Market Structure, Ownership, and the Provision of Residential Electricity: Evidence from the United States at Mid-Century*

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Abstract

Economists have long been interested in the implications of private versus public ownership for the provision of services and consumer prices. Empirically, the challenge is to disentangle the effect of ownership from other determinants of prices. In this paper, we use detailed historical data on retail electricity in the United States to identify the effect of private versus public ownership on prices. Our data include information on thousands of individual markets, which allow us to control for observed differences in supply, demand, and regulation across markets. We find that private utilities service markets closer to the transmission grid and charge prices between 6.7 and 9.4 percent lower than public utilities at typical usage levels. For "marginal" consumers that would have benefited from lower prices charged by private utilities following an expansion of the transmission grid we estimate an upper bound for savings of $19.0 million per year (in 2014 dollars). This compares favorably with contemporary electrification programs and the cost of expanding the transmission grid.

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1 Introduction

In the United States, the majority of utility services (e.g., for water, gas, and electricity) are provided by private enterprises. Still, in some instances, local governments intervene to substitute public for private ownership. For example, although investor-owned utilities accounted for over two thirds of electricity sales in 2012, publicly-owned firms substantially outnumbered privately-owned firms.[1] The determinants of ownership structure in industries with natural monopoly characteristics are the subject of a large empirical literature in economics (e.g., Levy and Spiller, 1994; Troesken, 1997; Troesken and Geddes, 2003).[2] An important, related issue is the impact of variation in ownership type on prices and provision (Stigler and Friedland, 1962; Peltzman, 1971). However, existing studies utilize data that cannot disentangle the effect of ownership from the effect of regulation.

In this paper, we develop a new data set to test for the impact of ownership structure on pricing in the early electricity industry. Our data include information for all utilities in the contiguous United States in 1935.[3] The historical setting allows us to incorporate information on proximity to the transmission grid, a key determinant of ownership structure in this time period. In addition, detailed information on the location of utilities allows us to control for demand, cost, and regulatory variables commonly used to explain the prevailing pattern of ownership.

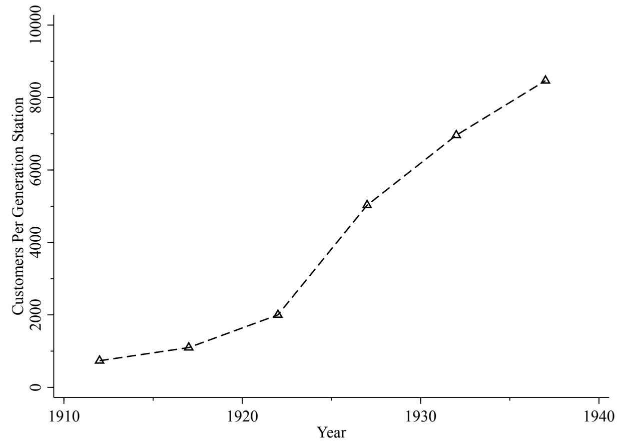
There are several theories to explain the choice of private versus public ownership and the consequences for provision and pricing. Traditional public interest theories emphasize the role of market failure stemming from natural monopoly, externalities, or financing constraints (Pigou, 1932). Most relevant for the observed differences in ownership type in the early electricity industry is the small size of many local markets (Marston, 1916; Schap, 1986). Theoretically, public ownership may be the outcome of an environment where demand is low relative to long-run average cost. In this case, it may not be profitable for private firms to enter given their technology and local politicians may elect to use public provision to ensure access. In our setting, technological change permitted the transmission of electricity

[1] In 2012, there were 179 investor-owned utilities and 975 utilities owned and operated by governments at the local, state, or federal levels.

[2] For a survey of early literature on public versus private ownership see Boardman and Vining (1989). Joskow (1997) covers more recent issues related to the regulation, vertical control, and performance of electricity utilities.

[3] Specifically, our data are drawn from a Federal Power Commission survey that reports typical bills based on rate schedules in effect as of January 1, 1935. Given the reporting dates, major changes in the regulatory and competitive environment due to the passage of the Public Utility Holding Company Act (1935), Federal Power Act (1935), creation of the Rural Electrification Administration (1935), and rollout of electrification under the Tennessee Valley Authority (1933) had not yet occurred or were substantially limited to after our study period.

Figure 1: Customers Per Establishment, 1912-1937



Source: For 1912 to 1922, data on the number of establishments stations and customers are from US Census Bureau (1922, Table 5 and Table 6). For 1927 and 1932, data are from US Census Bureau (1932, Table 5). For 1937, data are from US Census Bureau (1937, Table 12 and Table 13).

over larger distances and led to an increase in the number of customers per establishment, as Figure 1 shows, between 1900 and 1940. This increased market size might then have facilitated the growth of private provision.

Alternatively, contracting theories emphasize the threat to firms from opportunistic local politicians (Alchian, 1965; Goldberg, 1976; Williamson, 1985). This arises because the potential for bribes, pressure to lower prices, and other actions that might damage the long-run value of an industry's specific, non-redeployable capital. The result is private utilities underinvest or do not provide service at all, and municipal authorities must step in. For the electricity industry in the first half of the twentieth century, access to the transmission grid limited the size of investment required by individual utilities and their exposure to political opportunism.[4] Thus, as the transmission grid expanded so too did the potential for private utilities to profitably provide service. This reasoning is also consistent with parallel developments in the regulation of electric utilities that shifted authority from local to state governments over time to accommodate the increasing geographic scope of utilities implied by the technology embodied in the transmission grid (Priest, 1993; Knittel, 2006).

Advances in the transmission technology are central to both public interest and con-

[4]In particular, improvements in the generation and transmission technology reduced the specific-capital exposed to takeover by public officials. With access to the transmission grid, public officials were limited to only seizing local distribution wires, which were less valuable when unconnected to the a generation station. This reduced the risk for private utilities and, over time, allowed them to enter increasingly smaller markets as the grid expanded.

tracting explanations for the expansion of private ownership in the period we study. To test the relative importance of these explanations in our cross-section of all utilities, we use market size to directly control for factors affecting ownership type due to public interest and then separately estimate the effect of distance to the transmission grid, which captures the impetus for private (versus public) ownership under contracting theories. We find that privately-owned utilities tend to serve smaller markets. This provides suggestive evidence against public interest theories in which publicly-owned utilities are more likely to serve smallest markets. For distance to the transmission grid, the results suggest that beyond 20 kilometers a utility was less likely to be privately owned and this implies that 145,000 households are "marginal" between receiving service from a publicly- instead of a privately-owned utility. In addition, we find that state regulation and the size of the retail, wholesale, manufacturing sectors influenced whether a utility is publicly or privately owned.

Related to the impact of ownership type on the performance of electricity utilities, Peltzman (1971) finds prices are higher under private ownership. Meyer (1975), Neuberg (1977), Färe, Grosskopf, and Logan (1985), and Atkinson and Halvorsen (1986) provide cost estimates that suggest private ownership is no more efficient than public ownership. In each case, the authors exploit variation that cannot distinguish the effect of regulation from the effect of ownership type. The contrast between the early electricity industry when state-level regulation was minimal and publicly-owned firms appeared more efficient (Hausman and Neufeld, 1991) and the later period when the efficiency differential disappeared in the presence of state regulation (Hausman and Neufeld, 2002), highlights the distinct roles of regulation and ownership.

In the context of New Deal reforms during the 1930s, Emmons (1993, 1997) finds public ownership was associated with lower prices. His data are at the firm-level, that is, for holding companies of potentially many, geographically dispersed utilities. Our data are for the period preceding key legislative actions supported by the Roosevelt administration during the 1930s and contain price information on individual utilities across many locations. In this way, our empirical analysis makes comparisons between markets served by public and private utilities that face otherwise similar conditions.

Our results show prices charged by privately-owned utilities were lower by between 6.7 and 9.4 percent, or between \$4.46 and \$10.91 (in 2014 dollars) for an average bill.[5] Importantly, as stated above, this estimate is based on markets that are similar in terms of factors influencing demand, cost, competition, and regulation, and differ only with respect to public or private ownership of the utility. Combining our estimate of the price effect with

[5]Unless indicated otherwise, all figures are in 2014 dollars.

the number of consumers "marginally" served by publicly-owned utilities implies an overall additional expense between $7.8 and $19.0 million (in 2014 dollars). These potential savings are large compared to the cost of constructing the grid or other programs during the period that aimed to expand access to electricity.

We also find a role for regulation. Unsurprisingly, states that regulate private rates were more likely to have private firms, which is consistent with interest group theories (Stigler, 1971; Peltzman, 1976; Knittel, 2006). After controlling for differences in market composition, we find that prices of private relative to public utilities were lower in unregulated states than in regulated states. This is consistent with utilities in unregulated states engaging in a form of spatial competition or that utilities in regulated states over-accumulated capital to justify higher prices (i.e., the Averch-Johnson effect).

Our results highlight the role of controlling for market characteristics when estimating price differences between public and private utilities. First, we are able to address the selection by ownership type using detailed data on individual utilities and their proximity to the transmission grid. Second, these data allow us to separately identify price differences that arise due to public versus private ownership from differences that result from a particular regulatory environment. We show that failure to account for either of these two effects may lead to biased estimates of the role of public versus private ownership.

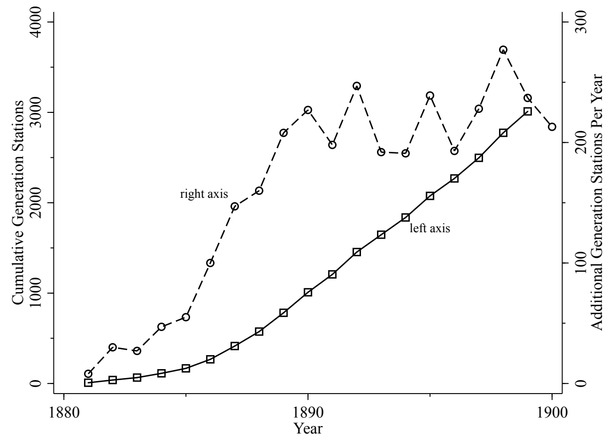
2 Historical Background

The retail electric light industry was effectively created in 1881 with the lighting of J.P. Morgan's home and the completion of Thomas Edison's Pearl Street Station in the following year. The Pearl Street station generated direct current electricity at a central plant in New York City, which was then distributed through wires to homes and businesses near the plant.

At first, delivery of electricity was limited to homes within approximately one mile of the central station. Edison's vision was to create a network of central service stations delivering electricity to homes for lighting via direct current. Soon after the formation of the Edison-Morgan partnership, a former Edison engineer Nikola Tesla, backed by George Westinghouse, developed the polyphase alternating current motor. Alternating current, due to its higher voltage, enabled delivery over much longer distances. Competition between direct and alternating current continued throughout the 1880s. In 1893, Westinghouse was awarded contracts to supply the Chicago World's Fair and setup generators on Niagara Falls to supply electricity to Buffalo. This cemented alternating current as the industry standard.

