CAPTURE OR CONTRACT?:

THE EARLY YEARS OF ELECTRIC UTILITY REGULATION

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Abstract

Jarrell (1978) found that electricity prices rose in states that adopted state regulation before 1917, suggesting that regulators were "captured" by the interests of the regulated electric utilities. An alternative explanation is that state regulation more credibly protected specialized utility assets from regulatory opportunism than did the municipal franchise contracting that preceded it. We test this alternative hypothesis using a panel of data from the *U.S. Electrical Censuses* of 1902-1937. We find that the shift from municipal to state regulation was associated with a substantial decrease in investment propensity, an outcome strongly supporting the capture hypothesis.

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1. INTRODUCTION

Electricity is perhaps the quintessential regulated industry, yet the historical roots of its regulation remain poorly understood. This lack of clarity exists despite the existence of a small but fascinating literature on the subject. In a pioneering paper that initiated the empirical study of regulation, Stigler and Friedland (1963) argued that the behavior of electric utilities subject to state regulation was not significantly different from that of other utilities.[1] Jarrell (1978) pointed out that interpreting this result was difficult, since utilities not subject to state regulation remained subject to municipal regulation, which had preceded state regulation historically. He showed that not only was state regulation adopted earlier in states with lower rates, these early-adopting states subsequently saw their electric rates rise faster than rates in other states; he thus characterized state regulation as a classic example of capture by the regulated industry. Priest (1993) took a more nuanced view, and showed that a close reading of municipal franchise contracts reveals many structural similarities between them and state commission regulation. Furthermore, he argued that contract theory had not been applied with sufficient diligence to understand the origins of public utility regulation, and concluded (on p. 323) that the "important issue is to identify and evaluate the determinants of the relationship and of its changes over time...Regrettably, we know too little today to evaluate the impact of the establishment of regulatory commissions."[2]

Knittel (2006) used an empirical hazard model to shed new light on the drivers of early

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[1] As described in Peltzman (1993), Claire Friedland later found that the paper had underestimated the impact of regulation on prices by a factor of ten, though the statistical significance of the result remained marginal.

[2] Troesken (1997) and Masten (forthcoming) study the historical origins of governance institutions for natural gas and water, respectively. These papers different significantly from the present one, however, in that they address

adoption of state regulation, and found they included not just low prices, but also capacity shortages and low residential electricity penetration rates. This suggests that a desire to increase investment may have been an important driver of regulation. The present paper takes a complementary approach, applying a contracting perspective to illuminate the differences between state regulation and municipal franchise regulation, and using panel data on investment over the period 1902-1937 to evaluate the effect of state regulation on investment.

Since the seminal papers by Goldberg (1976) and Williamson (1976), numerous authors have advocated studying public utility regulation as a particular form of long-term contract.[3] The literature on contracts, of course, focuses on relationship-specific investments and the adjustment of prices over time. Surprisingly, the literature on the origins of electricity regulation has ignored the issue of investment altogether. Indeed, although he cited numerous examples of opportunistic behavior by municipal regulators, Jarrell (1978) simply assumed that regulation had no effect on investment, and was solely an instrument for redistribution of surplus. Thus, it is natural to ask how the two governance institutions—municipal franchise contracts and state commission regulation—affected utility investment behavior. This question is the focus of the present analysis.

A focus on investment behavior is helpful in distinguishing between the views of regulation as capture and regulation as contract. If state regulation was simply an instrument of capture, it should have allowed utilities to increase their monopoly power, raising price and restricting quantity; with lower quantity sold, utilities would have needed *less* generation

different industries and focus on understanding public ownership, rather than municipal franchise contracts or regulation.

[3] Crocker and Masten (1996) survey the literature on long-term contracts and its implications for public utility regulation.

capacity.[4] If state regulation was adopted because it was expected to be a more effective governance institution, then it should have provided utilities with a greater assurance of recovering their capital investments, and induced them to invest *more* in generation capacity. While both the capture and contract theories are consistent with an increase in price, they differ sharply in their predictions regarding capacity. Thus, our empirical analysis offers a new approach to assessing whether capture or contract better explains the early years of state utility regulation.

Our empirical results show that state regulation was associated with a lower investment propensity than municipal franchise contracting, a result inconsistent with a contracting interpretation of regulation but consistent with the capture theory. It is also consistent with the allegations of politicians such as President Franklin Roosevelt who favored passage of the Public Utility Holding Company Act of 1935, claiming that holding companies diverted the excessive profits from their regulated utilities to fund investments in their unregulated enterprises.[5]

The remainder of the paper is organized as follows. Section 2 presents a brief overview of the transition from municipal franchise regulation to state regulation. Section 3 offers a comparative institutional analysis of municipal franchise contracts and state commission regulation, and their implications for investment. Section 4 discusses the data and the econometric challenges presented. Section 5 discusses the empirical specification to be tested, and section 6 presents the empirical results. Section 7 concludes.

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[4] We thank Roger Noll for pointing out this aspect of the capture theory.

[5] For an analysis of Roosevelt's policies toward the electric utility industry, see Emmons (1996).

2. THE TRANSITION FROM MUNICIPAL FRANCHISE REGULATION TO STATE UTILITY REGULATION

In the latter half of the nineteenth century, the high cost of copper wire, along with the fact that direct current (DC) electricity experienced severe voltage drops with distance, meant that electric generating stations could only supply customers within a small radius of the plant. Under these conditions, and in light of the fact that electric companies needed access to public streets in order to install a distribution infrastructure, the municipality was the natural unit for political governance of electric power.[6] As described in detail by Priest (1993), the institutional system that developed was municipal franchise regulation, in which a local municipality would grant a franchise contract to a particular firm for a fixed period of time.

