Electoral Backlash or Positive Reinforcement? Wind Power and Congressional Elections in the United States*

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Abstract

Divisive facilities, such as wind turbines or hazardous waste depositories, are important for society but controversial because they often carry local costs. Elections are the most important means for citizens to express their views about divisive facilities, but the political science literature on the topic has little to say about their electoral effects. To fill the gap, we examine the case of wind turbine construction in the United States. An instrumental variable analysis shows that over the years 2003-2012, wind turbine construction generated large electoral benefits for (pro-renewables) Democratic candidates: every 100 megawatts of wind power capacity increased the Democratic vote share in U.S. House elections by 2-3 percentage points. This electoral shift, in turn, has contributed to a pro-environmental shift in congressional roll call voting on the environment. The results suggest that at the level of congressional districts, the local benefits of wind capacity installation outweigh the local costs. The deployment of wind turbine construction strengthens the position of the pro-renewables Democrats at the expense of the anti-renewables Republicans. While the result is inconsistent with naive models of retrospective voting, it accords with positive reinforcement theories on how policies endogenously create their political support.

Keywords: renewable energy; energy policy; environmental policy; public opinion; American politics

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1 Introduction

The politics of “not in my backyard” (NIMBY) (Rabe, 1994; Devine-Wright, 2005; McAdam and Boudet, 2012) or “divisive facilities” (Aldrich, 2008; Stokes, 2015) presents a dilemma for contemporary societies. From homeless shelters to hazardous waste repositories and wind turbines, societies need facilities that the local population finds unacceptable. Such facilities are often necessary to deal with social or environmental problems, but they carry local costs, and these costs provoke opposition that makes finding sites for such facilities difficult. As Stokes (2015: 3) writes, for example, “a small group of spatially concentrated citizens with intensely held preferences are able to create incentives for politicians to abandon policy, bucking the preferences of 90% of the public.”

At the same time, other scholars emphasize the localized “co-benefits” of such facilities. In the case of wind turbines, for example, scholars have found that local populations benefit from subsidies provided by the government (Michaelowa, 2005; Bayer and Urpelainen, 2016). Perceived social needs, such as dealing with climate change or hazardous waste management, creates an opportunity for targeted political spending. As these subsidies create employment and business opportunities, the number of people who stand to benefit from the facilities and the subsidy policies accompanying them grows in what Aklin and Urpelainen (2013) call “positive reinforcement.” Thus, the opposite concern emerges: perhaps governments allocate resources inefficiently for political reasons, giving too much to influential constituencies. In the disguise of environmental policy, subsidies to renewable energy are an expedient political strategy.

How powerful are these two different forces in actual politics? In assessing the relative importance of the electoral backlash and positive reinforcement forces, the *electoral effects* of divisive facilities are the central focus. After all, in democratic polities, elections are the primary channel through which both dissatisfied populations can air their grievances (Downs, 1957; Dahl, 1971; Wittman, 1995; Cheibub, Gandhi, and Vreeland, 2010). However, political scientists know little about the electoral effects of divisive facilities. We know from existing studies that targeted spending generates political benefits to incumbents (Chen, 2013; Zucco, 2013) and that local residents punish incumbents for NIMBY costs under retrospective voting (Stokes, 2015), but the net effect of these two forces remains unclear. For democratic politics, this net effect is what makes a difference.

Drawing on the political economy literature for inspiration, we propose that the net effect of the two forces – electoral backlash and positive reinforcement – is to give pro-facilities candidates a decisive edge in elections. Under retrospective voting (e.g., Fiorina, 1981; Healy and Malhotra, 2013; Achen and Bartels, 2016), the electoral backlash from localized costs applies to all incumbents regardless of partisanship. What is more, pro-facilities incumbents can compensate by claiming credit among constituencies that favor the facilities for socio-tropic reasons, such as climate change or energy independence. At the same time, the positive reinforcement mechanism creates political constituencies who strongly favor the pro-facilities candidates. These benefits are only available to pro-facilities candidates. Because the effects of the positive reinforcement mechanism are not as localized as those of the electoral backlash, the number of people who may be swayed to support pro-renewables candidates is larger than the number of disappointed retrospective voters.

Empirically, we test these hypotheses by examining the effects of wind turbine construction in U.S. congressional elections. Congressional districts are sufficiently small that wind turbine construction can be considered a local issue, but they are not so small that the politics is all about NIMBY. In the American political system, the clear divide between Democrats and Republicans on renewable energy allows us to formulate clear expectations about the effects of wind turbine construction on the electoral fortunes of the two parties. We expect Democratic candidates to gain an advantage over Republicans where wind turbines are installed.

Between the years 2003-2012, wind electricity generation capacity grew rapidly across the United States both because of supportive policies and because of rapid decreases in the cost of wind electricity generation (Bird et al., 2005). We exploit the fact that the installation of wind turbines is strongly related to the quality of the wind resource in different U.S. congressional districts. Specifically, we use differential temporal trends in mean wind potential across districts as an instrumental variable for wind turbine installation. We demonstrate that temporal trends in covariates unrelated to wind turbines are parallel, and then estimate models with district and state-year fixed effects to deal with unobserved heterogeneity across districts and over time within states.

The results provide strong support for the positive reinforcement theory: where wind turbines are constructed, Democratic candidates reap major political gains at the expense of their Republican counterparts. For example, we estimate that adding 100 megawatts of wind turbine capacity increased democratic vote share by about 1.7 percentage points while reducing republican vote share by about 2.1 percentage points. These results are highly significant and remain robust to changing specifications. In contrast, we uncover little evidence for electoral backlash from retrospective voting: incumbents neither win nor suffer on average.

In the next stage of our analysis, we test another implication of the positive reinforcement theory: changes in the content of policy. Drawing on the universe of environmental roll call votes considered important by the League of Conservation voters, we show that the Democratic electoral advantage from wind turbines translates into a pro-environmental turn across the board, beyond the narrow case of renewable energy. Because voters now favor and select pro-environmental Democrats as Members of the House, wind turbines induce a shift toward pro-environmental policy. We estimate that installing 100 additional wind turbines increases the share of pro-environmental vote by 4.4 percentage points overall, and the effect is the most pronounced in the issue areas of land use, dirty energy and wildlife. While most of the effect is driven by Democrats' electoral success, we also recover some evidence of adaptation: those Members of the House that remain in power adjust to new political realities by reducing their anti-renewables voting.

These results are relevant to broad bodies of literature on (i) the politics of divisive facilities and (ii) the social bases of support for sustainable energy transitions. While most of the focus in the divisive facilities literature has been on local opposition and the politics of NIMBY (e.g., Aldrich, 2008; Stokes, 2015), the net electoral effects of divisive facilities still remain poorly understood. Our findings show that in the case of wind turbines, pro-renewables politicians have no reason to worry about, as they may expect electoral gains. The findings thus testify to the power of positive reinforcement: facilities and policies that generate their own support are political winners.

Our analysis is closely related to the causal inference analysis of Stokes (2015), who finds that local residents punished incumbent governments for wind turbine construction in Ontario, Canada. Our analysis is different in three respects. First, we focus on American instead of Canadian politics. Second, we focus on electoral districts, a larger geographic area. Finally, we analyze multiple elections over a decade. As far as our results go, we show that even if the local residents punish the incumbent, at the level of electoral districts the net effect is clearly beneficial to pro-renewables political candidates. Our findings do not contradict the notion that the NIMBY effect results in an electoral backlash against the incumbent, and yet we see that overall wind turbine construction generates clear benefits for pro-renewables candidates. These benefits reflect the political economy of positive reinforcement, which requires a certain extent of forward-looking, sophisticated voting by direct beneficiaries of renewable energy.