Cities and towns began electrifying early, first using direct current motors and later adopting alternating current motors. Figure 2 shows the growth in the number of establish-

Figure 2: Cumulative and Additional Generation Stations, 1881-1900



Source: Data are from US Census Bureau (1902, Table 2).

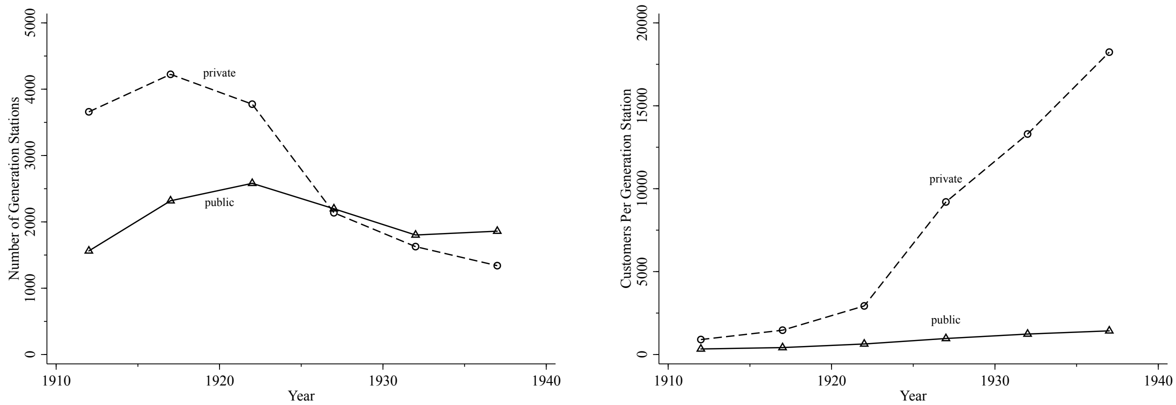
ments in last two decades of the nineteenth century. In 1881, there were just eight central service stations, this number increased to over 1,200 in 1890, and reached more than 3,200 stations by 1900. By ownership type, in 1900, nearly a quarter of generating stations were owned and operated by municipal governments.

In subsequent decades, investment and revenues for the industry as a whole increased dramatically: roughly fifty-fold in each case (US Census Bureau, 1932). This was accompanied by substantial churning as the number of utilities fluctuated first increasing and with privately-owned utilities outnumbering publicly-owned utilities. By 1927, the number of utilities by ownership type were approximately equal and over the next decade private ownership declined so that public ownership was the majority type. Figure 3A illustrates the evolution of the industry's size and ownership structure between 1912 and and 1937.

Churning in the industry was also characterized by switching from public to private ownership and merging of privately-owned utilities. This consolidation of privately-owned generation capacity is substantially responsible for the decline in Figure 3A and was primarily due to changing technology throughout the 1920s. Adoption of improved transformers allowed centrally generated power to be stepped up to higher voltages permitting the delivery of centrally-generated power over increasing distances. This led to a wave of consolidations and buyouts throughout the late 1920s and 1930s (Schap, 1986).[6] By the mid-1930s, the ownership structure in urban markets had stabilized, while additional expansion occurred

[6]In 1935, the Public Utility Holding Company Act was passed requiring interstate utility holding companies to be geographically contiguous. Large holding companies were successfully divested after 1946, following the *North American Company v. Securities and Exchange Commission*. However, these divestitures did not lead to substantial change in ownership at the local level.

Figure 3: Establishments and Customers Per Establishment by Ownership, 1912-1937



A. Number of Establishments B. Customers Per Establishment

Source: See sources for Figure 1.

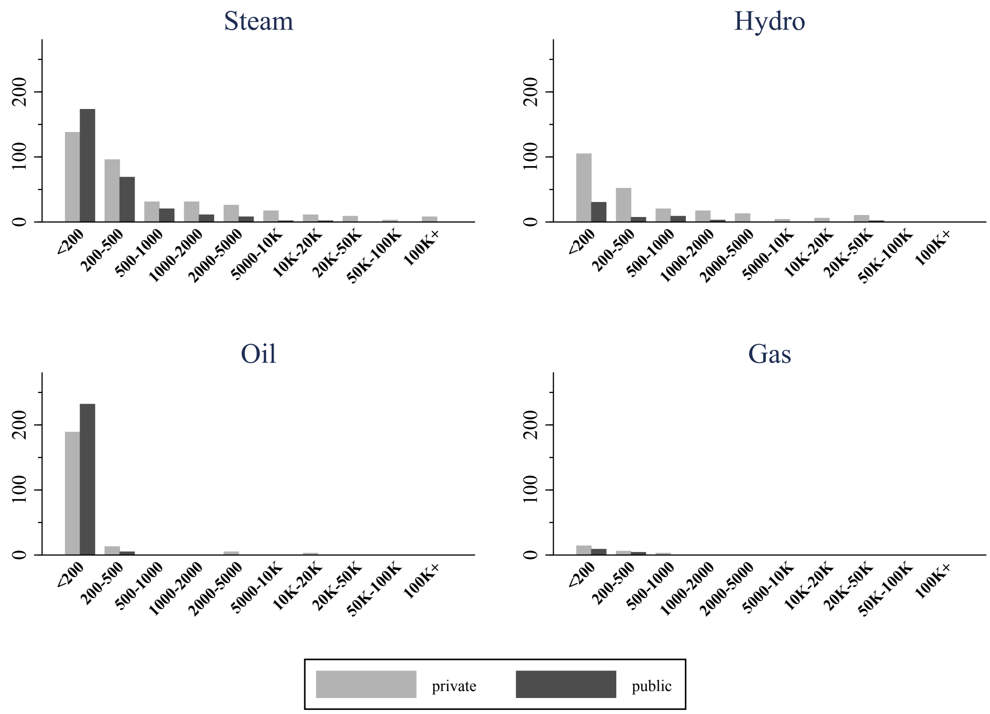
under federal programs such as the Tennessee Valley Authority and Rural Electrification Administration to provide electricity to under- or un-served areas.

Private and public ownership continued to coexist, but each adopted different generation technologies. In publicly-owned utilities, generation tended to use small diesel- and coal-fired steam plants. Privately-owned utilities tended to invest heavily in the development of hydroelectric dams and high-capacity central generation plants, which led to economies of scale (US Census Bureau, 1917). Figure 4 shows a breakdown of the size of generating stations by ownership and source of energy in 1917. The *Census of Electric Light and Power Plants* also reported that in 1917 privately-owned utilities generated 2.7 times more electricity per employee than publicly-owned firms; in 1927, private utilities used half as much coal-equivalents per kilowatt hour generated; by 1932, the average generation cost for private utilities was 26 cents per kilowatt hour and sometimes as low as 9 cents in hydroelectric facilities, compared with 51 cents per kilowatt hour for public utilities (US Census Bureau, 1927, 1932).

Figure 3B documents the differences between public and private ownership in terms of customers served per establishment. Starting in 1912, private enterprises served an increasing number of customers, reaching more than 18,000 per establishment in 1937. In contrast, over the same period, public enterprises never served more than 1,500 customers per establishment, on average.

The *Census of Electrical Industries* data also suggest the importance of generation mix. For plants with similar capacity and fuel type the cost for publicly- versus privately-owned

Figure 4: Generation Stations by Ownership and Source, 1917



Source: Data are from US Census Bureau (1917, Table 95).

utilities was similar. However, on average, private utilities were much larger and this ultimately led to lower costs per kilowatt hour (US Census Bureau, 1917). The ability to centrally generate and transmit electricity over greater distance contributed to several consolidations and the abandonment of some municipal plants (Dorau, 1930). Contemporary accounts highlight the role high voltage transmission lines played in determining the ownership structure of electricity utilities.

> The new technology of the electric light and power industry, embodied principally in the system of large-scale, centralized production of electricity, with broadened market reached by high tension long-distance transmission lines and with interconnection of these central supply stations, appears to have been the most important condition affecting the character and extent of municipal ownership of electric establishments. (Dorau, 1930)

Between 1900 and 1925, the National Electric Light Association reported reasons why roughly 800 publicly-owned utilities opted to sell their generation plants and distribution equipment to private utilities outright or purchase their electricity requirements from other systems (National Electric Light Association, 1925, pp. 87-227). Of these, 623 are included in our sample in 1935 and their proximity to the transmission grid highlights the grid's role in determining ownership. The average distance to the grid for utilities that switched from public to private ownership during the 1910s and 1920s was 64 percent closer than utilities that remained public until the mid-1930s

For specific evidence, take the case of Wytheville, Virginia, located between the two major cities in the region: Roanoke, Virginia, and Charleston, West Virginia.

> About 1905 the town of Wytheville built a small municipal plant, but after operating it a very short time leased it to a corporation, which, in turn, about 1911 sold the plant to the Appalachian Power Company, which was building a transmission system and hydro-development in the vicinity, so that the service is now supplied by that company (National Electric Light Association, 1925, pp. 207).

There are similar cases throughout the United States, such as in South Lyon, Michigan, and New Vienna, Ohio.

> We [Detroit Edison Company] abandoned the old plant and served the district from our transmission line. (National Electric Light Association, 1925, pp. 143).
>
> Taken over by Dayton Power and Light Company, which will supply by transmission, [municipal] plant to be dismantled. (National Electric Light Association, 1925, pp. 182)

These stories suggest proximity to the grid was central in determining the ownership type of utilities.

In general, from the point of view of utilities, there were several reasons for expanding the grid. The first was due to increasing demand from large cities. Engineers and scientists improved the materials and conductors used in transmission, which allowed for higher voltages. In turn, this permitted utilities to develop increasingly powerful and often distant hydroelectric sources to meet growing demand (Bohn, July 4, 1926). In 1922, California's Pacific Gas and Electric constructed the first 220 kilovolt transmission line from Pit River in the Sierra-Nevada Mountains to connect the San Francisco Bay Area. The increase in voltage from 110 to 220 kilovolts allowed a fourfold increase in power to the city, and this was transmitted from over 200 miles with minimal load losses (*Pacific Service Magazine*, 1922, p. 345).

In addition to enabling access to more remote sources of generation, interconnection provided more reliable service. Self-contained systems, particularly those dominated by hydroelectric power (e.g., in California, the Southeast, and the Pacific Northwest), were highly susceptible to drought. In 1925, a severe drought forced Southern Power Company to cut service to many consumers for several days, highlighting the importance of interconnecting plants and major markets (*New York Times*, January 24, 1926). As a result of this experience, there was a movement to promote interconnection throughout the South. Moreover, even in locations dominated by steam plants (e.g., in the Northeast), the benefits of interconnection were substantial.

