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ABSTRACT

In this paper, we quantify the difference between public and private prices of residential electricity immediately before and after major federal reforms in the 1930s and 1940s. Previous research found that public prices were lower in a sample of large, urban markets. Based on new data covering over 15,000 markets and nearly all electricity generated for residential consumption, we find the difference between public and private prices was small in 1935 and negligible in 1940 for typical levels of monthly consumption. These findings are consistent with a market for ownership that helped to discipline electricity prices during this period. That is, private rents were mitigated by the threat that municipalities would use public ownership to respond to constituent complaints and public rents were limited by electoral competition and the growth of private provision.

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1 Introduction

Private utilities account for the vast majority of electricity sales in the United States today. Nevertheless, publicly-owned utilities still substantially outnumber privately-owned utilities. This highlights the ability of policymakers to choose between public or private provision, which may impact the welfare of final consumers due to different incentives for extending service and price setting. For example, public utilities may respond to political pressure to extend service to important constituencies or use pricing to increase reelection chances (Peltzman, 1971).[1] Alternatively, profit-maximizing private utilities with exclusive territories may use monopoly pricing in the absence of regulation (Joskow and Schmalensee, 1986) or market segmentation and quantity discounts to price discriminate (Peltzman, 1971). Access to private ownership may have implications for the quality of service, technology adoption, and pricing (Rose and Joskow, 1990; Joskow, 1997).

Widespread federal regulation of the US electricity industry first began as part of the New Deal during the 1930s, inspired by the perception that private, investor-owned utilities used monopoly pricing, limited access, and evaded regulation at the state level. This paper contributes to the literature on role of ownership in determining retail electricity prices by examining the period immediately before and after reforms implemented under Franklin Delano Roosevelt. Earlier work on this period found that public utilities serving large urban markets tended to have lower prices than private utilities (Emmons, 1997). However, this work relied on a sample of urban markets and limited information on prices. We use newly digitized data from Federal Power Commission reports to revisit the evidence for these claims and understand the relationship between ownership and prices faced by residential consumers. In particular, our data cover 99 percent of retail electricity for over 15,000 markets in 1935 and 1940.[2] These comprehensive data allow us to include geographic controls for differences in cost and demand at the local level, which were absent from previous studies.[3]

In 1935, we find that public utilities charged lower prices than private utilities when monthly consumption was below 100 kilowatt hours (kWh), while private utilities tended to provide large quantity discounts. Specifically, at 15 monthly kWh, the price per kWh of public utilities was 6.7 percent lower than private utilities. The public-private price difference decreases to 5.7 percent at 25 kWh per month, 2.3 percent at 40 kWh, and disappears at

[1] Baskaran, Min, and Uppal (2012) and Min and Golden (2014) provide relevant evidence on politics and pricing for modern-day India.

[2] Markets range in size from small communities with at least 250 residents to large urban centers.

[3] For example, we control for county fixed effects as well as market level variables such as distance to the transmission grid, distance to generation facilities, and generation mix.

100 kWh. At 250 and 500 kWh per month the pattern reverses and public prices are 11.5 and 28.1 percent *higher*, respectively.[4] We also use data for 1940 to confirm that five years later price differences between public and private utilities were smaller, which suggests the similarity between public and private in the mid-1930s was not an artifact of the Great Depression.

These findings suggest that the threat of switching ownership types was an important feature disciplining electricity prices prior to the implementation of New Deal reforms. On the one hand, private monopoly rents were limited by the potential that local municipalities would take over ownership in the face of constituent complaints. While on the other hand, public rents were mitigated through electoral competition or increased demand for private provision. Ultimately, the prices faced by customers under the two types of ownership were similar.

Importantly, competition through ownership was only possible when technology relaxed the natural monopoly constraints on the industry and regulation maintained flexibility in organizational form. In particular, increased generation capacity and the expansion of the transmission grid that started in the late nineteenth century were central to the emergence of an active market for ownership during this period. This enabled private utilities to replace the substantial investment in local generation capacity, which could be coopted by opportunistic local politicians, with smaller investments to connect the town or city via the transmission grid (Neufeld, 2015).[5] In addition, during this period regulation moved from the local to the state level, which lowered borrowing and regulatory costs (Hausman and Neufeld, 2002; Knittel, 2006). Thus, communities that would have initially only obtained access through public provision were able to attract private ownership.

Policymakers today are faced with restructuring to address improvements in technology (e.g., Wald, October 19, 2014), growing concerns about the impact of climate change (e.g., Cardwell, March 13, 2013), and increasing demand (e.g., *The Economist*, February 27, 2016). During the growth of the early electricity industry in the United States, both public and private utilities played a role in helping to expand access, pass on the gains from new technology (e.g., lower prices, reduced intermittency), and satisfy other customer demands (e.g., reduce corruption). Our results show that the dual role of public and private utilities in this

[4]In 1935, between 15 and 40 kWh per month was enough electricity for lighting and smaller appliances, up to 150 kWh was enough to add refrigeration, 250 kWh included cooking, and 500 kWh allowed for the hot water heating (Federal Power Commission, 1935).

[5]For example, with utilities for gas and water Troesken (1997), Troesken and Geddes (2003), and Troesken (2006) discuss the benefits of ameliorating local corruption by removing regulation to the state level.

process did not lead to substantial differences in prices faced by residential consumers. Our findings also suggest important benefits from maintaining contractual flexibility.

2 Growth of the Early Electricity Industry

The retail electric light industry was 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 to homes and businesses near the plant. At first, delivery was limited to homes within approximately one mile of the central station. Between 1881 and 1900 the number of central service stations increased from 8 to over 3,000.

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.

In subsequent decades, investment and revenue increased dramatically: roughly fifty-fold in each case (US Census Bureau, 1932). This was accompanied by the development of conductive materials and technologies, particularly related to high voltage transmission over large distances. For example, in 1922 California's Pacific Gas and Electric constructed the first 220 kilovolt transmission line from Pit River in the Sierra-Nevada Mountains to the San Francisco Bay Area. The increase in voltage allowed a fourfold increase in power to the city and was transmitted over 200 miles with minimal load losses (*Pacific Service Magazine*, 1922, p. 345). Innovations such as these led to significant changes in industry structure throughout the 1920s (Schap, 1986).

Contemporary accounts highlight the relationship between ownership and growth of economies of scale in generation and the expansion of high voltage transmission lines. For example, Dorau (1930) writes,

> 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.