By the turn of the century, a series of technological advances led alternating current (AC) to emerge as the new technological standard. A key advantage of AC power was that it was more amenable to transmission over distance, as transformers could step up the voltage for transmission purposes, and step it down again for distribution to the ultimate user. As a result, large generating units could be located in inexpensive areas away from urban population centers, and scale economies could be more fully exploited.[7]

As the new central generating station technology was being rolled out, the governance institutions used in the U.S. were changing, too. The vast majority of electric power was generated by privately-owned firms under some form of government regulation. As mentioned above, municipal franchise regulation was the initial governance mode for electric utilities in all

[6] Epstein (1985) provides a contractual rationale for government involvement in utility regulation, in which a municipality grants a utility the right to use public streets in exchange for allowing municipal control over pricing.
[7] See Bunn and David (1988) for an insightful account of technological change in electricity and its implications for the structure of the industry.

U.S. states. Massachusetts was the first state to adopt state-level regulation of electric utilities, which it did in 1887, followed by New York, Wisconsin and Georgia, all of which adopted state regulation in 1907. Vermont, Michigan and New Jersey adopted state regulation in 1908, 1909 and 1910, respectively. Then between 1911 and 1915, another 22 states switched to state regulation of electric utilities. In less than a decade, the new institution had swept the country and become the dominant mode of governance for electric utilities.

The focus of this study is on the behavior of privately-owned utilities, and how it changed when state regulation was substituted for municipal franchise regulation. Nevertheless, municipal ownership remained a viable governance alternative for communities that were either too small to attract a privately-owned electric utility or that preferred government ownership for political or other reasons.[8] Thus, when assessing the effect of regulation on investment, it is important to consider the possibility that municipally-owned utilities responded to the changes faced by privately-owned firms. Even if state regulation appears to have increased the investment propensity of privately-owned firms, municipal investment might have fallen by an even greater extent, making the net effect of state regulation negative. This could have happened, for example, if state regulation empowered privately-owned firms to consolidate in ways that facilitated the transfer of assets from public to private hands, and reduced overall industry capacity in the process.

3. COMPARATIVE ANALYSIS OF MUNICIPAL FRANCHISE CONTRACTS AND STATE UTILITY REGULATION

[8] See Schap (1986) for a comprehensive treatment of the role of municipal ownership in the electric utility industry.

Although Jarrell (1978) assumed away any potential differences in efficiency between municipal and state regulation, Goldberg (1976), Williamson (1976), and Priest (1993) all argue that different forms of regulation might have different implications for economic efficiency. This presumption is strongly supported by the voluminous theoretical and empirical literature on contracts, which finds that the particular structure of contracts can have important effects on the willingness of parties to make relationship-specific investments.[9]

What, then, were the key differences between municipal and state regulation? Arguably, the single biggest change was the scope of control conferred by state regulation: a single agency now held responsibility for all utilities in the state, replacing dozens or possibly even hundreds of municipal city councils. The key theoretical issue is to elucidate the implications of this radical change in regulatory scope for investment behavior. The remainder of this section discusses these implications in three areas: exploitation of scale economies, regulatory commitment power, and political representation.

While Priest (1993) rightly emphasizes the important role of contractual structure, he implicitly dismisses the role of technological change in the emergence of state commission regulation, commenting (on p. 296) that "it is very hard to believe that the average cost curves of electric and gas utilities only began to slope downward after 1907, switching in direction at roughly the same time in each of these diverse states." Nevertheless, the literature shows that a series of important innovations in alternating current (AC) technology greatly increased the minimum efficient scale of utility operation in the early years of the twentieth century,[10] which had important implications for the relative efficiency of municipal and state regulation. In fact,

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[9] Crocker and Masten (1996) summarize the key insights from this literature.
[10] For a thorough discussion of these developments, see David and Bunn (1988).

Figure 1 shows that by 1917, the minimum efficient scale of operation for electric power generation was 200,000 megawatt-hours per year, enough to serve a third of the population of the average state.[11]

The data do not exist to indicate just when, in multiple states, all the components of an integrated electric system were assembled to create firms with substantial economies of scale. Nevertheless, the *1927 Census of Electrical Industries* pegs the "tipping point" of the shift to the steam turbine (a key component of the shift to the new central generating system) as occurring in the year 1912:

> In 1912 the steam turbine was still competing with the reciprocating engine as a prime mover for power plants; turbines of 20,000 kilowatts had, however, become an accomplished fact; no power plant had a reciprocating engine approaching this rating. The change was rapid. By the end of the year the turbine was considered the normal type. The year 1912 may therefore be considered to mark, as well as such gradual changes can be marked, the transition to the newer form of prime mover.[12]

Thus, despite Priest's skepticism, it appears that by roughly 1912 technological change had caused average cost curves to slope downwards over a much greater range of output than in the nineteenth century. The minimum efficient scale of an electric utility had grown much larger than the demand of a typical municipality.

The scale economies associated with the shift to AC power had several implications for the relative efficiency of municipal and state regulation. A system in which multiple municipalities contracted with a single utility presented a series of difficulties. At the simplest level, the need for a utility to contract with a number of different municipalities increased the

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[11] The data we use are described in detail in section 4 of the paper. This graph presents data from Table 96, p. 129, in the 1917 Census of Electric Utilities, which shows total expenses per kilowatthour for plants of various sizes. In 1917, the amount of electricity used by the average customer was 281 kilowatt-hours per year. Hence, the number of customers that could be served by an efficient-sized plant was 711,744. The average population per state in 1917 was 2,175,923, indicating that the average state needed approximately three efficient-scale plants.

transaction costs of operation relative to dealing with a single state regulatory body. More importantly, however, the provision of capacity that could be used by multiple cities created a common pool problem that required coordination across municipal regulators, further raising the cost of contracting, and presenting the opportunity for coordination failures and opportunistic behavior by individual municipalities. For all of these reasons, municipal contracting became progressively more costly, relative to state regulation, as the minimum efficient scale of utility operation grew. As a result, state regulation is expected to be associated with greater investment in electricity generation capacity and larger generating units.

