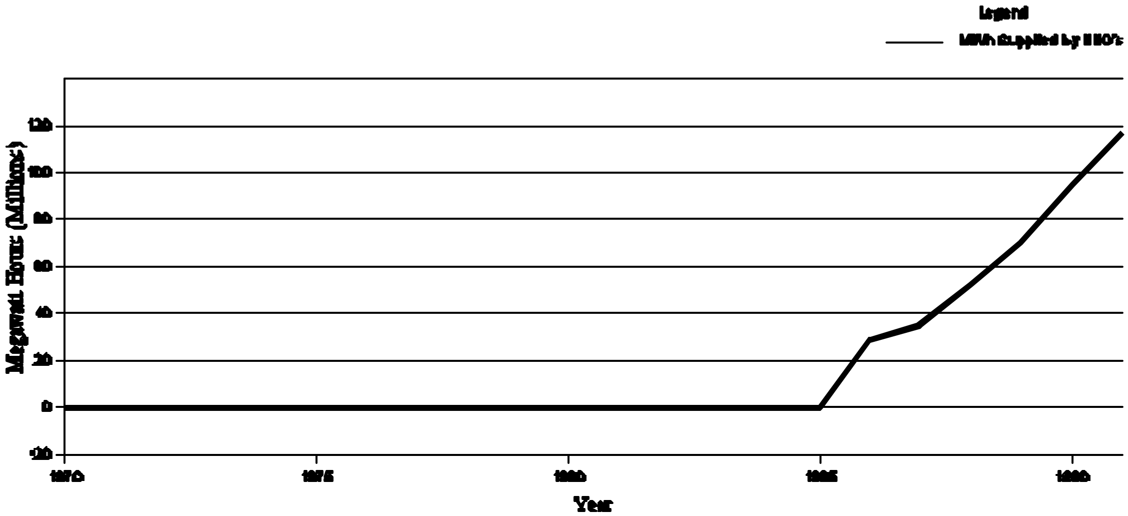
[20] PURPA defines two types of qualifying facilities: (1) cogenerators that sequentially produce electricity and another form of energy (e.g., steam) using the same fuel source: and, (2) small power producers that use waste, renewable, or geothermal energy as a primary energy source. These power producer are qualified under PURPA by meeting various ownership, operating, and efficiency conditions that are established by the Federal Energy Regulatory Commission. See 42 U.S.C. Section 824 a-3 (Supp. 1988). These qualifying facilities account for roughly three quarters of all nonutility power generation, while non-qualifying facilities (e.g., a plant that produces only electricity using conventional fossil fuel sources) account for the remainder. For a more detailed discussion of the nature and output from these nonutility generators, see Energy Information Administration (1993).

[21] See, for example, Joskow (1989), p. 174.

Figure 5: Power Supplied by Non-Utility Generators
1970-1991



estimated that fully one-half of all net additions to generating capacity through the 1990's will come from non-utility electric generating facilities.[22]

[22] See The Changing Structure of the Electric Power Industry, 1970-1991. Energy Information Administration, Office of Coal, Nuclear, Electric and Alternative Fuels, U.S. Department of Energy, Washington, D.C., March 1993.

A distinguishing feature of our empirical analysis is its use of firm-specific capacity data. These data are collected annually by the EIA on its Form 860. Unfortunately, EIA does not compile historical time series of firm-specific capacity data. Thus, it was necessary to construct a data series for each firm from the 22 individual years of Form 860 data.[23]

Another unique aspect of our data set is that it identifies, for every year of the sample period, all utilities that held an ownership stake in a nuclear plant that was under construction in that year. These data came from the Nuclear Regulatory Commission's *Information Digest, 1996 Edition*, which lists each commercial nuclear power plant in the U.S., along with the dates that its construction permit and operating license were issued. We considered a given plant to be under construction during the time period between the issuance of the construction permit and the operating license. By matching the nuclear plant construction data with plant-level ownership data from the EIA, we were able to identify every utility that had an ownership stake in a nuclear plant under construction for every year of the sample period.[24]

B. <u>The Empirical Model and Estimation Results.</u> Given the standard common carrier obligation facing utilities, our baseline empirical model specifies that investment by electric utilities is driven by a desire to fulfill expected demand with the available capital stock. Because of the importance of state-

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[23] We thank Robert Book for his assistance in writing a FORTRAN program to assemble and sort these data.

