The Effects of Ownership Structure on Coal Plant Retirements in the U.S.

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Abstract: Rapid decarbonization in advanced industrial economies requires accelerated retirement of fossil fuel infrastructure, including coal-fired power plants. In this paper, we evaluate how the ownership structure of these assets affects the degree to which economic, technological, and regulatory pressures induce retirement. Using public data from the U.S., we study the retirement of coal generation between 2002 and 2022, a two-decade period during which coal usage declined dramatically. Descriptively, we document major differences in retirements. Relative to publicly owned utilities and investor-owned utilities, more generation was retired, earlier in the period, at plants owned by independent power producers, and less was retired at plants owned by electric cooperatives. Using multiple regression to adjust for other variables associated with retirement timelines, we find that electric cooperative ownership remains statistically significantly associated with slower retirement, but do not estimate statistically significant differences between other ownership models. Overall, our results do not suggest a sizable natural advantage for public or private ownership for achieving rapid decarbonization in the electricity sector.

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1. Introduction

The U.S.'s coal generation fleet declined rapidly in the first two decades of the 21st century. Coal use in the U.S. peaked in 2007 at close to 1.13 billion short tons. By 2021, according to the U.S. Energy Information Administration (EIA), coal consumption had declined by more than half to approximately 578 million short tons. In 2007, 48 percent of electricity generated in the U.S. came from burning coal. By 2021, this had fallen to 22 percent. Coal's decline is the strongest contributor to the overall reduction in the greenhouse gas emissions in the U.S. over the past decade.

Existing research highlights several factors driving coal's decline. The financial crisis and recession beginning in 2007 triggered reduced demand for energy which never fully recovered, in part due to improvements in energy efficiency (Nadel, Elliott, and Langer 2015). Coal has also faced stiffer competition from natural gas and renewables (Houser, Bordoff, and Marsters 2017). New regulations imposed under the Obama administration increased operational costs for coal plants, making it more difficult for coal to compete with alternatives (Schiavo and Mendelsohn 2019). Finally, public pressure campaigns, particularly the Sierra Club's *Beyond Coal Campaign*, likely accelerated the retirement of certain coal generation (Drake and York 2021). These factors can compound. For instance, the success of *Beyond Coal* campaigners stemmed in part from their ability to argue that, in addition to causing public health problems, coal plants were more expensive to run than alternatives (Storrow 2019).

One factor that has not been closely examined is how the ownership structure of coal plants affects the closure timeline. Most power plants in the U.S., including coal-fired plants, are owned privately by investor-owned utilities (IOUs). But a significant share is owned by publicly owned utilities (POUs) and electric cooperatives (co-ops). Some are also owned privately by independent power producers (IPPs). In this paper, we study the effect of ownership on coal generation retirements in the U.S. over the 20 years from 2002 to 2022.

Descriptively, we find that plants owned by independent power producers retired generation earlier in the series, and plants owned by co-ops were slower to respond to retirement pressures. However, once we adjust for covariates in multiple regression, we no longer observe a relationship between IPP ownership (relative to IOU ownership) and pace of retirement. Including covariates reduces the magnitude of the estimated relationship between co-op ownership and retirement. However, across model specifications, we find that plants owned by co-ops were slower to retire than plants owned by IOUs, the most common ownership type.

Academics (Green and Robeyns 2022, Paul 2019), advocates (Aronoff 2020, Bozuwa et al. 2021), and policymakers have discussed greater public ownership of energy infrastructure as a mechanism for equitable decarbonization. [1] We show that the co-op model of ownership represents, in the case of coal plants, a barrier to rapid decarbonization. On the other hand, we do not find systematic evidence that government ownership of coal plants is associated with

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[1] House Democrats Jamaal Bowman (D-NY) and Cori Bush (D-MO) introduced a resolution in 2021 to increase the role of publicly owned electricity generation in the U.S. (See https://bowman.house.gov/press-releases?ID=5AFB38F5-4ACB-4B9E-BA6F-299D9ADB6411)

slower retirement than private ownership. Our analysis suggests that, at least when it comes to coal retirement, neither public nor private ownership has a natural advantage for decarbonization. The effect of greater government ownership on decarbonization timelines would likely depend on economic context and specifics of policy design and implementation.