A second consequence of expanding regulatory scope to the state level was to increase the reputational capital and hence the commitment power of the regulator. In a non-regulatory setting, Bernheim and Whinston (1990) show how multi-market contact can facilitate more cooperative outcomes. The basic idea is that when firms compete in multiple markets, the opportunities for punishment expand, and this enhanced threat supports more cooperative behavior. It is intuitive that a similar result might apply in a regulatory setting, *i.e.* that a regulator facing multiple firms may be punished by reduced investment on the part of *all* firms when it sets a non-compensatory price for any one of them. Indeed, Lyon and Mayo (2005) find empirical evidence of such spillover effects in the electric power industry during the 1980s: when regulators disallowed full cost recovery for utilities building nuclear plants, other nuclear power owner-operators in the same state cut back on their investments.[13]

The third implication of broadened regulatory scope was political. Municipalities lack incentives to respond to political pressures from beyond their political boundaries; hence one

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[12] George F. Wittig, "Technical Developments," *Census of Electrical Industries: 1927*, page 83.
[13] Shimshack and Ward (2005) find similar evidence of regulatory "reputation spillovers" in the enforcement of

would expect the interests of utilities that serve multiple municipalities to be systematically under-represented in municipal politics.[14] This "representation bias" was less of an issue at the state level, although firms operating in multiple states would observe a similar bias before state regulators.[15] As a result, one would expect state regulators to be more responsive than municipal regulators to the interests of integrated utilities. At the same time, individual customers became relatively less important in state-level regulatory deliberations, and had less incentive to expend the effort to represent their interests before state regulators. The net result is an increased opportunity for regulatory capture by the utility industry after the transition to state regulation.

The foregoing considerations reveal a tension between efficient governance and vulnerability to rent-seeking behavior in the move to state regulation. State regulation allowed for improved coordination across municipalities in a period of increasing economies of scale, and reduced the possibility that opportunistic behavior by municipal regulators would cause a coordination failure and associated lack of investment. At the same time, state regulation was also more vulnerable to influence by large, integrated utilities, which had incentives to raise prices, thereby dampening demand growth and the associated need for new investment. The net impact on investment, then, is an empirical issue

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environmental regulations by state agencies.

[14] For example, the *1907 Census* (p. 96) points out that "[T]he Boston Edison Company, whose system in 1885 covered an area of one-eighth of a square mile, and at present covers an area of 509 square miles…The map presented herewith…reveals the details of that vastly larger area in which it is now operating, within which lie 35 cities and towns of Massachusetts, with a combined population of approximately 1,000,000 inhabitants…Originally the engines in the generating plant were of 90 horsepower, but they have been displaced by steam turbines of 16,000 horse-power each…"

[15] According to Noll (1985), a similar representation bias could be observed in the traditional price structure of telecommunications prior to the breakup of AT&T. State regulators raised long-distance prices so they could use the resulting funds to subsidize local service, since local customers were more important politically than the profits of interstate firms.

4. DATA

Our primary data source is the series of reports issued by the U.S. Census Bureau on *Central Electric Light and Power Stations,* which were published at five-year intervals from 1902-1937. These volumes, used also by Stigler and Friedland (1962), and Jarrell (1978), provide information aggregated at the state level, and broken out by whether utilities are municipally or privately owned. Variables reported include total revenues, total output in kilowatthours (kwh), generator capacity in kilowatts (kw), output generated by hydroelectric sources (not available separately for municipal and privately-owned utilities), number of customers (1907-1937 only), and number of generating establishments.

These data were supplemented with data from a number of other sources: value added by manufacturing (*Twelfth Census of the United States 1900*, plus *U.S. Census of Manufactures 1909-1937*, interpolated), per capita income (*Statistical Abstract of the U.S.*, available 1917-1937 only), population in cities of 2500 of more residents (*U.S. Census*), fuel cost measured as the cost/BTU for coal (*Statistical Abstract of the U.S.*), yield on long-term corporate bonds (*Long Term Economic Growth 1860 - 1970, U.S. Department of Commerce, Bureau of Economic Analysis*, pp 224), and the consumer price index (*Long Term Economic Growth 1860 - 1970, U.S. Department of Commerce, Bureau of Economic Analysis*, pp 224 (1967=100)). We also used data from Stigler and Friedland (1962) regarding the dates when state commissions were instituted. Table 1 presents summary statistics.

For the most part, our focus is on the behavior of privately-owned utilities. However, as a control, we also consider the capacity possessed by municipally-owned utilities, in order to assess whether they responded differently to the shift toward state regulation. Although municipal utilities were obviously not subject to state regulation, they may have been affected indirectly, e.g. by acquisition attempts on the part of investor-owned utilities.