[24] We thank Sean Montgomery for his assistance in gathering and organizing the data on nuclear plant construction.

level regulation in this industry, we model investment as a function of both firm-specific variables (indicated by **X**) and state-specific variables (indicated by **Y**), plus interaction terms utilizing both of these categories.[25] Thus, we specify investment (I) by utility *i* in state *j* at time *t* as

$$\mathbf{I_{i,j,t} = \beta_0 + \beta_1 X_{i,t} + \beta_2 Y_{j,t} + \beta_3 X_{i,t} Y_{j,t} + \varepsilon_{it}.} \quad (1)$$

Several variables are included in the X-vector. First, the lagged value of the stock of capital (**CAPSTOCKLAG**) is included to account for replacement investment and as discussed in section II, we expect that its coefficient will be positive if capacity utilization is greater than the fraction of existing capacity that does not depreciate.[26] The level of current capacity (**CAPACITY**) and current sales (both **SALES TO CONSUMERS** and **SALES FOR RESALE**) are included to account for the proximity of the firm to its capacity constraint; we expect the demand coefficients to be positive and the capacity coefficient negative. Consistent with accelerator models of investment, we include **DEMF2AV**, the realized value of end-user retail electricity sales growth over the subsequent two years

[25] Our empirical specification purposefully eschews the interesting but for our purposes essentially irrelevant debate that centers on the possible relationship between a firm's cash flow and investment. While a number of papers, e.g. Fazzari and Petersen (1993), find evidence of such a relationship, Kaplan and Zingales (1997) present evidence that calls the relationship into question. In any event, there is little reason to expect the spillover effects that are of primary interest here—or the sign of the own-firm effects---to be affected in any systematic way by considerations of cash flow.

[26] See Jorgenson and Handel (1971). More generally, see Jorgenson (1971) for a survey of models that similarly account for replacement investment.

to account for the level of anticipated demand, and anticipate a positive coefficient.[27] Next, we include the amount of electric power supplied by nonutility generators, **SUPLYNUG**, to account for the impact of the PURPA legislation that requires incumbent utilities to purchase nonutility generators'power. Because this nonutility generator power can be used to satisfy consumer demand in lieu of investment activities by the incumbent utility, we expect that **SUPLYNUG** will negatively influence the investment propensities of incumbent utilities. Consistent with both standard investment theory and the model specified in Section II above, we include the **REAL INTEREST RATE** as an explanatory variable.[28] We also include a measure of the amount of purchased power from other utilities in the model, **SPLYUTIL**. To the extent that purchased power is more expensive than self-generated power, higher values of **SPLYUTIL** are likely to indicate capacity constraints that are unaccounted for in our other firm-level measures of capacity utilization. Accordingly, we expect higher values of **SPLYUTIL** to increase the investment propensity of electric utilities. Finally, several variables are included in the specification of equation (1) to account for the nature of the regulatory cost disallowances that were imposed on some electric utilities in our sample. Specifically, we include variables that permit us to

[27] Our approach here is akin to Oliner and Rudebusch (1991), who include current sales in an empirical model of investment. Given the longer planning horizon for electric utilities, we include a two year window of future sales growth. Note that while future peak day demand may be affected by current investment in new capacity, annual demand (which we use here) is unlikely to be so affected, especially given the significant amount of excess capacity carried by many utilities during this time period.

[28] The real interest rate variable does not vary across firms but only across time. Although we include a full set of year dummies to account for changes in the overall economic environment, the real interest rate is not a linear combination of these year dummies, so identification of the coefficient on the real interest rate is not a problem.

differentiate between the competing theoretical hypotheses regarding the impact of regulatory cost disallowances on firm-level investment. First, we include two alternative measures of regulatory cost disallowances for specific firms. $\mathbf{CUMDIS_{ijt}}$ is the cumulative real dollar value at time t of the disallowances faced by firm i operating in state j.[29] As an alternative specification that does not require the ability to accurately measure the dollar magnitude of the disallowance, we consider the indicator variable $\mathbf{DALLOW_{ijt}}$ indicating whether utility i operating in state j has been subjected to a regulatory cost disallowance in any year prior to time t. Under either the "regulatory opportunism" or "bad judgment" hypotheses, the effect of regulatory cost disallowances should be a reduction in the observed propensity to invest by the firm that is the target of the cost disallowance. Under the "bad luck" hypothesis, cost disallowances are essentially viewed simply as bad luck with no subsequent change in the firm's investment propensities.

While the firm-specific disallowance measures permit us to narrow the set of supportable hypothesis, they are not sufficient to fully distinguish among the competing hypotheses. Thus, in order to help differentiate among the competing hypotheses, we draw upon the behavior of firms that did not face cost disallowances but which were subject to the same regulatory authority as firms whose investments were disallowed. Specifically, for any given firm i operating in state j, $\mathbf{CUMDISST_{ijt}}$ represents the cumulative dollar value of regulatory cost disallowances up to time t faced by utilities k ... i that operate in the same regulatory jurisdiction as i. Alternatively, we specify $\mathbf{DALLOWST_{ijt}}$ to take on a value of one if any utility k ... i operating in state j has previously been subjected to a regulatory cost disallowance. The examination of investment behavior of individual firms in response to cost

29 Because disallowances are deflated to 1987 $, the impact of a disallowance on future investment subsides over time.

disallowances of other firms in the same regulatory jurisdiction allows us to distinguish between the "regulatory opportunism" and the "bad judgment" hypotheses. In particular, if the disallowance of firm *k* in state *j* has acted to signal an opportunistic shift in regulatory policy (Δ shifts from 1 to 0), then other firms that are subject to the same regulatory oversight (such as firm *i*) will be observed to reduce their investment propensities. Alternatively, if the "bad judgment" hypothesis is correct, then cost disallowances of firms $k \neq i$ should have essentially no effect on firm *i*'s propensity to invest. A complete listing of the model's variables along with their descriptive statistics is provided in Table 2.