> The other day a big generator broke in Providence [Rhode Island]. The electric company did not have sufficient reserve equipment to handle the demand for current from its customers. There was some rapid-fire long-distance telephoning. In a power house in Amsterdam [New York], up in the Mohawk Valley, a man threw a switch. A few minutes later the lights which had dimmed at Providence grew bright again. (Clark, February 22, 1925)

Interconnection also insured against the eventuality of damaged lines. For example, in 1927, the *New York Times* noted that the completion of the system connecting Pensacola, Florida, with Chicago and Boston, ensured continuous service in the event of a disaster (*New York Times*, October 2, 1927).

A final important contribution of interconnection was the reduction of capital requirements for local electricity provision and variable inputs such as coal. By connecting to the grid, utilities were able to reduce local capital investment needed to meet peak-load demand; locations with excess supply were able to transmit their power to those with excess demand. These savings were significant. For instance, in New York state, it was reported that 320 miles of transmission line that interconnected towns and cities with distant hydroelectric plants permitted utilities in the state to reduce coal consumption by 500,000 tons annually (*New York Times*, January 21, 1923). Assuming the the cost of coal was $69.5 per ton, interconnection saved $34.8 million annually in coal inputs (in 2014 dollars).[7]

In the first part of our empirical analysis we formalize the role distance to the grid played in determining ownership, taking advantage of the differing proximity across the United States as well as within states in 1935. In the second part of our analysis, we consider the consequences of ownership for prices faced by residential consumers. The next section discusses the data underlying our empirical analysis.

[7] Wright (2006) reports a cost of coal of $69.6 per ton in 1922 and $73.9 per ton in 1923 (in 2014 dollars).

3 Data

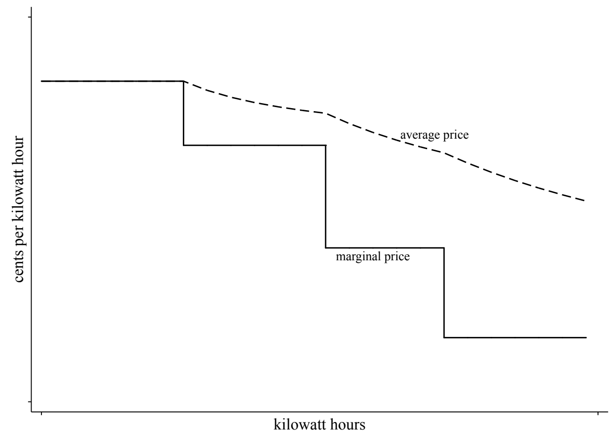
3.1 Sources and Variables

The data used in the empirical analysis are at the city- and town-level for all electrified communities in the United States with a population of at least 250 in 1935. These data are from the Federal Power Commission's *Electric Rate Survey* and were part of the first effort to record residential electricity prices for the entire country (Federal Power Commission, 1935a). The survey includes the name of the city or town, population, minimum bill, number of hours in the minimum bill, and typical bills at different levels of consumption (in terms of kilowatt hours). These data were estimated at the time of publication to cover 99 percent of all kilowatt hours generated in the United States (Federal Power Commission, 1935a, p. 2). From the information on typical bills we construct a measure of average price per kilowatt hour. For example, for 15 kilowatt hours Edison Electric & Illuminating Company serving the community of Acton, Massachusetts, charged $18.3 and this translates to an average price of $1.2, at 25 kilowatt hours the bill was $28.7 for an average price of $1.1 per kilowatt hour, and so on.

Our data do not contain information on the marginal prices at different consumption levels (i.e., the rate schedule) for each utility. Instead, we use information on the typical bill at different usage levels to construct the corresponding average price at those usage levels. Using average prices allows us to make comparisons between prices charged by different utilities for the same level of consumption. In addition, we can quantify the effect of ownership on average prices at different points throughout the rate schedule. Moreover, from a regulatory perspective, recent evidence suggests that average price is more salient than marginal price (Ito, 2014) and, therefore, the more relevant policy variable. Figure 5 shows how the average price variable we use relates to the marginal price (based on the rate schedule) set by a hypothetical utility.

The authors of the report underlying our data recognized potential for errors in the tabulated data, for example, due to complexity of the rate schedule, omitted surcharges, cooperative membership fees, late fees, etc. This may lead our data to understate the bills of either public or private utilities and the corresponding average prices. In some cases, the Federal Power Commission inserted its best guess of the average price given the rate schedule (Federal Power Commission, 1935a, p. 1). Other fees are difficult to detect, for example, municipalities that had contracts with the Tennessee Valley Authority (TVA) were subject to surcharges that may not be reflected in all cases in the Federal Power Commission report (Tennessee Valley Authority, 1934, p. 35). The data used to construct our average price

Figure 5: Marginal and Average Price for Hypothetical Utility



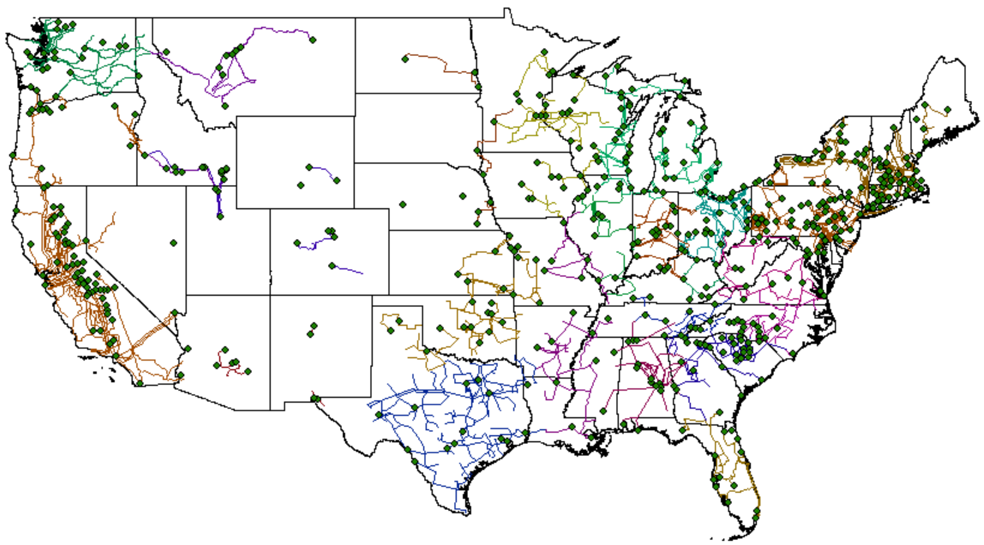
variable do not indicate whether TVA customers were subject to amortization or cooperative membership fees. To the extent these and other charges were omitted, particularly in reported prices for public utilities, our results will tend to understate price differences under the two ownership structures.

We merge the data from the *Electric Rate Survey* with information on the precise location of cities and towns from the National Atlas of the United States (2004). From this data, we construct the distance of each city or town to the transmission grid in 1935. The transmission grid, which includes high voltage lines and central generation plants as reported by the Federal Power Commission, were geocoded in ArcGIS and the corresponding digitized map is shown in Figure 6. We also use information on the regulatory environment in each state. Specifically, we construct an indicator variable equal to one if the rates of private utilities are regulated in the given state and zero otherwise (Federal Power Commission, 1935c). Finally, in some specifications, we use county-level data from Haines (2010).

3.2 Sample Construction

For our empirical analysis we impose minimal restrictions on the sample. Of the 17,739 unique towns and cities reported in the Federal Power Commission survey for the contiguous United States, we are able to match 16,627 to the National Atlas of the United States' *Cities and Towns of the United States* index. After dropping observations with missing data, we are left with 13,833 total utilities. At this point, we restrict the sample to communities with population less than 5,000 so as to focus on communities that were not large enough to attract the construction of high voltage transmission lines on their own. Thus, we focus on communities that received service as a byproduct of their proximity to larger cities that were

Figure 6: Transmission Grid, 1935



Source: The map was digitized from Federal Power Commission (1935b).

connected to the grid.[8] In addition, these smaller communities would not individually have been politically powerful enough to affect regulation at the state level. These restrictions together yield a sample of 12,179 cities and towns. Overall, our sample covers 12 percent of the population of the contiguous United States.

To determine the ownership of each utility, we count the number of utilities operated by a given firm within each state. If a utility only operates in one town or city in a state, then it is called "public" and otherwise the utility is labeled as "private." In 1932, the Census reported a total of 1,802 publicly-owned utilities; in 1935, we identify 1,773. After imposing our sample restrictions we are left with 1,186 public utilities and 10,993 private utilities. This coding scheme may create measurement error. However, in most cases, public firms serving multiple communities tended to do so in larger cities. By excluding large cities from our sample, we aim to minimize measurement error in our ownership variable. Nevertheless, if this coding scheme understates the number of publicly-owned utilities then our price estimates would tend to understate differences between public and private ownership.

Table 1 shows summary statistics for the characteristics of towns and cities nationwide

[8]One illustration is the example of Wytheville, Virginia, given in Section 2, which located between the larger cities of Roanoke, Virginia, and Charleston, West Virginia.

Table 1: Summary Statistics

	All Towns & Cities:	Sample Towns & Cities $< 5,000$:			
	Combined	Combined	Private	Public	Difference
	(1)	(2)	(3)	(4)	(5)
Miles to Transmission Grid	5.519	5.942	5.207	12.792	-7.584
Population (thousands)	5.019	1.091	1.054	1.432	-0.378
Population (thousands) Per Mile^2	0.234	0.183	0.192	0.095	0.097
County Tax Revenue Per Capita in 1880	0.921	0.949	0.932	1.108	-0.176
Local Tax Revnue Per Capita in 1880	1.362	1.343	1.345	1.326	0.019
Retail Emp. Share in 1935	2.522	2.438	2.443	2.383	0.061
Wholesale Emp. Share in 1935	0.532	0.506	0.505	0.509	-0.004
Manufacturing Emp. Share in 1935	4.679	4.384	4.473	3.552	0.921
State Regulates Private Utility	0.773	0.765	0.773	0.683	0.091
Observations	13,818	12,167	10,989	1,178	12,167

Notes: Miles to the transmission grid is the distance from each market to the grid, population is the population of the town or city, population density is the county population where the city or town is located in 1930 divided by the county's area (in square miles), county tax revenue per capita is total tax revenue collected by the county in 1880 divided by 1880 population, local tax revenue per capita is total tax revenue collected by cities in 1880 divided by 1880 population, and the retail, wholesale and manufacturing employment share are the 1935 employment divided by the 1930 county population.
Source: Miles from the transmission grid is authors' calculation based on Federal Power Commission (1935b). Population is the town or city population from Federal Power Commission (1935a). The regulation indicator is from Federal Power Commission (1935c). The remaining variables are from Haines (2010).