These improvements provided incentives for once isolated utilities to take advantage of efficiencies through joint operation, technical planning, siting, and smoothing of peak load requirements. Savvy entrepreneurs took this opportunity to consolidate operations. For instance, Thomas Martin, head of the Alabama Power Company, worked to create a geographically integrated system in the Alabama and in the Southeast more broadly. By 1927, Alabama Power had consolidated the fragmented holding in Alabama (Federal Trade Commission, 1931). In 1929, Martin consolidated the operations of the Alabama Power Company, Georgia Power Company, Gulf Power Company, South Carolina Power, and Mississippi Power to form Southeastern Power and Light, which covered 140,000 square miles (Taft and Heys, 2011).

This type of consolidation provided immediate benefits by altering the generation mix to run the most efficient plants at capacity and only older, less efficient plants at times of peak demand. The integrated system also made it possible to delay the construction of coal plants in Georgia via interconnection with plants in Alabama (Taft and Heys, 2011, p. 53). Other examples of this type of geographic integration exist, such as the formation of Duke Power.

In addition to growth through consolidation of private systems, notable changes were also occurring among publicly owned utilities. In particular, many municipalities abandoned systems established in the 1900s and 1910s by selling to private companies or contracting for power in the wholesale market and maintaining ownership over local distribution. Between 1912 and 1932, the fraction of public utilities generating all of their power requirement fell from 92 to 48 percent (National Electric Light Association, 1925; US Census Bureau, 1932). In 1925, the National Electric Light Association reported that over 800 municipal systems had been abandoned between 1900 and 1925. Other publicly owned utilities sold out completely, capitalizing on higher quality and lower cost service that was available through nearby private utilities. This was at least partially enabled by the presence of the transmission grid.

> A large number of transmission-line systems radiating from water-power developments and large stream-generating stations have been constructed which now serve many communities formerly dependent on isolated plants. Many of the local utilities which served these communities have been absorbed, although some preserve their entity and purchase power from the lines. This expansion of lines

> has proved a great benefit to consumers in most cases by making lower rates possible and by providing a continuous and dependable source of power. (Railroad Commission of Wisconsin, 1922, p. 13)

There were also innovations in financing that facilitated the industry's expansion. Initially, due to the limited reach of direct current systems, significant capital had to be purchased and installed before any revenue was earned. This fixed capital characteristic made it difficult for small markets to acquire capital from private investors given the high risk and exposure to local shocks. As a result, during the early expansion of the electricity industry, smaller town and cities resorted to municipal ownership.[6]

As capital markets developed, this financing constraint was relaxed as municipalities issued bonds to purchase the equipment from manufacturers or acquire equipment in exchange for an ownership stake in the local system (Hausman and Neufeld, 2002). To recoup their investment, General Electric (and others) sold stocks and bonds in local systems they acquired through the newly established subsidiary Electric Bond and Share (Buchanan, 1936). This arrangement made it possible for isolated markets to finance capital purchases and also reduced risk for investors through diversification. By 1924, Electric Bond and Share operated in 29 states and controlled shares of about 10 percent of all generating capacity in the United States (Federal Trade Commission, 1927). Thus, the holding company structure provided a way to allocate capital across space.

Finally, changes in the regulatory environment played a role in shaping the industry that emerged by the late 1930s. Between 1907 and 1935, 39 states enacted legislation creating regulatory bodies or added duties to existing commissions, shifting the burden of regulation from the local to the state level (Federal Power Commission, 1935). One outcome of this regulatory shift was that it created certainty regarding the local franchises held by electric utilities, reducing the borrowing cost for privately owned firms relative to municipally owned firms (Hausman and Neufeld, 2002). Regulation at the state level also reduced the incentives for private firms to selectively choose which customers to serve. Many states regulated the extension of distribution lines by private companies (Federal Power Commission, 1935).

[6] A contemporary describing the division between private and public incentives to extend access, wrote "Municipal plants have been established either because of the shortcomings of existing private companies or else because capital could be secured for the plants only when guaranteed by the municipality. . . . These small plants have been established as municipal plants because private capital was not available at the time for the development of such properties. The inhabitants wanted electric light, and had to pledge the community credit in order to get it. There was no choice between municipal and private ownership. It was municipal plant or nothing" (Marston, 1916).

These regulations could be very specific. For example, in Illinois all customers living within the franchise's territory were eligible for service and had to pay no money to the utility as long as they were within two pole lengths of the main distribution line (Illinois Committee on Public Utility Information, 1935, p. 20). When states implemented average rate of return regulation, the cost of serving rural areas was reduced through cross-subsidization. In Wisconsin, it was noted that,

> ...many companies were reluctant to make extensions in purely rural districts on account of the larges costs of construction and maintaining lines and the relatively small revenue obtainable. The demand for service has been persistent, however, and a system of procedure has been developed by the Wisconsin Electrical Association whereby the consumers finance the construction of lines and turn them over to the utility for maintenance and operation. Regulations governing the rates have also been devised in order that these extensions shall be self-supporting no matter what the character of territory served is. (Railroad Commission of Wisconsin, 1922, p. 13)

This was reinforced in states with large industrial sectors, where manufacturers pushed for state regulation to prevent local politicians from damaging their capital and rents through subsidies to preferred consumer classes (i.e., within residential service by income or between residential and commercial classes) (Knittel, 2006).

The historical record emphasizes the dual role of public and private ownership in extending service and responding to technological changes. In particular, although the private utilities expanded dramatically during this period, the number of public utilities was still quantitatively large. In the remainder of this paper we examine how the ownership structure that emerged by the late 1930s influenced the prices that residential customers faced under each type of ownership. We exploit the comprehensive coverage and geographic detail in our data to examine price differences by ownership type and monthly consumption levels across markets that are similar in terms of distance to the transmission grid, distance to generation facilities, and other market- and county-level characteristics.

3 Data

The data used in the empirical analysis are at the market-level for nearly all electrified communities in the United States in 1935 and 1940. 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. The survey includes the name of the market, whether electricity is provided publicly or privately, 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 and give the first comprehensive historical information on residential electricity prices at the market level. This is key to clarifying the findings from the previous literature, which rely on more aggregated data (i.e., at the state level) or selected samples (i.e., markets with population over 50,000). To examine the role of selection, our empirical analysis includes specifications that compare the differences in results based on using all markets and markets that are above (or below) a given population threshold.