2. Ownership models and retirement pressures

Four main types of actors own power plants in the U.S.: investor-owned utilities, governments, non-profits, and independent power producers. Investor-owned utilities (IOUs) and independent power producers (IPPs) are owned privately and operated for-profit, even if the holding company is publicly traded; publicly owned utilities (POUs) are owned by governments, often municipalities; electricity cooperatives (co-ops) are owned by non-profit organizations. In this section, we review four key factors that contribute to coal retirement: 1) economic incentives, 2) access to capital, 3) exposure to public policy, and 4) exposure to public pressure. We discuss how each might differentially affect the generator retirement decisions for plants owned by IOUs, POUs, co-ops, and IPPs.

2.1 Economic incentives

Coal plants often continue to operate even after they are no longer economically competitive with other sources of power like natural gas, wind, or solar (Bodnar et al. 2020). Indeed, many are not fully exposed to market competition (Cicala 2022).[2] For investor-owned utilities (IOUs), the decision to retire a coal plant is likely to depend in part on whether they continue to receive a regulated rate of return on the asset–as opposed to the cost-competitiveness of the asset. IOUs may seek to retire older coal plants that are fully depreciated and no longer in rate base (meaning they no longer generate a return), especially if they can replace them with new assets that generate a greater return. In some cases, shareholders might pressure IOUs to retire old coal assets and replace them with new generation to achieve greater returns.[3]

With newer, non-depreciated coal plant assets, the financial implications of early retirement can be more troublesome for IOUs. In deregulated markets, IOUs that retire coal plants early can be obligated to write off the remaining value. In rate-regulated markets, IOUs are generally able to recover costs from early retirement through customer rates, though this can depend on public utility commission proceedings. The safest strategy for recovering costs is often the ‘do-nothing’ option, simply continuing to operate plants, even when they are no longer cost-competitive with alternative generation sources (Copley 2019).

POUs and co-ops face somewhat different incentives from IOU’s. While IOUs are generally concerned with maximizing value for shareholders, POUs are primarily concerned with keeping rates down for their customers (while preserving reliability). They might, thus, be expected to seek to replace expensive coal plants with cheaper sources of power faster than IOUs.

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[2] This can be due to operating in regulated markets or previously signing long-term power purchase agreements.

[3] Environmental activists have also used cost as a rationale for pressuring owners to retire coal generation (Storrow 2019).

However, the benefits of replacing aging coal generation with cheaper sources of power are diffuse (spread over customers) and realized over long time horizons. This contrasts with the more concentrated benefits that investors reap from replacing depreciated coal generation with new infrastructure that generates a rate of return. In addition, even if they would prefer to shift to cleaner, cheaper electricity from non-coal sources, some electric co-ops might not be able to if they are locked into long-term contracts with larger generation and transmission cooperatives that primarily use coal (Smyth 2020).

The ability of IPPs to profit from coal plant investments generally depends on the plants' competitiveness in wholesale electricity markets. As natural gas and renewables have gotten cheaper, coal plants have had difficulty competing. Thus, we would expect IPPs to face the strongest and most direct economic incentive to retire. Some IPPs sell power bilaterally to electric utilities in vertically integrated markets. If these plants have long-term power purchase agreements, they might have less of an incentive to retire in response to market pressures.

2.2 Access to capital

POUs and co-ops may have stronger economic incentives to replace uncompetitive coal generation than IOUs, but differential access to finance means they could be less capable of doing so. New electricity generation requires large upfront capital expenditures. POUs and co-ops rely almost entirely on debt financing to develop new infrastructure, while IOUs raise both debt and equity (Blunt 2021). Inability to raise capital can impede the ability of POUs and co-ops to retire and replace expensive coal plants (Gheorghiu 2019). Many co-ops, in particular, are already saddled with high levels of debt, making it difficult to raise more capital to replace coal-fired generation (Smyth 2021).

