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Party affiliation, economic interests and U.S. governors' renewable energy policies☆

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ABSTRACT

This paper explores the impact of U.S. state governors' party affiliation and economic interests on renewable energy outcomes. Using data on installed renewable capacity, we find that, on average, Democratic governors had a positive impact on the state-level adoption of renewable energy. However, the effect is highly heterogeneous. There are no differences in renewable energy outcomes between Democratic and Republican governors in states where the energy-intensive manufacturing industries are economically important or in states where the natural renewable endowment is scarce. Consistent with a political economy approach, we argue that in the area of renewable and climate policy, governors' policy preferences are overridden by holding office motivations and economic interests.

1. Introduction

In the global response to tackle climate change, the transition to renewable energy has emerged as a crucial strategy to decarbonize the power sector, which is a primary source of carbon dioxide emissions. Governments worldwide have implemented a wide array of public support initiatives for renewable energy sources (RESs). These public interventions encompass production incentives, subsidies, and mandatory regulations, all of which are vital for breaking the "carbon lock-in" of conventional fossil fuel energy sources and fostering the diffusion of renewable energy sources in the market.[1]

In the context of the United States, the efforts to promote clean energy have primarily been carried out through the decentralized actions of state governments. This approach stems from the significant autonomy that state governments have in determining the stringency and scope of renewable energy policies, as well as broader environmental policies. The political economy literature has extensively studied the role of political institutional factors in the area of environmental policy.[2] However, whether politicians' attitude towards the environment affects environmental policymaking and performance is still a controversial debate. Furthermore, empirical findings also exhibit mixed results.

Several studies support the argument that politicians are primarily interested in winning offices, aligning with the "Downsonian" perspective in the political economy literature. In the domain of environmental policies, List and Sturm (2006) present evidence that the behavior

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[1] Some examples of these policies are renewable portfolio standards (RPSs), feed-in-tariffs, tax credits or investment grants. The common objective of government intervention is to ensure economic incentives to "non mature" energy sources in order to help them become cost competitive with conventional fossil fuel sources.

[2] For an extensive review of the literature see Oates and Portney (2003) and Hu et al. (2021). Hu et al. (2021) provide a recent review of the empirical studies examining the influence on environmental policies and performances of political factors such as electoral cycles, lobbying, partisan affiliation and political institutions.

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of U.S. governors' is largely driven by opportunistic concerns for reelection. Similar evidence, highlighting office-seeking behavior among politicians, is also found in Fredriksson et al. (2011), who explicitly examine the role of inter-party competition in shaping environmental policymaking. On the other hand, some studies suggest that partisan differences along the environmental dimension may exist. Beland and Boucher (2015) support that Democratic governors have been more successful in reducing concentrations of certain air pollutants. Kim and Urpelainen (2017b) provide evidence of increasing partisan policy divergence within U.S. federal climate policy. A recent study by Pacca et al. (2021) not only explores the impact of party affiliation on environmental policy but also delves into its interactions with political pressures from lobby groups.

To the best of our knowledge, no existing contribution studies the influence and the interplay of these factors on renewable energy outcomes.[3] Our analysis draws from the literature linking politics and the environment, with a particular focus on an area where the empirical findings are still rather scarce: the case of the U.S. renewable energy diffusion.

The case of U.S. state renewable energy policies is not only policy relevant but is also of particular interest for its political economy implications. Indeed, the willingness of politicians to support renewable energy involves a balance between environmental objectives and reelection concerns. Governors, who play a pivotal role in state-level policymaking, face political pressures from various interest groups striving to sway the political agenda in their favor. On one hand, there has been a growing sensitivity to climate change, particularly among Democratic voters, resulting in a wider partisan divide over climate policy. This divide became evident during the U.S. federal government's withdrawal from the Paris Climate Agreement. On the other hand, renewable energy policies have distributional consequences, raising the opposition or the support of different groups in the economy. Public interventions typically benefit renewable energy investors while shifting the costs of cleaner energy and stringent environmental regulation onto end-users, either through higher energy prices or increased regulatory burdens on polluting activities (Greenstone and Nath, 2020).[4]

We exploit the variation across U.S. states in renewable energy outcomes to study their political economy determinants. Using data on state renewable installed capacity, we first test whether the inter-party competition between Democratic and Republican governors results in differences in renewable energy outcomes, hypothesizing that Democratic politicians are more inclined to prioritize climate mitigation compared to Republicans. Secondly, we investigate whether governors' attitude towards renewable energy is enhanced or counteracted by state-specific economic interests. This is empirically studied by interacting governors' party affiliation with measures that capture the strength of different economic interests that could eventually act against or in favor of renewable energy deployment. Economic interests opposing renewable energy are proxied by alternative measures of the manufacturing industry size. More specifically, we argue that energy-intensive manufacturers, whose profits rely on the availability of affordable energy, are likely to oppose costly energy transitions. To capture the economic interests of renewable energy supporters, we leverage the exogenous variation in renewable energy resources (i.e., wind and solar potential) across U.S. states. In this context, we argue that the interests of renewable energy investors are concentrated in states where producing clean energy is more profitable.

Our empirical results suggest that renewable installed capacity has increased under Democratic governors compared to their Republican counterparts during the period 1995–2010. This reveals some degree of policy diverge between the two parties. However, the effect is highly heterogeneous across states and conditioned by the context of where governors operate. In particular, differences in renewable energy outcomes across Democratic and Republic governors shrink as the state energy-intensive manufacturing industry size becomes larger. This suggests that, in states where the manufacturing industry is relevant, Democratic governors do not differ from Republicans in renewable energy achievements. Instead, we find that Democratic governors are more successful in promoting renewable energy in states that are rich of renewable energy resources. We have found our results to be robust even after implementing a Regression Discontinuity Design (RDD) analysis to address potential endogeneity related to party affiliation, performing placebo tests on various dependent variables, and employing alternative empirical specifications. Overall, our evidence suggests that politicians' choices on renewable energy are influenced by material interests rather than being purely determined by policy preferences. These results align with those uncovered in prior studies on U.S. environmental policy by Fredriksson et al. (2011) and Pacca et al. (2021), while also making a novel contribution to the expanding body of literature on the diffusion of renewable energy from a political economy perspective.

We proceed with a review of the relevant literature in Section 2. In Section 3 we present a brief theoretical discussion of the possible behaviors of governors in the area renewable energy. In Section 4 we discuss the empirical approach and describe the data employed. In Section 5 and Section 6 we present our main empirical results and the robustness tests, respectively. Finally, Section 7 provides some concluding remarks.

2. Relevant literature

In the area of renewable energy, the literature has mostly focused on issues of effectiveness of policy instruments for renewable energy sources or on the determinants of renewable energy deployment,[5] rather than on the role of political economy factors. Menz and Vachon (2006) is one of the first econometric analysis examining the contribution to wind power development of several state-level policies in the United States. Carley (2009) empirically tests the effectiveness of renewable portfolio standards in the U.S. states. Among the few studies on the U.S. states, Lyon and Yin (2010) investigate several determinants of renewable energy policies, although only focusing on a specific policy instrument (i.e., Renewable Portfolio Standards).

Recent econometric analysis for OECD countries add more evidence on the determinants of renewable energy policies. Cheon and Urpelainen (2013) and Cadoret and Padovano (2016) find that the presence of manufacturing industries hindered renewable energy deployment. This effect is primarily motivated by the fact that this economic group has particularly strong incentives to oppose renewable energy policies to avoid costly energy transitions. On the other hand, Verdolini et al. (2018) document that, given the high variability of renewable energy production, its diffusion has been facilitated in countries equipped with fast-reacting modern fossil technologies (such as gas generation) whose back-up capacity acts more as a complement rather than a substitute to renewable energy sources. Nicolli and Vona (2019) document a positive effect of energy market liberalizations on the diffusion of renewable energy policies, suggesting that entry barrier

[3] In their extensive review, Hu et al. (2021) [p. 251] notice that *"...the question of how political factors influence the development of renewable energies remains understudied, therefore deserving more attention from future researchers"*.

[4] Greenstone and Nath (2020) comprehensively evaluate the direct and indirect costs on the power system of renewable energy sources across the U.S. states. According to their study, average retail electricity prices increased by 17% in states 12 years after the adoption of a Renewable Portfolio Standard. The estimates take into account the charges on electricity bills to finance renewables incentives, the larger operational costs of renewable energy power plants and the indirect costs related to their intermittent energy production and grid connections.

[5] See Bourcet (2020) for a systematic literature review.

reductions favor the emergence of decentralized energy producers such as renewable energy investors.

Due to the absence of a consistent literature linking political factors to renewable energy development, our paper draws inspiration from the literature on politicians' motivations in shaping environmental and public policies. Previous contributions explore how re-election concerns create incentives for politicians to deviate from their policy preferences. List and Sturm (2006) develop a theory in which incumbent politicians strategically distort their policy preferences in order to attract votes to their platform and improve the probability of being reelected. By exploiting the variation in gubernatorial term limits, they show that environmental expenditures in U.S. states differ between years in which governors can be reelected and years in which they face a term limit. In addition, they find that in states classified as "brown" (i.e., where citizens exhibit lower environmental sensitivity), re-electable governors undertake less environmental policies than governors facing a binding term, while the opposite pattern occurs in "green" states. Extending the work of List and Sturm (2006), Fredriksson et al. (2011) explicitly study the effect of governors' party affiliation on environmental expenditures. They do so by comparing environmental expenditures not only across re-electable and "lame duck" governors but also across governors from the Democratic and Republican party. They find that there are no significant policy differences across governors from the two parties whenever they can run for another term. The findings of List and Sturm (2006) and Fredriksson et al. (2011) support the assumptions of opportunistic politicians underlying the median voter theorem (Downs, 1957) and related political economy literature.