For energy and climate policy, our findings provide additional evidence for the importance of positive *political* feedback loops. The literature on energy and climate policy has increasingly moved away from an exclusive focus on efficient policies, such as carbon taxes, and instead focused on the difficult question of political feasibility (e.g., Hughes and Urpelainen, 2015; Meckling et al., 2015). Our study provides robust causal estimates for a key claim underpinning the emphasis on political feasibility: pro-renewables candidates reap major electoral gains from their investments. When pro-renewables candidates have an opportunity to enact their preferred policies, these policies become self-reinforcing because they create their own political support. Those who benefit from renewable energy policies support the continuation and expansion of such policies, and thus pro-renewables candidates improve their electoral performance.

The general implications of our findings pertain to electoral politics. Our findings are inconsistent with simple models of retrospective voting (Fiorina, 1981; Healy and Malhotra, 2013), as they cannot explain why renewable energy deployment benefits pro-renewables candidates in particular. If people voted retrospectively, they should either punish or reward, depending on their preferences regarding wind power, *both* parties for installations. To explain the Democrat-Republican difference, it is instead necessary to allow for some attentiveness and forward-looking calculation among the electorate along the lines of Gasper and Reeves (2011) and Ashworth (2012). To explain our results, American voters need not be sophisticated strategists, but they must be able to identify Democratic candidates as more likely to furnish benefits from future wind energy installations.

2 Wind Turbines and American Politics

The use of wind in electricity generation has grown rapidly in the United States.[1] At the end of year 2015, the United States had installed 73,992 megawatts (MW) of capacity, an 18-fold increase from a capacity of only 4,147 MW at the end 2001. Geographically, wind energy generation is concentrated in Texas (12,353 MW), California (5,829 MW), and the Midwest (Iowa 5,177 MW; Illinois 3,568 MW; Minnesota 3,035 MW). The most important general factor driving the rapid increase of wind energy capacity in the 2000s is the rapid decrease in the cost of electricity generation. According to the U.S. Department of Energy, the cost of a kilowatt-hour in dollar cents (2014 constant prices) has decreased from over 60 in 1980 to about 20 in 1990 and between 5-10 in the 2000s (DOE, 2015: 3).

Environmental concerns are another important reason for the growth of wind power. Because wind energy generation produces very few carbon dioxide emissions or air pollutants, it plays an important role in efforts to mitigate climate change and other environmental problems (Sine and Lee, 2009; Vasi, 2011). Compared to alternatives such as coal, wind power is a significantly cleaner source of power. Indeed, both federal and state policymakers offer incentives for installing wind turbines and generating electricity with them. Since 1992, the federal government has offered a production tax credit for wind electricity generation on a per-kilowatt basis, and studies suggest that this policy has been critical for spurring the growth of wind energy (Lantz et al., 2014). Different U.S. states have also used renewable portfolio standards to mandate renewables use by electric utilities (Shrimali, Lynes, and Indvik, 2015), with forerunners such as Texas setting and then exceeding their aggressive generation targets (Hurlbut, 2008).

However, wind power also carries costs. Wind energy generation requires land, generates noise, and changes the landscape. Moreover wind turbines increase bat and bird mortality. The perception of high costs has mobilized local opposition against wind turbines across the United States and elsewhere in the world (Krohn and Damborg, 1999; Devine-Wright, 2005; van der Horst, 2007; Swofford and Slattery, 2010; Stokes, 2015). In this regard, local opposition to wind power is one

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[1] The data in this paragraph is from the American Wind Energy Association at `http://www.awea.org/Resources/Content.aspx?ItemNumber=5059` (accessed) May 17, 2016.

example of the NIMBY phenomenon (see Rabe, 1994; Stokes, 2015). As Zichella and Hladik (2013: 24) note in their discussion paper on siting issues in the United States, increased renewable energy deployment will require "smart strategies to avoid the risk of environmental and cultural-resource conflicts."

At the federal level, Democratic and Republican legislators diverge sharply in their views of wind power – and renewable energy more generally. Democrats tend to favor displacing fossil fuels with renewables, even if achieving the goal requires subsidies; Republicans tend to oppose such measures. Consider, for example, the 2012 Senate Roll Call Vote 39 on extending the production tax credit for wind energy and other renewables: of the 51 Senate Democrats, all but four voted in favor; of the 47 Senate Republicans, all but two voted against – and the remaining two did not vote at all.[2]

This clear partisan cleavage motivates our theory building. Given that Republicans and Democrats hold polar opposite views of the merits of wind energy, it seems unlikely that their electoral fortunes would react similarly to wind energy deployment. We thus advance an argument on asymmetric voter responses to wind energy deployment.

3 Renewable Energy Deployment: Distributional Conflicts and Electoral Effects

Theorizing about the electoral effects of renewable energy deployment – or any other divisive facilities – requires considering both benefits and costs. Renewable energy deployment generates benefits to the society in the form of improved environmental quality and local employment opportunities, but these benefits come at the cost of higher electricity prices, landscape changes, and other local negative externalities. To evaluate the electoral effects of these costs and benefits, we thus bring together theories of retrospective voting (see Fiorina, 1981; Chen, 2013; Healy and Malhotra, 2013) and forward-looking, sophisticated voting (see Gasper and Reeves, 2011; Ashworth, 2012). At election time, voters look back at the time since the last election, and support the incumbent if they are sufficiently satisfied with their lives. However, they also consider, if only to a limited extent,

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[2] See `http://scorecard.lcv.org/roll-call-vote/2012-39-clean-energy-tax-incentives` (accessed May 17, 2016). The two Independent Senators also voted in favor.

the incumbent's ability to deliver such benefits in the future.

Based on this logic, we can theorize about the electoral effects of renewable energy deployment. To summarize, we hypothesize that renewable energy deployment benefits pro-renewables candidates and hurts anti-renewables candidates. In particular, renewable energy policies do not generally result in an electoral backlash against the incumbent. While Stokes (2015) has shown that renewable eneryg generates a highly localized electoral backlash, at the level of an electoral district, this effect is swamped by the bias in favor of pro-renewables candidates. Because we look at the relatively large electoral districts of the United States, we can consider both the localized NIMBY opposition and the wider circles of support for renewable energy among American voters. When we do so, we see that the pro-renewables effects dominates over the anti-renewables backlash.

3.1 Benefits and Costs: Positive Reinforcement, Electoral Backlash

Although the social value of wind turbines is global thanks to climate mitigation, political economy approaches to renewable energy deployment also emphasize their localized political value (Michaelowa, 2005; Aklin and Urpelainen, 2013). Renewable energy deployment generates employment opportunities, enables the growth of industry and services, and creates value from sales of power. When policymakers invest in installing renewable electricity generation capacity, they create local demand for labor. When this demand is met, the location of installation becomes attractive for related investments because of the availability of skilled workforce. And when the installation is done, the owner of the renewable electricity generation capacity profits from sales of power to distribution companies. According to the American Wind Energy Association (AWEA), for example, by the year 2016 the number of jobs in the industry had reached 88,000.[3] In 2013, six hundred wind-energy related patents were filed in the United States.[4]

In general, public opinion studies in the United States also show that most Americans are favorable to wind power in general, in stark contrast to generally hostile attitudes toward coal, natural gas, and nuclear power (Ansolabehere and Konisky, 2009). Drawing on a survey of coastal Michigan, Bidwell (2013) reports that the belief that wind power generates local economic benefits

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[3] See `http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=8736` (accessed August 9, 2016).