New financing mechanisms are emerging to help catalyze the shift away from coal to cleaner, cheaper sources of power—including for capital-constrained POUs and co-ops. In recent years, utilities have started to use a securitization procedure to retire uncompetitive coal plants. The utility sells bonds secured by future customer rates and uses the cash raised to build or contract renewable infrastructure. However, not all states permit this type of securitization (Fong and Mardell 2021). While securitization has mostly been used by IOUs, in recent years POUs have used similar mechanisms to replace aging coal plants with renewables (Merchant 2020). The emergence of these and other new financing mechanisms may reduce disparities in the ways public, private for-profit, and non-profit generation owners access capital and transition to cleaner sources of power.

2.3 Exposure to public policy

Federal regulations under the Obama administration on air pollution emissions made it more difficult for coal to compete with natural gas and renewables (Schiavo and Mendelsohn 2019). But it is not just federal policy that affects coal retirements. State governments in the U.S., particularly in liberal-leaning regions of the country, have adopted policies like Renewable Portfolio Standards (RPS) with the aim of growing clean energy and reducing their reliance on fossil fuels (Rabe 2004; Trachtman 2020). These types of clean energy policies, by supporting the growth of renewables, also lead to reduced utilization and profitability of coal facilities (Hollingsworth and Rudik 2019).

Different ownership models lead to different relationships vis-à-vis government regulators and regulations. POUs and co-ops are often exempted from state regulations on rates, investments decisions, and other operations—including RPS policies (Lawson 2020). One reason is publicly owned utilities are usually smaller, so fixed costs borne from achieving compliance are spread over fewer customers. This can increase regulators' concerns about a potential public backlash against new regulations.

More broadly, some research provides a theoretical rationale, and empirical evidence, for why publicly owned power generators might be *less strictly regulated* than privately-owned power generators. In their 1977 essay, Wilson and Rachal advanced the proposition that "it is easier for a public agency to change the behavior of a private organization than of another public agency" (1977, 4). In their view, government agencies could more easily exploit connections with sympathetic politicians to avoid regulation. Wilson and Rachal highlight several cases in which government organizations were able to mobilize political allies to defend themselves from regulation by other agencies. Bringing quantitative empirical evidence to bear, Konisky and Teodoro (2016) indeed find that government agencies were more likely to violate the Clean Air Act and Safe Drinking Water Act, and less likely to be penalized for those violations, than private organizations.

2.4 Exposure to public pressure

Public pressure campaigns highlighting the negative health effects of coal-fired electricity generation have been a key driver of many coal plant retirements in recent years (Drake and York 2021, Yang and Chou 2018). It is not immediately clear whether pressure campaigns would be more effective at shuttering privately or publicly owned plants. On the one hand, public agencies run by executives appointed by public officials might be more receptive to campaigns organizing their constituents. On the other, IOU profits depend directly on rates of return determined through public agency procedure. They thus have a strong economic interest in maintaining public support. What is more, public campaigns can, in addition to targeting IOUs themselves, pressure IOUs' shareholders and institutional investors, potentially giving them greater leverage (Apfel 2015).