The data do not report whether firms contract with other utilities for wholesale power. They also do not include how long the market has had service or the history of operation in a particular market. As a result, we can only classify the ownership type serving each market in 1935 or 1940. In addition, although the data do not contain information on marginal prices (i.e., the rate schedule) in each market, we use the typical bill at different usage levels to construct the corresponding average price at those usages. For example, in 1935 Edison Electric & Illuminating Company serving the community of Acton, Massachusetts, charged \$1.05 for a monthly usage 15 kilowatt hours, which translated to an average price per kilowatt hour of 7.0 cents; for a monthly usage of 25 kilowatt hours the bill was \$1.65, which gives a price of 6.6 cents per kilowatt hour. Specifically, for each market i we compute:

$$\text{price per kWh}_{\ell i} = \frac{\text{average bill for market } i \text{ at } \ell \text{ kWh}}{\ell \text{ kWh per month}}$$

where $\ell \in (15, 25, 40, 100, 250, 500)$ is the monthly consumption in kilowatt hours (kWh). Using average prices allows us to make comparisons between prices charged by different utilities for the same level of consumption.[7] We are also able to quantify price differences by ownership type throughout the rate schedule.[8]

We merge data from the *Electric Rate Survey* in 1935 and 1940 with the exact location of each market from the National Atlas of the United States (2004). Figure 1 shows newly

[7]Recent evidence suggests that average price is more salient than marginal price (Ito, 2014). He attributes this behavioral response to the information costs of (i) understanding the nonlinear rate schedule and (ii) tracking cumulative monthly consumption.

[8]Figure A1 shows how the average price variable we use relates to the marginal price (based on the rate schedule) set by a hypothetical utility. During the period we study rate schedules were typically declining. Today, many utilities have adopted increasing schedules to reduce the capital requirements during peak loads.

digitized maps of the transmission grid in 1935 and 1941–including high voltage lines and central generation plants–as reported by the Federal Power Commission. From this information, we calculate the distance of each market to the transmission grid and the nearest generation station in each year.[9] We also use the size (e.g., 0 to 15, 15 to 50, 50 to 100, or 100 plus megawatts) and type (e.g., hydroelectric, fuel) reported in the surveys to determine the number of plants of each size and type within 100 miles of our markets. In the empirical analysis these variables proxy for cost differences across markets that face different sources of generation capacity and type.

Table 1 provides summary statistics for the average prices (Panel A) and market characteristics (Panel B) in 1935 and 1940. In Panel A, columns 1 and 4 show that across all consumption levels the cents per kilowatt hour decrease in each sample year. In Panel B, the average population of markets served decreases from 4,280 to 3,591, which reflects improved access for smaller markets. Finally, the average distance to generation and transmission infrastructure decreased from 30.7 to 17.7 miles and 15.8 to 3.7 miles, respectively, together indicating closer to proximity to electricity infrastructure.

4 Empirical Framework

We use ordinary least squares to estimate the relationship between ownership and electricity prices, controlling for other factors that may influence demand and cost:

$$\log(\text{price per kWh}_i) = \beta \text{public ownership}_i + X_i\gamma + \theta_c + \varepsilon_i \tag{1}$$

The dependent variable is the (log) of the average price per kilowatt hour in market i at monthly consumption ℓ. The main variable of interest (public ownership$_i$) is an indicator equal to one if market i is served by public ownership and zero otherwise. To interpret β as the causal effect requires assuming random assignment of ownership, which may not be appropriate.

As a step toward relaxing this assumption we include market-level variables, X_i, to control for the distance to the transmission grid, distance to the nearest generation plant, and the number of plants of a given size and generation type within 100 miles.[10] These variables proxy for cross-market cost differences associated with the generation mix and

[9] For 1940, we calculate the distance between the location of the transmission grid and nearest generation station in 1941.

[10] That is, we count the number of plants that use hydroelectricity versus fuel of a given size (e.g., 0 to 15, 15 to 50, 50 to 100, or 100 plus megawatts).

Figure 1: Transmission Grid in 1935 and 1941

A. 1935

B. 1941

Source: See text of Section 3.

Table 1: Summary Statistics

	1935			1940		
	(1) All	(2) Public	(3) Private	(4) All	(5) Public	(6) Private
Panel A. cents per kWh						
at 15 kWh	9.7	9.1	9.8	8.0	8.1	8.0
	(2.5)	(2.6)	(2.5)	(2.5)	(3.0)	(2.4)
at 25 kWh	9.1	8.8	9.1	7.0	6.8	7.1
	(3.3)	(4.5)	(3.2)	(2.3)	(2.5)	(2.2)
at 40 kWh	8.1	8.1	8.1	6.4	6.2	6.4
	(2.3)	(2.6)	(2.3)	(1.9)	(2.6)	(1.8)
at 100 kWh	5.6	5.8	5.5	4.6	4.5	4.6
	(1.4)	(2.0)	(1.4)	(1.0)	(1.3)	(1.0)
at 250 kWh	3.9	4.5	3.8	3.2	3.3	3.2
	(1.1)	(1.6)	(1.0)	(0.7)	(1.1)	(0.7)
at 500 kWh	3.0	4.0	2.9	2.3	2.6	2.3
	(1.1)	(1.6)	(1.0)	(0.8)	(1.1)	(0.7)
Panel B. market characteristics						
population (thousands)	4.3	4.8	4.2	3.6	4.1	3.5
	(40.2)	(33.5)	(40.9)	(36.2)	(32.2)	(36.7)
miles to generation plant	30.6	33.9	30.2	17.7	20.0	17.4
	(24.2)	(25.6)	(24.0)	(14.0)	(15.4)	(13.8)
miles to transmission grid	15.7	22.2	15.0	3.7	4.8	3.5
	(24.2)	(33.6)	(22.9)	(5.5)	(6.7)	(5.3)
N (# of markets)	16,484	1,581	14,903	21,191	2,678	18,513

Notes: This table presents summary statistics for prices (in 1940 dollars) and market characteristics. Panel A shows the average price (in cents) per kilowatt hour at $\ell \in (15, 25, 40, 100, 250, 500)$ total monthly kilowatt hours in 1935 and 1940. Panel B shows the percent of markets that are public, population (in thousands), miles to the nearest generation station, and miles to the transmission grid in 1935 and 1940. Standard deviations are in parentheses.
Source: See text of Section 3.

transmission distance. In addition, X_i contains indicators for each of the holding companies that controlled service territory throughout the United States.[11] This allows us to control for cost differences due to, for example, differences in geographic coverage or access to financing across holding companies. Finally, X_i also includes a second-order polynomial in the latitude and longitude of each market to proxy for differences in cost or demand due to changes in geography.