Other strands of the theoretical literature drawing from Wittman (1983) and Calvert (1985) have instead emphasized politicians to be policy-motivated. These theories recognize the role of partisan considerations in shaping policies. Indeed, as discussed in Persson and Tabellini (2002), the underpinning assumptions regarding politicians' motivations constitute a controversial issue within the theoretical literature. In this respect, several contributions have recently attempted to develop new theories bridging office and policy motivations into a more realistic framework. Callander (2008) develops a theory of electoral competition where candidates may be either office or policy motivated. Voters are assumed to value policy-motivated candidates not only for their pre-election campaign platforms but also because they are likely to implement policies more effectively once elected. In a similar spirit, Kartik and Preston Mcafee (2007) present a model where some candidates have an exogenous policy preference called "character" that is valued by voters as a signal of reliable policy commitment. Thus, even strategic candidates imitate politicians with character and move away from the median voter's stance in order to gain credibility from voters.

Our work aims at enriching the debate over politicians' motivations as well, by explicitly studying the role of partisanship and partisan activities. Several recent empirical works on U.S. environmental policymaking have looked into how some political parties have been successful in prioritizing environmental protection in their agendas. Indeed, empirical results in this area remain controversial. Beland and Boucher (2015) estimate the impact governors' party affiliation on several state air pollution indexes, finding that Democratic governors significantly reduce concentrations of some pollutants relative to Republicans. However, their analysis does not take into account the interplay with other factors related to lobbying activities or state-related economic interests. Kim and Urpelainen (2017b) support that the American environmental policy is highly polarized between the Democratic and the Republican party. By studying the voting behavior of the congress members at the federal level, they find that the propensity to vote in favor of the environment increases substantially for elected Democratic congressmen relative to republican ones. Gagliarducci et al. (2019) bring compelling evidence on how the occurrence of disasters and extreme events influences politicians' behavior over climate policies. In their study, they find evidence that U.S. congress members are more prone to support climate legislation only after their district has been hit by a hurricane. Using facility-level data on the Clean Air Act, Innes and Mitra (2015) find that the election of Republican congressional representatives has depressed inspection rates for polluting facilities in their own constituency. In contrast, focusing on state governors, Fredriksson and Wang (2020) report different results with respect to the impact of party affiliation on local environmental enforcement. They find that Democratic governors, on average, depress inspection rates compared to Republicans, with no differences in punitive actions between the two parties.

A common limitation of the previously mentioned works is their lack of explicit consideration of lobbying, economic interests, and their interplay with other political factors as determinants of environmental policy. Our contribution takes into account these important elements of policy making. Indeed, the theoretical literature has stressed the importance of considering simultaneously electoral competition and lobbying when studying the policy making process. A seminal example is the paper by Besley and Coate (2001) that integrates in one framework the citizen-candidate model of representative democracy and the "menu auction" model[6] of lobbying as introduced and applied to international trade by Grossman and Helpman (1994).[7]

The recent theory of environmental regulation has embedded a common-agency approach as well, by focusing on the interactions between competing interest groups over environmental policy and their implications in terms of efficiency and social welfare. Fredriksson (1997) builds on Grossman and Helpman (1994) and develops a model explaining how pollution tax policy is shaped by environmental and lobbying groups. The framework developed by Aidt (1998) shows that the competition among lobbies is an important source of political internalization of economic externalities in the domain of environmental policies. Thus, government's failure in choosing socially efficient policies is the result of incomplete political internalization of citizens' interests.

Within the growing literature on lobbying and environmental policies, the contribution by Pacca et al. (2021) is one of the few examples where both government' party affiliation and lobbying behavior have been simultaneously taken into account. Their paper considers the role of political pressures (and their interactions with political factors) in the policy formation process of environmental policies in the U.S. states. In their framework, governors' choices about the level of environmental expenditures depend on their party affiliation and on the political contributions from environmentalist and industrialist interest groups, both of whom allocate resources to shift the policy outcome in their favor. Their findings show that Democratic governors tend to decrease the environmental expenditures in states where the industrialist interest group constitutes a larger share of the economy.

We aim to fill a gap in the literature by studying the impacts of political factors on renewable energy diffusion. Our work contributes to the literature linking environmental policy making and electoral incentives (List and Sturm, 2006), partisan activities (Fredriksson et al., 2011; Kim and Urpelainen, 2017b), and lobbying (Pacca et al., 2021).

[6] The basic menu auction model was developed by Bernheim and Whinston (1986).

[7] The lobbying literature divides along two approaches. The political-support approach advanced by Grossman and Helpman (1994) envisions interest groups to offer political contributions to politicians in exchange of the implementation of determined policies. In contrast, the political competition approach stresses that contributions by lobbies are motivated to influence the election outcome rather than the policy (Hillman and Ursprung, 1988). Moreover, the literature has expanded to include various types of political contributions that politicians value for re-election. Lobbying influence is exerted not only through campaign contributions but also by securing voting blocs (Bombardini and Trebbi, 2011), by persuading the public opinion (Yu, 2005) or by providing information to policy-makers (Belloc, 2015).

However, rather than focusing on well-explored research areas like environmental spending or congressional voting behaviors, our focus is on the timely topic of renewable energy and low-carbon transition.[8] In this area, the role of political factors related to partisan activities, political incentives and economic interests remains understudied, therefore deserving further research (Hu et al., 2021). We are inspired by Pacca et al. (2021) with regards to the theoretical arguments, even though the policy context, relevance and implications of our work significantly differ. Accordingly, our approach and robustness analysis stand apart from their empirical strategy as well. We focus on renewable energy, a policy area with a clear divide between contrasting interests. This allows us to better qualify who are the winners and losers from the green transition. Moreover, renewable energy production depends on resource endowments (e.g., wind and solar), enabling us to leverage fully exogenous sources of economic opportunities for renewable energy generation. In contrast, the lobbying proxies used in Pacca et al. (2021) rely on weaker exogeneity assumptions.

Regarding the use of natural endowment as a source of variation in renewable energy support, our study is also related to Gennaioli and Tavoni (2016). They study the link between public policies and rent seeking practices. Their paper explores whether the presence of renewable natural resources led to an increase in corruption and illegal activities in the wind market. Using data on the Italian provinces, they find that high-wind provinces, compared to non-windy provinces, experienced increased criminal association activity after the introduction of public incentives for renewable energy. Similar to Gennaioli and Tavoni (2016), we show that investors in renewable energy have a significant stake in contexts with abundant renewable resources.

3. Theoretical background

Government intervention is essential to ensure clean energy transition. Environmental economists claim that pollution's costs are not reflected in energy prices without public regulation. Governments can correct this market failure by taxing fossil fuels and supporting renewable energy. There are several barriers to renewable energy deployment. Government intervention is motivated to break the "carbon lock-in" of conventional energy sources that historically benefited from larger infrastructures, investments and scale economies compared to newer technologies. Renewable energy policies aim to enhance the profitability and competitiveness of renewable energy sources in the market.

The decision of investing in renewable energy sources is therefore political. In the context of the United States, state governments have substantial autonomy in designing and implementing renewable energy policies (Menz and Vachon, 2006; Carley, 2009; Delmas and Montes-Sancho, 2011) and, more broadly, environmental policies (List and Sturm, 2006; Pacca et al., 2021). Public support for renewable energy can take the form of financial incentives given to households or companies to deploy renewable energy. Public incentives include subsidies, production incentives, tax exemptions, grants or loans. A second category of policies contains regulations that mandate the power system to produce a certain quota of clean energy. Policy regimes can require an increasing percentage of the electricity that electric utilities sell to come from renewable energy sources by a specific date (e.g., Renewable Portfolio Standards) or offering green power options to consumers (e.g., Mandatory Green Power Option).

We borrow from the existing political economy theories in order to describe the possible behaviors of state governors in the area of renewable energy policy. Within each state government, the governor has substantial influence on the policy-making process. The role of the governor is central to determine the level of public support for renewable energy. Governors can target more (less) stringent renewable energy policies by increasing (lowering) the level of public support. Voters, on the other side, have heterogeneous preferences on renewable energy policies: they balance the benefits of clean energy (e.g., environmental quality) against the costs (e.g., higher fiscal burden to finance the subsidies or higher electricity prices).

Looking at policy outcomes, several combinations are possible depending on the assumptions we make about politicians' motivations. If politicians are solely office-motivated and not interested in policies, we should not expect to observe differences in the stringency of renewable energy policy across governors from different parties. This is the main implication of the median voter theorem which states that politicians ultimately compete for the support of the median voter. Consistent with this theory, variations in environmental policy stringency across states can be attributed to local factors, such as differences in public opinion or the median voter's environmental sensitivity, rather than the political orientation of the government.

Conversely, if politicians are also interested in policy implementation, divergences in policy outcomes across different parties may occur after elections. A relaxation of the Downsonian paradigm conceives that politicians do not exclusively care about winning office, but they also have an incentive to implement the preferred policy if they are not fully committed to electoral platforms (Alesina, 1988). Politicians may have heterogeneous motivations, while voters value some characteristics inherent to policy-motivated politicians as suggested by the theories developed by Callander (2008) or by Kartik and Preston Mcafee (2007). In the event that policy-motivated politicians are "selected out" through electoral competition, it is possible that policy outcomes shift away from the median voter's preference.

We draw from these theories and allow politicians to be partisan. We assume that governors may align their preferences on climate policies with their affiliated party's position. Policy-motivated candidates plausibly pursue their careers in a political party that better represents their personal policy preferences. In the case of the United States, there are essentially two competing parties: the Democratic and the Republican party. Thus, policy divergence between Democrats and Republicans emerges if two conditions simultaneously hold. First, there are differences in policy preferences between the Democratic and the Republican parties. Second, governors are sufficiently policy-motivated to stick to their policy preferences after elections. Note that it is not sufficient to observe policy convergence to conclude that politicians do not have a preference: it may simply be the case that both the Democratic and Republican parties share the same policy position.