3. Plant ownership and retirements, 2002 - 2022

Our analysis primarily uses public data reported through the EIA's Form 860 from 2002-2022.[4] We used the Public Utility Data Liberation (PUDL) project database, which synchronizes reported years of the form to access the data. We developed a SQL query to pull fields from four primary tables: *generators*, *plants*, *utilities*, and *owners.*

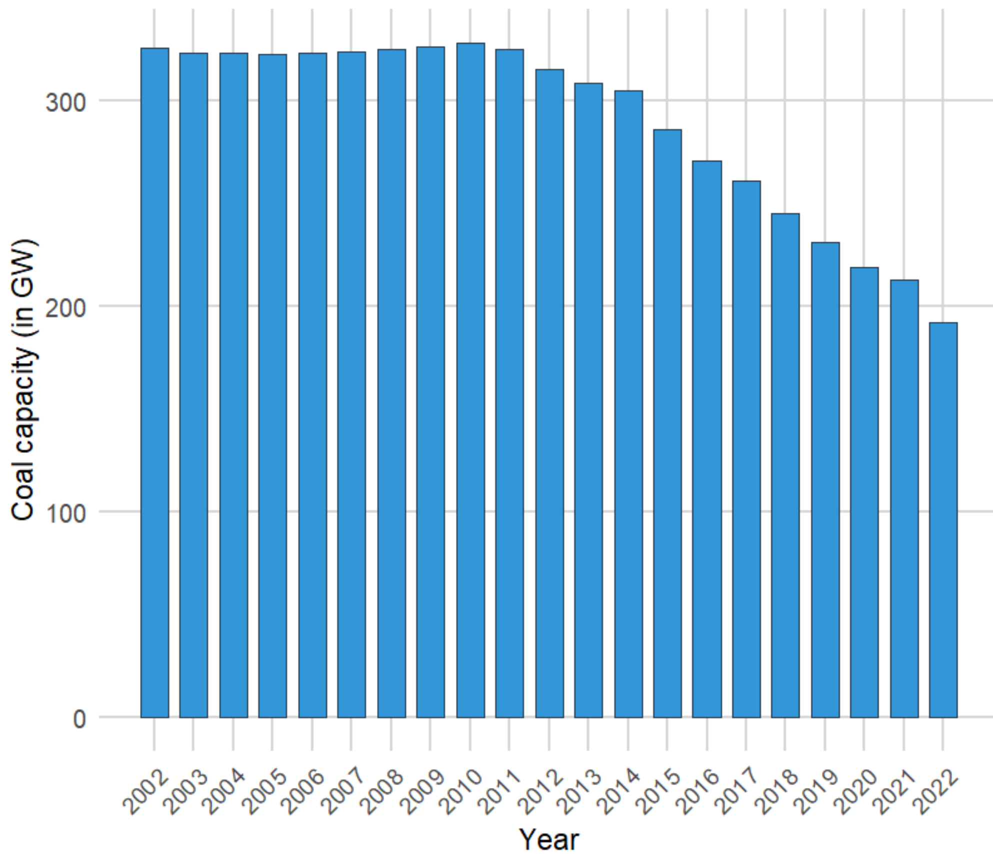
[4] Though the EIA 860 form was also available in 2001, we excluded this year due to reliability issues reported by the EIA.

We conduct the analysis at the plant level. Plants include one or more generators (on average 3.5 generators per plant in 2002). Tracking plants over the 20-year series allowed for greater accuracy than tracking generators, whose identifiers sometimes changed over the period.[5] We excluded industrial and commercial coal plants from the analysis, focusing on plants generating power for the electric grid. Overall, our analytical sample includes 479 coal plants that were operational as of 2002: 227 owned by IOUs, 76 owned by POUs, 32 owned by co-ops, and 97 owned by IPPs.

We track operational coal capacity for each plant in the sample over the 20 years from 2002 to 2022.[6] As demonstrated by Figure 1, operational coal capacity in the U.S. overall held relatively steady for units in our sample between 2002 and 2011, before starting to fall. Total capacity was 325 GW in 2002, and had actually risen to 328 total GW by 2010, the high point. By 2022, operational capacity had fallen to 192 GW.

[5] Our analysis does not account for the rare cases where plants are co-owned by different types of owners (e.g. IOU and POU), or for cases where ownership changes, which introduces a small amount of measurement error that could attenuate estimates. We follow the EIA in coding plant ownership based on who is the majority owner.
[6] This refers, more specifically, to nameplate capacity for units greater than 1 MW connected to the power grid that are in service for commercial operation and produced some electricity during the reported year.