The fact that several data series are not available for the entire sample period 1902-1937 (per capita income, value of plant and equipment, number of customers) led us to try a number of different specifications with different numbers of observations. In the end, we opted for a parsimonious empirical specification that allows us to maximize the number of observations available for analysis.[16]

In several cases, data on certain individual states are not reported separately, in order to avoid releasing confidential corporate data. Thus, Arizona data is combined with New Mexico for 1932-1937; Georgia is combined with South Carolina in 1937; Washington DC and Maryland are combined with Delaware in all years; Mississippi is combined with Alabama in 1937; Rhode Island is combined with Vermont in 1927-1937; Utah is combined with Montana in 1927-1937; West Virginia is combined with Delaware in 1927-1932. Since inconsistent aggregation of data could bias our results, we treat the data as missing whenever such a combination occurs.

The resulting dataset is a panel of state-level data on privately- and municipally-owned electric utilities, with observations every five years for the period 1902-1937. We use a dummy variable indicating the year in which state regulation became effective. Following previous authors, we assume state regulation became effective three years after the legislation creating a state commission was passed.[17] Table 1 presents summary statistics for our variables.

Figure 2 presents a preliminary look at our investment rate data. It plots investment

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[16] Details of other results are available from the authors upon request.
[17] Hausman and Neufeld (1999) test this assumption explicitly and find it reasonable.

(measured as change in capacity) divided by lagged capacity, for both of the ownership structures and both of the regulatory regimes we consider. We note a general downward trend in investment rates over time for all ownership-regulation combinations, although the year 1927 appears to have been unusual in some respects. In general, there are not large differences between the investment rates for privately-owned and municipally-owned utilities. More relevant for our purposes, though, we see that for both private ownership and municipal ownership, investment rates were greater under municipal regulation than under state regulation. While this is certainly suggestive, it does not account for such important factors as population growth rates, the idiosyncracies of individual states, or the peculiarities of individual years. To obtain a more precise understanding of how state regulation affected investment, it is necessary to move to a formal econometric framework, which we do in the following section.

5. THE ECONOMETRIC MODEL

The main question of interest in this paper is whether the investment propensity of regulated firms changed as a result of the shift from municipal to state regulation. Our units of observation are at the state level, and the time periods with which we work are the five-year intervals captured in the Census Bureau data. Our basic econometric model takes the form of a treatment regression:

$$\mathbf{y}_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + \mathbf{D}_{it}\boldsymbol{\delta} + \boldsymbol{\varepsilon}_{it},$$

where $\mathbf{y}_{it}$ is the investment in new generation capacity in state *i* and period *t* divided by the amount of installed capacity in period *t-1*, $\mathbf{X}_{it}$ is a matrix of control variables, $\mathbf{D}_{it}$ is an indicator variable indicating that the state has adopted state-wide regulation, and $\boldsymbol{\varepsilon}_{it}$ is a possibly compound error term. Because data on the value of plant and equipment are not available after 1922, we measure investment as the increase in electric generation capacity (in megawatts) since the previous period, relative to initial capacity.

Previous work on investment behavior suggests a number of variables to include in $\mathbf{X_{it}}$.[18] First, the need for increased generation capacity is expected to rise with increases in the population of the utility's service territory, which we represent using the *change in the log of state population*. Second, the need for generation capacity is expected to increase with growth in the presence of manufacturing industry in a utility's service territory, which we measure using the *change in the log of real value added in manufacturing*, to the extent that the load pattern of industrial electricity use is comparable to that of residential customers. Specific data on this point are not available for our sample period, but the stylized facts indicate very different load patterns for residential and industrial customers. Residential demand peaked in the early evening, as homeowners turned on electric lights and kitchen appliances; industrial demand, conversely, peaked during the daytime hours. Thus, there is no clear sign prediction regarding the link between generation capacity and industrial presence. Third, new capacity is likely to be needed as the *utilization of existing capacity* increases.

In a panel covering as long a time period as this one, it is essential to control for time-period effects. For this reason, we include year dummies in all specifications. To control for the marked variation in economic development and geography across states, we cluster our observations at the state level in all regressions.[19] Furthermore, we exploit the panel dimension

[18] See, for example, Lyon and Mayo (2005), and the references therein.
[19] This is a more conservative approach than simply allowing for heteroskedastic standard errors. It allows for the possibility that all observations from a given state are related, although observations from different states are assumed to be independent. This effectively reduces the sample size, which makes it more difficult to find

of our data to allow for the presence of time invariant heterogeneity. In other words, we allow for the possibility that:

$$\boldsymbol{\varepsilon_{it} = \eta_i + \upsilon_{it}},$$

where $\boldsymbol{\eta_i}$ is a state-specific component and $\boldsymbol{\upsilon_{it}}$ is the observation-specific error. As our data are already first differenced, the presence of non-zero $\boldsymbol{\eta_i}$ would imply time-invariant differences in capacity growth-rates across states.

We estimated ordinary least squares (OLS) and both random- and fixed-effects models of the effect of state regulation on capacity investment. However, we report only the results of the OLS and fixed effects models below. We do this for two reasons. First, the validity of the random effects model relies on the assumption that the unobserved heterogeneity in the error terms is orthogonal to the observed variables. We find this assumption to be extremely strong. Second, for the most part, when the algorithm for estimating random effects models is applied to our data, it returns coefficient estimates identical to those given by OLS. This "degenerate" outcome occurs as a consequence of the nature of the estimation algorithm and small sample issues.

In an effort to further ensure the robustness of our findings, we explore the consequences of relaxing the assumption that past behavior has no effect on current investment. We do this by including one lag of the dependent variable to allow previous investment decisions to affect current investment behavior, as has been found to occur in a variety of other investment settings.[20] This dynamic specification has the form:

$$\mathbf{y_{it} = X_{it}\boldsymbol{\beta} + y_{it-1}\boldsymbol{\alpha} + D_{it}\boldsymbol{\delta} + \boldsymbol{\varepsilon}_{it}}.$$

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statistically significant results.