In lieu of observed county-level characteristics, we include county fixed effects (θ_c) to control for additional factors related to demand or cost that may play a role in price setting and are common to all markets in the same county. The within-county comparisons of markets served by public versus private ownership is enabled by the (empirical) fact that most counties have at least one public and one private market. In fact, moving from a specification that does not include county fixed effects to one that does leads us to drop 110 markets in 1935 and 9 markets in 1940. Taken together, the identifying assumption is that for markets in the same county–after controlling for other market-level characteristics–the remaining variation in prices is due to ownership or other factors orthogonal to ownership.

This assumption would be violated if prices respond to very local differences in demand or costs that also determine ownership. Our focus on within-county comparisons of markets helps to rule out substantial differences in costs. Another factor is local preferences, for example, for public provision of utility services that permit higher or demand lower prices. To quantify the extent to which bias arising from selection into ownership based on characteristics that remain unobserved we use the approach in Oster (2014), which combines changes in the coefficient on public ownership with changes in the total variation in prices explained by observed characteristics. Applying this approach, suggests that selection into ownership structure does not bias our results.

To further examine these issues we perform robustness checks to examine how the relationship between ownership and prices varies with market-level characteristics (i.e., distance to the transmission grid, distance to the nearest generation plant, and population) and county-level characteristics (i.e., severity of the Great Depression, Democratic vote share in 1940, and the share of electrified households). Large differences throughout the distribution of proximity to generation infrastructure, impact of the Great Depression, market size, political affiliation, or electrification rates may indicate the presence of costs or preferences not

[11] A map of the service territory is shown in Appendix Figure A2 and is taken from Federal Power Commission (1935). We treat markets that fall outside the service territories controlled by one of 57 holding companies as "unaffiliated" and include a separate indicator for these markets.

controlled for in equation (1).

We estimate equation (1) separately for each level of $\ell \in (15, 25, 40, 100, 250, 500)$ kilowatt hours per month. Standard errors are clustered by service territory to allow for correlation across markets in the territory of the same holding company. Note that we do not pool data for 1935 and 1940 to estimate a model including market-level fixed effects given the small number of switches in ownership (excluding the region of the TVA) over this period. As robustness, we consider the sensitivity of our results to excluding markets in the TVA service territory.

5 Results

The first contribution of this paper is to revisit the relationship between ownership and residential electricity prices prior to the implementation of major federal reforms as part of 1930s New Deal. We start by presenting the results of estimating equation (1) in Table 2 for 1935 and Table 3 for 1940. In each case, the columns show results for the price per kWh at $\ell \in (15, 25, 40, 100, 250, 500)$ total monthly kilowatt hours. All specifications include market-level controls for the distance to the transmission grid and the nearest generation plant, the number of plants of a given size and generation type within 100 miles, and indicators for holding company service territory. Finally, the panels of each table show estimates for specifications without county fixed effects (Panel A), with county fixed effects (Panel B), and excluding markets in the TVA service territory (Panel C).

From Panel A of Table 2, publicly owned utilities charged lower prices on average than private utilities between 15 to 40 kWh–enough for lighting and small appliances–in 1935. These differences are statistically significant at the 5 percent level for monthly bills that included at least 15 and 25 kWh, however, the magnitudes are small: implying *total* bills that were 3 to 9 cents lower in 1940 dollars terms. At monthly consumption above 100 kWh–enough for refrigeration, cooking, and hot water–publicly owned utilities charged higher prices on average than private utilities.[12] These differences are statistically significant at the 5 percent level for 250 and 500 kWh, and the magnitudes are larger: ranging from 11.5 to 28.1 percent. In nominal terms, this suggests monthly bills that were up to $5.19 larger.

One concern is that the pattern in 1935 may be due to temporary changes in the electricity

[12] To put these findings in the context, in particular, to see how the differences between private and public utilities affected the typical household, we tabulated information from the *Study of Consumer Purchases in the United States, 1935-1936* (US Department of Labor, 2009) suggesting that typical consumption was between 40 and 100 kilowatt hours per month. Based on a sample of urban households, Appendix, Figure A3 shows the distribution of electricity consumption for urban households.

Table 2: Difference Between Public and Private Ownership, 1935

	Monthly Consumption (ℓ) at:					
	15 kWh	25 kWh	40 kWh	100 kWh	250 kWh	500 kWh
Panel A. no controls ($N = 15,089$)						
public ownership	-0.0982	-0.0814	-0.0417	0.0074	0.1176	0.2858
	(0.0215)	(0.0255)	(0.0251)	(0.0190)	(0.0219)	(0.0329)
R^2	0.012	0.009	0.002	0.000	0.026	0.084
Panel B. w/o county fixed effects ($N = 14,983$)						
public ownership	-0.0505	-0.0406	-0.0069	0.0344	0.1335	0.2958
	(0.0193)	(0.0207)	(0.0202)	(0.0155)	(0.0192)	(0.0313)
R^2	0.454	0.467	0.463	0.385	0.358	0.401
Panel C. w/ county fixed effects ($N = 14,979$)						
public ownership	-0.0666	-0.0568	-0.0230	0.0153	0.1153	0.2807
	(0.0180)	(0.0159)	(0.0152)	(0.0135)	(0.0179)	(0.0304)
R^2	0.712	0.719	0.712	0.656	0.615	0.658
Panel D. exclude markets in TVA ($N = 14,046$)						
public ownership	-0.0592	-0.0447	-0.0100	0.0348	0.1361	0.3065
	(0.0176)	(0.0156)	(0.0153)	(0.0136)	(0.0171)	(0.0291)
R^2	0.465	0.464	0.453	0.365	0.325	0.395

Notes: The table shows the results of estimating equation (1) for 1935. The columns give differences at each $\ell \in (15, 25, 40, 100, 250, 500)$ kilowatt hours per month. All columns market-level controls for distance to the transmission grid and the nearest generation plant, the number of plants of a given size and generation type within 100 miles, and holding company service territory. In addition, Panel A does not include county fixed effects, Panel B includes county fixed effects, and Panel C excludes markets in the TVA service territory. Standard errors (in parentheses) are clustered at the service territory level.