[4] See `http://www.cepgi.com/2014/04/clean-energy-patent-growth-index-2012-year-in-review.html` (accessed August 10, 2016).

is the best predictor of support for wind energy. Positive attitudes toward wind energy reflect the perception that it is a clean and abundant source of energy.

As Bayer and Urpelainen (2016) show in the cross-national context, governments can also use renewable energy policies for political targeting. Because renewable energy generation on a large scale requires land, for example, renewable energy subsidies generate value to rural households that own a lot of land. Thus, governments can use the value generated by renewable energy to reward their loyal supporters and/or attract new supporters. For example, renewable energy feed-in tariffs in Germany generate economic rents for rural landowners in particular, given that both wind and solar electricity generation require a lot of land. Aklin and Urpelainen (2013), in turn, argue that these investments create a cycle of "positive reinforcement." As government policy allocates resources to beneficiaries, these beneficiaries begin to support the government and demand additional policies to support renewable energy policy.

In this Stiglerian political economy (Stigler, 1971), pro-renewables politicians can consolidate and expand their support through strategic policy investments. Renewable energy policies create winners, and winners engage in political collective action to support the policies creating the winners. According to Stokes (2016: 7), for example, "if a policy is effective at creating or expanding renewable energy industries – or, shifting power away from policy opponents – this can make expansion more likely and retrenchment less likely." As the use of renewable energy increases, the number of voters that gain from renewable energy policies increases, and these voters are more likely to vote for pro-renewables candidates.

However, renewable energy deployment also carries political costs (Aldy, Kotchen, and Leiserowitz, 2012; Petrova, 2013; Stokes, 2015). Renewable energy policies raise the cost of electricity generation relative to cheaper but polluting fossil fuels, with negative economic effects on industry, commercial, and residential consumers (Palmer and Burtraw, 2005). At the same time, the installation of renewable energy capacity may reduce the value of real estate because of perceived landscape deterioration and concerns about noise (Krohn and Damborg, 1999: 957). As Stokes (2015) notes, many of these costs – especially those related to landscape – are highly localized. While higher electricity prices may apply to a relative large geographic area, the NIMBY costs are limited to the immediate vicinity of the windmills themselves. While the benefits of renewable energy are only somewhat concentrated, the most visible and salient costs of wind energy are very localized.

3.2 Partisan Politics: Giving Credit, Assigning Blame

If there are both benefits and costs to renewable energy deployment, how can we assess its net electoral effects? In the American political context, the sharp polarization of Democrats and Republicans (see Fiorina and Abrams, 2008) allows us to generate hypotheses about the importance of costs and benefits in different political settings. Based on the LCV data on environmental votes that we use, the average Republican in the House and/or the Senate voted in favor of renewables only 23% of the time between 1974-2013, whereas the average Democrat voted in favor of renewables 75% of the time. Based on these numbers, we can safely assume that renewable energy deployment benefits (pro-renewables) Democrats at the expense of (anti-renewables) Republicans.

Consider first Republican candidates. Because Republican candidates are generally against renewables, they cannot secure political support through positive reinforcement. Public opinion studies show that voters who are ideologically conservative, and might thus support Republicans, tend to hold more negative views of renewable energy than their liberal counterparts (Leiserowitz et al., 2013). Whether incumbent or challenger, a Republican candidate also cannot expect the beneficiaries of renewable energy to vote for him or her, given that her party leadership is vocally opposed to renewables (Coley and Hess, 2012). Even if such a voter gained directly from renewable energy, perhaps through subsidies or employment, he or she would have to be completely naive to support an anti-renewables Republican candidate in the election. After all, the Republican candidate's party is campaigning to reduce investments in renewable energy.

Only a purely retrospective voter, who does not even understand his or her interests when they directly depend on the policymaker's choices, would vote Republican when benefiting from renewable energy. At the same time, Republican voters may punish Republican incumbents for failing to stop renewable energy deployment in spite of their anti-renewables platform. In a standard retrospective voting model, the incumbent would suffer an electoral backlash because of the negative effects of renewable energy. Thus, akin to Gasper and Reeves (2011), an electorate that is both somewhat retrospective and somewhat attentive would mean that renewable energy is bad news for Republicans. Such an electorate would consider the benefits or costs that past renewable energy investments have brought, but then pay enough attention to recognize that, in the polarized American political environment, Republicans are the anti-renewables party. Thus, Republicans would lose votes.

Now, consider Democratic candidates. Because Democratic candidates are in favor of renewable energy, they benefit from positive reinforcement dynamics. The direct beneficiaries of renewable energy have a strong self-interest in supporting candidates that favor renewable energy, as such candidates can protect policies like subsidies, tax breaks, and employment support for renewable energy. When applied to renewable energy, political economy theories of positive reinforcement thus predict the direct beneficiaries of renewable energy to support pro-renewables candidates in elections. On the other hand, as incumbents, Democratic candidates may suffer some electoral backlash from local opponents or those who suffer from higher electricity prices, but at the same Democratic candidates can active and energize their environmental supporters through renewable energy deployment.

Notably, these asymmetric effects do not depend on incumbency. Democratic incumbents may claim credit for renewable energy deployment, thus gaining an advantage over Republican challengers; however, positive reinforcement also benefits Democratic challengers. Republican incumbents may be punished for failing to stop renewable energy deployment; however, the gains of Democratic incumbents are also reduced because of localized electoral backlash. Therefore, our theoretical synthesis does not predict major differences between incumbents and challengers. The much more important cleavage, we maintain, is the difference between pro-renewables and anti-renewables candidates.

4 Research Design

Our empirical challenge is to estimate the effects of wind turbine construction on electoral outcomes (Democratic vote share, Republican vote share, incumbent vote share) and roll call votes (environment and energy) in the United States House of Representatives. However, this exercise is fraught with challenges. In particular, the installation of wind turbines may depend on political outcomes. In states and districts that vote for Democrats, both public opinion and policy may be more supportive of wind turbine construction than in areas that support Republicans. Given this confounding both in the forms of reverse causality and omitted variable bias, demonstrating a partial correlation between wind turbine construction and voting outcomes would not constitute evidence of causal effects.

To deal with the non-random construction of wind turbines, we exploit the fact that wind turbines are constructed over time in districts with good wind resources, which are plausibly uncorrelated with other determinants of electoral and roll call voting outcomes. The unit of analysis is either a state-district-year or a state-district-election period. We restrict our attention to years 2003-2012, because electoral districts were gerrymandered in 2002 and then again in 2013.

Because wind turbine construction is endogenous, such that congressional districts may differentially select into installing wind turbines based on unobserved characteristics that are correlated with voting preferences, we use an instrumental variables approach with time trends in wind potential as the instrument. Our primary identifying assumption is that variation in the *wind resource* generates quasi-random variation in the time trends of wind turbine installation across electoral district. As wind power becomes economically more competitive over time, installations grow fast in districts with good wind resources, but not in districts without such a resource.