[20] See Bond and Van Reenen (2007) for a recent survey. We include only one lag because we feel that it is implausible to assume that investment decisions 10 years prior would still be affecting contemporaneous behavior.

In this framework, the existence of time-invariant effects (either fixed or random) would mean that the estimated coefficients are inconsistent. This is because the lagged dependent variable would be correlated with the fixed component of the error term. The bias does dissipate as the length of the panel goes to infinity; it is unclear *a priori* how large it will be with six observations per group.[21] Alternatively, one can rely on a large number of groups and estimate the model using one of the recently developed generalized method of moments (GMM) dynamic panel estimators.[22] However, in finite samples, these estimators have been shown to be quite imprecise.[23] For this reason, we report the results of employing Bruno's (2005) recently developed method of correcting for the bias in fixed-effects estimates of dynamic panel models.

6. RESULTS

In this section, we present a series of regressions that explore the determinants of investment in electric generation capacity in the early part of the twentieth century and the impact of the shift to state regulation on investment propensity. In Table 2, estimation (1) presents a simple baseline OLS regression of the rate of growth in private capacity on our baseline explanatory variables without the regulatory treatment dummy. These variables explain thirty-two percent of the variation in investment behavior. The growth in the state's urban population has a strongly positive and significant relation to capacity growth, as expected. After accounting for population growth, neither the change in real value-added nor the lag of capacity utilization has a statistically significant effect on the growth rate of capacity investment by

[21] See Cameron and Trivedi (2005) for details.
[22] See, for example, Blundell and Bond (1998) or Cameron and Trivedi (2005) for details.
[23] See Bruno (2005).

private utilities.

Estimation (2) adds a dummy variable indicating whether the state has adopted state regulation, and finds that the effect is negative though statistically insignificant at conventional levels. The signs and significance of the other variables remain largely unchanged. Although statistically insignificant, the coefficient on the regulatory dummy implicitly lends support to Jarrell's (1978) argument that state regulators were captured. This is because the alternative hypothesis posits that the higher prices Jarrell found under state regulation were imposed to encourage private utilities to incur the cost of dramatically expanding capacity. Estimation (2) strongly suggests that this did not occur.

Estimation (3) adds state-level fixed effects; as a result, the impact of adopting state regulation increases in magnitude and becomes statistically significant. An F-test rejects the null hypothesis that the fixed effects are jointly insignificant at more than the one percent level, indicating that there is time-invariant heterogeneity in the growth rates of capacity. The negative and significant coefficient on the state regulation dummy further reinforces Jarrell's (1978) argument that state regulators were captured by industry. Moreover, the results suggest that the economic significance of the change in regulation was very large. The sample mean for the growth rate of private capacity in states not subject to state regulation was 120 percent. Relative to this baseline, the adoption of state regulation would cause growth rates to fall by more than half.

Estimation (4) adds an interaction between the state regulation dummy variable and the change in the log of population, and is estimated by OLS. The effect of the interaction variable is negative and statistically significant. The general character of the other coefficients remains the same except for the fact that the main effect of the change in regulation (i.e. the coefficient on the regulation dummy) becomes positive and insignificant. The results continue to imply that the change in the regulatory framework is negatively linked to the growth rate of private capacity, and suggest that this effect is more pronounced in states with faster growing populations. Estimation (5) adds state fixed effects to estimation (4), and shows that the results found there are robust to controlling for persistent unobserved heterogeneity. In fact, the magnitude and significance of the coefficient on the interaction term increase. The main effect of the switch in regulation also increases in magnitude and becomes negative again, though it is not statistically significant. At the mean level of change in the log of urban population, 0.19, and the mean level of investment in states not subject to state regulation, estimation (5) implies state regulation led to a five-year growth rate 75 percent lower than it would have been under municipal franchise regulation.

Table 3 reports the results of regressions whose specifications are identical to those in Table 2 but which consider changes in the growth of capacity owned by municipal authorities rather than private firms. We would not expect a change in the regulatory framework to directly affect investment behavior by municipalities. However, it is still possible that the adoption of state-wide regulation had indirect effects on municipally-owned capacity. For instance, even if state regulation led to a reduction in privately-owned investment, it is possible that municipally-owned utilities made up the difference through increased investment. Alternatively, if the shift to state regulation corresponded to increased influence by privately-owned utilities, they might have sought to remove potential competitors by buying up their assets. This latter effect would have been enhanced if, as suggested above, the change in regulatory framework allowed private utilities to invest in plants capable of greater scale efficiencies, which would have given municipal authorities an incentive to procure their power from the privately-owned utility, rather than build their own plants.[24]

Anecdotal evidence supports the theory that private companies sought to either acquire the assets of municipal authorities or come to an agreement in which they would provide power to them, sometimes even engaging in price wars in an effort to force the municipal authorities to the table.[25] The regression results shown in Table 3 also are consistent with the idea that the adoption of state regulation allowed private utilities to supplant municipal utilities. We find that a switch to state regulation was generally correlated with slower growth in municipally-owned capacity, although the effect is weaker than for privately-owned utilities. Unlike what we found for privately-owned capacity, only the main regulatory effect is ever significant. Interestingly, the magnitude of the main effect in estimation (3), the fixed effects model without a regulatory interaction term, is actually larger than the corresponding one in Table 2.[26] In estimation (5), the net effect of state regulation on investment at the sample means, incorporating both the direct and the interaction effects, is -1.13, confirming that the overall effect of state regulation on municipal investment was negative. As before, we see that capacity growth is positively associated with population growth.