Table 3: Difference Between Public and Private Ownership, 1940

	Monthly Consumption (ℓ) at:					
	15 kWh	25 kWh	40 kWh	100 kWh	250 kWh	500 kWh
Panel A. no controls ($N = 21,191$)						
public ownership	-0.0203	-0.0693	-0.0541	-0.0347	0.0005	0.0408
	(0.0305)	(0.0488)	(0.0416)	(0.0266)	(0.0181)	(0.0156)
R^2	0.001	0.008	0.006	0.005	0.000	0.026
Panel B. w/o county fixed effects ($N = 21,189$)						
public ownership	-0.0110	-0.0390	-0.0325	-0.0163	0.0105	0.0440
	(0.0118)	(0.0171)	(0.0133)	(0.0082)	(0.0067)	(0.0089)
R^2	0.376	0.443	0.446	0.411	0.320	0.242
Panel C. w/ county fixed effects ($N = 21,182$)						
public ownership	0.0099	0.0123	0.0070	0.0085	0.0297	0.0637
	(0.0141)	(0.0202)	(0.0182)	(0.0113)	(0.0066)	(0.0067)
R^2	0.648	0.712	0.713	0.688	0.630	0.566
Panel D. exclude markets in TVA ($N = 19,893$)						
public ownership	0.0090	0.0176	0.0093	0.0107	0.0330	0.0688
	(0.0140)	(0.0213)	(0.0188)	(0.0119)	(0.0072)	(0.0069)
R^2	0.652	0.699	0.686	0.666	0.598	0.548

Notes: The table shows the results of estimating equation (1) for 1940. The columns give differences at each $\ell \in (15, 25, 40, 100, 250, 500)$ kilowatt hours per month. All columns market-level controls for distance to the transmission grid and the nearest generation plant, the number of plants of a given size and generation type within 100 miles, and holding company service territory. In addition, Panel A does not include county fixed effects, Panel B includes county fixed effects, and Panel C excludes markets in the TVA service territory. Standard errors (in parentheses) are clustered at the service territory level.

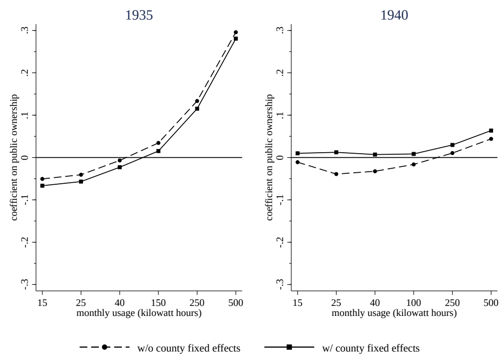
industry as factories scaled back production during the Great Depression or as consolidation of generation, transmission, and distribution continued. If prices differed by ownership, for example, because private utilities were more susceptible to the Great Depression then our estimates may understate the public-private difference in prices. To address this concern, we repeat the analysis of the 1935 cross-section for 1940. From Panel A of Table 3, the results suggest that publicly owned utilities continued to price lower than private firms between 15 to 40 kWh per month and higher prices above 100 kWh, although the magnitudes are attenuated toward zero. For example at 15 kWh per month the public prices were 6.7 percent lower in 1935 but only 1.0 percent lower in 1940; at 500 kWh public prices were 28.1 in 1935 versus 6.4 percent higher in 1940. This flattening of the price-kWh gradient for private utilities between 1935 and 1940 may be related to several factors. For example, as part of their response to the downturn of the 1930s, many private utilities had excess generation capacity that was used to provide large quantity discounts. Moving from 1935 to 1940, private utilities sold-off excess capacity and faced stronger demand following the recovery of industrial production. In addition, New Deal policies targeting monopoly practices and seeking to increase competition were implemented.

So far we have focused on specifications that include market-level controls for distance to the transmission grid and the nearest generation plant, the number of plants of a given size and generation type within 100 miles, and holding company service territory. Panel B of tables 2 and 3 adds county fixed effects to focus on comparisons across markets with shared unobserved county characteristics, which may include determinants of cost and demand differences. Panel A of Figure 2 plots the estimated coefficients at each level of monthly consumption in 1935 and 1940 for visual inspection. Overall the differences are small in magnitude and none are statistically significant at the 5 percent level. Formally, Altonji, Elder, and Taber (2005) and Bellows and Miguel (2009), Oster (2014) provide formulas for selection on unobservables under a proportional selection hypothesis. Following Oster (2014), we compute the implied bias due to selection on unobservables and find values that range from 0.0094 to 0.0194 in 1935 and from 0.0018 and 0.0182 in 1940, which are small relative to the coefficients reported tables 2 and 3.[13]

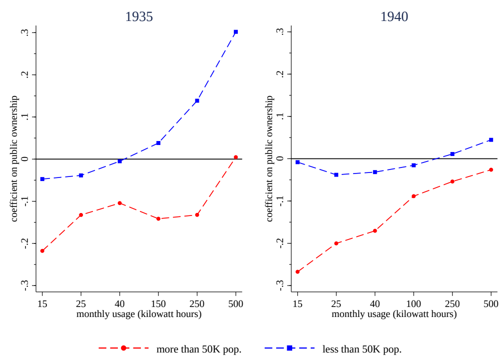
The Tennessee Valley Authority expanded after 1935, dictated a uniform price schedule,

[13]The bias is given by $\Pi = \delta \times \left[\mathring{\beta} - \tilde{\beta}\right] \times \frac{R_{max} - \tilde{R}}{\tilde{R} - \mathring{R}}$, where $\mathring{\beta}$ is the coefficient from the regression of price on public ownership$_i$ with no controls and $\mathring{R}$ is the corresponding R^2, $\tilde{\beta}$ from the regression of price on public ownership$_i$ with all controls and $\tilde{R}$ is the corresponding R^2, and R_{max} is the R^2 from a hypothetical regression of price on all observed *and* unobserved controls. δ is the coefficient of proportionality. As suggested by Oster (2014), we use $\delta = 1$ and $R_{max} = 1.3 \times \tilde{R}$

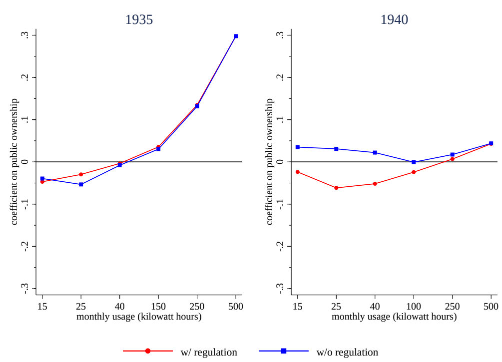
Figure 2: Public-Private Difference in Price Per kWh