(column 1) as well as all locations in our sample (columns 2-5). Column 2 includes towns and cities with population less than 5,000, columns 3 and 4 present summary statistics for private and public utilities, respectively, and column 5 gives the difference between the two ownership structures. Locations in our sample have 1,091 residents on average compared to 5,019 in cities and towns nationwide and are less densely populated (183 people per square mile in our sample versus 234). Overall, our sample is similar to the nationwide sample in terms of distance to the transmission grid, exposure to regulation, per capita taxation, share of the population employed in retail, wholesale, and manufacturing.

Within our sample, columns 3 through 5, make clear that there are significant differences in terms of the characteristics of markets served by private and public utilities. First, locations served by a public utility are larger, on average, but less than half as densely populated. Second, public utilities are farther from the transmission grid: 12.8 miles versus 5.2 miles, on average. It is also the case that public utilities tend to be located in states that do not regulate private utilities.

In addition, markets served by public utilities have similar tax burdens as measured by per capita revenue (in 1880 dollars) locally and countywide in 1880.[9] Public utilities also tend to have similar shares of the population employed in the retail and wholesale sectors in 1935, and smaller shares employed manufacturing (3.5 percent with public utilities versus 4.5 percent with private). Given the differences in Table 1, in our empirical analysis we use propensity scoring matching to enforce comparisons between utilities with similar characteristics, in particular, between utilities with a similar probability of being either privately or publicly owned. We describe our empirical approach in detail in the next section.

4 Empirical Framework

The summary statistics in Table 1 make clear that public and private utilities operate in different markets. Without correcting for differences in markets served by ownership type, our estimate of the price difference between public and private utilities will potentially be biased. To account for these differences and enforce comparisons between public and private utilities that serve similar markets we use propensity score matching (Rosenbaum and Rubin, 1983). To implement this approach we use observed characteristics of utilities (and their markets) that reflect underlying differences in demand, cost, and regulation: distance to the transmission grid, population and population density, local tax revenue per capita, share of the population employed in manufacturing, retail, and wholesale, and whether the utility is regulated by a state commission. These observed characteristics are then used to construct the propensity score that predicts that equilibrium ownership structure as follows:

$$O_i = f(d_i) + \mathbf{X}_i\beta + \theta_s + \varepsilon_i \tag{1}$$

In equation (1), O_i is an indicator equal to one if market i is served by a privately-owned utility and zero otherwise. $f(d_i)$ is a function of market i's distance to the transmission grid and $\mathbf{X}_i$ is the vector of remaining observed characteristics summarized in Table 1. In practice, we use a fourth-order polynomial to approximate the function $f(\cdot)$. In addition, in some specifications, we include state dummy variables, θ_s.[10] We assume that the error term, ε_i, is normally distributed so that equation (1) can be estimated using a probit regression.

To recover the effect of ownership structure on log average price, $p_i^\ell = \log P_i^\ell$, in market i at usage level ℓ, we follow Abadie and Imbens (2006) and use nearest-neighbor matching

[9] We use tax revenue in 1880 since this year predates electrification. This avoids changes in revenue that were responsive to the introduction of electricity and the ownership structure.

[10] State dummy variables are co-linear with the indicator used to capture the *state* regulatory environment. Therefore, in specifications that include state dummy variables we omit the regulation indicator.

to estimate the average treatment on the treated.

$$\tau^{\ell} = \frac{1}{N_1} \sum_{i=1}^{N_1} O_i \Bigg(\log P_i^{\ell} - \frac{1}{M} \sum_{j \in J_M(i)} \log P_j^{\ell} \Bigg) \qquad (2)$$

where N_1 is the number of treated observations (i.e., markets served by privately-owned utilities), M is the number of matches for each observation, and $J_M(i)$ is the set of nearest-neighbors matches to i.[11] Finally, we use formulas proposed by Abadie and Imbens (2011, 2012) to correct standard errors for the fact that the propensity score is estimated.

Importantly, ownership decisions are made by profit-maximizing firms and, therefore, are not randomly assigned.[12] Instead, identification of the effect of ownership structure depends on controlling for (observed) market characteristics that reflect demand and cost conditions, as well as the regulatory environment. In our setting, population and population density are included to capture market size, while county and local tax revenue per capita in 1880 reflect preferences for public goods prior to the introduction of electricity. Also on the demand-side, the shares of the population employed in retail, wholesale, and manufacturing capture the influence of a market's industry structure. This follows, for example, the emphasis that Peltzman (1971) and others place on the role of interest group in determining prices.

On the supply side, the historical literature suggests that proximity to the transmission grid was a key determinant of ownership structure. Hence, we control for a polynomial in each utility's distance to the grid. In addition, previous studies were unable to distinguish the role of regulation from the role of ownership. In some specifications we control directly for whether private utilities were regulated by a state commission; more generally, our preferred specifications include state dummy variables, which ensures comparisons between public and private utilities that face a similar regulatory environment as well as other characteristics that are common to particular states.

To be clear, the identification assumption is conditional mean independence. In our setting this means the expected effect of ownership structure on average prices (at a given usage) only depends on observed factors reflecting demand, cost, and regulation. Two details are important to note. First, by focusing on utilities serving smaller markets we avoid violations of the identification assumption that arise, for example, because ownership structure

[11]In addition, we also estimate the average treatment effect on the treated by reweighting each observation by the propensity score, as outlined by Hirano, Imbens, and Ridder (2003). This gives qualitatively similar results, which we report in Appendix A.

[12]Chandra and Collard-Wexler (2009) use propensity score matching to study the impact of (endogenous) merger decisions on prices in the Canadian newspaper industry.

influences the regulatory environment. Second, we control for the most important source of demand-side variation in prices (i.e., population, population density) as well as controlling for a key determinant of ownership (i.e., distance to the grid). The potential for remaining unobservables to bias our estimates is further limited by inclusion of state dummy variables.

5 Results

We discuss our results in three parts. First, in Section 5.1, we discuss the determinants of ownership structure and diagnostics related to constructing the propensity score. A key contribution of this section is to identify the number of "marginal" consumers served by publicly-owned utilities based on distance to the transmission grid. In Section 5.2 we present our results for the impact of ownership type on residential electricity prices and show how the comparison of public and private utilities serving similar markets affects estimates of the price difference by ownership type and usage. Finally, in Section 5.3, we combine the results from sections 5.1 and 5.2 for an estimate of the aggregate implications of public versus private ownership and discuss the magnitude in the context of contemporary policies (i.e., the Rural Electrification Administration and Tennessee Valley Authority).

5.1 What determines ownership structure?

The results from estimating equation (1) using a probit regression are shown in Table 2. Column 1 includes only the fourth-order polynomial in market i's distance to the transmission grid; column 2 adds $\mathbf{X}_i$ excluding the indicator for state regulation; column 3 adds the indicator for state regulation; and column 4 replaces state regulation with state dummy variables. The results follow closely the differences highlighted in Table 1. Population is associated with a lower probability of private ownership and density is associated with a higher probability. Neither county or local tax revenue (in 1880 dollars) is statistically significant. A higher share of the population employed in the wholesale sector decreases the probability of private ownership, while a higher share in manufacturing increases the probability. Taken together, this pattern provides support for contracting theories relative public interest theories.

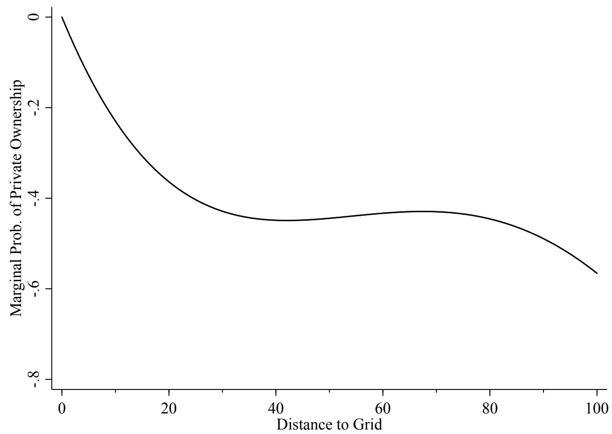
An important contribution of this study is to disentangle the effect of ownership from the effect of regulation. Nevertheless, it is interesting to note the influence that regulation has on the ownership decision and then, as we discuss in Section 5.2, how the effect of ownership on prices differs across regulatory regimes. Column 3 shows that state regulation is associated with increased probability of private ownership. The marginal effect of switching to state regulation is to increase the probability of private ownership by 2.7 percentage points. Also, recall that our sample is limited to utilities serving markets with less than 5,000 people.

Table 2: Probit Regression for Determinants of Ownership Type

	(1)	(2)	(3)	(4)
Miles to Transmission Grid	-0.0287	-0.0295	-0.0279	-0.0254
	(0.0042)	(0.0044)	(0.0045)	(0.0049)
Miles to Transmission Grid^2 $\div$ 10^2	0.0628	0.0644	0.0604	0.0622
	(0.0134)	(0.0139)	(0.0139)	(0.0148)
Miles to Transmission Grid^3 $\div$ 10^4	-0.0526	-0.0535	-0.0507	-0.0502
	(0.0136)	(0.0139)	(0.0140)	(0.0145)
Miles to Transmission Grid^4 $\div$ 10^6	0.0129	0.0130	0.0124	0.0120
	(0.0041)	(0.0042)	(0.0042)	(0.0043)
Population (thousands)		-0.1980	-0.1993	-0.2360
		(0.0138)	(0.0139)	(0.0145)
Population (thousands) Per Mile^2		0.2421	0.2296	0.1769
		(0.0865)	(0.0852)	(0.0799)
County Tax Revenue Per Capita in 1880		-0.0382	-0.0331	-0.0148
		(0.0140)	(0.0143)	(0.0163)
Local Tax Revnue Per Capita in 1880		-0.0009	-0.0057	0.0236
		(0.0110)	(0.0113)	(0.0212)
Retail Emp. Share in 1935		-0.0166	-0.0075	0.0673
		(0.0160)	(0.0167)	(0.0381)
Wholesale Emp. Share in 1935		-0.1064	-0.0992	-0.1171
		(0.0389)	(0.0398)	(0.0636)
Manufacturing Emp. Share in 1935		0.0157	0.0098	-0.0006
		(0.0048)	(0.0048)	(0.0055)
State Regulates Private Utility			0.1852	
			(0.0375)	
Constant	1.5513	1.8315	1.6894	2.4577
	(0.0312)	(0.0522)	(0.0591)	(0.1415)
State Dummy Variables	No	No	No	Yes

Notes: This table shows the results of estimating equation (1). The dependent variable is the indicator, O_i, which equals 1 for private ownership and 0 otherwise. Column 1 includes only the quadratic function in distance, $f(d_i)$; column 2 adds $\mathbf{X}_i$, excluding the state regulation indicator; column 3 adds the state regulation indicator; and column 4 replaces the state regulation indicator with state dummy variables, θ_s.
Source: See Section 3 and Table 1.