In addition, we consider the role of context-specific economic interests in motivating politicians' deviations from their partisan ideology. Politicians might deviate under circumstances that give them an incentive to do it. In the context of renewable energy, we argue that the presence of state-specific economic interests influences governors' policy choices. Governors are likely to distort their policy preferences when interest groups opposing or supporting renewable energy exert political influence or lobbying pressures to hinder or promote the transition.[9] Indeed, the lobbying literature supports the evidence on the relationship between the strength of the economic interests of specific industrial clusters and their lobbying activity. For example, using data on lobbying contributions targeting U.S. candidates from Political Action Committees (PACs), Pacca et al. (2021) show that

[8] Previous contributions from the political-economy literature on U.S. states (List and Sturm, 2006; Fredriksson et al., 2011; Pacca et al., 2021) have primarily addressed research questions related to natural resources' conservation, focusing on specific environmental expenditures categories (e.g., "fish and game", "forests and parks" or "other natural resources").

[9] The political economy literature has investigated several channels through which lobby groups can contribute to politicians' electoral support. For example, they can lobby politicians through financial contributions (Grossman and Helpman, 1994) or by guaranteeing blocks of votes (Bombardini and Trebbi, 2011).

contributions from polluting sectors are higher in states where these industries are economically stronger.

Deviations from the mainstream partisan ideology could also arise for reasons that are not strictly directly related to lobbying activity.[10] Politicians are differently exposed to socio-economic contexts that vary across states and influence their views on green policies and economic growth. Indeed, the political science literature detects noticeable variations along state lines when measuring the U.S. parties' political positioning (Bafumi and Herron, 2010). We can expect that governors in heavily industrialized states adopt a more conservative approach to environmental policies, regardless of their party affiliation. This is not only due to potential lobbying activity but also because of a different political sensitivity in balancing a green agenda with other policies, as compared to politicians elected in states with different prevailing economic interests.

In states where the economic interests of the group of opponents are stronger, we expect that governors might be more reluctant to promote renewable energy. The group of opponents to renewable energy is constituted by the producers from the energy-intensive manufacturing industries. Manufacturing industries, which are heterogeneous with some specializing in green production (Bontadini and Vona, 2023),[11] may vary in exposure to transition costs and their ability to capitalize on new business opportunities from the green transition. Accordingly, we suspect a stronger opposition to renewables from heavy industries.[12] A well known cluster of energy-intensive manufacturing sectors comprises the industries of refining and fuel products, primary metals, non-metallic mineral products, paper, printing activities, and food.[13] These manufacturers typically use energy as a large input for production. Profits therefore depend on the use of inexpensive electricity sourced from conventional polluting sources. Since these producers have much to lose from a climate policy that increases the electricity prices, they are expected to align against the political initiatives related to the public support for renewable energy sources.

We also expect that the presence of wind and solar energy resources might generate large economic opportunities for the group of supporters of renewable energy policies. This group includes the renewable energy producers. Renewable technologies produce energy from natural resources (e.g., wind speed or solar irradiation) without requiring additional inputs or efforts other than the maintenance of power plants. Profits depend on the quantity of energy that is produced and sold in the market. They also depend on the level of public support guaranteed to renewable energy production through direct or indirect subsidies, remunerative incentive schemes or regulation. Thus, at the same level of public support, the expected returns of investments in renewable energy projects are larger in those geographical areas where renewable natural resources are abundant. We expect that economic interests and political activism of renewable energy producers in influencing governors to increase public support will focus on areas where they can maximize profits, i.e., regions rich in renewable resources.

In short, we formulate two testable hypothesis:

Hypothesis 1. Hypothesizing that Democratic politicians generally hold greener policy preferences than Republicans, partisan motives lead to differences in policy outcomes, with Democratic governors more likely to support renewable energy.

Hypothesis 2. Democratic governors do not support stringent renewable energy policies in the presence of strong energy-intensive manufacturing economic interests but favor them in areas with abundant renewable energy resources.

In what follows, we empirically test these hypothesis. First, we estimate the effect of governors' party affiliation on renewable energy policy stringency and, second, we explore whether the effect is conditioned by context-specific economic interests. In the next section we present the empirical methodology and the data.

4. Empirical methodology and data

4.1. Empirical strategy

The first purpose of our empirical strategy is to assess whether there are differences across Democratic and Republican governors in the stringency of renewable energy policies. Our focus is on estimating the effect of governors' party affiliation on renewable energy outcomes. Our baseline estimation approach is a standard difference-in-differences (DiD) research design with the following structure:

$$Y_{it} = \alpha + \beta_1 D_{it} + \gamma' Z_{it} + \delta_i + \phi_t + \epsilon_{it} \tag{1}$$

where the dependent variable, Y_{it}, is our policy outcome variable: the installed renewable capacity (in log) in state i and year t. Our primary regressor is the treatment dummy variable D_{it} which is equal to one whenever the current governor is Democrat, and zero if she is Republican. The coefficient β_1 in (1) captures the main effect of interest: the effect of governor party affiliation on the state level of renewable installed capacity. The vector Z_{it} contains the control variables as discussed below. A dummy for RPS adoption accounts for the presence of mandatory Renewable Portfolio Standard in force in state i and year t. Electricity use per capita accounts for energy characteristics that are specific to each state. We include standard control variables as in previous analysis, such as those used by List and Sturm (2006) and Fredriksson et al. (2011). These are state population, state real personal income per capita, percentage of the population over 65 and between 5 and 17. By exploiting the panel structure of our data, we include state fixed effects, δ_i, and time fixed effects, ϕ_t, in order to control for unobserved state characteristics and common time shocks, respectively. Finally, ϵ_{it} is the observation specific error.

The second purpose of the analysis is to explore whether governors deviate from their baseline partisan political preference due to state-specific economic interests. We test for potential heterogeneity effects of political party affiliation across states by interacting the party dummy with terms representing the strength of the economic interests related to the groups of opponents and supporters of renewable energy sources. To do so, we extend our baseline specification (1) as follows:

$$Y_{it} = \alpha + \beta_1 D_{it} + \beta_2 D_{it} \times M_i + \beta_3 D_{it} \times E_i + \gamma' Z_{it} + \delta_i + \phi_t + \epsilon_{it} \tag{2}$$

where M_i represents our proxy measure of the state-specific economic interests against renewable energy policies. This variable is either indicated as GSP energy-intensive manufacturing or employment share in energy-intesive manufacturing industries. We also explore whether our results extend to total manufacturing, by considering alternative interaction terms on GSP and employment manufacturing share. The proxy variable capturing the strength of the interests of pro-renewable supporters is expressed as E_i. The variable indicates the state-specific renewable natural endowment, including wind potential, solar potential or a combined indicator of both.

[10] We thank an anonymous referee for pointing out that there might be differences in governors' baseline political leanings that are not necessarily related to direct lobbying activity but might be instead motivated by the exposure to different green-leaning socio-economic environments, more broadly defined.

[11] Bontadini and Vona (2023) find that green production is highly concentrated in few industries: computer, electronic and optical equipment, electrical equipment, machinery and equipment, and other transport equipment. These industries are also characterized by lower GHG emission intensities relative to heavy industries. We thank an anonymous referee for recalling our attention to consider the differences in terms of green and brown specializations across manufacturing industries.

[12] In the empirical analysis, we explore whether the effect extends to total manufacturing.

[13] A more detailed description of the energy-intensive industries and manufacturing indicators is provided in Section 4.3.

Both M_i and E_i are time-invariant variables and appear in Eq. (2) only interacted with our treatment variable D. Given the fixed effects estimation, we cannot retrieve their direct (not interacted) effects. Regardless of this, our main focus is on exploring the possible sources of heterogeneity in governors' policy outcomes. Thus, we are interested in the interaction effects between the political party indicator and the proxies of different economic interests. As an additional investigation, we run regressions by considering the yearly time-variant measure of GSP energy-intensive manufacturing share. Natural endowment measures are otherwise only available as time-invariant.

The interaction terms are meant to proxy the potential interests of different economic groups that are likely to act against or in favor of renewable energy deployment. These measures do not directly gauge lobbying activity but they rather capture the presence of context-specific material interests, more broadly defined. Indeed, the relationship between these two aspects has been highlighted by previous contributions (Pacca et al., 2021). We exploit the variation of the interaction terms across states in order to assess if the party affiliation effect varies with them. Moreover, the use of these proxy variables has several advantages over the use of direct measures of lobbying contributions which are likely to suffer from reverse causality with the dependent variable. Regarding the natural renewable endowment, the use of wind and solar potential does not pose significant endogeneity concerns. In fact, these measures have the advantage of being fully exogenous in the empirical specification since they strictly depend on geographical and climate characteristics of each state. However, measures of the share of manufacturing GSP and employment may still face endogeneity issues, particularly due to reverse causality with the dependent variable. To mitigate this problem, we use time-invariant variables calculated as four-year averages (1990–1994) preceding our panel's time window. This helps attenuate the bias in our estimated coefficients caused by concurrent effects of clean energy transition on the economic sectors. Including a full set of control variables and fixed effects also contribute to limit omitted variable bias. In addition, both M_i and E_i are continuous variables. Thus, we do not have to worry about sensitivity issues due to the use of discrete indicators and state classifications or to sample splitting by arbitrary cutoff points.