The estimation of equation (1) involves both cross section and time series data. Accordingly, the prospect of individual firm effects arises [Judge, et al (1985)]. To test for the presence of such individual firm effects, we employed the Lagrange multiplier (LM) statistic developed by Breusch and Pagan (1980). Specifically, under the null hypothesis that cross-sectional firm effects are zero (i.e., firm-specific effects do not exist), Breusch and Pagan show that the Lagrange multiplier statistic, λ_{LM} is given by

$$\lambda_{LM} = [NT/2(T-1)][((\Sigma(\Sigma\,\varepsilon_{it})^2)/\mathbf{e'e}) - 1]^2,$$

where $\mathbf{e}$ is the vector of residuals, ε_{it} from the OLS regression and N and T are the number of cross-sectional and time-series observations, respectively. In the case at hand, the Lagrange multiplier statistic, which is distributed χ^2 (1) is far in excess of the critical value necessary to reject the null hypothesis.

Given the presence of firm-specific effects, the question remains as to whether a random error specification or fixed effects specification is more appropriate. To shed light on this issue, we performed the specification test proposed by Hausman (1978). The results indicate misspecification of the random error model and accordingly point toward the use of the fixed effects model. In addition to firm fixed effects, we include a full set of year dummies to account for other potentially important shocks to the industry's environment, such as business cycle effects, oil price shocks, and changes in natural gas legislation.

The fixed effects estimations are reported in Table 3, where Model 1 uses dummy variables for whether or not a disallowance has occurred, while Model 2 makes use of cumulative dollar values of disallowances. For purposes of comparison, the OLS results are reported as well for each model. (OLS estimations also include year dummies.) Overall, the estimation results are very encouraging. Both the F-value and the R^2 s indicate the aggregate strength of the empirical models. Moreover, the individual parameter values and their statistical significance provide specific insight into the particular determinants of electric utility investment propensities. As hypothesized, the level of capital stock (**CAPSTOCKLAG**), capacity (**CAPACITY**) and current demand (**SALES TO CONSUMERS** and **SALES FOR RESALE**) are important determinants of electric utility investment. Not surprisingly---given regulators' interest in protecting residential customers---**SALES TO CONSUMERS** is a much more important driver of investment than is **SALES FOR RESALE**. As expected, an increase in future demand growth (**DEMF2AV**) increases utilities' propensity to invest. Also as expected, we find that the supply of nonutility power (**SUPLYNUG**) that arose in the wake of PURPA has been a powerful factor that has significantly reduced the propensity of incumbent electric utilities to invest. The estimates also indicate that greater purchases from other (non-NUG) utilities heighten the firm's propensity to invest in new plant and equipment. This suggests that utilities view short-term purchases from other utilities as indicative of capacity shortfalls on their own systems, and thus as indicative of a need to build additional capacity. The real interest rate has a positive and significant coefficient.[30]

We turn now to our second broad hypothesis, which concerns the appropriate interpretation of the effects of disallowances on investment behavior. As discussed in section II, we wish to discriminate between three hypotheses: (1) regulatory opportunism, (2) bad luck on the part of some utilities, and (3) bad management on the part of some utilities. We begin this inquiry by noting that utilities that have been subject to regulatory cost disallowances (for whom **CUMDIS** and **DALLOW** are positive) have markedly reduced propensities to engage in investment. Model 1 shows that a utility that has been disallowed subsequently reduces annual investment by about $93.5 million. Alternatively, Model 2 indicates that every million dollars disallowed led the affected firm to reduce annual investment by $242,000. Since the 37 plants in our sample that were disallowed suffered an average disallowance of nearly $520 million, Model 2 suggests a subsequent investment reduction of about $126 million for utilities that were disallowed. These results provide strong evidence that the disallowances were not simply the result of "bad luck," e.g., unfortunate draws from the distribution of possible future demand levels. As discussed earlier, the "bad luck" hypothesis implies no shift in investment propensity after a disallowance: instead, utilities should continue with their existing investment practices, recognizing that demand and cost uncertainty means that some negative outcomes must be anticipated. This is clearly not observed in the data.

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[30] The positive coefficient on the real interest rate may be due to the regulatory treatment of "allowance for funds used during construction" (AFUDC), an accounting device designed to allow utilities to earn a return on investment before the ultimate completion and rate-base treatment of a plant. AFUDC levels adjust with the interest rate to reflect changes in the utility's cost of capital.