Figure 7: Distance to Transmission Grid and Private Ownership



Source: See Section 5.1 and Table 2.

These utilities' ability to influence regulation at the state level was more limited, in contrast with utilities in the largest metropolitan areas which played a substantial role in shaping regulation.[13]

Overall, the probability of private ownership is a decreasing function of distance from the transmission grid. For a better sense of the shape implied by the polynomial function for distance to the transmission grid, Figure 7 plots the relationship private ownership and the distance to the transmission grid. The slope of the function is steepest between zero and approximately 20 miles from the grid, with the majority of privately-owned utilities falling in this range. In 1935, approximately 145,000 households were between 20 and 80 miles of the transmission grid *and* served by public utilities.[14] These consumers are "marginal" in the sense that expanding the transmission grid would significantly increase their probability of receiving service from a private utility and hence their exposure to lower electricity prices. In the Section 5.2 we quantify the price effect of private versus public ownership and in Section 5.3 we provide an assessment of the aggregate effect.

Before moving on to discuss our price estimates, it is useful to present a few diagnostic tests in favor of our identification strategy based on propensity scoring matching. First,

[13]In many instances, the utilities serving individual towns or cities are connected through a common holding company. In this paper, we are primarily interested in the effect of private versus public ownership on prices. To the extent that holding companies influence regulation at the state level, our estimates of the price difference between private and public utilities may be overstated. However, in Section 5.2, we find that the price difference is larger in unregulated than in regulated states, which provides some evidence against this interpretation.

[14]This calculation is based on the population in our sample between 20 and 80 miles from the transmission grid that served by a public utility and the average family size computed from the 1930 census (Haines, 2010).

Figure A1 in Appendix A shows the frequency distribution for the number of markets served by private and public utilities at different ranges of the propensity score; the figure indicates significant overlap in the distributions. Second, the sample is well-balanced in the sense that after using the propensity score to find the nearest neighbor or reweighting observations using the propensity score typical measures of bias decrease substantially.[15]

5.2 Residential electricity prices and ownership structure

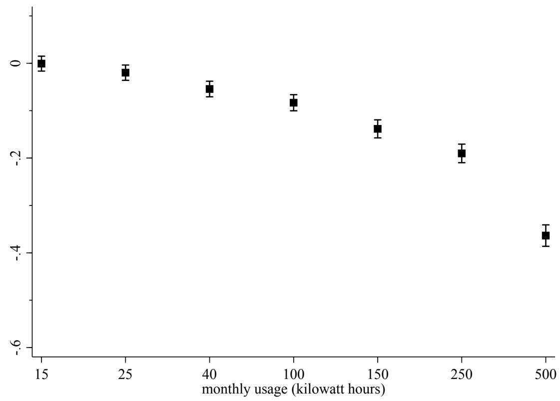
Our results for the effect ownership on prices are summarized in Figure 8. In each panel, the level of usage ℓ is on the x-axis and the estimate of τ^ℓ is on the y-axis. Panel A shows the results for the differences in average price between private and public utilities unadjusted for the propensity scores, which range from 0 percent lower at 15 monthly kilowatt hours to 36.3 percent lower at 500 monthly kilowatt hours. Panel B shows the results using only the fourth-order polynomial in distance to the transmission grid to construct the propensity score. In this specification average prices for private utilities are between 0 and 33.1 percent less than prices for public utilities over the same range. In Panel C, we control for all of the variables included in $\mathbf{X}_i$ (i.e., market characteristics and regulatory environment) and Panel D replaces the indicator for state regulation with state dummy variables.

Moving from Panel A to Panel D, the estimated price difference between private and public utilities decreases, which suggests that failure to control for market selection may produce biased estimates. After matching on the full set of covariates and state dummy variables (Panel D), there are only small differences in average prices for usages of 15 and 25 kilowatt hours per month. This is due to the fact that the minimum bill included these usage levels. Indeed, from our data we calculate that 65 percent of all markets have minimum monthly bills between 10 and 25 kilowatt hours. As a result, there was little scope for price variation.

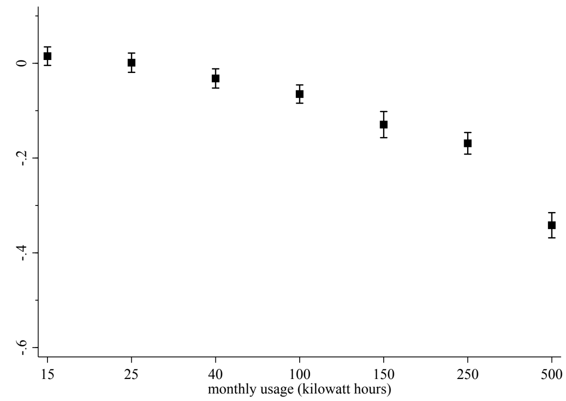
However, as usage levels increase, the price difference between private and public utilities widens: from 2.1 percent at 15 kilowatt hours per month to 33.3 percent at 500 kilowatt hours in Panel D. Peltzman (1971) notes the substantial and increasing differences between private and public utilities at higher usage levels is consistent with profit-maximizing behavior. We focus attention on consumption between 40 and 100 kilowatt hours, since this range includes average monthly usage during this time period (*New York Times*, April 19, 1926,S). Over this range prices for private utilities are between 6.7 and 9.4 percent lower than the prices charged by public utilities.

[15]For example, using our different specifications for the propensity score (see the panels of Figure 8) the median standardized bias ranges from 0 to 2.8; the mean standardized bias ranges from 0 to 3.7 (see Rosenbaum and Rubin, 1985).

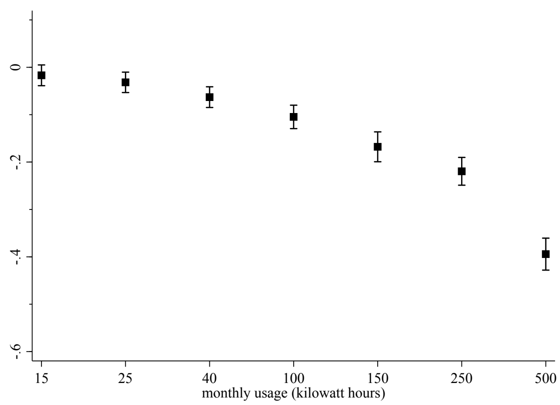
Figure 8: Price Effect of Private versus Public Ownership



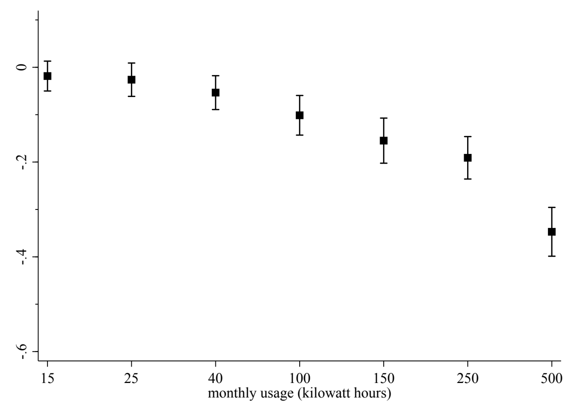
A. Controls: None



B. Controls: $f(d_i)$



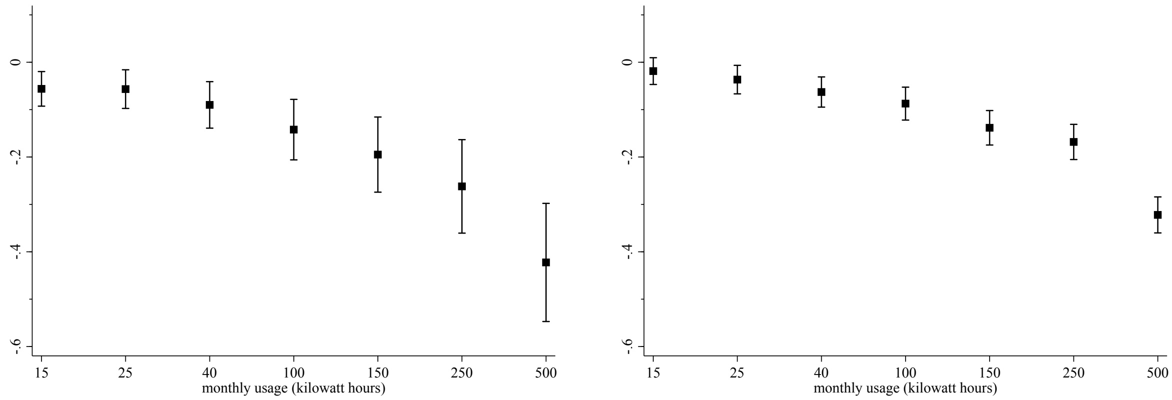
C. Controls: $f(d_i), \mathbf{X}_i$



D. Controls: $f(d_i), \mathbf{X}_i, \theta_s$

Notes: The figure shows estimates from different specifications of equation (2). The dependent variable is log of average price in market i at usage level ℓ, $\log P_i^\ell$. Panel A shows the percent difference between private and public utilities without adjusting for covariates; Panel B adds the quadratic function in distance, $f(d_i)$; Panel C adds $\mathbf{X}_i$, both market characteristics and the state regulation indicator; Panel D replaces the state regulation indicator with state dummy variables, θ_s.
Source: See Section 3 and Table 1.