When estimating equations (1) and (2), the empirical investigation is challenged by the potential endogeneity problem associated with the governor's party affiliation. Since states where Democratic governors are elected can differ significantly from those where a Republican candidate wins, failing to account for these differences may introduce omitted variable bias, resulting in biased estimates. Even though all our DiD empirical specifications account for observable differences by including relevant control variables and fixed effects, there can still be some unobservable differences related to the political leaning of the constituency and voters' preferences, which are likely to influence both renewable energy capacity and the outcomes of gubernatorial state elections. This could result in a non-random assignment of the treatment. To address this, we test the robustness of our results with a Regression Discontinuity Design (RDD) analysis, which simulates quasi-random variation in the assignment of the Democratic governor treatment D_{it}. However, one potential drawback of our RDD analysis is that, due to the limited sample size, we do not have a sufficiently large number of observations around the cutoff when examining what the literature has typically considered competitive electoral races (e.g., elections with marginal victories of 1%, 2% or 3%).[14] The limited time window and sample of our analysis[15] are constrained by the policy context of the research question. State renewable energy policies are relatively recent and have overlapped with federal programs in the U.S. after 2010 (see Section 6.2). Due to these data limitations, we justify our choice to use a DiD approach for the main analysis, while employing the RDD analysis to assess the robustness of the treatment effect.

In all empirical specifications, we use robust standard errors clustered at state-electoral term pairs. This choice accounts for the fact that our treatment variable is at the gubernatorial term and not at the state level. Clustering standard errors by state-electoral term pairs correctly reflects the treatment assignment mechanism of Democratic governors' terms.[16]

4.2. Dependent variable

As a proxy measure of renewable energy policy stringency, we use the installed capacity (in MW) from renewable energy sources excluding hydropower (see Appendix A.1 for more details). When constructing the dependent variable we focus on non-mature technologies. We omit hydroelectric power capacity because it is a mature technology that does not require public support.[17] The data is sourced from the U.S. Energy Information Administration (EIA). Installed capacity is an outcome variable of renewable energy policies, but it is not a direct policy indicator. Unfortunately, there is no comprehensive policy indicator that quantifies renewable energy policies. It is challenging to calculate this indicator over time due to the complexity and diversity of state public support schemes. Thus, given the importance of public support in renewable energy deployment, we use outcome variables directly correlated with policy objectives.[18]

Indeed, qualitative anecdotal evidence from the United States support the connection between state politics, governors' agendas and renewable energy capacity. For example, in Colorado, after voters approved a Renewable Portfolio Standard in 2004, Democratic Governor Bill Ritter, who served from 2007 to 2011, led the efforts towards a greener economy with the "New Energy Economy" political campaign. Under his term, the requirements of the renewable portfolio standard have been subsequently boosted up to the goal of achieving 30% renewable generation for Investor Owned Utilities (IOUs) by 2020.[19] By the end of 2012, Colorado installed capacity of wind and solar power generation had increased up to around 2415 MW from the levels of 221 MW in 2003 and of 289 MW in 2006.[20] Yet, Gallagher (2013) provides an excellent qualitative study with detailed examples from several U.S. states on the link between government's support for renewable energy, economic motives and achieved renewable energy deployment.

We prefer to use the data on the installed capacity instead of net electricity generation (in MW/hours). First, installed capacity does not fluctuate with temporary exogenous shocks in the supply or in demand of electricity. It is also less geographically/climate sensitive than electricity generation. Second, installed capacity better reflects the

[14] See Appendix B.2 for a more detailed discussion.

[15] The sample of our main analysis consists of just over 700 state-year observations.

[16] Moreover, Cameron et al. (2011) and Abadie et al. (2023) inform that clustering at the most aggregate level when there are "few" clusters can lead to complications to statistical inference. Complications are typically such that adjusted standard errors are unnecessarily conservative, t-statistics tend to over-reject and confidence intervals are too narrow.

[17] The literature on renewable energy diffusion typically excludes hydro from the calculation of renewable energy capacity due to its distinct characteristics, especially regarding the need for public support, compared to newer renewable technologies (see, for example, Carley (2009), Delmas and Montes-Sancho (2011), Cheon and Urpelainen (2013), Verdolini et al. (2018)). However, we consider hydroelectric power capacity as dependent variable in the placebo test presented in Section 6.2.

[18] The use of installed capacity as an indicator of renewable energy deployment or as an outcome variable of renewable energy policies is also supported by the existing research. See, for example Menz and Vachon (2006), Delmas and Montes-Sancho (2011), Nicolini and Tavoni (2017) or Verdolini et al. (2018).

[19] See the Colorado bill HB10-1001 signed by Governor Bill Ritter on March 22,2010.

[20] Data from the Energy Information Administration.

investment undertaken in renewable energy technologies and, thus, it is highly correlated with the policy tool driving it. Finally, we extend our baseline empirical specification using as dependent variables the installed capacity of hydroelectric, nuclear and fossil fuel (i.e., coal, natural gas and oil) energy production as a "placebo test" in order further inspect the validity of our results.

4.3. Independent variables

Party affiliation. Our key explanatory variable is a dummy treatment variable which is equal to one if the current governor in a given state-year belongs to the Democratic party, and zero if she belongs to the Republican party. The data are retrieved from Dave Leip 's Atlas of U.S. Elections.[21]

Energy-intensive manufacturing. We have previously hypothesized that producers from energy-intensive manufacturing industries will likely oppose public support for renewable energy as it negatively impacts on their profits by raising the costs of energy. To proxy for the economic interests of this opposing group, we employ the share of energy-intensive manufacturing industries in total Gross State Product (GSP) and, alternatively, the share of employment in energy-intensive manufacturing industries in the total state population. We consider the following six industries known to be highly energy-intensive by the state of the existing research: petroleum and coal products manufacturing, primary metals, non-metallic mineral products, paper manufacturing, printing and related support activities, food, beverage and tobacco product manufacturing.[22] In addition, we build other two more general indicators to proxy the economic interests against public support for renewable energy (total manufacturing GSP and manufacturing employment shares) to check whether the results extend to a more general context. The data are sourced from the Bureau of Economic Analysis (BEA). For a more detailed description of these indicators, we refer to section Appendix A.2.

GSP energy-intensive manufacturing and employment shares do not directly measure lobbying activity but rather capture context-specific economic interests, more broadly defined. However, Pacca et al. (2021) show that these two aspects are linked and that the shares of polluting industries in the Gross State Product (GSP) are good proxy measures explaining the pattern of lobbying activity at the U.S. state level. The use of these proxy variables is also supported by the other existing research.[23] Yet, to support the use of these proxies and the theoretical argument presented in Section 3, we offer preliminary evidence of the connection between electricity prices, renewable energy generation, and manufacturing. In Fig. 1, we plot a correlation between the average retail electricity prices to ultimate customers and the share of electricity generation from renewable energy sources (excluding hydropower) for each state-year observation over the period 1995–2018. The figure shows a positive correlation, suggesting that an increase of the penetration rate of renewable energy sources is associated with higher electricity prices. This increase seems to be more pronounced in the residential sector. End-use electricity prices are also lower for industrial customers due to their larger usage and higher voltage. The second suggestive pattern is reported in Fig. 2, which displays the correlation between the total average electricity prices (i.e., residential, commercial and industrial sector) per state and the relative GSP energy-intensive manufacturing share. Both variables are reported as means over the period 1995–2018. The graph seems to suggest that, historically, energy-intensive manufacturing states have been associated with lower electricity prices. However, we do not claim any causal inference from these simple correlations. In fact, our research does not aim to rigorously analyze the effects of renewable energy on the electricity market or its interactions with economic sectors. These patterns rather inform us about potential political economy dynamics and further support the use of measures related to energy-intensive industries as a factor opposing renewable energy deployment.

Finally, we prefer to employ alternative measures based on GSP manufacturing values and employment levels since these two dimensions might emphasize different aspects. Larger industry sector's contribution to the economy indicates a greater economic interest at stake.[24] Alternatively, a high share of workers employed in the industry sector could serve as another indicator of the political strength of industries within the economy.[25]

Natural endowment. To proxy the political influence of the interest group supporting renewable energy policies, we exploit the exogenous variation in the presence of renewable energy resources across the U.S. states. As previously discussed, we argue that pro-renewables supporters' interests concentrate where it is more profitable to produce renewable electricity (i.e., in geographical areas abundant of renewable energy resources). Our measures of renewable resource endowment are wind and solar potential (see for further details section Appendix A.3). In addition, we construct a combined indicator (in log and normalized to zero) of natural renewable endowment by multiplying wind and solar potential. The data are sourced from the National Renewable Energy Laboratory.

We highlight that these measures are meant to proxy the potential economic interests of pro-renewables supporters. The literature widely supports that natural endowment is crucial for the economic viability of the renewable energy transition. The development of renewable energy industries naturally depends on the presence of renewable resources such as wind and solar potential that are specific to a particular

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21 Since we are interested in estimating the effect of party affiliation to the two main political groups (Democrats and Republicans) we exclude elected governors from other political parties. We also want to focus on the behavior of politicians that are directly accountable to voters through a competitive electoral process. We therefore do not consider lieutenant governors or politicians standing in office in the event of death, resignation or removal of the incumbent governor without a recall gubernatorial election. In any case, these two exclusion criteria involve a very small number of observations and do not significantly affect our sample size.

22 For the definition energy-intensive industries we rely on the work and classification used by the EIA, the U.S. Energy Information Administration (recent EIA reports are available at https://www.eia.gov/outlooks/archive/ieo16/). The EIA includes basic chemicals within the energy-intensive cluster while the pharmaceutical industry is defined as a non-energy intensive industry. In our data, the chemical manufacturing industry is not detailed into basic chemicals and pharmaceuticals, thus we do not consider it as energy-intensive. Other contributions from the literature define as energy-intensive similar clusters of industries. For example, Fredriksson et al. (2004) found that the most energy intensive industries in OECD countries are the basic metal industry, the non-metallic industry, paper products, and printing and publishing. In addition to this selection of industries, Cheon and Urpelainen (2013) also consider petroleum and coal products manufacturing as energy-intensive. The robustness of our results is not affected if we only consider these subsets of industries in place of the broader EIA definition.