A. compare specifications



B. compare large vs. small markets



C. compare regulated vs. unregulated markets

Notes: The table shows the results of estimating equation (1) for 1935 and 1940 for different samples. Panel A plots the estimated coefficients without (dash) and with (solid) county fixed effects, Panel B plots coefficients for markets with more (red, dash) and less (blue, dash) than 50,000 residents, and Panel C plots coefficients for markets with (red, solid) and without (blue, solid) state regulation.

and required utilities purchasing its electricity to be publicly or cooperatively owned (McCraw, 1971; Kitchens, 2014). In Panel C of tables 2 and 3 we consider whether excluding markets in the TVA service territory alters our results. The results are qualitatively very similar; formal tests of the difference at each level of monthly consumption and in each year cannot reject equality of the coefficient on public ownership at the 5 percent level.

A key advantage of our data is the comprehensive coverage ranging from the largest markets, which have been analyzed in previous work, to the smallest markets. In Figure 2B we plot the estimated price difference between public and private utilities for markets with above and below 50,000 in 1935 and 1940. Previous work by Emmons (1997) considers the impact of ownership and other institutional variables, but data for his analysis was only available for firms serving markets with population larger than 50,000. The dashed red line in each panel replicates the results from this earlier literature for the largest markets: publicly owned utilities had prices that were up to 19.8 percent lower in 1935 and 27.6 perent lower in 1940 than privately owned utilities.

These results are quantitatively similar to those obtained by Emmons (1997, pp. 284-85) and suggest that urban markets served by publicly owned utilities did indeed have lower prices than similar markets served by private firms in both years. In addition, our data also allow us to quantify the extent to which there is variation in this relationship at different levels of consumption. The dashed blue lines in Figure 2B show results focusing on markets with population less than 50,000. In general, the difference between public and private prices is smaller up to 100 kWh, while private prices are higher at or above 250 kWh.[14] This finding highlights the importance of using markets that are representative of the entire population and considering price differences across a range of monthly consumption levels rather than relying on a single average price for a subset of larger markets. Historically, the most likely cause of cross-subsidization among private firms was regulation that codified cross-subsidization as a means to extend service in small markets (Railroad Commission of Wisconsin, 1922).[15]

Finally, Figure 2C shows results separately for markets that faced state regulation versus markets that faced no state regulation. These results are motivated by the large litera-

[14]The pattern is similar when using population in each year as weights in estimating equation (1).

[15]In addition, theoretical work by Faulhaber (1975) and Panzar and Willig (1977) shows how costs that are common to a firm serving several markets may lead to lower prices among private versus public firms. In the context of electricity, the common cost components include generation and transmission infrastructure, which were substantial and allowed private utilities to set prices below public utilities for a given market size.

ture on the different incentives provided by state regulatory regimes (Stigler and Friedland, 1962; Peltzman, 1976; Jarrell, 1978). In addition, Hausman and Neufeld (2002) and Knittel (2006) highlight that incentives under state regulation may be different for public and private entities. In 1935 and 1940, the difference between public and private prices across state regulatory regimes is similar throughout the rate schedule. Taken together, the results suggest that differences between public and private prices were small by 1940 and this conclusion is not sensitive to conditioning on unobserved characteristics at the county level, excluding markets in the Tennessee Valley Authority, or differences in state regulation.

6 Heterogeneity in Price Setting by Ownership

Our empirical analysis controls for several market-level characteristics as well as county fixed effects. However, it may be the case that price setting by ownership type differs across markets with similar characteristics. For example, this would be the case if private firms cross-subsidized across markets of different sizes or if demand for public provision of utility services and corresponding willingness to pay was higher in some markets. To examine the differences in public and private price setting by market (or county) characteristics, in this section we consider the results from local linear regressions that allow the prices to vary by ownership as well as market-level characteristics (i.e., distance to the transmission grid, distance to the nearest generation plant, and population) and county-level characteristics (i.e., severity of the Great Depression, Democratic vote share in 1940, and the share of electrified households).

In the appendix, Figure A4 shows how prices vary by ownership and population (Panel A), distance to the transmission grid (Panel B), and distance to the nearest generation plant (Panel C).[16] Within each panel we also show the variation across different levels of monthly consumption. For population, the differences between public and private prices are substantive. In particular, public prices decline more quickly than private when moving from smaller to larger markets at all consumption levels. Since our specifications include indicators for each investor-owned holding company, the shallower slope across population for private markets may reflect cross-subsidization. Alternatively, differences between public and private prices in Panel A threaten a causal interpretation if these differences reflect selection of markets connected under public versus private ownership.

[16] The dependent variable (y-axis) in the panels of Figure A4 (and Figure A5) is the residual term from equation (1). The independent variable (x-axis) is standardized to have mean zero and standard deviation one. Each plot gives the variation in (log) cents per kWh into portion explained by differences in ownership and the given market-level (or county-level) characteristic.

Two pieces of evidence suggest that cross-subsidization is the appropriate interpretation. First, firms were well known to use cross-subsidization to extend service to markets that may not have been individually profitable. For example, this issue became central in the transfer of territory and real assets from the Tennessee Electric Power Company (TEPCO) to the TVA in 1939. TEPCO transferred its entire territory in the state of Tennessee to the TVA as a result of the TVA's targeted efforts to contract with large cities in TVA region. TEPCO officials noted that if it lost its franchise in cities such as Chattanooga, then it would not be profitable to serve the remaining territory surrounding the city. In the end, they conceded their entire territory (McCraw, 1971). Second, many states regulated the rates of private utilities, effectively institutionalizing cross subsidization by setting caps or defining the rate of return (Federal Power Commission, 1935).

Moreover, cross-subsidization as opposed to selection based on the cost of providing service is supported in the remaining panels of Figure A4, which plot the difference in public versus private ownership by distance to the transmission grid and to the nearest generation plant. Differences across markets served public or private ownership may indicate selection, for example, if privately owned utilities have lower prices at shorter distances because of targeted expansion of the transmission grid or construction of generation capacity. For distance to the transmission grid in Panel B and distance to the nearest generation plant in Panel C the differences between public and private are not statistically significant.