We sharpen our identification by dropping all states without any wind turbine construction during the period of investigation. With state-year fixed effects included in all specifications, we only compare districts within any given state for a given year. As a result, we also drop states with only one district and states that do not have districts with and without wind farms. We further drop Texas due to concerns about endogenous district boundary changes. Table 1 shows basic summary statistics for the state-district-year and state-district-election period panels. Our sample includes 287 congressional districts within 25 states for a total of 2,870 observations spanning a decade. There are 104 districts treated with wind turbine installation by 2012 and 614 observations in the treated districts.

[Table 1 about here.]

Drawing on these assumptions, the causal relationship of interest is specified by the equation below:

$$Y_{ijt} = \alpha_i + \beta_{jt} + \gamma \text{Wind Turbines}_{ijt} + \varepsilon_{ijt}, \tag{1}$$

where i denotes districts, j states, and t years. The primary outcome variables of interest Y_{ijt} are either the vote shares of candidates during election years or the share of pro- and anti-environmental votes of elected representatives. α_i is a set of district fixed effects that account for any unobserved time-invariant determinants of electoral or environmental voting outcomes for each district, such as climate and geographic conditions. β_{jt} is a set of state-by-year fixed effects that flexibly account for time-varying differences in the outcome variables that are common across districts in each state, such as state-wide adoption or modification of Renewable Portfolio Standards (RPS). We cluster the standard errors ε_{ijt} by district allowing for the error terms to be autocorrelated over time within a given district. The inclusion of both district (α) and state-year (β) fixed effects ensures that we are comparing districts that are statistically indistinguishable, except for the differing pattern of wind turbine construction induced by variations in the wind resource over time.

4.1 Dependent Variables

We begin by estimating the effects of wind turbine construction on electoral outcomes of representatives in the House. The main specifications predict Democratic, Republican, and incumbent (regardless of partisanship) vote shares (0-100%) during the biennial elections. We collapse data into state-district-election periods for the 2004, 2006, 2008, 2010, and 2012 congressional elections. For incumbency analysis, our focus is on personal incumbency instead of partisan incumbency, because the latter has been shown to have a negligible effect in the United States (Fowler and Hall, 2014) and the electoral backlash against wind turbine construction is likely to affect the individual candidates and not the party. To detect possible partisan heterogeneity in electoral backlash, we also analyze samples split by the partisanship of the incumbent (Democratic or Republican).

To further investigate whether the electoral effects come from interest groups or local residents mobilizing non-voters to vote against representatives for constructing windmills or existing voters switching their votes (e.g., Chen, 2013; Chong et al., 2015), we analyze the effect of wind turbine construction on voter turnout. Turnout is measured by the total number of votes casted in each election year. An increase in turnout would suggest that anti-wind groups mobilized new voters to vote against elected officials for building costly and undesirable infrastructure.

We then examine how electoral backlash manifests in energy and environmental roll call voting outcomes by drawing on the National Environmental Scorecard data compiled by the LCV (2013) for the years 2003-2012. Since 1970, the LCV has been collecting voting records of all members of Congress on the most important enviromental legislations. Each vote is classified into one or more issue categories, such as climate change, energy, public lands, and wildlife conservation, and the LCV determines whether a 'yea' or 'nay' counts as a pro-environmental or anti-environmental vote. The determination of pro- and anti-environmental votes by the LCV is transparent and consistent over time not only because it reflects the consensus of environmental and conservation organizations in the United States, but also because we as researchers have no control over how the measure is coded.

4.2 Explanatory Variable

The explanatory variable is a measure of wind turbine installation, measured in either capacity (megawatt) or count. The data comes from the USGS Onshore Industrial Wind Turbine Locations for the United States and contains more than 48,000 wind turbine records with geolocations verified by high-resolution aerial imagery in ArcGIS. We calculate the capacity and count of installed turbines for each congressional district according to the year electricity generation started. To deal with missing values, we compute the cumulative turbine capacity and count for each district and use them as the main independent variables. We also estimate models with logarithmized measures to ensure that outliers and the skewed distribution of the explanatory variable does not bias our results.

In Figure 1, we overlay the distribution of windmills on the congressional district boundaries for the beginning of our sample period in 2003 and wind resource across the United States. As the figure shows, most states in the continental United States have windmills. The major exception is the South, which is mostly dropped from our sample due to a lack of within-state variation in windmill construction. There are considerable variations in the number and capacity of wind turbines installed across states. For instance, there are about 20 windmills installed per year on average in Minnesota but only 1 in Ohio over the sample period.

[Figure 1 about here.]

The growth in wind power generation in the sample is shown in Figure 2 and spatial variation in Figure 3. As these figures show, wind power has grown almost linearly over the period of investigation, supporting our use of a linear time trend. The growth also appears to be concentrated in areas with good wind resources, such as the Midwest.

[Figure 2 about here.]

[Figure 3 about here.]

4.3 Instrumental Variable

The instrument is a time trend multiplied by the (time-invariant) wind resource of the electoral district. We calculate the zonal wind potential for each district using the National Renewable Energy Lab (NREL) Wind Energy Resource Atlas, which provides the annual average wind resource potential at 50 meter height above surface with a resolution of 25 kilometers. Wind potential is represented by a wind power class ranging from 1 to 6, with 6 being the windiest. Our main specifications use the average wind potential for each congressional district, although using other statistics such as median and maximum wind potential does not affect the results (Tables A11-A12).[5]

Since the wind resource for each district is time-invariant, we interact it with a time trend to flexibly allow for districts endowed with more wind to have a different time trend than districts with less wind. This is advantageous because we can then also include district fixed effects to account for other time-invariant district-specific unobservables, such as climate and geography.

We can now write our two-stage specification as follows:

$$Y_{ijt} = \alpha_i + \beta_{jt} + \gamma \widehat{\text{Wind Turbines}}_{ijt} + \varepsilon_{ijt}; \tag{2}$$

$$\widehat{\text{Wind Turbines}}_{ijt} = \alpha_i + \beta_{jt} + \gamma t \times \text{Wind Resource}_{ij} + \varepsilon_{ijt}. \tag{3}$$

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[5] To be sure, the 50 meter height is by now below the height of new wind turbine installations. Given that our analysis begins in the year 2003, it would be inappropriate to focus on heights such as 80 meters. At any rate, high-resolution maps on the wind resource at such heights are not freely available for scientific replication purposes.

where Wind Turbines_{ijt} is the treatment variable that denotes the cumulative wind turbine capacity or count, instrumented by the average wind resource Wind Resource_{ij} interacted with time. In the second stage, the outcomes variables Y_{ijt} are either electoral vote shares of candidates for the state-district-election period panel or the share of pro- and anti-environmental votes of elected representatives for the state-district-year panel.

4.4 Testing the Identifying Assumptions

For average wind resource instrument to be valid, it must meet two criteria: relevance and exclusion restriction. The relevance criterion simply states that the instrument is strongly correlated with the explanatory variable ($\gamma \neq 0$). In our case, the relevance criterion is met because (i) wind turbines are installed in locations with good wind resources and (ii) wind turbine installation grows rapidly over time. As we saw in Figure 2 above, the growth of both turbine capacity and count is almost linear over time.

The relevance criterion can be tested empirically with the first-stage of the instrumental variable regression. The results from the analysis are shown in Table 2. As the table shows, the product term of mean wind potential and a time trend is highly correlated with the four measures of wind turbine installation. The F-statistic ranges from 16.23-33.15, and is thus well above the conventional threshold of 10.

[Table 2 about here.]