Figure 1: U.S. operational coal capacity for power grid, 2002-2022



Source: EIA 860, accessed through Public Utility Data Liberation (PUDL)

However, as demonstrated by Figure 2, this fall was much less pronounced for plants owned by co-ops than for plants owned by IOUs, IPPs, and POUs. Overall, over the period, the capacity at co-op plants fell just slightly, from 18 GW to 16 GW. By comparison, capacity at plants owned by POUs and IOUs fell nearly 40 percent–for POUs from 42 GW to 26 GW, and for IOUs from 198 GW to 120 GW. Capacity at plants owned by IPPs fell 56 percent, from 67 GW to 30 GW.

Figure 2: U.S. operational coal capacity for power grid, by ownership type
Percent of 2002 total

Source: EIA 860, accessed through Public Utility Data Liberation (PUDL)

To estimate the effect of ownership on coal generation retirement, we needed a plant-level measure to track the pace of retirement over the period. We sought to use a measure to distinguish between generation capacity retired earlier or later in the period. In this vein, we computed the percent of a plant's initial operational coal capacity that was operational in each year and summed those values across the 20-year period to compute what we refer to as *operational year equivalents* (OYEs). Since this study focuses on coal *retirement*, we capped the value each year at 1 so that our measure would not be affected by plants adding capacity.[7] Thus, the maximum outcome for any plant was 20 (for those that did not lose any coal capacity over the period).

For a plant that maintained its initial operational capacity for the first 10 years of the period, 2002 - 2012, before shutting down in 2012, the OYE outcome would be 10. For a plant that maintained its initial operational capacity for the first 10 years before retiring half of its capacity

[7] Only 12 percent of plants (55) in the sample had greater capacity at the end of the study period than at the start.

in 2012 and maintained at that level through the end of the period, the OYE outcome would be 15 (calculated as 10 plus 10/2).

This measure distinguishes between earlier or later retirements, which helps to estimate the relationship between ownership and retirements more precisely. We use multiple linear regression, adjusting estimates for other variables that could be correlated with ownership and also associated with the pace of retirement. We adjust for covariates measured at the plant-level, utility-level, county-level, and state-level (where the plant is located). At the plant and utility levels, we adjust for plant size, plant age, utility size, and whether the plant operates in a competitive wholesale market.[8] At the county-level, we adjust for population, median income, a measure of urbanity, percent Black, and percent Hispanic. At the state-level, we adjust for party control of state government over the period (a measure of political lean), coal and gas extraction, and GDP per capita. The Appendix (6.1) contains more details on covariate adjustment and data sources.

Table 1 presents estimates derived from linear regression of the relationship between plant ownership and OYEs. We treat ownership as a categorical variable. (IOUs, the largest category, are excluded from the regression to eliminate collinearity.) Thus, the coefficient on indicator variables representing each of the other categories can be interpreted as the estimate relative to IOUs. Standard errors are clustered at the utility level. Column (1) presents descriptive, unadjusted estimates. The coefficient of 2.42 on co-op indicates that plants owned by co-ops, descriptively, operated for the equivalent of nearly 2.42 years more years than plants owned by IOUs. The coefficients on POU and IPP ownership are negative, but much smaller in magnitude and not statistically significant.

When we include plant- and utility-level covariates in Column (2), the coefficient on co-op ownership is still large (nearly 2 OYEs) and statistically significant. Coefficients on POU and IPP remain small and not statistically significant. In terms of the covariates, as demonstrated in Table A1 (SI), both plant size (nameplate capacity) and plant age, as expected, are strongly associated with retirement, as measured by OYEs. Larger plants retire at a slower pace, and older plants (measured by age at the start of the period) retire at a faster pace. Other covariates in the analysis are not statistically significantly associated with OYEs. Notably, we do not estimate a statistically significant relationship between plants operating in competitive markets and the pace of retirement.