Next, we turn to the variables that allow us to differentiate between the "regulatory opportunism" and the "bad judgment" hypotheses, **DALLOWST** and **CUMDISST**, which capture whether a regulatory disallowance for firm *i* in state *j* had spillover effects on firms *k...i* in the same state. Model 1 indicates a small negative spillover to other firms, but the coefficient is not statistically significant. Model 2, on the other hand, shows a very small but *positive* and significant effect on the investment propensities of such firms. (For every million dollars disallowed, other firms in the same state increased annual investment by about $12,000 each.) These firms apparently saw an opportunity to accelerate their own building programs to supply some power demand that might be unmet by the firms in the state that had been disallowed. These results suggest that other firms in a state showed little fear of a regulatory "regime shift;" if anything they slightly *increased* their own investment upon seeing a disallowance in the same state! This indicates that post-disallowance investment behavior cannot be simply attributed to a "regulatory regime shift" or a sudden abandonment of an implied regulatory contract.

Given the difficulties experienced by nuclear power in the United States, one wonders whether investment behavior for nuclear plants has been significantly different than that for other technologies. We investigate this question by identifying those utilities that were in the process of building a nuclear power plant in any given year. We allow for both the possibility that these firms had overall investment propensities different from those of other firms, and for the possibility that the "spillover" effects of third-party disallowances are different for utilities that are building nuclear power plants than for utilities not involved in nuclear plant construction. Thus, we include dummy variables that indicate whether a firm was involved in the construction of a nuclear power plant during each sample year, either as the plant operator (**NUKE OPERATOR**) or as an owner (**NUKE OWNER)**. In addition, to allow for differential spillover effects, we include in Model 1 the interaction variable **$\mathbf{DNUKEOPST_{ijt}}$ = $\mathbf{DALLOWST_{ijt}}$*$\mathbf{NUKE\ OPERATOR_{it}}$** and the variable **$\mathbf{DNUKEOWNST_{ijt}}$ = $\mathbf{DALLOWST_{ijt}}$*$\mathbf{NUKE\ OWNER_{it}}$.** Similarly, we include in Model 2 the interaction variable **$\mathbf{CUMNUKEOPST_{ijt}}$ = $\mathbf{CUMDISST_{ijt}}$*$\mathbf{NUKE\ OPERATOR_{it}}$** and the variable **$\mathbf{CUMNUKEOWNST_{ijt}}$ = $\mathbf{CUMDISST_{ijt}}$*$\mathbf{NUKE\ OWNER_{it}}$.** If these variables have significant effects, then this would indicate that utilities believed cost disallowances signalled an opportunistic shift in regulatory policy toward nuclear plants, separate from any shift that may have been happening for utilities constructing new plants using other technologies.

We provide in Table 4 some descriptive statistics for firms that engaged in nuclear plant construction during our sample period. Panel A shows that 79 of our 132 firms were located in the 18 states that made one or more disallowances during our sample period. Of these firms, 32 had no part in nuclear construction during the sample period. Twenty firms were operators of nuclear plants built during the sample period and 35 were partial owners but not operators of nuclear plants during this period.[31] Panel B shows that 53 of our firms were located in the 32 states that made no disallowances during the sample period. Of these, 37 had no part in nuclear construction during the sample period, while 13 firms were nuclear plant operators and 4 held ownership stakes in plants they did not plan to operate. It is interesting to note that the fraction of firms electing to operate nuclear plants is almost exactly the same in states with disallowances (25.3%) and states without them (24.5%). Clearly not all nuclear plant operators had costs disallowed.

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[31] Note that 8 firms were operators of one or more nuclear plants and also held ownership stakes in other nuclear plants.

The regressions focusing on nuclear technology are reported in Table 5. We discuss only the results that differ in important ways from those reported in Table 3. To begin with, utilities building nuclear plants that they intend to operate once construction is completed (**NUKE OPERATORS**) invest between $105 million (Model 2) and $122 million (Model 1) per year more than do other utilities. Utilities with an ownership stake in a nuclear plant under construction (**NUKE OWNERS**), but who will not be the plant operator, invest more than firms with no stake in a nuclear plant (between $46 million and $51 million, depending on the model used), but less than nuclear plant operators.

The story becomes more intriguing when we turn to the issue of spillovers involving utilities engaged in nuclear power plant investments. The variables **DNUKEOPST** and **CUMNUKEOPST** are negative and highly statistically significant while **DNUKEOWNST** and **CUMNUKEOWNST** are statistically insignificant. Taken together, these results provide insight into the way utilities using nuclear technology viewed regulatory cost disallowances. Specifically, both Model1 and Model 2 indicate that firms that merely had an ownership share of a nuclear power plant, but did not plan to operate the plant, did not significantly alter their investment behavior as a consequence of in-state regulatory cost disallowances. In this case, the post-disallowance investment behavior does not provide support for the "regime shift" story. Rather, the investment behavior of these non-disallowed firms is most consistent with the "bad management" hypothesis.

A similar story emerges for firms that were not involved in nuclear plant construction at all. For these firms, Model 1 shows the spillover effect of a disallowance induced these firms to increase their investment by about $7.5 million per year, but the effect is not statistically significant. Model 2 also shows a positive spillover effect, which in this case is statistically significant at the 1% level. Evaluated at the sample mean for **CUMDISST,** which is $86.6 million, Model 2 indicates that non-nuclear firms increased their annual investment by about $1.8 million on average following a disallowance of another firm in the same state. Using data for 1989, by when the mean value of **CUMDISST** had risen to $463.97 million, the spillover effect to other non-nuclear firms is estimated at $9.74 million per firm.