Also in the appendix, Figure A5 shows how prices vary by ownership and the change in retail sales between 1929 and 1933 (Panel A), the Democratic vote share in 1932 (Panel B), and the share of households with electricity service in 1940 (Panel C). In Panel A, differences in public and private ownership due to the change in retail sales from 1929 to 1933–a proxy of the Great Depression–are small and not statistically significant. In Panel B, differences in public and private ownership by political affiliation indicate few differences. This suggests that observable political preferences at the county-level, which may be indicative of local demand for more or less public provision of utility services, did not lead to significant price differences. In Panel C, the difference between public and private prices is again small across counties with different overall rates of access to electricity. Taken together, the evidence suggests that the small estimated difference between public and private utilities is not due to differences in selection across markets in terms of proximity to generation infrastructure, severity of the Great Depression, market size, political affiliation, or electrification rates, any of which may indicate differences in costs or local preferences.

7 Conclusion

The growth of the electricity industry in the United States during the first half of the twentieth century was enabled by the technological improvements that increased efficiency at various stages generation, transmission, and distribution. In addition, institutions played a vital role in managing the transition to an increasingly electrified economy. In particular, previous work has emphasized the development of capital markets (Hausman and Neufeld, 2002; Neufeld, 2015), which led to larger initial investments and increased the efficiency of centrally-generated electricity transmitted over larger distances, and state regulation (Hausman and Neufeld, 2002; Knittel, 2006), which minimized uncertainty due to opportunism on the part of local politicians.

Our paper uses newly digitized data covering electricity prices for the universe of electrified communities in the United States in 1935 and 1940 to quantify the difference in the price faced by residential consumers under public and private ownership. Importantly, our data do not limit us to the selected samples or aggregated data analyzed in earlier work. We find that public utilities charged lower prices than private utilities when consumption was less than 100 kWh and higher prices at or above 250 kWh per month. The difference is statistically significant, but economically small (i.e., 6 percent or less for the typical level of household consumption) in 1935. By 1940, price differences between public and private utilities were even smaller.

The small estimated difference between public and private ownership prior to the implementation of New Deal legislation suggests that ownership was less important than other factors in determining electricity prices. Nevertheless, after surviving several court challenges, the federal regulation placed the private system under greater scrutiny limiting the ability of holding companies to allocate capital across space via the Public Utility Holding Company Act and constrainting expansion of private provision outright in the case of the Tennessee Valley Authority. The evidence presented in this paper indicates that the *a priori* benefits of switching to public ownership were small in terms of residential electricity prices, while recent evidence by Rose and Joskow (1990) suggests that access to private ownership leads to substantial benefits in terms of the quality of service, technology adoption, and pricing. Thus, future research should focus on the interaction between New Deal reforms and other aspects of the electricity industry (e.g., local competition, technology adoption).

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A Online Appendix: Additional Figures & Tables

Figure A1: Marginal and Average Price for Hypothetical Utility

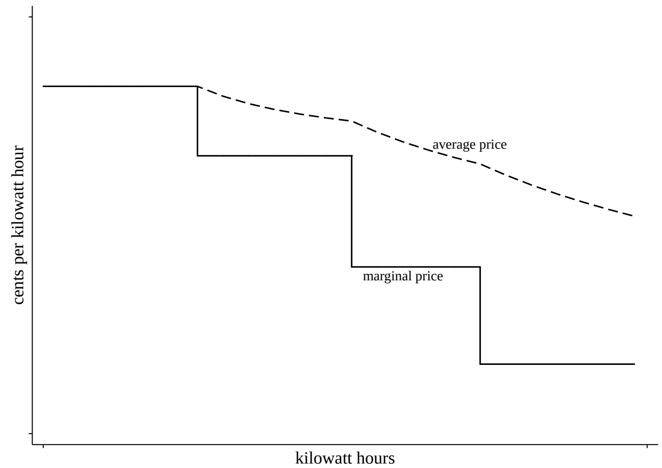
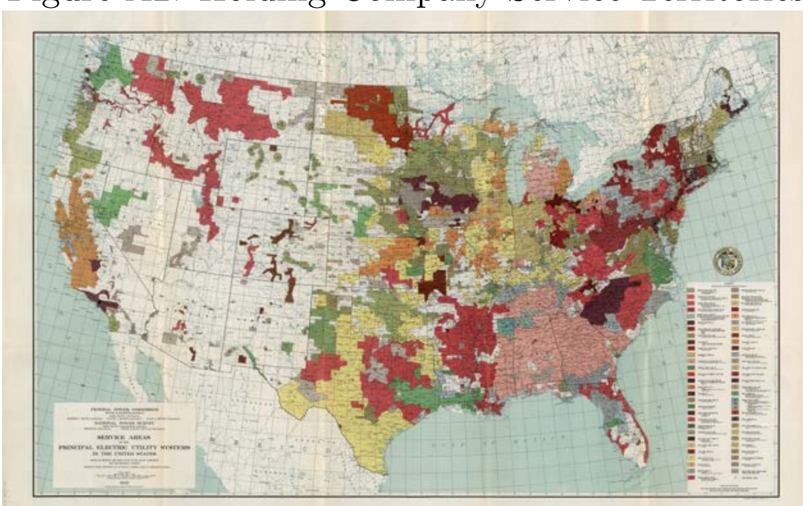
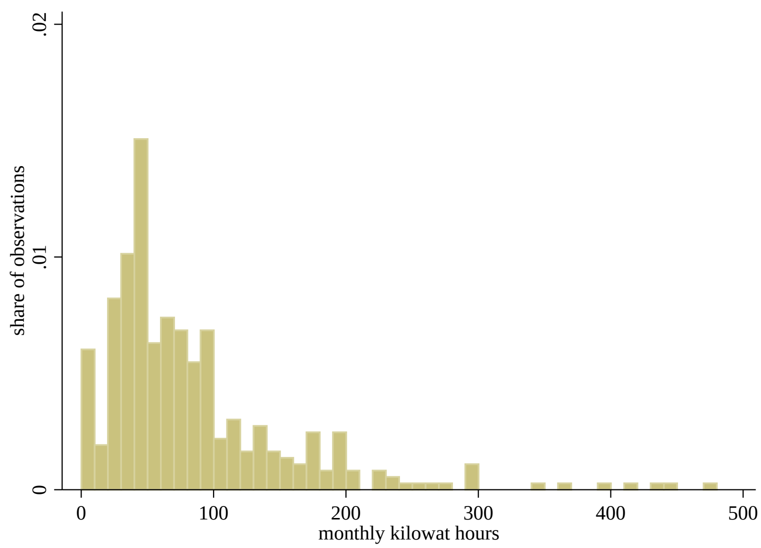