Finally, in column (3) we include the full set of covariates, adding variables measured at the county- and state-level where the plants are located. The coefficient on co-op remains statistically significant (and the other ownership measures remain not statistically significant), now at the $p<.05$ level, but the magnitude drops to around 1 OYE. This is markedly different from the estimate of 2.42 in column (1), suggesting there are likely other systematic differences between co-op owned plants and IOU-owned plants driving the observed descriptive difference.

[8] This variable is only observed in the data set for the years 2010-2012, so does not provide a precise measure of market exposure (a plant may have joined a competitive market in 2013, for instance). We code a binary variable, 1 if a plant operated in a competitive market in any of the years 2010-2012, and 0 otherwise.

In particular, plants owned by co-ops tended to be younger than the plants owned by IOUs at the start of the series, and lower age (at the start of the period) is associated with lower likelihood of retirement during the period. In the full column (3) specification, removing plant age from the analysis causes the coefficient on co-op ownership to nearly double, to 2.24.

Table 1: Association between coal plant ownership and generation retirement

	Operational year equivalents		
	(1)	(2)	(3)
Co-op ownership	2.42**	2.00**	1.23*
	(0.74)	(0.56)	(0.59)
POU ownership	-0.05	0.32	0.15
	(0.66)	(0.56)	(0.57)
IPP ownership	-0.70	-0.45	-0.39
	(0.58)	(0.47)	(0.49)
Plant and utility covariates	NO	YES	YES
State and county covariates	NO	NO	YES
Observations	452	452	452
R2	0.02	0.42	0.45

Note: Robust standard errors in parenthesis.
**p<.01
*p<.05

None of the county-level variables we include are statistically significant, but we do find a statistically significant association between state-level extraction of coal and gas and retirements. In particular, we find that plants located in states with more coal extraction retire at a slower pace, and plants located in states with more gas extraction retire at a faster pace.

Overall, our descriptive analysis shows coal generation owned by co-ops retiring at a slower rate than generation owned by IOUs and POUs, and generation owned by IPPs retiring at a faster rate. The regression analysis, however, demonstrates that the observed difference between IPPs and IOUs is not statistically significant. It also demonstrates that the descriptive difference between co-ops and the other ownership models is partially a product of other variables also associated with slower retirement.

4. Conclusion and policy implications

Overall, our findings suggest a small but robust relationship between coal plant ownership and retirement. We find that descriptive differences across ownership types can, for the most part, be explained by other variables associated with both ownership and pace of retirement. The exception is co-op ownership, which we find, across model specifications, to be associated with slower retirement relative to IOU ownership. The co-op ownership model is associated with 1.22 more OYEs relative to IOU ownership. This is a substantively meaningful difference. Age is the strongest predictor of retirement, and the difference between co-op and IOU ownership, in our model, is equivalent to the effect of a plant being 6 years older at the start of the series.

We suspect a combination of factors are at play in driving this difference. As discussed, generation owned by co-ops and POUs tends to be less subject to state regulations than generation owned by IOUs and IPPs. Co-ops also do not raise capital as easily as IOUs and POUs, and IPPs, and tend to rely more on debt than equity financing. The estimated difference in retirement timelines for co-ops, but not POUs relative to IOUs, points perhaps to the role of financing since POUs have greater access to capital through municipal bonds and local taxes.

Public policy reforms could potentially lead to faster coal retirements and decarbonization trajectories for electric co-ops. The Biden administration's Inflation Reduction Act (IRA) provides funds through the New ERA program for electric co-ops to build clean energy infrastructure, which could replace coal generation. The Powering Affordable Clean Energy (PACE) Program targets the finance mechanism directly by providing low interest loans to co-ops for clean energy projects. Our findings point to the importance of programs like these, which could, over time, mitigate the observed disparity in decarbonization trajectories between co-ops and utilities with other ownership models.