23 Fredriksson et al. (2004) provide evidence on energy intensities across sectors and on the effect of lobby group size on policy outcomes. Greenstone and Nath (2020) point out that manufacturers are the most exposed group in the economy to the negative impacts of renewable energy programs that increase the electricity prices. Moreover, evidence on industrialized countries suggests that the presence of strong manufacturing interests hindered the penetration of renewable energy sources (Aklin and Urpelainen, 2013; Cadoret and Padovano, 2016).

24 We do not consider coordination problems. Fredriksson et al. (2004), instead, argue that the effect of industry sector size is ambiguous since interest groups larger in size have also larger coordination costs (i.e., due to the fact that a large industry usually comprises a large number of firms).

25 For example, Bombardini and Trebbi (2011) show that interest groups could also lobby politicians by directly ensuring electoral support in terms of votes of the respective employers instead of devoting monetary contributions.

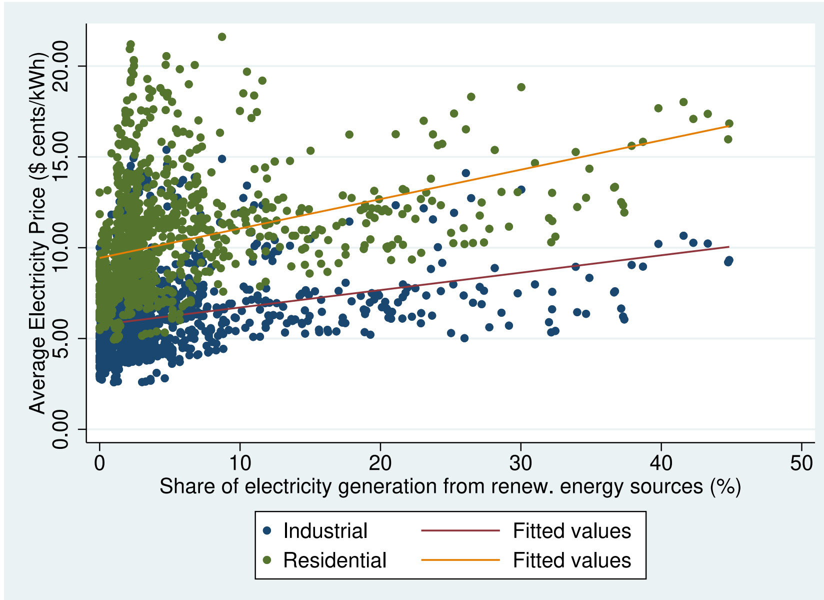

Fig. 1. Electricity prices and electricity generation from renewable energy sources, 1995–2018
Notes: The figure shows the annual average retail electricity prices (for residential and industrial end-users) measured in cents per kilowatt-hour ($ cents/kWh) and the share of electricity generated from renewable energy sources (excluding hydropower) for each state-year observation spanning the period 1995–2018. Data on state electricity prices and net electricity generation are sourced from the U.S. Energy Information Administration.

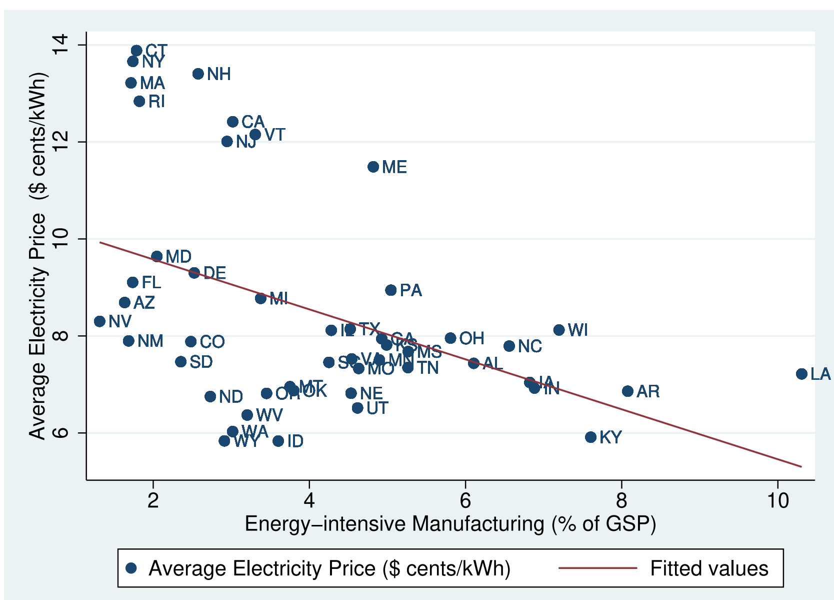

Fig. 2. Average electricity prices and GSP energy-intensive manufacturing share by state, 1995–2018
Notes: The figure displays the mean values of average electricity prices (for residential and industrial end-users) in dollars per kilowatt-hour ($ cents/kWh) and the share of energy-intensive manufacturing in each state's Gross State Product (GSP) over the period 1995 to 2018. Data on electricity prices are sourced from the U.S. Energy Information Administration. Data on GSP manufacturing industries are sourced from the Bureau of Economic Analysis.

geographical location and cannot be moved across territories. Gennaioli and Tavoni (2016) provide evidence that higher levels of natural renewable endowment can attract the interests of clean energy producers. On one side, the natural context plays a major role for the establishment of "green" energy corporations and constituencies. On the other side, it makes it easier for policy-makers to introduce renewable energy policies.

Other variables. The set of control variables includes regulatory and energy variables related to each state. A dummy variable is equal to one if the state had a Renewable Portfolio Standard (RPS) in place and zero otherwise.[26] A RPS is a popular state-enacted policy tool for renewable energy in the United States. These programs mandate that a minimum percentage of the state's electricity generation portfolio must come from designated renewable energy sources within a specified time schedule. Typically, the required amount of electricity generated from renewables increases over time. The objectives are to facilitate

[26] The variable is constructed such that, for adopting states, it is equal to one for each year following the first year of implementation to capture long-term effects.

Table 1
Renewable capacity, governor's party affiliation and interactions, 1995–2010.

	Dependent variable: ln (Renew. capacity)				
	(1)	(2)	(3)	(4)	(5)
Democrat	0.426***	0.413***	0.471***	0.415***	0.483***
	(0.158)	(0.155)	(0.147)	(0.157)	(0.148)
Democrat × GSP Energy-int. Manu. (Time-inv.)			−0.194***		−0.223***
			(0.0737)		(0.0698)
Democrat × Ren. Endowment (Time-inv.)				0.220**	0.275**
				(0.103)	(0.108)
RPS		0.288	0.301	0.257	0.264
		(0.187)	(0.183)	(0.186)	(0.181)
ln(Electricity use per capita)		0.699	0.846	0.536	0.665
		(0.543)	(0.541)	(0.512)	(0.510)
ln(Population)		5.205***	5.497***	4.801**	5.038***
		(1.876)	(1.692)	(1.900)	(1.729)
ln(Real personal income per capita)		3.434**	2.338	3.456**	2.202
		(1.550)	(1.535)	(1.537)	(1.558)
Percentage population over 65		−0.168	−0.307*	−0.215	−0.385**
		(0.201)	(0.183)	(0.202)	(0.184)
Percentage population between 5 and 17		−0.531***	−0.545***	−0.472***	−0.473***
		(0.120)	(0.121)	(0.118)	(0.120)
State F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
Observations	704	704	704	704	704
R2	0.772	0.803	0.812	0.808	0.820

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: The table shows OLS regression results for estimating Eq. (1) and Eq. (2). Columns (1) and (2) report results from the baseline empirical specification which concerns the relationship between renewable installed capacity and political party affiliation with no interactions. Columns (3) and (4) report the results from interacting the political dummy indicator with GSP energy-intensive manufacturing share and combined natural renewable endowment, respectively. Column (5) shows the results from including both interaction terms.
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

investments by utilities in renewable energy generation and to reduce the state dependence on fossil fuels in the long run. Thus, the effects of this policy are typically in the long term and binding over different gubernatorial terms. This could lead to varying trends in renewable installed capacity among U.S. states influenced by past programs rather than the policy decisions of the incumbent government. By including this variable in the empirical specification, we are able to control for these potentially confounding different trends in outcomes between adopting and non-adopting states.[27] The indicator is compiled from the Lawrence Berkeley National Laboratory excluding any voluntary RPS programs.

The variable *state electricity use per capita* (MWh per person) represents the total electricity demand of each state. It is calculated as the total annual amount of net electricity generation divided by the associated state population. This variable comes from the U.S. Energy Information Administration (EIA) and captures state characteristics related to the energy market that can motivate different state-specific trends. In addition, we include control variables accounting for socio-economic characteristics of each state: *state population, state real personal income per capita, percentage of the population over 65* and *percentage of the population between 5 and 17*. These controls are also found in List and Sturm (2006) and Fredriksson et al. (2011) and allow for a better comparison with the results from the previous political economy literature. Data on state population and personal income come from the US Bureau of Economic Analysis (BEA). Data on the percentage of the aged and young population are from the US Census Bureau database.

We perform the main empirical analysis using a panel dataset for the period 1995–2010 with annual observations on 48 U.S. states.[28] Table A.1 in section Appendix A.4 provides summary statistics of the sample. Our analysis focuses on period from 1995 to 2010 which corresponds to the initial phase of renewable energy deployment. During this period renewable technologies were not competitive with conventional sources and required significant public support to develop in the market. It is therefore an ideal time window to study the political-economy drivers of their diffusion. In Section 6.2, we extend our dataset until 2018 and we discuss the advantages and drawbacks of including the most recent years in the econometric analysis.

5. Results

Table 1 reports results of estimating Eq. (1) (i.e., without interactions) and Eq. (2) (i.e., with interaction terms of lobbying proxies).