Unlike for the private generators, we find that municipal capacity investment was directly

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[24] While theoretically possible, it was very difficult for one municipal authority to serve another community. As Rudolph and Ridley (1986, p. 44) report, "The municipally owned utility in Watertown, New York, for example, tried for two years to obtain permission to sell power to surrounding communities but the proposal was blocked in the state legislature. After a long fight, the city of Hagerstown, Maryland, was the first [municipal authority] to receive approval from its state legislature to expand, but the private utilities had the Maryland Court of Appeals set the law aside on the grounds that it applied only to Hagerstown and was therefore discriminatory."

[25] See Rudolph and Ridley (1986, p.43-44) and Schap (1986, p. 30).

[26] We conducted a joint test of the significance of the main and interaction effects in estimation (5). The null hypothesis that they are both equal to zero is rejected. The test statistic is F(2, 41) = 2.01, which has a p-value of

affected by changes in capacity utilization. This suggests that the municipal authorities may have been more budget-constrained than their private competitors, investing only when demand for new capacity was particularly high. Thus, a dynamic investment specification may be especially important for municipally-owned utilities.

Table 4 contains the estimates for our autoregressive specifications of private and municipal capacity investment. Overall, the models offer strong support for the results found in our static regressions even if they do not offer conclusive evidence about the importance of controlling for past investment behavior. Estimation (1) is an OLS regression of private investment on a one-period lag of itself plus all the regressors previously used. The lagged term is negative, as expected, but not quite statistically significant at conventional levels. The interaction effect remains negative and statistically significant, but we now find that the main effect is positive and significant. For values around the sample mean of population changes, however, the net effect of the change in regulation remains negative.

Estimation (2) is a fixed-effects regression of the autoregressive model. As noted above, its estimates are biased, though the magnitude of the bias is not clear. In this model, the lagged investment term is statistically significant and of the intuitively appropriate sign. Both the main and the interaction effects of state regulation are negative, with the latter being statistically significant. Estimation (3) presents results of a fixed-effects model using Bruno's (2005) bias correction method. Once more, the lagged investment term is statistically insignificant at conventional levels, while the regulatory interaction term remains negative and highly significant.

Estimations (4) through (6) present analogous models of municipal investment rates. Our

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0.1472.

analyses find that previous capacity investment has a positive and often statistically significant correlation with current period municipal investment. This is opposite to the standard result in autoregressive investment models.[27] However, we believe that the positive coefficient can be understood by noting that during our extensive sample period, municipal investment was often changing in importance over time as a result of local political trends. We hypothesize that the coefficient is capturing this path dependency. As in Tables 2 and 3, we find that adopting state regulation has a smaller effect on municipal capacity investment rates than private investment rates.

Overall, our empirical results offer robust and consistent evidence that the shift to state regulation had a substantial effect on investment behavior. We find that private utilities significantly reduced their rate of investment, which is consistent with an effort to maintain higher prices. Furthermore, consistent with anecdotal evidence, we find that a shift to state regulation was linked to slower municipal capacity growth, suggesting that growing dominance by private utilities was achieved at least in part by buying out some municipal generators. Interestingly, we find evidence that the effect of the change in regulatory framework was most pronounced in the fastest growing states. All of these results support the argument laid out in Jarrell (1978) that the regulatory shift permitted private utilities to capture their regulators.

7. CONCLUSIONS

Although Jarrell (1978) showed that the shift from municipal franchise regulation to state regulation raised electric utility prices in the early part of the 20th century, this finding alone was

[27] It generally is assumed that budget constraints and non-convexities in the cost of capital investment will lead to a negative correlation between previous and current investment.

not sufficient to demonstrate that state regulation was a case of regulatory capture. An alternative hypothesis is that municipal franchise regulation resulted in opportunism on the part of regulators, who refused to allow compensatory rates to investors, and hence failed to elicit adequate investment in new capacity. State regulation might have remedied this problem by providing a more credible commitment to protect the specialized investments of utility companies, a possibility consistent with contractual theories of regulation, but assumed away by Jarrell.

This paper has tested whether state regulation did indeed result in a stronger propensity to invest on the part of electric utilities. We found no support for this hypothesis. Instead, we found robust evidence that state regulation actually reduced the investment propensity of investor-owned utilities. From the perspective of enhancing investment, any protection against regulatory opportunism conferred by state regulation was outweighed by its vulnerability to capture by regulated firms.

Our findings lend renewed credence to the accusations of electric utility industry reformers of the New Deal era like President Franklin D. Roosevelt and Senator George Norris of Nebraska, who charged that utility holding companies in the 1920s and 1930s had engaged in a variety of abusive practices that raised regulated electricity rates and diverted the proceeds away from reinvestment in the utilities themselves and into other, unregulated subsidiaries. Congress ultimately passed the Public Utility Holding Company Act of 1935 (PUHCA) to stem these practices.[28]