Figure 9: Price Effect of Private versus Public Ownership by Regulatory Status



A. Unregulated B. Regulated

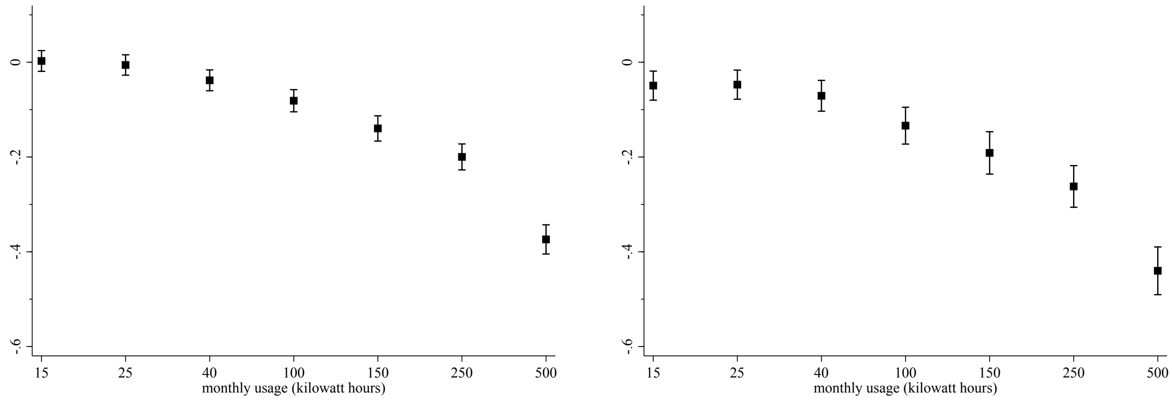
Notes: The figure shows estimates of equation (2) by regulatory status. The dependent variable is log of average price in market i at usage level ℓ, $\log P_i^\ell$. Panel A shows the results for states that do not regulate privates rates and Panel B shows the results for states that do regulate private rates. The specifications includes the following covariates: $f(d_i)$, $\mathbf{X}_i$, and θ_s.
Source: See Section 3 and Table 1.

These results reflect the combined effect of markets in regulated and unregulated states. The results from re-estimating the price difference between private and public utilities separately for regulated and unregulated states are shown in Figure 9.[16] In the first row, we present results for towns and cities located in unregulated states and the second row contains the results for regulated states. The estimated magnitudes of private ownership are larger in unregulated versus regulated states (i.e., the price difference between private and public utilities is more negative in unregulated states). This pattern may arise from the fact that contracts in unregulated states were less secure than in regulated states. This increased the threat of entry and hence competition. Alternatively, utilities in regulated markets face different incentives. For example, the tendency of regulated firms to over-invest (Averch and Johnson, 1962) or bureaucratic drift (see McCubbins, Noll, and Weingast, 1987; Troesken, 2006) may lead private utilities to charge higher prices.

In addition, as robustness checks we consider the sensitivity of our estimates to changes in utility policy during the New Deal and the population cutoff of town and cities in our sample. First, the New Deal led to a variety of changes to electricity markets during the 1930s including the Tennessee Valley Authority, the Rural Electrification Administration, the creation of the Bonneville Power Administration, and the passage of the Public Utility Holding Company Act. Most of these projects did not begin until after our data were col-

[16] Among the contiguous states, Colorado, Delaware, Florida, Iowa, Kansas, Michigan, Minnesota, Mississippi, South Dakota, and Texas are unregulated.

Figure 10: Robustness of Price Effect of Private versus Public Ownership



A. Exclude TVA States B. Include Towns & Cities $< 1,000$ Only

Notes: The figure shows the results of two robustness checks. The dependent variable is log of average price in market i at usage level ℓ, $\log P_i^\ell$. Panel A shows the results for dropping states included in the service area of the Tennessee Valley Authority (i.e., Alabama, Mississippi, Tennessee) by 1935. Panel B shows the results for dropping towns and cities with population greater than 1,000. The specifications includes the following covariates: $f(d_i)$ and $\mathbf{X}_i$.
Source: See Section 3 and Table 1.

lected: the Rural Electrification Administration was established in 1935 and the Bonneville Power Administration in 1937. The Public Utility Holding Company Act was passed in 1935, but not upheld in the courts until 1943.

Thus, for New Deal era policies we focus on the effect of the Tennessee Valley Authority. Prior to 1933, when the TVA was enacted, there was concern that private utilities in the TVA region were preemptively cutting their rates. To check that our estimates are not affected by the TVA, we drop towns and cities located in states included in the TVA's service area (i.e., Alabama, Mississippi, and Tennessee), then re-estimate τ^ℓ. The results in Figure 10A show that the estimates are qualitatively unchanged. This is consistent with Kitchens (2014), who provides evidence that private utilities were not lowering rates in response to the threat of the TVA.

Another issue is related to using the population cutoff of 5,000. This choice was motivated by concern that larger towns and cities were more able to influence the construction of high voltage transmission lines as well as state regulation. Indeed, our discussion in Section 2, emphasizes the role of the nation's largest cities and regional centers in decisions about grid expansion. To ensure that our results are not sensitive to this choice, we re-estimate equation (2) after dropping towns and cities with population less than 1,000. The results, shown in Figure 10B, are similar.

5.3 Interpretation

The results we have presented so far are robust to a variety of different specifications.[17] In this section our goal is to provide an estimate of changes in the potential gains associated with private ownership. To do this, we focus on private ownership that would have resulted from expansion of the transmission grid. In particular, from our preferred specification of the price effect we find that private utilities charge prices 6.7 and 9.4 percent lower than public utilities at 40 and 100 kilowatt hours per month, respectively. We also note that a number of consumers are "marginal" in the sense that expanding the transmission grid would significantly increase their probability of receiving service from a private utility. Assuming the average family size is four during this time period there were 145,000 "marginal" households between 20 and 80 miles from the transmission grid.

Now consider the average monthly bill for public utilities between 20 and 80 miles from the transmission grid at usages of 40 and 100 kilowatt hours, which are shown in column 1 of Panel A in Table 3. Column 2 shows the actual monthly bill for public utilities between 20 and 80 miles from the transmission grid. Based on our estimates of the price effect at these usages, column 3 shows the monthly bill implied by expanding the transmission grid and inducing a switch from public to private ownership. Multiplying the difference between the actual and discounted bills by the number of households gives the monthly savings, which is shown in column 5. Annual savings are shown in column 6 and equal $7.8 million at 40 kilowatt hours per month and $19.0 million at 100 kilowatt hours per month. Panel B shows alternative estimates counting as "marginal" only those households between 40 and 80 miles from the transmission grid.

For some context, consider the upper bound estimate of $19.0 million estimates relative to the size of government programs during the 1930s aimed at expanding access to electricity. Between 1935 and 1940, the Rural Electrification Administration (REA) loaned cooperatives $786.5 million annually (in 2014 dollars). Thus, at our upper bound, yearly consumer savings, expanding the transmission grid amounts to 2.4 percent of annual REA appropriations. Alternatively, between 1933 and 1940, average annual appropriations for the TVA were $689.0 million per year (in 2014 dollars). Based on our upper bound estimate, annual savings translate to 2.8 percent the TVA's annual budget.[18]

[17]In Section 5.2 we showed the robustness of our results to excluding town and cities potentially treated by service under the Tennessee Valley Authority and restricting our sample to communities with population less than 1,000. In addition, in the appendix, re-specifying the price variable in levels does not alter our conclusions and, alternatively, using inverse probability weighting to implement our matching estimator produces similar results.

[18]The figures for REA and TVA are authors' calculations from Slattery (1940) and the annual reports of the Tennessee Valley Authority between 1933 and 1940, respectively.

Table 3: Impact of Expanding the Transmission Grid to Serve "Marginal" Households

Usage (in kilowatt hours) (1)	Actual Monthly Bill (2)		Discounted Monthly Bill (3)		Number of Households (4)		Monthly Savings (5)		Annual Savings (6)
A. Between 20 and 80 miles from transmission grid									
40:	($66.64	−	$62.17)	×	145,000	=	$647,525	⟹	$7,769,100
100:	($116.06	−	$105.15)	×	145,000	=	$1,581,950	⟹	$18,983,400
B. Between 40 and 80 miles from transmission grid									
40:	($67.69	−	$63.15)	×	55,000	=	$249,700	⟹	$2,996,400
100:	($116.41	−	$105.45)	×	55,000	=	$602,800	⟹	$7,233,600

Notes: This table shows how the price difference between private and public utilities would effect "marginal" households in markets that would switch from public to private provision following an expansion of the transmission grid. The table shows these calculations under two scenarios. Panel A shows the results of expanding the transmission grid so that households between 20 and 80 miles would be be served by private utilities. Panel B shows the same calculations for expanding the grid to those between 40 and 80 miles. All monetary values are in 2014 dollars. For additional details, see text of Section 5.3.

Finally, consider the savings relative to the cost of constructing the transmission grid. In 1927, the project to interconnect Pennsylvania and New Jersey cost $348 million for 208 miles of transmission line and the required substations (*New York Times*, September 27, 1927). Similarly, in 1933, the connection between the Mohawk Valley and New York City spanned over 200 miles and costs about $270 million (*New York Times*, April 13, 1933). Given these costs, the monthly savings of switching from public to private ownership could be used to construct approximately one additional mile of high voltage transmission line and related infrastructure. These savings were potentially larger when compounded over the lifetime of the transmission grid.[19]

Our analysis quantifies the potential benefits of transmission grid expansion that would accrue through lower prices charged by privately-owned electricity utilities. In addition, the historical narrative highlights the benefits of interconnection via the grid in terms of movement from partial to full-day service, reduced interruptions (e.g., due to weather), and lower peak-load capacity requirements. Indeed, for the United States more recently, Davis and Hausman (2014) give an estimate of $380 million as the value of additional transmission capacity in the California market.[20] Davis and Wolfram (2012) and Hausman (2014) point to the positive effects of private ownership on operating performance and safety conditions

[19] A recent report by the Bonneville Power Administration (2012) estimates the share of circuit miles of steel lines over forty years old to be 60 percent.

[20] In the case of India, Alcott, Collard-Wexler, and O'Donnell (2014) quantify the losses that result from unreliable service to be 5 percent of revenue.

in the context of nuclear generation.

Compared to contemporary federal government programs, increased access through the grid avoided the potential costs, for example, associated with dam construction under the Tennessee Valley Authority.[21] At the local level, grid expansion meant that privately-owned facilities were less susceptible to expropriation in the form of bribes or onerous regulation on the part of local politicians.[22] Today, public ownership is increasingly utilized or threatened in order to satisfy local preferences (Cardwell, March 13, 2013). This paper's results suggest that changes in ownership should be made in light of higher prices charged by publicly-owned utilities as well as the potential foregone benefits of interconnection.

6 Conclusion

Innovation that allowed electricity utilities to centrally generate and transmit power over increasing distances led to substantial changes in the access to and price of retail electricity during the 1920s and 1930s. Improved transmission technology provided customers with all-day service, while interconnection reduced the risk of outages and allowed utilities to smooth peak-load demand across space. Furthermore, proximity to the transmission grid reduced the risk that industry-specific, non-redeployable capital would be expropriated or damaged by local politicians. Over time, these factors combined to make smaller markets increasingly attractive for private utilities.