In contrast, utilities who were the *operators* of nuclear power plants under construction did reduce their annual investments substantially in response to in-state cost disallowances of other utilities. Here our two models diverge somewhat, although in both models the spillover effect to nuclear plant operators is significant at the 1% level. The amount of investment reduction for each such firm is estimated at $4.7 million to $25 million (using Model 2 evaluated at the sample mean for **CUMDISST** and this variable's 1989 value, respectively) and $121 million (Model 1). These results suggest that firms that were sufficiently committed to nuclear technology to operate nuclear power plants may have seen the cost disallowances as a regulatory regime shift. Nevertheless, because the change in investment behavior was restricted to firms that were committed to one particular technology (nuclear) and were sufficiently committed to serve as the plant operator, the support for an overall regulatory regime shift here is quite limited.[32]

To put our results in perspective, we summarize them by identifying the quantitative importance of several key factors that have contributed to reduced investment by electric utilities, as shown in Table 6. The figures reported in the table were developed by using the coefficients from Table 5, multiplied

[32] Indeed, the post-disallowance reductions in nuclear operator investment may be due to a perception of regulatory regime tightening. They could, alternatively, be due to a concern on the part of these nuclear plant operators that a cost disallowance of another nuclear operator signals the emergence of an awareness on the part of regulators regarding the poor managerial judgment exhibited by firms that choose to become nuclear plant operators.

by the changes in the independent variables over the sample period. First, we group together in the category of "capacity utilization" the net impact of changes in capital stock, generation capacity, and contemporaneous sales levels. Together these factors account for roughly 22% of the observed decline in investment. Second, we find that the steep growth of non-utility generation in the 1980s has had only a modest effect on the investment propensities of utilities, accounting for only about 7.5% of the observed decline in investment. Third, a shift away from capital-intensive nuclear technology accounts for about 24.5% of the investment decline. It is important to note that the shift away from nuclear power predates the cost disallowances included in our sample, since the last construction permit for a nuclear plant in the U.S. was issued in 1978, well before any of the disallowances we observe. Fourth, the effect of disallowances on investment by the offending firms accounts for about 22.75% of the total investment reduction. Fifth, the spillover effects of disallowances—in the aggregate—probably led to an *increase* in utility investment on the order of about 4.5% of the observed reduction in investment. Here, as discussed above, the two models differ somewhat, with Model 1 showing almost no spillover effect, while Model 2 shows a significant increase in investment by non-nuclear utilities that substantially outweighs the small reduction in investment by nuclear plant operators. Finally, all other factors—including year dummies, real interest rates, purchases from other utilities, and projected demand growth—account for about 27.5% of the drop in investment.

Clearly the cost disallowances of the 1980s had a significant effect on investment. However, the vast majority of that effect came about through the responses of firms that directly suffered disallowances. The investment reductions of these firms appear to have been motivated by two factors: 1) punishment for imprudent overinvestment in generation facilities, and 2) a shift in the regulatory treatment of nuclear plant operators. We cannot disentangle these effects for the "own-firm" disallowances. However, we can establish that the spillover effects from "regulatory opportunism" had—if anything---a *positive* overall effect on investment in the electric utility industry. Thus, while there appear to be some instances of regulatory opportunism in our sample, they are limited to one type of technology, and do not seem prevalent enough to support the charge that the "regulatory contract" has been irrevocably broken. In fact, the "regulatory contract" appears surprisingly robust given the extremely difficult circumstances of the late 1980s.

IV. Conclusions

Models of regulation and regulated firm behavior typically portray an unwavering relationship between regulators and a given regulated firm. Within this framework, equilibrium behavior of the regulated firm can be derived and empirically tested. There is, however, the very real prospect that the regulatory regime, and in particular the "toughness" of regulators toward the utilities within their jurisdiction, may periodically change. Because regulators' actions are open to varying interpretations, however, any underlying shift in regulatory regime is unlikely to be directly observable. It is possible, though, to infer the presence of such changes in regulatory behavior by observing the behavior of utilities that are ostensibly unaffected by particular regulatory actions.

In this paper, we have developed a model of regulator-regulated firm interaction that is sufficiently general to accommodate the existence of such changes in regulatory behavior. We have then tested the model and its implications in what we believe is a novel way. In particular, we examined whether the behavior of electric utilities in the wake of the large-scale cost disallowances of the mid-

1980s is best explained by regulatory opportunism or by several alternative hypotheses that are developed in the paper. By utilizing investment behavior of both firms that have faced disallowances and those that have not (but which are subject to the same regulatory jurisdiction as the "offending" firms) we are able to shed light on the merits of these competing hypotheses.