The main explanatory variable of interest is a political party dummy equal to one for Democratic governors (treatment effect) and equal to zero for Republican governors.[29] In columns (1) and (2), we first

[27] As RPSs are green policies, one might ask why we do not use it as dependent variable. However, we highlight that there is a wide range of policy tools that have been implemented by state governments to foster renewable energy (e.g., feed-in-tariffs, tax credits or investment grants among others). We are therefore interested in the overall effect of these policies which is proxied by the outcome variable (i.e., installed capacity), rather than focusing on only one policy instrument.

[28] As is common in the literature using U.S. state data, we exclude Alaska and Hawaii due to their unique geographical-climate location and their reliance on federal funds.

[29] Note that we have also controlled whether the fact that the governor faces a term limit can affect our findings. Indeed, previous contributions have investigated the role of institutional term limits. Politicians that cannot run for re-election are not constrained by electoral incentives and are assumed to choose their preferred policy (List and Sturm, 2006; Fredriksson et al., 2011; Pacca et al., 2021). For example, one empirical approach to examine differences between re-electable and term-limited governors is to use a term limit dummy variable (representing the years during which the governor is not eligible for re-election) as a proxy for electoral incentives and interact it with the party affiliation variable. In this analysis, we find that term limits do not significantly impact renewable energy deployment, whether the variable is included alone or interacted with the party dummy. These results are similar to the ones presented by Pacca et al. (2021) since they also do not find significant differences in state environmental expenditures between term-limited and re-electable governors. These results are available upon request.

Table 2
Renewable capacity, governor's party affiliation and other interactions, 1995–2010.

	Dependent variable: ln (Renew. capacity)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Democrat	0.432***	0.457***	0.434***	0.418***	0.450***	0.417***	0.369**	0.373**
	(0.150)	(0.149)	(0.150)	(0.155)	(0.149)	(0.158)	(0.145)	(0.147)
Democrat × Empl. Energy-int. Manu. (Time-inv.)	−0.459**							
	(0.194)							
Democrat × GSP Manu. (Time-inv.)		−0.0558**						
		(0.0219)						
Democrat × Empl. Manu. (Time-inv.)			−0.195***					
			(0.0521)					
GSP Energy-int Manu. (Time-var.)				−0.0445	0.0587			
				(0.0421)	(0.0714)			
Democrat × GSP Energy-int Manu. (Time-var.)					−0.133*			
					(0.0684)			
Democrat × Wind Potential						0.190*		0.181*
						(0.102)		(0.0985)
Democrat × Solar Potential							4.676***	4.625***
							(1.186)	(1.181)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	704	704	704	704	704	704	704	704
R2	0.809	0.810	0.815	0.803	0.808	0.806	0.819	0.823

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: The table reports the OLS results for estimating Eq. (2) by interacting the Democratic party dummy with alternative interaction terms: employment energy-intensive manufacturing share (column 1), GSP and employment manufacturing shares (columns 2 and 3), GSP energy-intensive manufacturing share (Time variant) (columns 4 and 5), wind and solar endowments (columns 6, 7 and 8). All the control variables described in Section 4 are included.
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

estimate the average governor's party affiliation effect on the state level of renewable installed capacity (in log). In colums (3) and (4) we report results of interacting our treatment D with the (time-invariant) GSP energy-intensive manufacturing share and the (time-invariant) combined renewable endowment (in log), respectively. Column (5) includes both interactions term. Model in column (1) includes only state and time fixed effects. All other estimations also include the following controls: a dummy indicator equal to one if the state has a Renewable Portfolio Standard in force, electricity use per capita (in log), state population (in log), real personal income per capita (in log), share of population older than 65, share of population younger than 17.[30] Since all arguments of the variables are expressed in natural logarithms (with the exception of share variables), we can interpret the coefficients as elasticities and semi-elasticities.

The relevant coefficient β_1 from Eq. (1) is always positive and significant at conventional levels across different specifications. The coefficient remains stable after including the interaction terms. The magnitude ranges between 0.413 and 0.483. This suggests that renewable capacity increased about 51% and 62% under Democratic governors as compared to Republican ones. The estimated coefficients are approximately twice the relative inherent variability of the dependent variable, which is approximately 31.6% when calculated as the percentage of its standard deviation relative to the mean. This suggests that the governor's party affiliation has a significant impact on explaining the variations in the dependent variable.[31]

However, there is evidence of heterogeneity effects of governor's party affiliation across states. In column (3), the coefficient β_2 from Eq. (2) on the interaction term with the GSP energy-intensive manufacturing share is negative and significant. The party affiliation effect is decreasing with larger levels of GSP energy-intensive manufacturing share. The opposite pattern is observed in column (4) when we interact our treatment variable D with renewable endowment (in log). The coefficient β_3 is positive and significant. The effect of Democratic governors becomes larger with greater renewable endowment. The coefficients remain stable in column (5) after including both interaction terms. This is our preferred specification since it incorporates both proxy measures of the economic interests, against and in favor of renewable energy deployment respectively. For instance, as GSP energy-intensive manufacturing is raised by 1% relative to the average, the difference in renewable energy outcomes between Democrats and Republicans shrinks by about 32%. Instead, as the endowment increases by 10%, the effect of Democratic party affiliation is about 4% percentage higher than the average effect.

Model (5) suggests that Democratic governors promote more renewable energy than the Republican counterparts only under specific circumstances which depend on state characteristics. Fig. 3 plots the marginal effect of Democratic party affiliation for different levels of GSP energy-intensive manufacturing shares (panel a) and for different levels of renewable endowment (in log) (panel b). The figure graphically shows that the difference in renewable capacity between Democratic and Republican governors becomes smaller (and not significant) in those states with a large share of GSP manufacturing. Meanwhile, the difference becomes bigger (and significant) for a sufficiently large level of natural renewable endowment. These results suggest that effect of party affiliation is not relevant in magnitude and is not statistically significant for those states where the energy-intensive manufacturing industry is relevant or the endowment of natural renewable resources is scarce. For instance, our estimates suggest no differences in renewable energy outcomes among governors from different parties in states where the share of GSP energy-intensive manufacturing exceeds approximately 6% (Fig. 4),[32] which corresponds to the 75th percentile of our sample distribution.[33]

In Table 2 we present the results from regressing Eq. (2) using alternative proxy measures of the economic interests against or in favor

[30] The results remain stable even if we remove the control variables from the estimation.

[31] The effect of Democratic party affiliation is also large in magnitude considering the exponential annual growth rates characterizing renewable energy deployment.

[32] In this figure GSP manufacturing share is not expressed as deviation from the mean.

[33] More precisely, around 32% of the observations in our sample are characterized by a GSP energy-intensive manufacturing share larger than 6%.

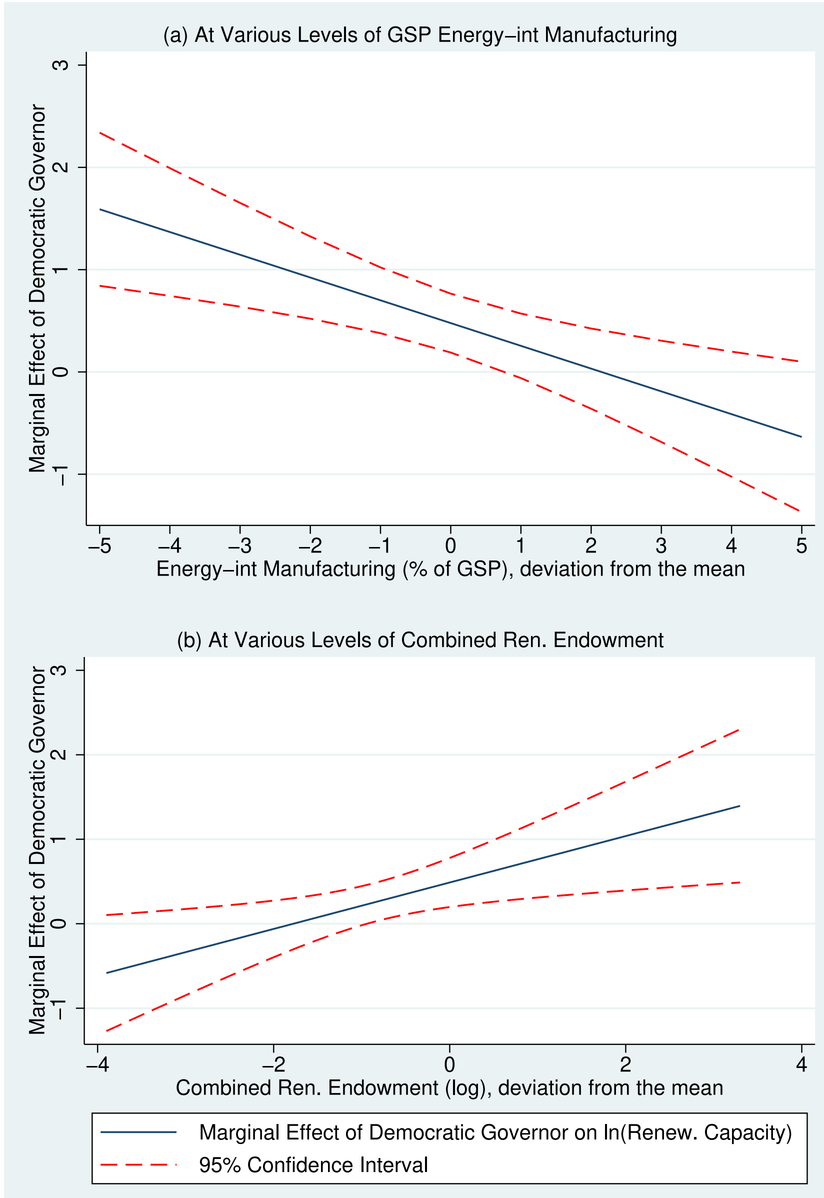

Fig. 3. Heterogeneous effect of party affiliation on renewable capacity
Notes: The figure plots the marginal effect of Democratic party affiliation on state renewable installed capacity (excluding hydropower). Point estimates are derived from estimating Eq. (2) using the GSP energy-intensive manufacturing share and the combined renewable endowment as interaction terms. All the control variables described in Section 4 are included in the estimation.

of renewable energy policies. In column (1), we interact the Democratic dummy with the share of energy-intensive manufacturing employment in the total population. The variable is time-invariant and, similarly to the GSP energy-intensive manufacturing share, it is calculated as average over 1990–1994 in order to address potential endogeneity.