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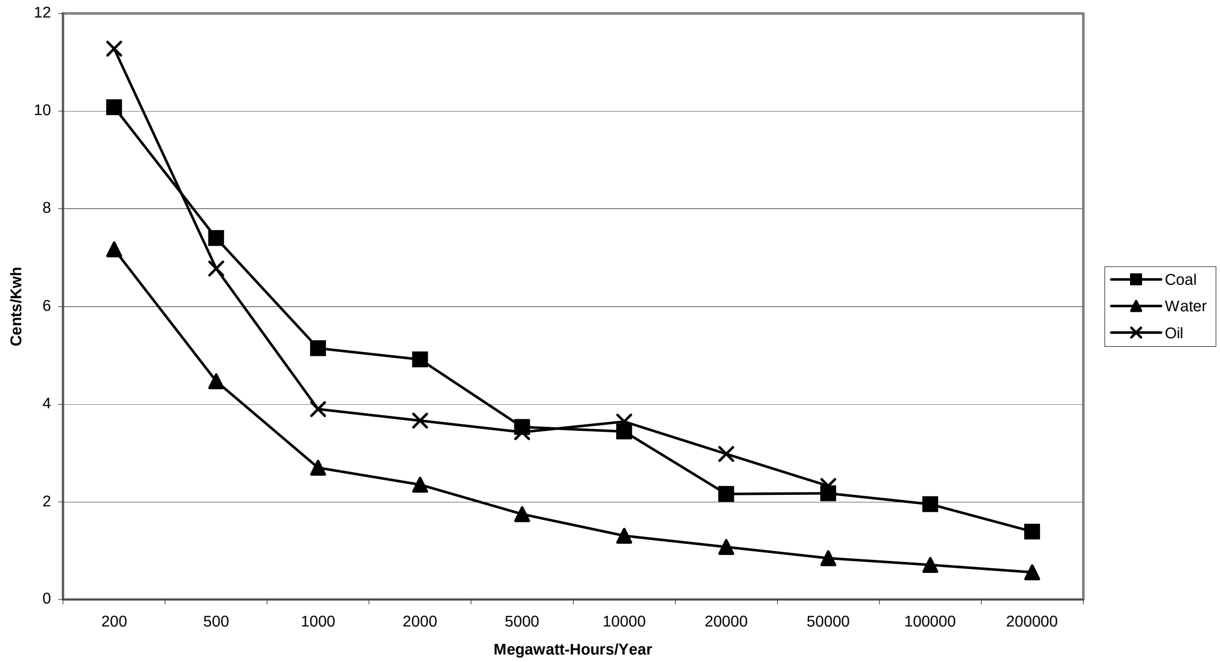
[28] For Roosevelt's views on the subject, see his Portland speech of 1932, in Roosevelt (1938) or his Message to Congress Recommending Regulation of Public Utility Holding Companies on March 12, 1935, which can be found in Woolley and Peters (2009). See Emmons (1993, p. 901) for an analysis of Roosevelt's policies towards the electric power industry.

The repeal of PUHCA seventy years after its passage unleashed a new round of mergers and acquisitions in the electric utility industry.[29] The U.S. appears to be going through another increase in the geographic scope of electric utilities, and at present there remains substantial disagreement about whether this will ultimately improve the performance of the industry.[30] It would be ironic if contemporary regulatory institutions do no better job of restraining the abuses of newly consolidated firms than did their counterparts in the early twentieth century.

[29] See Yung (2007) for details on this merger wave.
[30] Borenstein and Bushnell (2000) argue that it could be years before we are able to assess definitively whether current restructuring efforts are worthwhile.

Figure 1: Economies of Scale in Electricity Generation, 1917

Generation Cost in Cents/Kwh



Source: U.S. Bureau of the Census, Census of Electrical Industries, *Central Electric Light and Power Stations*, 1917, Table 96, page 129

Figure 2: Investment Rates by Regulation and Ownership Type

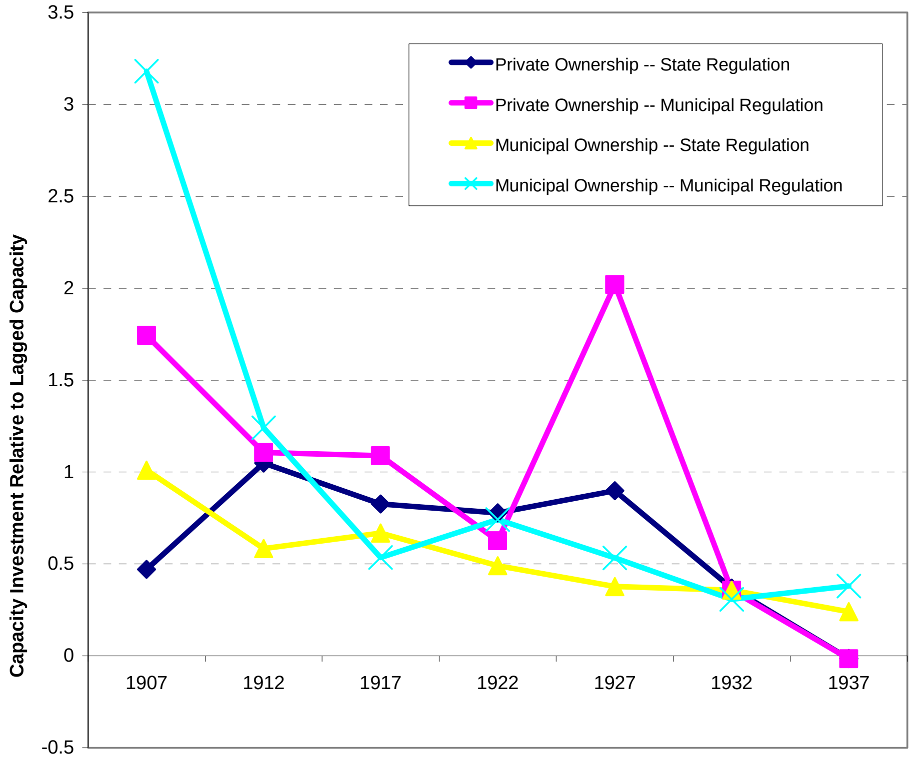


Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Private Capacity (kw)	336	339,745	605,015	764	4,672,380
Private Generation (Mwh)	335	972,000	1,820,000	1,509	15,100,000
Municipal Capacity (kw)	326	24,636	49,225	35	442,045
Municipal Generation (Mwh)	329	49,700	120,000	56	1,150,000
Urban Population	336	1,232,792	1,746,870	8,429	11,000,000
Real Value Added ($ Millions)	336	446	704	2	3,850
Investment / Capacity (t-1)	294	0.86	1.08	-0.61	8.20
Municipal Investment / Municipal Capacity (t-1)	281	0.90	2.69	-0.96	40.71
Change in Log of Urban Population	294	0.14	0.13	-0.12	1.25
Change in Log of Real VA	294	0.15	0.27	-0.66	1.50
Private Capacity Utilization at t-1	293	0.26	0.14	0.03	2.05
Municipal Capacity Utilization at t-1	284	0.19	0.08	0.02	0.54
Change in Log kwh/kw	292	0.09	0.39	-2.30	2.04
Change in Log Municipal kwh/kw	281	0.02	0.42	-2.40	2.51