The empirical results do not support the proposition that there was a massive overall regulatory "regime shift" or a violation of the "regulatory contract" as a result of the cost disallowances of the 1980s. Regulators appear to have become more stringent in their treatment of nuclear plant operators, but there is no evidence of a shift in treatment of nuclear plant owners (who do not operate the plant) nor of utilities building conventional generating facilities. Most utilities apparently saw the disallowances as indicative of poor investment choices by the affected firms, and saw no reason to change their own investment practices. In fact, the spillover effects of disallowances—in the aggregate—appear to have led to a modest *increase* in utility investment.

The overall pattern we observe here can be interpreted as part of a repeated game between regulators and firms,[33] in which regulators took advantage of an "endgame" in which nuclear power was becoming obsolete in the U.S. As mentioned above, no new nuclear power construction licenses have been issued since 1978. Knowing this, regulators in the 1980s might well have decided that opportunistic treatment of completed nuclear plants would have few negative consequences, as long as it was clear that such behavior was not going to become the standard for all future investments. Clarity was not fully achieved, however, as evidenced by the alarming comments of many industry observers at the time suggesting that a regulatory regime shift was underway. Our results, however, indicate that

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[33] For formal models, see Salant and Woroch (1992) or Gilbert and Newbery (1994).

when push came to shove, most utilities inferred correctly that non-nuclear technologies did not face the same harsh regulatory treatment reserved for the last vestiges of the nuclear era.

Our results raise some interesting questions about the regulatory treatment of "stranded costs" during the move to deregulate the generation segment of the industry. From the perspective of economic efficiency, the only reason for regulators to allow utilities to recover their stranded costs is to maintain a reputation for "fairness" that will sustain future investment in transmission and distribution.[34] Our findings, however, call for caution in assuming the existence of any such spillover from stranded generation costs to investment in transmission and distribution. Indeed, in the recent past, utilities differentiated sharply between regulatory treatment of nuclear plants and of conventional generating technologies. The distinction between generation and transmission/distribution is also quite sharp, and the process of removing generation from regulatory scrutiny sets up an "endgame" similar to the nuclear endgame mentioned above. Of course, industry restructuring is a more sweeping change than the regulatory treatment of nuclear power plants, and the magnitude of current stranded costs is greater than the nuclear power investments that were at risk during the period we study. Nevertheless, recent history provides little support for the proposition that utilities will quit investing in transmission and distribution if they do not recover their "stranded" generation costs.

As with many research efforts, the present research has opened numerous paths for subsequent analysis, which we are only beginning to explore. For example, the results presented here suggest that

[34] As Baumol, Joskow and Kahn (1994, p. 40) point out: "[E]conomic efficiency, including the provision of proper incentives for the making of efficient investments, require (sic) assurances only that such future investments will be accorded a reasonable opportunity to earn the market cost of capital."

new theoretical work that allows for multiple firms under a single regulatory jurisdiction is likely to yield new and improved insights into regulated firm behavior. Further work identifying why firms differ in their investment behavior would also be valuable. Also, additional empirical research into the presence of regulatory opportunism and its quantitative importance appears warranted, especially work that identifies the underlying determinants and causes of shifts in regulatory behavior. This final agenda of examining the fundamental determinants of observed shifts in regulatory behavior holds promise for substantial new insights into the political economy of government-business relations.

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Table 1: Largest Cost Disallowances by Plant

	UNIT	Fuel	UTILITY	Disallowed ($Million)	Year
1	Nine Mile Point 2	Nuclear	Multiple	2141	1987
2	Diablo Canyon 1&2	Nuclear	Pacific Gas & Electric Co.	2000	1988
3	Wolf Creek 1	Nuclear	Multiple	1617.6	1985
4	Shoreham 1	Nuclear	Long Island Lighting	1395	1985
5	Comanche Peak 1&2	Nuclear	Texas Utilities	1381	1991
6	Fermi 2	Nuclear	Detroit Edision Co.	1310	1988
7	River Bend 1	Nuclear	Gulf States Utilities Co.	1297	1987
8	Susquehanna 1&2	Nuclear	Pennsylvania Power & Light	847	1985
9	Clinton 1	Nuclear	Illinois Power Co.	665	1989
10	Perry 1	Nuclear	Multiple	665	1989
11	Seabrook 1	Nuclear	Multiple	646.4	1989
12	Vogtle 1&2	Nuclear	Georgia Power Co.	541	1987
13	Hope Creek 1	Nuclear	Multiple	511.6	1987
14	Callaway 1	Nuclear	Union Electric Co.	413.7	1985
15	South Texas 1&2	Nuclear	Houston Lighting & Power	375.5	1990
16	Limerick 1	Nuclear	Philadelphia Electric Co.	368.9	1986
17	Millstone 3	Nuclear	Multiple	353	1986
18	Waterford 3	Nuclear	Louisiana Power & Light	284	1987
19	Greenwood 1	FO#2	Detroit Edison	283	1986
20	Braidwood 1	Nuclear	Commonwealth Edison Co.	278.3	1988
21	San Onofre 2 & 3	Nuclear	Multiple	252	1987
22	Grand Gulf 1	Nuclear	Multiple	246.2	1988
23	Trimble County	Coal	Louisville Gas & Electric	200	1988
24	Palo Verde 1-3	Nuclear	Multiple	188	1988
25	Byron 2	Nuclear	Commonwealth Edision	180.6	1988
26	Beaver Valley 2	Nuclear	Multiple	125.3	1989
27	Summer 1	Nuclear	South Carolina Electric & Gas	123	1984
28	Hunter 3	Coal	Utah Power & Light	112.5	1986
29	Byron 1	Nuclear	Commonwealth Edision	101.5	1985
30	Belle River 1&2	Coal	Detroit Edison	96.87	1985
31	Bath County	PS	West Penn. Power	31	1987
32	Helms 1-3	PS	Pacific Gas & Electric	21.99	1985
33	Daniel	Coal	Mississippi Power	19	1981
34	Kettle Falls	Water	Washington Water & Power	9	1984
35	Reid Gardner 4	Coal	Nevada Power	4.37	1983
36	Big Bend 4	Coal	Tampa Electric Co.	3.68	1985
37	Holcomb 1	Coal	Sunflower Electric Power	0.5	1985
	TOTAL			19089.5	