Our results show that the effect of the economic interests related to the energy-intensive manufacturing is particularly strong when the industry size is large in term of workers/employers.[34] In fact, the coefficient on the interaction term with the employment share (time-invariant, mean over 1990–1994) is more than two times higher in magnitude (−0.459) than the interaction coefficient with the energy-intensive manufacturing share (−0.194). The voting representative population of the energy-intensive manufacturing industries seems to significantly condition governors' decisions, even more than what we could expect by looking at industries' contribution to the state's economy.

In columns (2) and (3), we use the GSP and employment shares of the manufacturing sector as a whole as interaction terms, calculated as time-invariant variables (mean over 1990–1994). Instead of only considering the subset of energy-intensive manufacturing industries, we explore whether the relevance of the manufacturing sector in the state economy could explain deviations in governors' policy preferences.[35] The coefficients estimated for the interaction terms are smaller in

[34] Some authors (Bombardini and Trebbi, 2011) have suggested that, when the size of interest groups is large in terms of voter representation, there exists a substitution effect from lobbying *via* financial contributions to lobbying *via* electoral support which could be offered by the interest groups in place of money.

[35] Even though recent studies reveal relevant heterogeneity across manufacturing industries in terms of green and brown production (Bontadini and

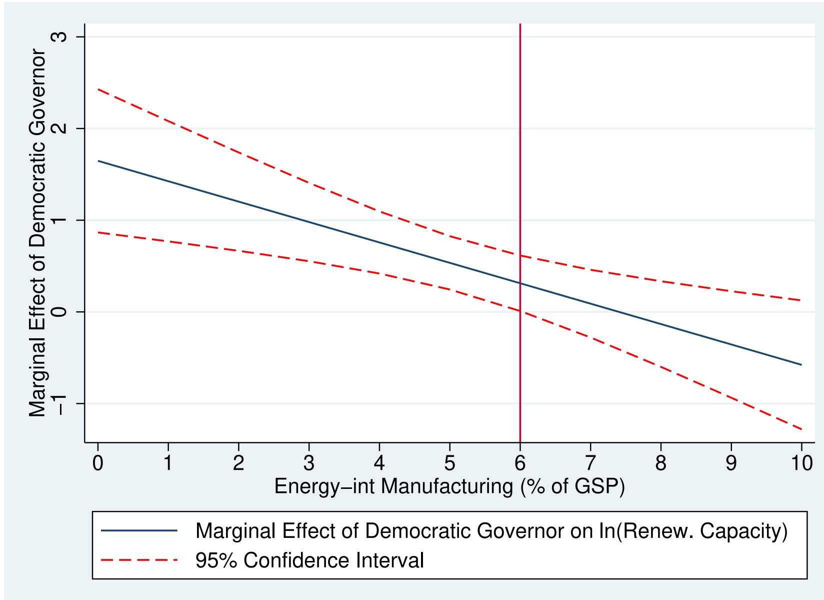

Fig. 4. Heterogeneous effect of party affiliation on renewable capacity (continued)
Notes: Point estimates are derived from estimating Eq. (2). GSP Manufacturing share is not normalized to zero but it is kept in the original form. All the control variables described in Section 4 are included in the estimation.

magnitude than those obtained by interacting our treatment *D* with GSP and employment energy-intensive manufacturing shares, respectively. These results are in line with our theoretical argument that energy-intensive industries are the most penalized by renewable energy policies and, therefore, have the strongest interest in influencing the policy-making.

Columns (4) and (5) of Table 2 add to the specification the yearly time variant measure of GSP energy-intensive manufacturing share. This allows us to study its direct effect on renewable installed capacity (i.e., not only the interaction effect with the political party dummy). The coefficient on (time variant) GSP energy-intensive manufacturing share is not significantly different from zero. The coefficient on the interaction with the party dummy is comparable to the one obtained by employing the time invariant measure of GSP energy-intensive manufacturing share in Table 1. This gives more robustness to our previous results. However, it is important to note that including this time-variant measure raises endogeneity concerns. In fact, reverse causality may be an issue since renewable energy deployment is likely to affect the size and composition of manufacturing industries as well.

In columns (6), (7) and (8), we disentangle the effect of interacting our treatment variable (i.e., *D*) with wind or solar potential. In fact, combining the two measures into a single variable may potentially raise aggregation concerns. First, the variable is calculated by multiplying two indicators of renewable energy potential that are expressed with different units of measure. Second, an aggregated variable does not allow to evaluate the single contribution of the two renewable endowments. The results in column (8) of Table 2 indicate that, even if both effects are positive, the coefficient on the interaction effect with solar potential is larger in magnitude and more significant than the interaction coefficient with wind potential. This suggests that heterogeneity in the party affiliation effect is mainly driven by the variation in state solar resources rather than in wind potential.

Summarizing, results from Table 1 and Table 2 show that there is some degree of partisan divergence in renewable energy outcomes. Democratic governors achieved, on average, higher levels of renewable installed capacity during their terms relative to Republicans. However, we find important heterogeneity in the effect. In states where the energy-intensive manufacturing industry is strong, Democratic governors are less successful in pursuing a renewable energy agenda due to context-specific interests. Democratic governors are instead more successful in promoting renewable energy sources in states abundant with renewable endowment, where renewable supporters have a high stake. These results support the notion of primarily office-motivated politicians, as suggested by previous contributions like List and Sturm (2006) and Fredriksson et al. (2011). Similar to Pacca et al. (2021), our evidence also suggests that politicians tend to deviate from their partisan policy preferences in the presence of strong economic interests. Since our analysis focuses on context-specific interests that may influence governors' decisions through various channels, we highlight that these deviations may occur because politicians respond to the political pressures of economic groups or due to variations in politicians' ideological leanings in different socio-economic contexts.

6. Robustness checks

6.1. RDD analysis

In the following sections, we assess the robustness of our results. The tables showing results from our robustness tests are reported in Appendix B.1. First, we implement a Regression Discontinuity Design (RDD) analysis to assess whether the average Democratic treatment effect found via our DiD specifications is robust to potential endogeneity. To address the endogeneity problem of party affiliation, the RDD approach exploits the quasi-random variation in the treatment assignment generated by close electoral races between Democratic and Republican candidates in U.S. elections (Lee et al., 2004; Lee, 2008). By focusing on the elections where the vote shares of the two candidates are similar and the Democratic candidates barely won, the approach allows to compare states with a similar distribution of voters' preferences and with a similar probability of electing a Democratic governor. Thus, this identification strategy enables us to estimate the effect of governor's party affiliation on renewable policy outcomes, holding voters' preferences constant.

Vona, 2023), other contributions of the literature have considered the manufacturing sector as whole as a context-specific factor capturing the strength of anti-renewables interest groups (Cadoret and Padovano, 2016).

As usual in the literature,[36] the forcing variable of our sharp RD design is the Democratic margin of victory which is the difference between the vote share of the Democratic candidate and the vote share of the Republican. The discontinuity in the treatment status occurs at the cutoff point which is by definition equal to zero. A margin of victory above zero indicates that the Democratic candidate won the election; otherwise it indicates a victory of the Republican opponent. The estimated gap in the outcome variable for observations just above and below the cutoff (i.e., close elections) uncovers the local average treatment effect of electing a Democratic governor over a Republican.

Based on the previous considerations, we extend our baseline specifications of Eqs. (1) to a RDD setting:

$$Y_{it} = \alpha + \beta D_{it} + \lambda f(m_{it}) + \delta_i + \phi_t + \epsilon_{it} \tag{3}$$

where the treatment variable D_{it} equal to one indicates observations above the zero cutoff and the function $f(.)$ includes polynomials of the running variable m_{it} (i.e., the margin of victory of Democratic governors) with different slopes above and below the cutoff.[37] In the RDD setting, controlling for the margins of victory ensures that the RD coefficients capture the local average treatment effect (LATE), resulting from the exogenous variation of the treatment around the cutoff. We include in all specifications state (δ_i) and year fixed effects (ϕ_t).

First, we employ a global RDD approach that uses regressions on the full sample (Lee and Lemieux, 2010). Parametric global regressions allow us to maximize the sample size by using all observations (both close and far away from the cutoff). On the other hand, advances in the methodological literature show that global methods could lead to noisy estimates when higher polynomials are applied to the function of the running variable, along with sensitivity issues to the degree of the polynomial (Gelman and Imbens, 2019). Thus, we complement the parametric results with those obtained from the local robust non-parametric approach proposed by Calonico et al. (2014).[38] Finally, we test for heterogeneity effects using a global RDD approach, following Becker et al. (2013) and Pacca et al. (2021).[39] This model allows us to assess the robustness of the heterogeneity effects found through Eq. (2), i.e., whether the effect of Democratic party treatment varies with the presence of context-specific factors related to energy-intensive manufacturing and renewable endowment.