In the 1930s, private utilities sought to integrate their generators with the largest markets. In this setting, we study the relationship between electricity prices and whether a utility is privately or publicly owned. Although there is a large literature that examines the impact of ownership type on the provision, efficiency, and pricing of utility services, previous studies utilize data that cannot distinguish the impact of ownership from the role of the regulation. In this paper, we compile new data on electricity rates in 1935. In our empirical analysis, we use propensity score matching to address the the selection of utilities by ownership type into particular markets. Specifically, we enforce comparisons between similar markets in terms of proximity to the transmission grid as well as demographic, economic, and regulatory characteristics.

In our preferred specification, which restricts comparisons to public and private utilities

[21] Kline and Moretti (2014) provide some evidence that the post-1940 benefits of the TVA were greater than the fiscal costs. However, Kitchens (2013) shows that TVA dam construction increased malaria rates, with costs due to mortality estimated to be $340 million (in 2009 dollars) and due to morbidity to be $1.7 million.

[22] Neufeld (2008) discusses the historical context for adoption of state regulation of publicly-owned utilities as a check on municipal corruption. His interpretation is also consistent with Knittel (2006). Troesken (1997) and Troesken and Geddes (2003) discuss similar evidence for gas and water utilities.

with similar market characteristics within a given state, we find that prices for private utilities were lower than for public utilities. For typical household usages during the period (i.e., between 40 and 100 kilowatt hours), privately-owned utilities charged prices between 6.7 and 9.4 percent lower than publicly-owned utilities. The implied aggregated savings for "marginal" customers (i.e., customers that would have benefited from the prices charged by private utilities following an expansion of the transmission grid) are between $7.8 and $19.0 million annually (in 2014 dollars).

Finally, our results are relevant for communities considering a switch from private to public provision of electricity services. In particular, as these communities gain greater control and the potential to satisfy local preferences through public ownership, our findings suggest this may lead to higher prices. In addition, the historical narrative highlights the critical role the transmission grid played in moving to full-day service, decreased service interruptions, and reduced peak-load capacity requirements. These benefits are also relevant as policy makers consider the value of improving the grid and weigh this against alternatives of moving toward new forms of generation, transmission, and distribution.

References

Alberto Abadie and Guido W. Imbens. Large sample properties of matching estimators for average treatment effects. *Econometrica*, 74(1):235–267, 2006.

Alberto Abadie and Guido W. Imbens. Bias-corrected matching estimators for average treatment effects. *Journal of Business & Economic Statistics*, 29(1):1–11, 2011.

Alberto Abadie and Guido W. Imbens. Matching on the estimated propensity score. Working Paper, 2012.

Armen Alchian. Some economics of property rights. *II Politico*, 30(4):816–829, 1965.

Hunt Alcott, Allan Collard-Wexler, and Stephen O'Donnell. How do electricity shortages affect productivity? evidence from india. NBER Working Paper 19977, 2014.

Scott Atkinson and Robert Halvorsen. The relative efficiency of public and private firms in a regulated environment: The case of us electric utilities. *Journal of Public Economics*, 29(3):281–294, 1986.

Harvey Averch and Leland L. Johnson. Behavior of the firm under regulatory constraint. *American Economic Review*, 52(5):1052–1069, 1962.

Anthony E. Boardman and Aidan R. Vining. Ownership and performance in competitive environments: A comparison of the performance of private, mixed, and state-owned enterprises. *Journal of Law and Economics*, 32(1):1–33, 1989.

Frank Bohn. Water power reaches out for new empire. *New York Times*, page 25, July 4, 1926.

Bonneville Power Administration. Steel lines, sustain program, asset management strategy, 2012. URL `https://www.bpa.gov/`.

Diane Cardwell. Cities weigh taking over from private utilities. *New York Times*, March 13, 2013.

Ambarish Chandra and Allan Collard-Wexler. Mergers in two-sided markets: An application to the canadian newspaper industry. *Journal of Economic and Management Strategy*, 18 (4):1045–1070, 2009.

Evans Clark. Giant power transforming america's life. *New York Times*, page 21, February 22, 1925.

Lucas Davis and Catherine Hausman. The value of transmission in electricity markets: Evidence from a nuclear power plant closure. NBER Working Paper 20186, 2014.

Lucas W. Davis and Catherine Wolfram. Deregulation, consolidation, and efficiency: Evidence from us nuclear power. *American Economic Journal: Applied Economics*, 4(4): 194–225, 2012.

Herbert B. Dorau. *The Changing Character and Extent of Municipal Ownership in the Electric Light and Power Industry.* The Institute for Research in Land Economics and Public Utilties, 1930.

William M. Emmons. Franklin d. roosevelt, electric utilities, and the power of competition. *Journal of Economic History*, 53(4):880–907, 1993.

William M. Emmons. Implications of ownership, regulation, and market structure for performance: Evidence from the us electricity utility industry before and after the new deal. *Review of Economics and Statistics*, 79(2):279–289, 1997.

Rolf Färe, Shawna Grosskopf, and James Logan. The relative performance of publicly-owned and privately-owned electric utilities. *Journal of Public Economics*, 26(1):89–106, 1985.

Federal Power Commission. *Electric Rate Survey*. Government Printing Office, Washington, DC, 1935a.

Federal Power Commission. *National Power Survey Interim Report, Power Series No. 1*. Government Printing Office, Washington, DC, 1935b.

Federal Power Commission. *Electric Rate Survey: State Commission Jurisdiction and Regulation of Electric Rates and Service. Rate Series No. 6*. Government Printing Office, Washington, DC, 1935c.

Victor Goldberg. Regulation and administered contracts. *Bell Journal of Economics*, 7(2): 426–452, 1976.

Michael R. Haines. *Historical, Demographic, Economic, and Social Data: The united States, 1790-2000*, volume ICPSR02896-v3. Inter-university Consortium for Political and Social Research [distributor], Ann Arbor, MI, 2010.

Catherine Hausman. Corporate incentives and nuclear safety. *American Economic Journal: Economic Policy*, 6(3):178–206, 2014.

William J. Hausman and John L. Neufeld. Property rights versus public spirit: Ownership and efficiency of u.s. electric utilities prior to rate-of-return regulation. *Review of Economics and Statistics*, 73(3):414–423, 1991.

William J. Hausman and John L. Neufeld. The market for capital and the origins of state regulation of electric utilities in the united states. *Journal of Economic History*, 62(4): 1050–1073, 2002.

Keisuke Hirano, Guido W. Imbens, and Geert Ridder. Efficient estimation of average treatment effects using the estimated propensity score. *Econometrica*, 71(4):1161–1189, 2003.

Koichiro Ito. Do consumers respond to marginal or average price? evidence from nonlinear electricity pricing. *American Economic Review*, 104(2):537–563, 2014.

Paul L. Joskow. Restructuring, competition and regulatory reform in the u.s. electricity sector. *Journal of Economic Perspective*, 11(3):119–138, 1997.

Carl Kitchens. A dam problem: Tva's fight against malaria, 1926-1951. *Journal of Economic History*, 73(3):694–724, 2013.

Carl Kitchens. The role of publicly provided electricity in economic development: The experience of the tennessee valley authority, 19291955. *Journal of Economic History*, 74 (2):389–419, 2014.

Patrick Kline and Enrico Moretti. Local economic development, agglomeration economies and the big push: 100 years of evidence from the tennessee valley authority. *Quarterly Journal of Economics*, 129(1):forthcoming, 2014.

Christopher R. Knittel. The adoption of state electricity regulation: The role of interest groups. *Journal of Industrial Economics*, 54(2):201–222, 2006.

Brian Levy and Pablo T. Spiller. The institutional foundations of regulatory commitment: A comparative analysis of telecommunications regulation. *Journal of Law, Economics, and Organization*, 10(2):201–246, 1994.

Glenn Marston. Shortcomings of municipal plants. *National Electric Light Association*

Bulletin, 3(10):821–823, 1916.

Mathew D. McCubbins, Roger G. Noll, and Barry Weingast. Administrative procedures as instruments of political control. *Journal of Law, Economics, and Organization*, 3(2): 243277, 1987.

Robert A. Meyer. Publicly owned versus privately owned utilities: A policy choice. *Review of Economics and Statistics*, 57(4):391–399, 1975.

National Atlas of the United States. Cities and towns of the united states, 2004. URL `http://nationalatlas.gov/`.

National Electric Light Association. *Political Ownership and Electric Light and Power Industry*. National Electric Light Association, New York, 1925.

Leland G. Neuberg. Two issues in the municipal ownership of electric power distribution systems. *Bell Journal of Economics*, 8(1):303–323, 1977.

John L. Neufeld. Corruption, quasi-rents, and the regulation of electric utilities. *Journal of Economic History*, 68(4):1059–1097, 2008.

New York Times. Big power tie-up to be finished now. page 25, April 13, 1933.

New York Times. Electric rates cut 76 times in 3 years. page 32, April 19, 1926.

New York Times. Big plants turn to water power. page E2, January 21, 1923.

New York Times. Find way to end power shortage. page E17, January 24, 1926.

New York Times. Superpower links north with south. page E1, October 2, 1927.

New York Times. Biggest power pool to serve 2 states. page 1, September 27, 1927.

New York Times. 1.7/ page N15, September 7, 1930.

Pacific Service Magazine. Leading features of achievemnt by which "pacific service," during the past year, aided materially in the development and prosperity of the territory covered by its operations. 14:343–347, June 1922.

Sam Peltzman. Pricing in public and private enterprises: Electric utilities in the united states. *Journal of Law and Economics*, 14(1):109–147, 1971.

Sam Peltzman. Toward a more general theory of regulation. *Journal of Law and Economics*, 19(2):211–240, 1976.

Arthur Cecil Pigou. *The Economics of Welfare*. Macmillan and Co., London, 1932.

George L. Priest. The origins of utility regulation and the 'theories of regulation'. *Journal of Law and Economics*, 36(2):289–323, 1993.

Paul R. Rosenbaum and Donald B. Rubin. The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1):41–55, 1983.

Paul R. Rosenbaum and Donald B. Rubin. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician*, 39(1):33–38, 1985.

David Schap. *Municipal Ownership in the Electric Utility Industry*. Praeger Publishers, 1986.

Harry Slattery. *Rural America Lights Up*. National Home Library Foundation, Wasington, DC, 1940.

George J. Stigler. The theory of economic regulation. *Bell Journal of Economics and Management Science*, 2:3–21, 1971.

George J. Stigler and Claire Friedland. What can regulators regulate? the case of electricity. *Journal of Law and Economics*, 5:1–16, 1962.

Tennessee Valley Authority. *Annual Report*. Gvoernment Printing Office, Washington, DC, 1934.

Werner Troesken. The sources of public ownership: Historical evidence from the gas industry. *Journal of Law, Economics, and Organization*, 13(1):1–25, 1997.