Table 2: Static Models of Privately-Owned Capacity Growth

	(1) OLS	(2) OLS	(3) FE	(4) OLS	(5) FE
Regulatory Dummy		-0.19	-0.67**	0.12	-0.16
		[1.29]	[2.39]	[0.70]	[0.57]
Regulatory Dummy * Change in Log Urban Pop				-2.80**	-3.90***
				[2.21]	[2.86]
Change in Log Urban Population	2.63***	2.53***	2.43*	3.05***	2.81**
	[3.13]	[2.96]	[1.81]	[3.42]	[2.20]
Change in Log Real Value Added	0.25	0.31	0.22	0.33	0.14
	[0.68]	[0.84]	[0.55]	[0.87]	[0.35]
Lag of Capacity Utilization	-0.11	0.01	0.12	0.08	0.09
	[0.19]	[0.03]	[0.16]	[0.17]	[0.12]
Constant	0.95***	0.94***	0.29	0.77***	0.06
	[3.40]	[3.45]	[0.93]	[3.08]	[0.19]
Observations	293	293	293	293	293
State Fixed Effects	No	No	Yes	No	Yes
R-squared	0.32	0.33	0.34	0.34	0.36
Number of groups			42		42
F-Stat of Joint Insignificance of fixed effects			70.05		48.74
P-value of F-Stat			0		0

Robust t statistics in brackets
* significant at 10%
** significant at 5%
*** significant at 1%

Table 3: Static Models of Municipal Capacity Growth

	(1) OLS	(2) OLS	(3) FE	(4) OLS	(5) FE
Regulatory Dummy		-0.25	-1.15*	-0.03	-1.46*
		[1.60]	[1.86]	[0.13]	[2.00]
Regulatory Dummy * Change in Log Urban Pop				-1.95	2.38
				[1.11]	[1.08]
Change in Log Urban Population	2.16	2.01	2.7	2.37	2.5
	[1.53]	[1.38]	[1.47]	[1.39]	[1.32]
Change in Log Real Value Added	1.46	1.56	1.87	1.57	1.92
	[1.31]	[1.33]	[1.55]	[1.34]	[1.57]
Lag of Capacity Utilization	4.81*	4.95*	7.38*	5.02*	7.22*
	[1.96]	[1.98]	[1.87]	[1.99]	[1.82]
Constant	1.17*	1.16*	-0.82	1.05	-0.65
	[1.74]	[1.72]	[1.09]	[1.50]	[0.83]
Observations	281	281	281	281	281
State Fixed Effects	No	No	Yes	No	Yes
R-squared	0.15	0.15	0.21	0.15	0.21
Number of groups			42		42
F-Stat			4.35		4.27
P-value of F-Stat			0		0

Robust t statistics in brackets
* significant at 10%
** significant at 5%
*** significant at 1%

Table 4: Dynamic Models of Capacity Growth

	(1) Priv-OLS	(2) Priv-FE	(3) Priv-Bruno	(4) Muni-OLS	(5) Muni-FE	(6) Muni-Bruno
Lagged Investment	-0.07	-0.16***	-0.07	0.18***	0.04	0.13**
	[1.57]	[3.84]	[1.14]	[2.77]	[0.58]	[2.47]
Regulatory Dummy	0.35*	-0.03	-0.04	0.37**	0.14	0.26
	[1.72]	[0.08]	[0.11]	[2.10]	[0.52]	[0.77]
Regulatory Dummy * Change in Log Urban Pop	-4.23***	-4.79***	-4.47***	-3.66**	-3.17*	-3.57**
	[2.72]	[3.07]	[2.61]	[2.16]	[1.81]	[2.04]
Change in Log Urban Population	4.98***	5.73***	5.31***	4.85***	7.60***	7.52***
	[4.07]	[3.79]	[3.71]	[3.93]	[3.77]	[4.78]
Change in Log Real Value Added	-0.08	-0.25	-0.24	0.3	0.44	0.41
	[0.31]	[1.03]	[0.67]	[1.15]	[1.55]	[0.94]
Lag of Capacity Utilization	0.13	0.5	0.46	1.77**	0.37	0.28
	[0.31]	[1.20]	[1.02]	[2.20]	[0.27]	[0.27]
Constant	-0.40*	0.51		-0.49	-0.5	
	[1.92]	[1.68]		[1.65]	[1.03]	
Observations	251	251	251	238	238	238
State Fixed Effects	No	Yes	Yes	No	Yes	Yes
R-squared	0.29	0.35	.38	0.3	0.3	.37
Number of group(code)		42	42		42	42
F-Stat		23.42			4.34	
P-value of F-Stat		0			0	

Clustered robust *t* statistics in brackets except for Bruno regressions, where standard errors are bootstrapped.

* significant at 10%
** significant at 5%
*** significant at 1%

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