The more challenging task is to show that the exclusion restriction is met. While there is no formal test for the exclusion restriction, we provide empirical evidence strongly suggesting that the instrument affects the dependent variables only through the treatment variable and is uncorrelated with any other determinants of the dependent variable. To ensure that any other potential confounders of the outcomes variables are balanced across districts with and without wind turbines, we collect and merge in annual census data from the American Community Survey (ACS) available for the years 2005-2011. We use a specification similar to the first-stage regression, but replace Wind Turbines_{ijt} with the ACS census variables.

As shown in Appendix Tables A4-A6, our instrument is uncorrelated with a comprehensive set of potential confounders across demographics, income, education and employment. The three exceptions are population (slightly faster growth in areas with good wind resource), the share of white population (slightly smaller in areas with good wind resource), and median rent (slightly lower in areas with good wind resource). In Tables A9-A10, we show that (i) our results remain unchanged if these variables are included as controls and (ii) the controls themselves are not correlated with wind energy deployment.

We further examine the sensitivity of our main results for electoral outcomes in Table 3 while relaxing the instrument exclusion restriction. Using the union of confidence interval method described in Conley, Hansen, and Rossi (2012), we allow γ – the residual correlation between the instrument and the outcome after accounting for the endogenous variable of interest – to be not strictly equal to zero with the support $\gamma \in [-1, 1]$. These bounds are conservative, because the theoretical minimum and maximum values that the estimated coefficients on the instrument could take from an OLS regression are -1.0 and 0.8. The upper and lower bounds are shown in Appendix Figure A2, where each graph represents one set of regression results with the specified outcome variable (Democratic, Republican or incumbent vote share) and explanatory variable (cumulative capacity or count). We see that the confidence intervals are above zero for democratic vote share, below zero for republican vote share and around zero for incumbent vote share. In addition, the magnitudes for each regression are close to our point estimates except for the most extreme cases when γ is approaching 1. This provides further evidence for the validity of our IV approach.

5 Findings: Electoral Outcomes

We begin with a summary of our results on electoral outcomes and then distinguish between Democratic and Republican incumbents. We show that wind energy deployment has a strong positive effect on the electoral performance of Democratic candidates, then demonstrate that the effect is not only about incumbency effects, and finally provide evidence against turnout as a key causal mechanism.

5.1 Main Results

In Table 3, we report the results from the election analysis. For purposes of comparison, Panel A shows the ordinary least squares estimates that do not account for the endogeneity of wind turbine construction; Panel B, in turn, shows the instrumental variable estimates. All models include district and state-year fixed effects. As the table shows, the OLS estimates consistently understate the effect of wind turbine construction on Democratic and Republican vote shares due to issues of omitted variables bias and reverse causality. This provides further justification for our instrumental variable research design. According to models 1 and 3, adding 50 megawatts of wind power is enough to shift the vote in favor of Democratic candidates by about 1 percentage point. Given a sample mean of 46 megawatts and a maximum of 2936 megawatts, this is a large effect. In terms of counts, about 30-35 additional windmills is enough to produce such a shift. In contrast to Stokes (2015), the incumbent's vote share does not depend on wind turbine construction, as the coefficients are very close to zero and have wide confidence intervals.

[Table 3 about here.]

Table 4 replicates our main electoral analysis with logarithmized values of the explanatory variable; the structure of the table is otherwise similar to that of Table 3. The results are robust, as increasing the logarithm of cumulative capacity or the cumulative count by 1 (i.e., increasing the actual capacity or count by a factor of 2.71) shifts votes toward Democratic candidates by a margin of 5.6-6.3 percentage points.

[Table 4 about here.]

One might be worried that these results are driven by states that are both traditionally strongly favorable to Democrats and have witnessed considerable growth in wind power already *before* the American wind boom began. To ensure that this is not the case, we rerun the analysis excluding California, the one state that saw a wind energy boom already in the early 1980s (Gipe, 1991). We see in Appendix Tables A7 and A8 that while the estimated coefficients are slightly attenuated perhaps due to the decrease in sample size, they remain statistically significant and are qualitatively similar to those under the full sample.

Overall, these results underscore the partisan logic of renewable energy deployment: the pro-renewables Democrats benefit and the anti-renewables Republicans are hurt. However, this analysis is not yet enough to distinguish between the endogenous and selective electoral backlash accounts. Thus, we now turn to comparing the electoral fortunes of Democratic and Republican incumbents when new wind turbines are added.

5.2 Democratic and Republican Incumbents

We now turn to comparing the electoral fortunes of Democratic and Republican incumbents when additional wind turbines are installed. In Table 5, we replicate the incumbent vote share models with samples split by Democratic and Republican incumbents. As models 1-2 in Panel B show, Democratic incumbents appear to gain from wind turbine installations, though the coefficients are noisy; models 3-4 of Panel B, in turn, show that Republican incumbents suffer, though again the confidence intervals are relatively wide. In Table 6, we show that the estimates from logarithmized explanatory variables are largely similar.

[Table 5 about here.]

[Table 6 about here.]

Overall, these results do not support the incumbency story at the congressional district level. The coefficients for incumbents are virtually identical to those from the full models, and the confidence intervals around them wider, partially because of smaller sample sizes. There appears to be a general shift from Republicans to Democrats, independent of whether the incumbent is a Democrat or a Republican. This shows that even if residents hold elected officials accountable by punishing the incumbent at the local level, the effect of positive reinforcement appears to dominate that of electoral backlash at the congressional district level. The net effect of wind turbine construction is clearly beneficial to pro-renewables Democrats.

5.3 Mechanisms of Change: Turnout

In Tables 7 and 8, we consider the possibility that changes in voter turnout are responsible for the shift in favor of Democrats. As the tables show, there is no evidence that wind turbine construction has led to new voters being mobilized to vote in favor of Democrats. The coefficients are very small and never statistically significant throughout.

[Table 7 about here.]

[Table 8 about here.]

In Table A13, we next use survey data from the American National Election Studies to see if there are differential turnout responses by partisanship. The analysis shows that survey respondents who identify as Democratic, Republican, or Independent do not increase or decrease their turnout because of wind power construction. These results suggest that partisan turnout effects along the lines of Chen (2013) and Chong et al. (2015) are not driving the results. This evidence is again consistent with the notion that turnout is not the mechanism through which Democratic candidates gain votes.

6 Findings: Environmental Policy

We next examine the consequences of wind power installation for environmental policy in the United States. The positive reinforcement theory, which is supported by the electoral results, suggests that wind power installation generates a shift toward more support for environmental policy (e.g., Aklin and Urpelainen, 2013).

6.1 Main Findings

Table 9 shows the results for environmental policy roll call votes. In models 1-2, the dependent variable is the share of pro-environment votes in a district-year; in models 3-4, the dependent variable is the share of anti-environment votes. The results show that as wind power grows in a district, Representatives from that district begin to favor more often in favor of the environment. For example, each additional megawatt increases the probability of a pro-environmental vote by 0.025 percentage points; thus, a standard deviation's increase (209 MW) would cause an increase in pro-environmental voting of over 5 percentage points. The effects on reducing anti-environmental voting are comparable.

[Table 9 about here.]

Next, in Table 10 we replicate the main environmental policy analysis with logarithmized values of the explanatory variable. Now, increasing the logarithm of cumulative capacity by 1 would increase the probability of a pro-environmental vote by 6.5 percentage points. The effects on reducing anti-environmental voting are comparable.

[Table 10 about here.]

Overall, these results are consistent with the positive reinforcement story: renewable energy deployment generates support for Democratic candidates, and Democratic candidates then vote in favor of the environment.