TABLE 2
Descriptive statistics

Variable Name	Description	Mean	Std. Dev.	Min.	Max.	Source
RINV	Real investment (millions of 1987 $) by utility i in year t measured as additions to utility plant, deflated using the Handy-Whitman index of utility plant construction costs.	212.9412	286.9136	-22.7852	2088.869	1, 2
CAPSTOCKLAG	Lagged real (1987 $millions) capital stock measured as net electric utility plant in year t - 1. Deflated using Handy-Whitman index.	1807.66	2287.87	2.7511	17787.09	1, 2
CAPACITY	Nameplate capacity in MW	3.412	3.823	.0011	24.900	3
SALES TO CONSUMERS	Sales to ultimate consumers, in millions of kwh	10.5	12.4	0	70.2	1
SALES FOR RESALE	Sales to other utilities for resale, in millions of kwh	1.883	2.831	0	22.4	1
DEMF2AV	Demand forecast computed using the realized value of sales growth in percent over years t to t + 2.	7.270	18.406	-75.96	443.48	1
SUPLYNUG	Thousands of mwh purchased from non-utility generators	72.92835	751.6961	-53.882	19,400	1
SPLYUTIL	Thousands of mwh purchased from other utilities	1664.517	3688.999	-10,100	115,000	1
REAL INTEREST RATE	The financial cost of capital, as proxied by the prime lending rate	4.339	3.135	-.880	9.745	4
NUKE OPERATOR	Dummy variable=1 if utility was building in year t a nuclear plant that it would eventually operate	.156	.363	0.00	1	6
NUKE OWNER	Dummy variable=1 in year t if utility held ownership share in a nuclear plant under construction that it would not operate	.188	.391	0.00	1	6
DALLOW	Dummy variable =1 if utility has been subject to a regulatory disallowance prior to year t	0.049	0.216	0.00	1	5

DALLOWST	Dummy variable =1 if a utility in the same state as firm i has been subject to a disallowance prior to year t.	0.098	0.298	0.00	1	5
DNUKEOPST	DALLOWST*NUKEOPERATO R	.0092	.0953	0.00	1	5,6
DNUKEOWNST	DALLOWST*NUKEOWNER	.011	.105	0.00	1	5,6
CUMDIS	Cumulative real 1987 $million disallowed from utility i	20.341	138.244	0.00	1946.095	5
CUMDISST	Cumulative real 1987 $million disallowed other utilities in the same state	86.817	374.365	0.00	3536	5
CUMNUKEOPST	CUMDISST*NUKEOPERATO R	8.742	110.487	0.00	2658.2	5,6
CUMNUKEOWNST	CUMDISST*NUKEOWN	11.568	154.097	0.00	3343.3	5,6

Sources: 1 = Financial Statistics of Selected Electric Utilities, Energy Information Administration.
2 = Current Construction Reports, U. S. Dept. of Commerce.
3 = Energy Information Administration, Form 860.
4 = Survey of Current Business, U. S. Dept. of Commerce.
5 = Oak Ridge National Laboratory (1987), U.S. Department of Energy, (1989) and LaBeoeuf, et. al. (1991)
6 = U.S. Nuclear Regulatory Commission (1996).