Figure A2: Holding Company Service Territories



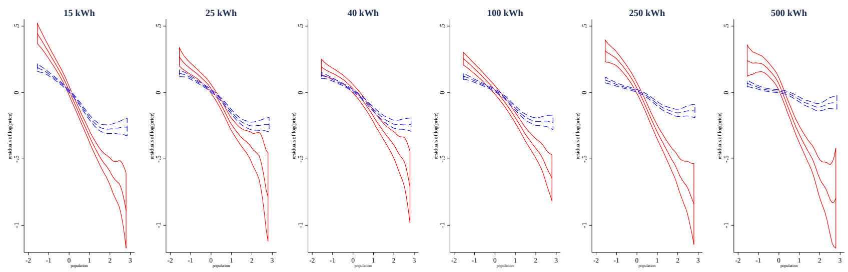
Source: Federal Power Commission (1935)

Figure A3: Histogram of Household Electricity Consumption

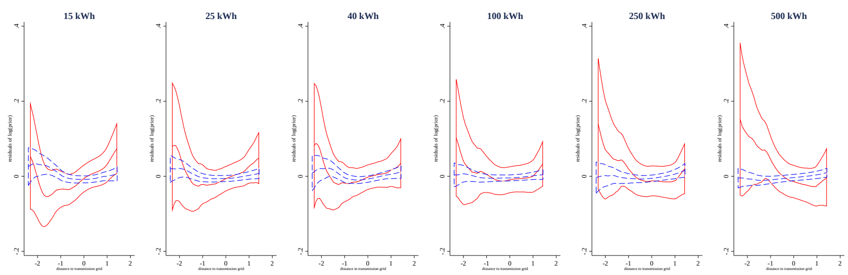


Notes: This figure shows a histogram of monthly electricity consumption for urban households in 1936. Most of the mass of the distribution is below 100 kilowatt hours per month.
Source: See Section 5 and US Department of Labor (2009).

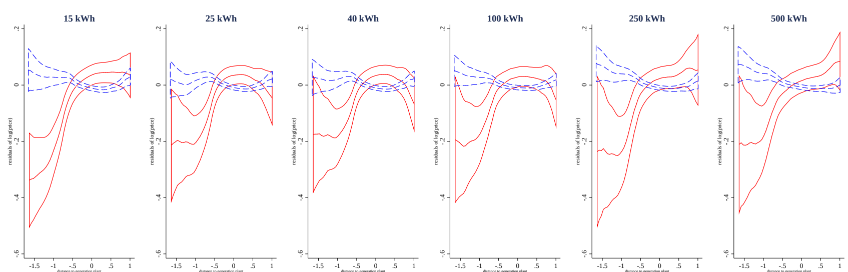
Figure A4: Price Per kWh by Ownership and Market Characteristics, 1940



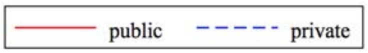
A. population



B. distance to transmission grid

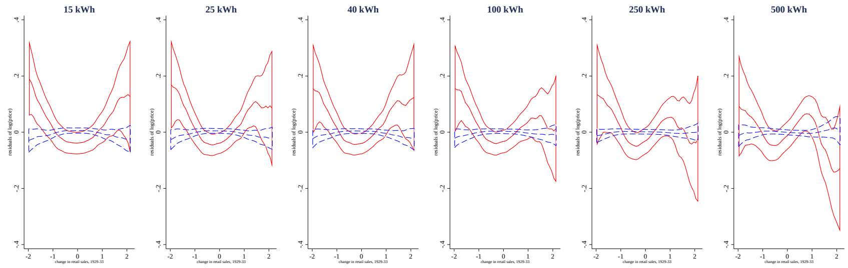


C. distance to generation plant

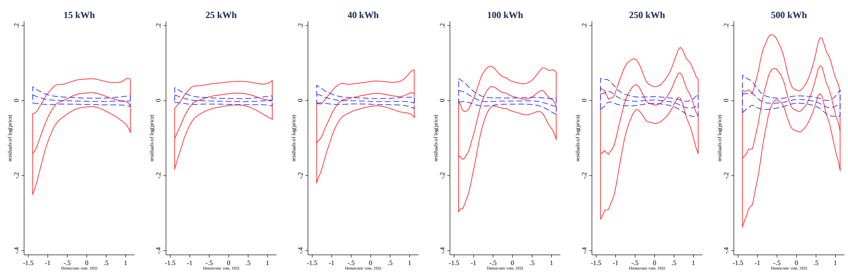


Notes: The dependent variable (y-axis) in each panel is the residual term from equation (1) and the independent variable (x-axis) is standardized. The panels decompose the residual price per kWh by ownership and population (Panel A), distance to the transmission grid (Panel B), and distance to the nearest generation plant (Panel C). Each panel shows the point estimate and 95 percent confidence interval.

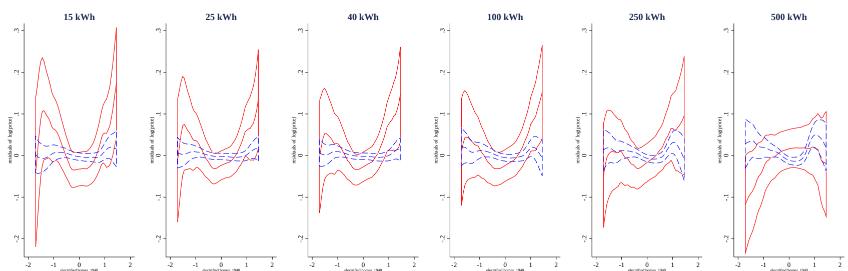
Figure A5: Price Per kWh by Ownership and County Characteristics, 1940



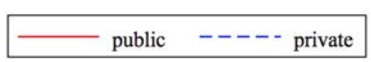
A. change in retail sales, 1929-1933



B. Democratic vote share, 1940



C. share of electrified dwellings, 1940



Notes: The dependent variable (y-axis) in each panel is the residual term from equation (1) and the independent variable (x-axis) is standardized. The panels decompose the residual price per kWh by ownership and the change in retail sales between 1929 and 1933 (Panel A), the Democratic vote share in 1932 (Panel B), and the share of households with electricity service in 1940 (Panel C). Each panel shows the point estimate and 95 percent confidence interval.