6.2 Types of Environmental Policy

In Figure 4, we next show the estimated effects of wind power construction on environmental roll call votes by issue area. The figure shows the coefficient estimates for all four measures of wind turbine installation from the instrumental variable regressions. As the estimates show, there is very little evidence of issue-specific voting adjustments. Across all types of environmental issues, wind turbine installation increases pro-environmental voting, as the electoral popularity, and ultimately success, of Democratic candidates results in a shift in roll call votes. The effects are not particularly large for issues related to clean energy or climate change, and even pro-environmental voting on mostly unrelated issues such as land and wildlife increases.

[Figure 4 about here.]

These estimates are consistent with a simple electoral story: wind power promotes pro-environmental voting because Democrats benefit from wind installations. Although the story is simple, these estimates are theoretically and practically important. They show that wind power construction does not only result in more policy support for targeted spending on wind power and related issues, such as renewables more generally. Instead, the growing support of Democratic candidates translates into a wave of pro-environmental preferences across the board.

6.3 Changes in Legislator Behavior

In Section A5, we replicate the environmental policy analysis with legislator fixed effects included. This analysis removes the electoral effects and focuses exclusively on changes in the behavior of legislators – conditional on their remaining in power. The analysis shows that the effects of wind power construction are significantly weakened, with smaller and less precisely estimated coefficients. In this regard, wind turbine construction seems to mostly shape legislative behavior through elections: pro-renewables candidates gain an advantage over their anti-renewables candidates. However, we do see some evidence of adaptive behavior, especially in regard to a decrease in anti-environmental voting. For every 100 megawatts of wind turbine constructed, the probability of adopting an anti-environmental position (instead of pro-environmental or neutral) decreases by 1.6-2.8 percentage points.

These results have a natural theoretical interpretation. It seems that incumbents are adjusting to the growing popularity of renewables due to wind turbine installation, but this adaptive behavioral effect is weaker than the electoral effect. This dual effect is easy to understand when one considers that the anti-Republican effect of wind turbine construction threatens the electoral fortunes of Republican candidates, and thus forces them to adapt to changing electoral circumstances by moderating their environmental policy positions. Thus, anti-Republican selection effect is probably driving the adjustment effect among elected officials.

7 Conclusion

We have shown that Democratic candidates for the U.S. Congress reap large political gains from wind turbine construction, regardless of whether they are incumbents or not. These gains, in turn, prompt a shift toward more pro-environmental roll call voting in general. These results are consistent with a positive reinforcement approach to renewable energy development: although wind turbines are divisive and may generate local opposition, their net effect in congressional elections is to shift votes from Republicans to Democrats.

In evaluating the significance of the result, it is important to remember the relatively large size of U.S. congressional districts. Our findings are by no means inconsistent with theories of local grievances against divisive facilities; it is entirely possible that within districts there are clusters of intense opposition. But because we focus on outcomes at the district level – the electoral unit that determines the outcome – such opposition does not overturn the broader political gains from wind turbine construction. The district-level gains from employment, profits, and environmentalists are sufficiently large to generate a net positive effect. It is entirely possible that if we had instead investigated local elections very close to wind parks, we would have seen the opposite result.

For scholarship on divisive facilities, the results highlight the importance of focusing on net effects of setting up facilities. Even if divisive facilities have negative political effects at the local level, these effects must be weighed against positive gains. Thus, future studies should assess the conditions under which positives outweigh the negatives. Moreover, researchers should try to identify the extent to which voters reward and punish different politicians at different levels of governance. Do politicians at higher levels of government secure the gains from divisive facilities, while politicians at lower levels incur the costs? What can local politicians do to protect themselves from political backlash?

These considerations are also of practical significance. Solving global problems such as climate change ultimately depends on building domestic political support for policies that trigger a transition to sustainable energy, and such support is by no means guaranteed, given the costs of abandoning fossil fuels and the political power of interest groups such as the heavy industry and fossil fuel producers. Our results, and the research agenda on electoral backlash versus positive reinforcement in the case of divisive reinforcement more generally, can help policymakers at different levels develop effective strategies to generate popular support for new policies.

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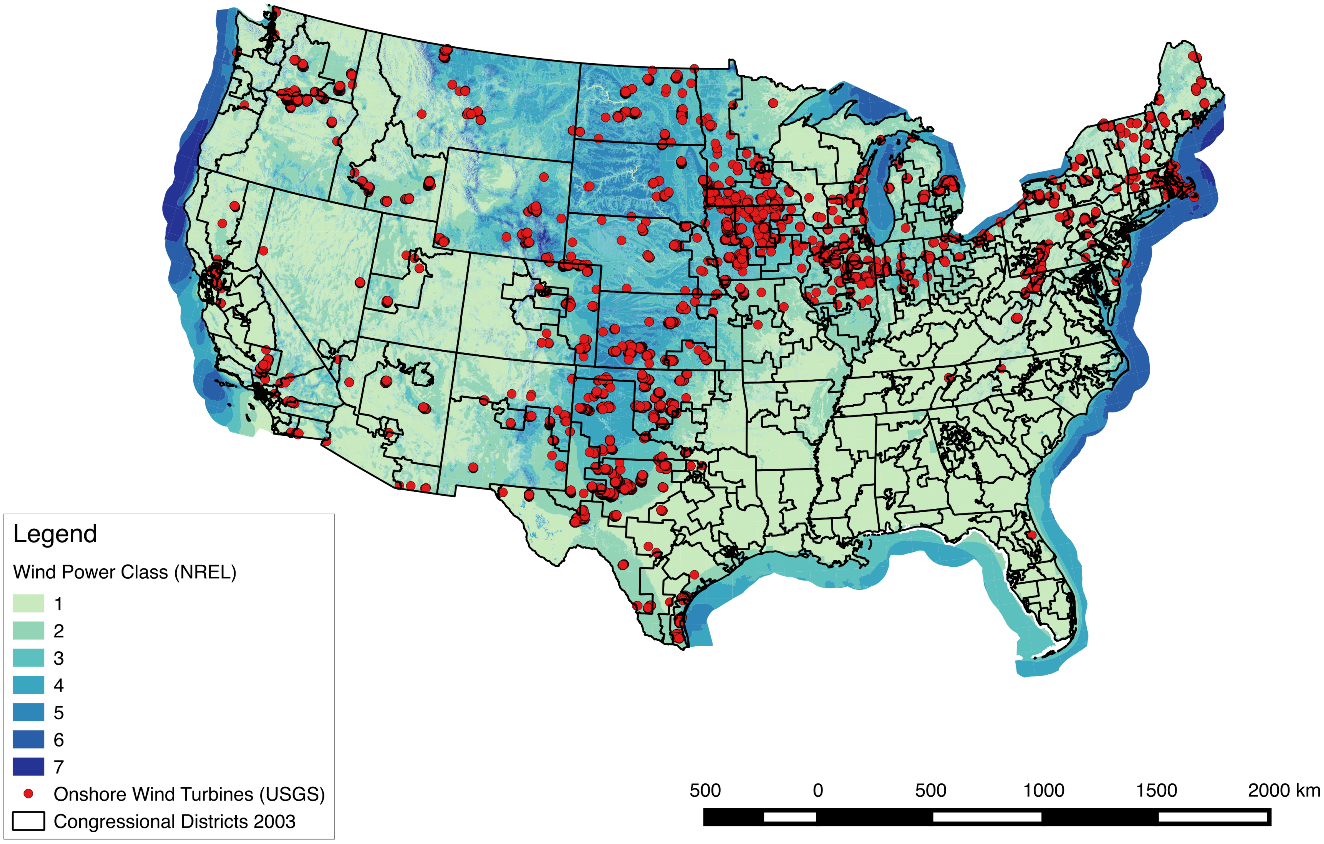

Figure 1: The distribution of onshore windmills installed in the United States between 1981 and 2014. The map overlays 2003 congressional district boundaries with the strength of wind resource as classified by National Renewable Energy Lab (NREL).We exclude states that do not have any windmills, those that have only one district, and those that do not have districts with and without wind farms during the sample period of 2003-2012. We also exclude Texas due to boundary changes (gerrymandering).