TABLE 3

ELECTRIC UTILITY INVESTMENT

	Model 1		Model 2	
Variable	Fixed Effects	OLS	Fixed Effects	OLS
Intercept	151.1141*** (11.329)	-12.783 (-1.279)	133.3442*** (10.094)	-14.968 (-1.518)
CAPSTOCKLAG	.0865*** (19.441)	.1042*** (31.868)	.098*** (21.712)	.111*** (33.300)
CAPACITY	-73.3*** (-16.777)	-24.2*** (-9.532)	-73.6*** (-17.208)	-25.8*** (-10.277)
SALES TO CONSUMERS	10.7*** (7.023)	9.94*** (13.171)	11.0*** (7.200)	9.41*** (12.597)
SALES FOR RESALE	3.91** (2.032)	2.35** (2.355)	3.73** (1.982)	2.70*** (2.748)
DEMF2AV	.205* (1.691)	.3465*** (2.578)	.222* (1.871)	.356*** (2.686)
SUPLYNUG	-.0174*** (-5.132)	-.0303*** (-8.723)	-.0162*** (-4.881)	-28.3*** (-8.242)
SPLYUTIL	.00237*** (2.763)	-.00258*** (-3.402)	.00224*** (2.660)	-.00276*** (-3.678)
REAL INTEREST RATE	6.753*** (5.513)	4.195*** (2.990)	6.680*** (5.568)	4.317*** (3.119)
DALLOW	-93.499*** (-7.456)	-95.9446*** (-7.457)		
DALLOWST	-5.266 (-.534)	1.365 (.134)		
CUMDIS			-.242*** (-12.695)	-.219*** (-11.239)
CUMDISST			.012* (1.777)	.012* (1.732)
Number of observations	2508	2508	2508	2508
Adjusted R^2	0.363	0.824	0.484	0.829
F	30.22	435.07	35.20	449.59

t-statistics are in parentheses
***Significant at the.01 level.
**Significant at the .05 level.
*Significant at the .10 level

TABLE 4: Descriptive Statistics for Nuclear Plant Construction

Panel A: Utilities that Engaged in Nuclear Construction in the 18 States with Disallowances during the period 1970-1991

		Owner but not Operator		
		No	Yes	TOTAL
Nuclear Plant Operator	No	32	27	59
	Yes	12	8	20
	TOTAL	44	35	79

Panel B: Utilities that Engaged in Nuclear Construction in the 32 States with No Disallowances During the Period 1970-1991

		Owner but not Operator		
		No	Yes	TOTAL
Nuclear Plant Operator	No	37	3	40
	Yes	12	1	13
	TOTAL	49	4	53

TABLE 5

ELECTRIC UTILITY INVESTMENT: NUCLEAR VS. NON-NUCLEAR UTILITIES

	Model 1		Model 2	
Variable	Fixed Effects	OLS	Fixed Effects	OLS
Intercept	96.098***	-26.320***	89.235***	-26.488***
	(7.088)	(-2.802)	(6.652)	(-2.824)
CAPSTOCKLAG	.0832***	.0938***	.091***	.0968***
	(18.936)	(29.511)	(20.454)	(29.565)
CAPACITY	-64.5***	-21.0***	-66.8***	-23.0***
	(-15.040)	(-8.833)	(-15.854)	(-9.629)
SALES TO CONSUMERS	10.7***	8.38***	11.0***	8.62***
	(7.221)	(11.645)	(7.546)	(12.011)
SALES FOR RESALE	4.33**	1.48	4.42**	2.09**
	(2.326)	(1.577)	(2.410)	(2.253)
DEMF2AV	.2209*	.334***	.242**	.3597***
	(1.884)	(2.669)	(2.094)	(2.874)
SUPLYNUG	-.0141***	-.0223***	-.0133***	-.0215***
	(-4.301)	(-6.782)	(-4.087)	(-6.544)
SPLYUTIL	.00275***	-.00226***	.00263***	-.00224***
	(3.314)	(-3.175)	(3.204)	(-3.144)
REAL INTEREST RATE	6.206***	4.442***	6.190***	4.461***
	(5.241)	(3.397)	(5.299)	(3.414)
NUKE OPERATOR	121.578***	145.523***	105.923***	133.772***
	(11.638)	(17.759)	(10.184)	(16.159)
NUKE OWNER	46.618***	39.208***	50.643***	39.953***
	(4.707)	(6.412)	(5.241)	(6.641)
DALLOW	-68.417***	-72.291***		
	(-5.537)	(-5.999)		
DALLOWST	7.536	11.284		
	(.735)	(1.107)		
DNUKEOPST	-121.200***	-197.159***		
	(-4.726)	(-7.619)		
DNUKEOWNST	-10.1663	-13.163		
	(-0.460)	(-.558)		
CUMDIS			-.202***	-.169***
			(-10.711)	(-9.031)
CUMDISST			.021***	.0141*
			(2.727)	(1.877)
CUMNUKEOPST			-.054***	-.097***
			(-2.588)	(-4.471)
CUMNUKEOWNST			.005	-.0016
			(.318)	(-.095)
Number of observations	2508	2508	2508	2508
Adjusted R^2	0.647	0.847	0.663	0.847
F	33.77	449.04	36.79	449.86

t-statistics are in parentheses
***Significant at the.01 level.
**Significant at the .05 level.
*Significant at the .10 level

Table 6: Factors Reducing Electric Utility Investment 1971-1989
(As percentage of total reduction)

Factor	Model 1	Model 2
Excess Capacity	22.76%	20.91%
Purchases from NUGs	7.87%	7.42%
Shift from nuclear technology	25.33%	23.74%
Direct effect of disallowances	21.27%	24.24%
Spillovers from disallowances	0.13%	-9.03%
To firms building nukes	4.38%	1.31%
To other firms	-4.25%	-10.34%
Other	22.64%	32.72%
TOTAL	100.00%	100.00%