Werner Troesken. Regime change and corruption: A history of public utility regulation. In Edward L. Glaeser and Claudia D. Goldin, editors, *Corruption and Reform: Lessons from America's Economic History*. University of Chicago Press, Chicago, 2006.

Werner Troesken and Rick Geddes. Municipalizing american waterworks, 1897-1915. *Journal of Law, Economics, and Organization*, 19(2):373–400, 2003.

US Census Bureau. *Census of Electrical Industries: Central Electric Light and Power Stations*. Government Printing Office, Washington, DC, 1902.

US Census Bureau. *Census of Electrical Industries: Central Electric Light and Power Stations*. Government Printing Office, Washington, DC, 1917.

US Census Bureau. *Census of Electrical Industries: Central Electric Light and Power Stations*. Government Printing Office, Washington, DC, 1922.

US Census Bureau. *Census of Electric Light and Power Plants*. Government Printing Office, Washington, DC, 1927.

US Census Bureau. *Census of Electrical Industries: Central Electric Light and Power Stations*. Government Printing Office, Washington, DC, 1932.

US Census Bureau. *Census of Electrical Industries: Central Electric Light and Power Stations*. Government Printing Office, Washington, DC, 1937.

Oliver E. Williamson. *The Economic Institutions of Capitalism*. Free Press, New York, 1985.

Gavin Wright. Anthracite coal production, employment, foreign trade, and average value, 1808-2000. In Susan B. Carter, Scott Sigmund Gartner, Michael R. Haines, Alan L. Olmstead, Richard Sutch, and Gavin Wright, editors, *Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition*. Cambridge University Press, Cambridge, UK, 2006.

A Additional Tables

Figure A1: Histogram for Propensity Score of Private versus Public Observations

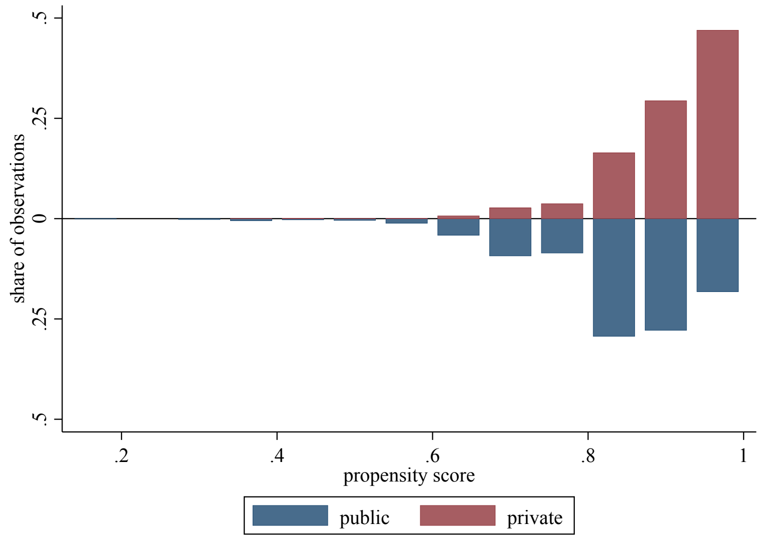
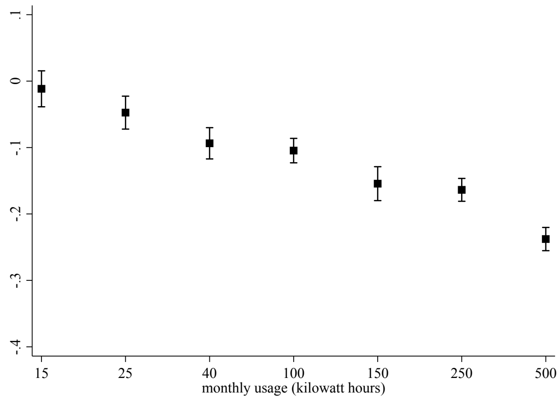
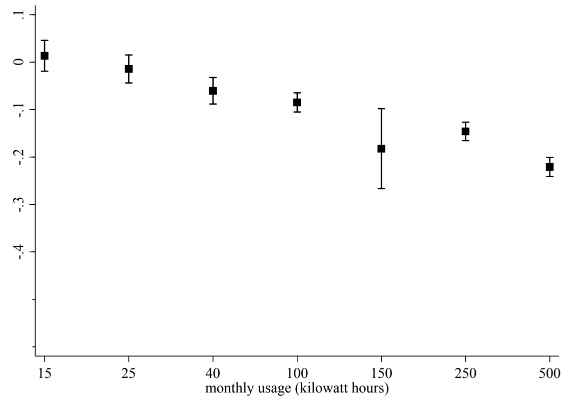


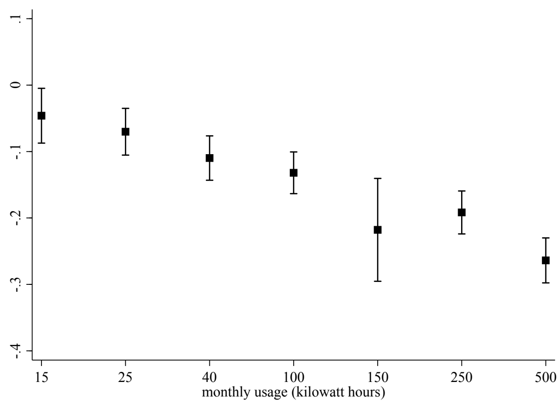
Figure A2: Price Effect of Private versus Public Ownership (in levels)



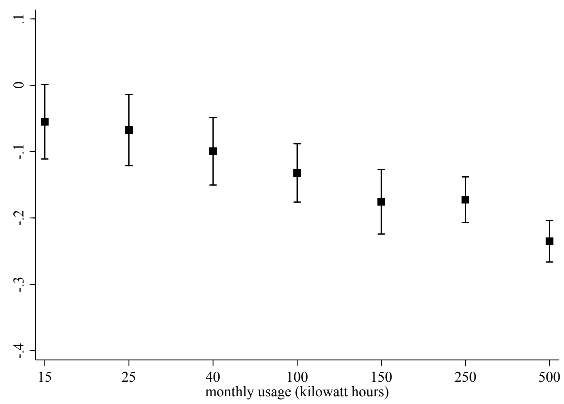
A. Controls: None



B. Controls: $f(d_i)$



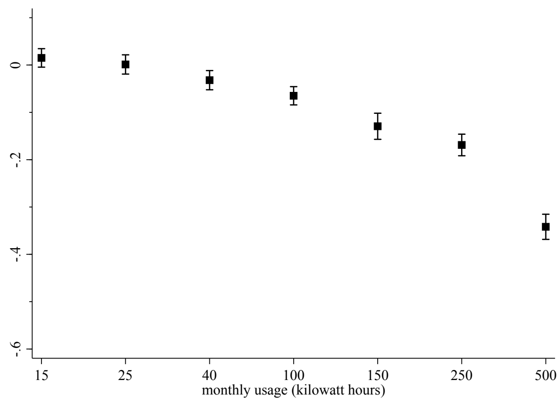
C. Controls: $f(d_i), \mathbf{X}_i$



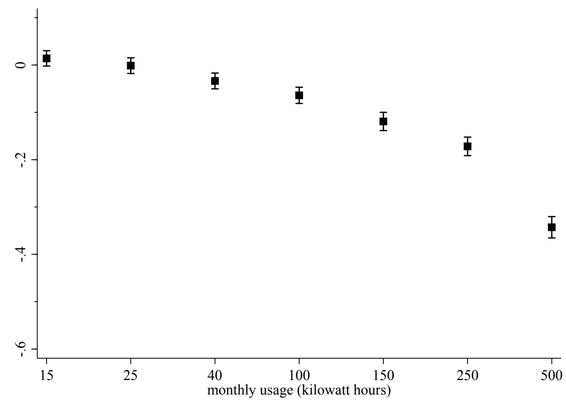
D. Controls: $f(d_i), \mathbf{X}_i, \theta_s$

Notes: The figure shows estimates from different specifications of equation (2). The dependent variable is average price in market i at usage level ℓ, P_i^ℓ. Panel A shows the percent difference between private and public utilities without adjusting for covariates; Panel B adds the quadratic function in distance, $f(d_i)$; Panel C adds $\mathbf{X}_i$, both market characteristics and the state regulation indicator; Panel D replaces the state regulation indicator with state dummy variables, θ_s.
Source: See Section 3 and Table 1.

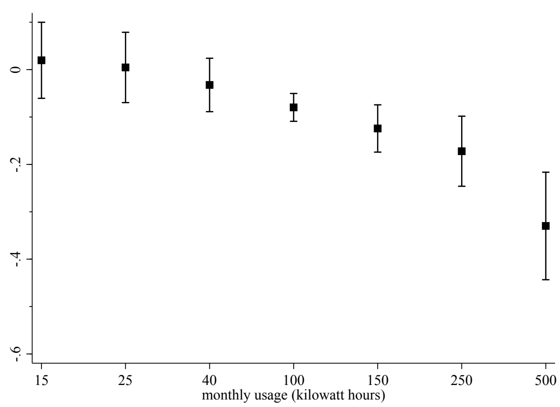
Figure A3: Price Effect of Private versus Public Ownership (inverse probability weighting)



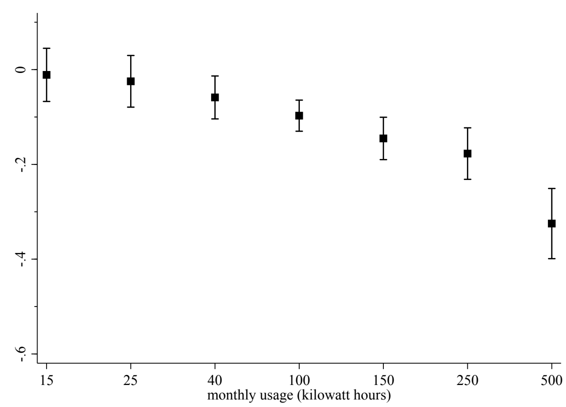
A. Controls: $f(d_i)$



B. Controls: $f(d_i)$



C. Controls: $f(d_i), \mathbf{X}_i$



D. Controls: $f(d_i), \mathbf{X}_i, \theta_s$

Notes: The figure shows estimates from different specifications of equation (2) using inverse probability weighting. The dependent variable is log of average price in market i at usage level ℓ, $\log P_i^\ell$. Panel A shows the percent difference between private and public utilities without adjusting for covariates (same as Panel A in Figure 8); Panel B adds the quadratic function in distance, $f(d_i)$; Panel C adds $\mathbf{X}_i$, both market characteristics and the state regulation indicator; Panel D replaces the state regulation indicator with state dummy variables, θ_s.
Source: See Section 3 and Table 1.