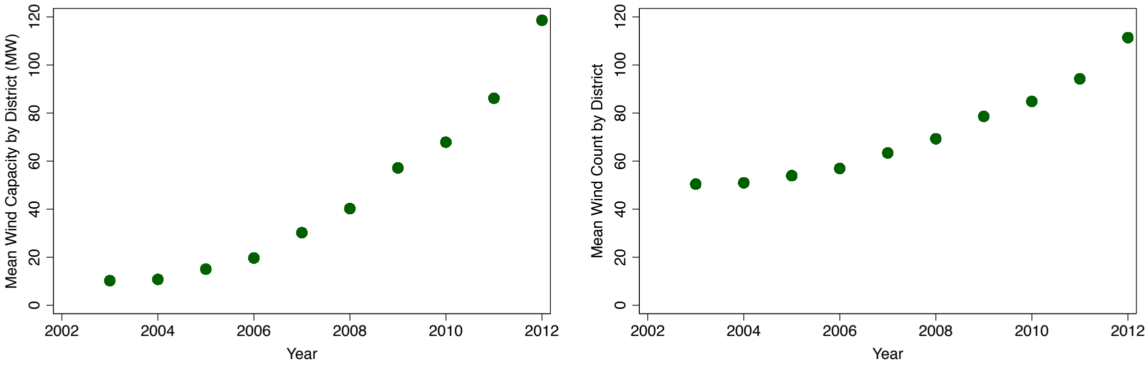

Figure 2: Growth of wind turbines in the 287 sample state-districts, 2003-2012.

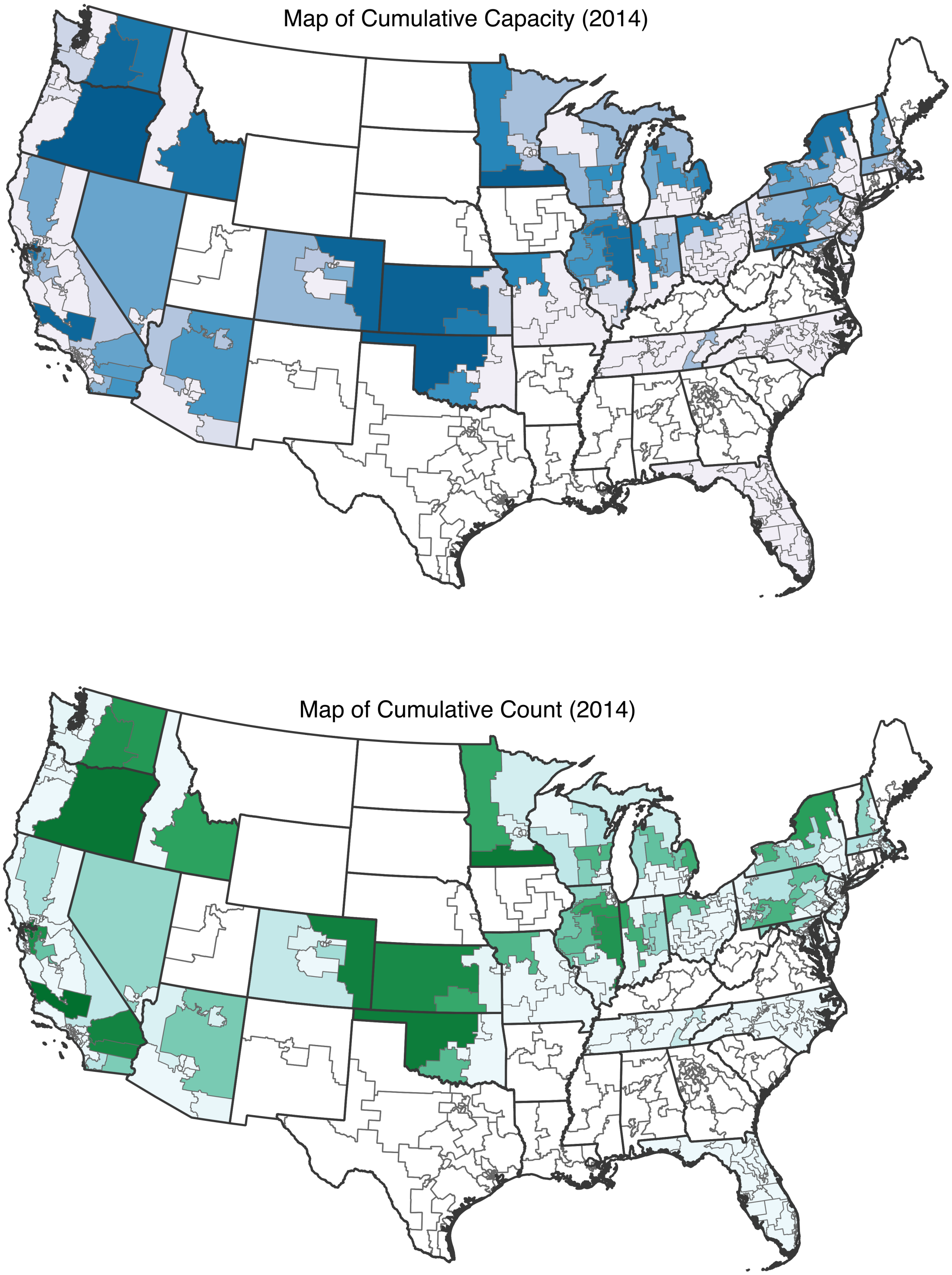

Figure 3: Spatial variation of cumulative capacity and count of wind turbines in the 287 sample state-districts by 2014.