More generally, results presented here can inform contemporary debates about public versus private ownership in the energy system as decarbonization proceeds. Advocates for a greater role of public ownership suggest a model much more akin to POUs than to co-ops. Overall, we do not find evidence that either public or private ownership of energy infrastructure has a natural advantage for retirement of fossil fuel assets. Transitioning to public ownership is unlikely to be a silver bullet for decarbonization. Yet, public ownership, in this case, has not strongly impeded decarbonization.

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6. Supplementary Information

6.1 Covariate data sources and measurement

We used data from several sources: EIA, National Conference on State Legislatures (NCSL), Bureau of Economic Analysis (BEA), and United States Department of Agriculture (USDA), to adjust estimates of the relationship between ownership and pace of coal plant retirement. These data are observed at the plant, utility, county, and state levels. We recognize that there are a huge number of variables at many levels that could plausibly be correlated with both plant ownership and retirement pressures. We attempt to include a wide array of such variables but cannot rule out omitted variable bias.

Table A1: Covariate information

Covariate	Level	Source	Unit	Years of coverage	Mean outcome
Plant size	Plant	EIA	GW	2002	0.81
Plant age*	Plant	EIA	years	2002	33.04
Utility size	Utility	EIA	GW coal assets	2002	3.17
Competitive market**	Utility	EIA	binary	2002-2022	0.29
Years Democratic trifecta	State	NCSL	years	2002-2022	3.34
Years Republican trifecta	State	NCSL	years	2002-2022	8.97
GDP per capita	State	BEA	million $, logged	2002-2022 (average)	10.78
Coal production	State	EIA	thousand short tons, logged	2002-2022 (average)	6.13
Natural gas production	State	EIA	million cubic ft	2002-2022 (average)	5.07
Population	County	Census	million people	2005-2009	0.23
Median income	County	Census	thousand $	2005-2009	47.93
Percentage Black	County	Census	percentage	2005-2009	8.9
Percentage Hispanic	County	Census	percentage	2005-2009	6.64
Rural-urban continuum code	County	USDA	categorical	2003	NA

*We compute nameplate capacity-weighted average of generator ages.
**We use form EIA-860 to code a binary variable for whether a plant belonged to an ISO or RTO in each year in the study period and took the average.
***We include three levels corresponding to: 1) metro area, 2) non-metro adjacent to a metro area, and 3) non-metro non-adjacent to a metro area.

6.2 Full regression estimates

Table A2: Association between coal plant ownership and generation retirement (full regression estimates)

	Operational year equivalents		
	(1)	(2)	(3)
Co-op ownership	2.42**	2.00**	1.23*
	(0.74)	(0.56)	(0.59)
POU ownership	-0.05	0.32	0.15
	(0.66)	(0.56)	(0.57)
IPP ownership	-0.70	-0.45	-0.39
	(0.58)	(0.47)	(0.49)
Plant size (GW)		2.26**	2.19**
		(.33)	(.33)
Plant age in years		-.20**	-.20**
		(.02)	(.02)
Utility size		-.02	-.03
		(.07)	(.07)
Competitive market		.48	.52
		(.39)	(.43)
Years Democratic trifecta (state-level)			.005
			(.05)
Years Republican trifecta (state-level)			.04
			(.04)
Log GDP per capita (state-level)			1.14
			(1.53)
Log coal production (thousand short tons, state-level)			.12*
			(.05)
Log gas production (million cubic feet, state-level)			-.08*
			(.03)
Population (county-level)			-.81
			(.42)
Median income (county-level)			-.01
			(.02)

Percentage Black (county-level)			-2.28
			(1.60)
Percentage Hispanic (county-level)			-2.65
			(2.29)
Nonmetro, adjacent to metro area			.09
			(.49)
Nonmetro, non-adjacent to metro area			.64
			(.64)
Observations	452	452	452
R2	0.02	0.42	0.45

Note: Robust standard errors in parenthesis.
**p<.01
*p<.05