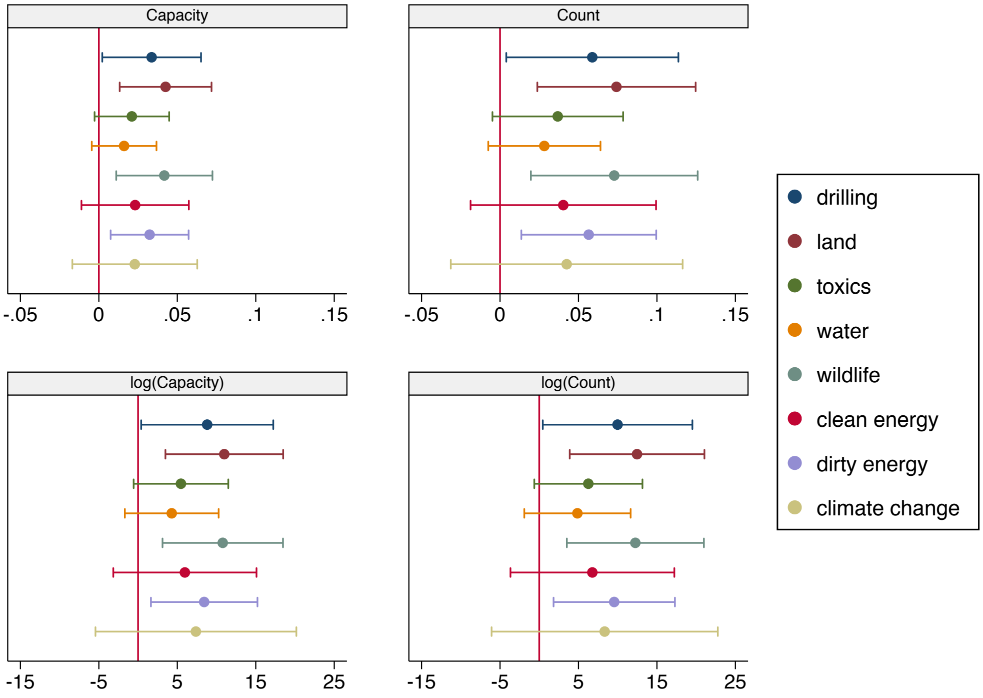

Figure 4: Estimated coefficients of wind power construction on environmental roll call votes by issue area.

Geographic unit	Total	Wind	No Wind
Years	10	10	0
States	25	25	0
State-districts	287	104	183
State-district-years	2870	614	2256

Table 1: Summary of observations in state-district-year panel.

	(1) Capacity	(2) Count	(3) log(Capacity)	(4) log(Count)
Mean wind potential * time	37.208^{***} (9.131)	21.325^{***} (5.294)	0.144^{***} (0.025)	0.127^{***} (0.022)
Observations	2868	2868	2868	2868
Districts	287	287	287	287
R^2	0.73	0.98	0.86	0.90
F-statistic	16.61	16.23	33.15	32.51

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: First-stage results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Democratic Vote		Republican Vote		Incumbent Vote	
	(1) Model	(2) Model	(3) Model	(4) Model	(5) Model	(6) Model
Panel A: OLS						
Cumulative capacity (MW)	0.003		-0.003		-0.002	
	(0.002)		(0.002)		(0.002)	
Cumulative count		0.006		-0.007		-0.005
		(0.004)		(0.004)		(0.004)
Panel B: IV						
Cumulative capacity (MW)	0.017**		-0.021***		0.004	
	(0.007)		(0.007)		(0.008)	
Cumulative count		0.030**		-0.037***		0.008
		(0.013)		(0.013)		(0.014)
Observations	1141	1141	1141	1141	1029	1029
Districts	287	287	287	287	285	285
R^2	0.86	0.86	0.87	0.87	0.74	0.74

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Election outcomes: OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Democratic Vote		Republican Vote		Incumbent Vote	
	(1) Model	(2) Model	(3) Model	(4) Model	(5) Model	(6) Model
Panel A: OLS						
log(Cumulative capacity+1)	-0.306		0.236		-0.252	
	(0.447)		(0.432)		(0.450)	
log(Cumulative count+1)		-0.357		0.258		-0.184
		(0.506)		(0.488)		(0.502)
Panel B: IV						
log(Cumulative capacity+1)	5.563**		-6.871***		1.411	
	(2.436)		(2.345)		(2.330)	
log(Cumulative count+1)		6.262**		-7.735***		1.583
		(2.760)		(2.678)		(2.597)
Observations	1141	1141	1141	1141	1029	1029
Districts	287	287	287	287	285	285
R^2	0.84	0.84	0.83	0.84	0.73	0.73

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Election outcome robustness check: Comparison of OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Democratic Incumbent		Republican Incumbent	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
Cumulative capacity (MW)	-0.010*		-0.006	
	(0.006)		(0.004)	
Cumulative count		-0.018*		-0.011
		(0.009)		(0.007)
Panel B: IV				
Cumulative capacity (MW)	0.040		-0.019*	
	(0.034)		(0.010)	
Cumulative count		0.073		-0.035*
		(0.063)		(0.019)
Observations	569	569	402	402
Districts	158	158	127	127
R^2	0.77	0.77	0.74	0.74

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Hetereogenous incumbent effect by party: Comparison of OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Democratic Incumbent		Republican Incumbent	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
log(Cumulative capacity+1)	-0.980		0.015	
	(0.928)		(0.380)	
log(Cumulative count+1)		-1.043		0.091
		(1.039)		(0.434)
Panel B: IV				
log(Cumulative capacity+1)	4.642		-6.747	
	(3.725)		(4.895)	
log(Cumulative count+1)		5.222		-7.503
		(4.126)		(5.625)
Observations	569	569	402	402
Districts	158	158	127	127
R^2	0.76	0.76	0.60	0.60

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Hetereogenous incumbent effect by party robustness check: Comparison of OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Turnout		log(Turnout)	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
Cumulative capacity (MW)	1.978		0.000	
	(4.562)		(0.000)	
Cumulative count		3.440		0.000
		(7.938)		(0.000)
Panel B: IV				
Cumulative capacity (MW)	-12.832		-0.000	
	(11.674)		(0.000)	
Cumulative count		-23.188		-0.000
		(20.958)		(0.000)
Observations	1134	1134	1133	1133
Districts	287	287	287	287
R^2	0.97	0.97	0.97	0.97

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Turnout: Comparison of OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Turnout		log(Turnout)	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
log(Cumulative capacity+1)	-847.879		-0.001	
	(593.542)		(0.002)	
log(Cumulative count+1)		-1009.025		-0.001
		(699.108)		(0.003)
Panel B: IV				
log(Cumulative capacity+1)	-4283.253		-0.002	
	(3459.987)		(0.012)	
log(Cumulative count+1)		-4819.687		-0.002
		(3878.380)		(0.013)
Observations	1134	1134	1133	1133
Districts	287	287	287	287
R^2	0.97	0.97	0.97	0.97

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Turnout robustness check: Comparison of OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Pro-Environment Vote		Anti-Environment Vote	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
Cumulative capacity (MW)	0.01190^{**}		-0.01006^{**}	
	(0.00482)		(0.00472)	
Cumulative count		0.02299^{**}		-0.01907^{**}
		(0.00895)		(0.00891)
Panel B: IV				
Cumulative capacity (MW)	0.02502^{**}		-0.03077^{***}	
	(0.01091)		(0.01149)	
Cumulative count		0.04365^{**}		-0.05368^{***}
		(0.01880)		(0.01990)
Observations	2868	2868	2868	2868
Districts	287	287	287	287
R^2	0.86	0.86	0.87	0.87

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Environmental voting outcome: OLS and IV regression results. The instrument is the product of the time trend with the average wind power resource. All models include district and state-year fixed effects. Standard errors are clustered by district.

	Pro-Environment Vote		Anti-Environment Vote	
	(1) Model	(2) Model	(3) Model	(4) Model
Panel A: OLS				
log(Cumulative capacity+1)	0.04610		-0.02681	
	(0.57562)		(0.53855)	
log(Cumulative count+1)		0.05647		-0.08436
		(0.65270)		(0.61604)
Panel B: IV				
log(Cumulative capacity+1)	6.46610**		-7.95217***	
	(2.98240)		(3.04499)	
log(Cumulative count+1)		7.34170**		-9.02901***
		(3.40236)		(3.47553)
Observations	2868	2868	2868	2868
Districts	287	287	287	287
R^2	0.85	0.85	0.85	0.85

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Environmental voting outcome robustness check: Comparison of OLS and IV regression results