Table B.1 reports results from the RDD analysis. Specifications (1) and (2) implement the parametric RD regressions (linear and quadratic, respectively) using the global sample. In specifications (3) and (4), we present the results from local linear and quadratic RD regressions following the robust non-parametric bias-correction method (with robust standard errors) as proposed by Calonico et al. (2014). Specifications (5) and (6) implement the parametric heterogeneous RD allowing for interacting the Democrat dummy with energy-intensive manufacturing and renewable endowment. All estimations include state and year fixed effects. The RD coefficients are all positive across specifications. Only in one case (column 2) the point estimate is noisy and not precisely estimated, when we apply a quadratic polynomial for the running variable in the global regression. The coefficients of the non-parametric regressions in columns (3) and (4) are instead significant and robust to a quadratic polynomial form.[40] Finally, regarding the heterogeneous parametric RDD in columns (5) and (6), the coefficient of the Democrat dummy variable is positive and stable across specifications, even though it is less precisely estimated when applying the quadratic RD regression (specification 6). The magnitude of the effect is comparable to the average treatment effect, as found in the baseline specifications. The coefficients of the interaction terms (significant at conventional levels) have the expected signs and are also comparable in magnitude to those found in our baseline specifications of Table 1.

Finally, it is important to note that the RDD analysis identifies a local average treatment effect, meaning the estimated coefficients apply to cases where the margin of victory of Democratic governors approaches zero. However, the similarity of coefficients across RD and baseline specifications suggests that, all else being equal, the average treatment effect (ATE) and the local average treatment effect (LATE) are comparable, which enhances the robustness of our analysis.

6.2. Placebo test and additional robustness checks

In Table B.2 we report results from a "placebo" test performed by replacing the dependent variable of our baseline specifications (i.e., renewable installed capacity, excluding hydroelectricity) with the installed capacity of the following technologies: hydroelectric, fossil fuels and nuclear, respectively.

By doing so, we want to test whether our treatment (i.e., Democratic party affiliation) has a technology-based effect or not. If our treatment had a common impact across all technologies, we could not attribute the increase in renewable energy capacity to a specific commitment of governors in clean energy transition. The increase would be rather associated with other confounding factors or policies that are not technology-specific but have an impact on the total level of installed capacity. Our arguments and results would be undermined even if we find a common pattern with technologies that does not need public support or specific "green" regulation.

The placebo test excludes that our treatment variable had a significant impact on hydroelectric power capacity (column 1) and on fossil fuel capacity (column 2). Note that hydro-power is a renewable energy source, but it was developed in the market before modern renewables and its existing capacity has been saturated depending on geographical characteristics. The coefficient of party affiliation on nuclear capacity is significant at 10% but very small in comparison to the coefficient on renewable capacity. The evidence suggests that, under Democratic governors, only renewable installed capacity increased significantly. This suggests that Democratic governors implemented specific policies targeting "non mature" clean technologies, supporting the robustness of our identification strategy.

We next experiment with empirical specifications that allow us to deal with zero values in renewable installed capacity. In fact, we lose about 6% of our sample observations when we log-transform the dependent variable. In Table B.3 we report results for two different empirical specifications that account for the potential sample selection bias. In columns from (1) to (4), we present the results obtained by substituting $\ln(Renew.Capacity + 1)$ as dependent variable in our baseline equations. The coefficients estimated are comparable in magnitude to those presented in Table 1, even though the coefficient on the interaction with renewable endowment is less precisely estimated. In columns from (5) to (8), we report results obtained by applying a Poisson Pseudo Maximum Likelihood estimation (PPML), as suggested

[36] For some examples of RDD applications to the U.S. context, see Fredriksson et al. (2011), Kim and Urpelainen (2017b), or Pacca et al. (2021).

[37] Note that the model also includes the functions of the running variable $f(m_{it})$ interacted with the treatment variable D.

[38] More specifically, we implement local regressions via the RDROBUST package by Calonico et al. (2017) on a restricted sample of observations satisfying $|m_{it}| < h$ (where h is the bandwidth choice). We estimate the local linear regression using a triangular kernel function on the distance to the cutoff, which gives more weight to the observations closer to the cutoff. Using a triangular kernel is a common approach in the literature since it leverages the variation around the cutoff. Other common approaches include a rectangular kernel or uniform kernels. Our results do not change significantly by applying other kernel functions.

[39] Unfortunately, the RDROBUST package still does not allow for covariate-heterogeneity methods for RD to explore heterogeneity effects.

[40] These estimations are implemented via the RDROBUST package (Calonico et al., 2017) with a bandwidth choice based on the built-in MSE-optimal bandwidth selector. In Appendix B.2, we also experiment with different bandwidth choices performing a sensitivity analysis to the bandwidth.

by Silva and Tenreyro (2006).[41] Using a PPML estimation, the dependent variable is expressed in levels and not in logs. The coefficients are again similar to those estimated in our baseline specifications. Only the coefficient on the interaction with GSP energy-intensive manufacturing is smaller in magnitude and less precise. In column (9), we experiment with expressing Eq. (2) as first differences, which allow to correct for potential time series co-integration issues in our panel. Yet, the coefficients estimated seem to remain stable and with the expected signs, even though the coefficients on the interaction terms are less precisely estimated.[42]

Finally, we run our main estimations extending the considered period to 2018, according to data availability. The results are presented in Table B.4. As shown in the table, the Democrat coefficient is positive but not significant in any specifications considered. The interaction term between the treatment variable *D* (i.e., Democratic party affiliation) and the proxy for renewable energy supporters (i.e., combined renewable endowment) is positive but not significant, as shown in columns (3) and (4) (only the coefficient for the interaction with solar potential remains significant, column 9). The only coefficients that remain significant in the extended panel are the interaction terms between *D* and the following proxies of anti-renewables economic interests: the time-invariant measure of GSP energy-intensive manufacturing share (column 4), the GSP manufacturing share (column 5), and the total manufacturing employment share (column 7). The coefficients remain negative, indicating the significant impact of anti-renewable economic interests on restraining renewable energy diffusion, even with the extended time window of our analysis.

The evidence shows that, after extending the panel, there are no differences in renewable energy outcomes between Democratic and Republican governors. However, including recent years has potential drawbacks related to the scope of our research. Indeed, there are several explanations for the time heterogeneity in our results. First, in 2009, the Obama Administration enacted the American Recovery and Reinvestment Act in response to the economic crisis.[43] Since the package includes explicit policies for renewable energy, there is an overlap of state-level policies with federal programs introduced afterwards. Thus, it becomes more difficult to disentangle the effects of state-level political factors from federal incentives.

Second, during the past decade, renewable technologies have become more competitive in the energy market. Between 2010 and 2018, the levelised cost of electricity (LCOE)[44] of renewable power plants has fallen into the fossil-fuel cost range (IRENA, 2019). This was mainly due to the technological progress and drops in costs for components (wind turbines and solar panels) as the European Union and Asian countries started heavily investing in renewable energy. Renewable energy sources have become more "mature" technologies and less dependent on policy regimes that subsidize their deployment. Thus, decomposing the political determinants from market forces in the clean energy transition becomes even more challenging with the inclusion of recent years in the empirical analysis.

The weakening of the heterogeneity effects arising with renewable endowment is also linked to technical progress. It may indicate that, since greater efficiency compensates natural potential, the endowment of renewable resources may no longer drive investment decisions in renewable energy. Instead, our results suggest that the presence of strong manufacturing interests continued to restrain, even until recent years, renewable energy penetration in states ruled by Democratic governors.

7. Conclusion and policy implications

To the best of our knowledge, this paper is the first empirical attempt that focuses on politicians partisanship, economic interests and their interactions to explain differences in renewable energy outcomes across the U.S. states. We argue that politicians' choices over renewable energy policies depend both on policy preferences and their interactions with context-specific economic interests that influence (positively or negatively) the scope of climate policies. The U.S. setting constitutes an ideal testing ground given the substantial autonomy of state governments in environmental policy. We first investigate to what extent the party affiliation of governors, who have a prominent power in the policy formation process of each state, had an impact on state renewable energy achievements. The outcome variable is the state installed capacity from renewable power plants excluding hydropower. The focus is therefore on "non mature" renewable technologies that need public support schemes and regulations to develop in the market. Secondly, we investigate whether the party affiliation effect is conditioned on state-specific economic interests, opposing or supporting renewable energy production. Empirically, we do so by interacting party affiliation with proxies of the strength of the economic interests that oppose and support public intervention for renewable energy. The strength of the opponents is proxied by measures related to the state energy-intensive manufacturing industry size. The interests of pro-renewable supporters are captured by the renewable energy endowment, reflecting the profitability of renewable energy investments.

We find that, on average, there are differences in renewable energy outcomes between Democratic and the Republican governors. However, the effect highly depends on state characteristics which suggests that other political-economy dynamics are in action. We do not observe differences in renewable energy outcomes across Democratic and Republican governors in states where the energy-intensive manufacturing industry is relevant or where the endowment of natural renewable resources is scarce. Interestingly, when extending the analysis until 2018, governors' party affiliation is no longer a significant determinant of renewable energy deployment, but there is still a persistent hindering effect on renewable energy diffusion in the presence of strong manufacturing economic interests. This is indeed in line with our expectations. In 2009, the Obama administration passed the American Recovery and Reinvestment Act which offers tax credits and payments to renewable energy investors through federal investments. This constitutes a clear structural break. Subsequently, federal programs have overlapped with state-level policies, making it more difficult to disentangle the effects of state-level political factors. Additionally, over the past decade, renewable energy sources have become more competitive in the energy market due to a sharp decline in electricity prices from renewable power generation. As renewable energy sources rely less on subsidies, market forces are increasingly merging with political factors as the main drivers of renewable energy diffusion.

Our findings extend the insights on state-level environmental spending by Fredriksson et al. (2011) and Pacca et al. (2021) and bring novel evidence on the political-economy of renewable energy deployment, an area where research is still relatively limited. Our results show that

[41] Silva and Tenreyro (2006) argue that using log-linearized OLS under heteroskedasticy not only fails to handle zero values naturally but can also result in inconsistent parameter estimates.

[42] As an additional check, we assess the robustness of our results when changing the timing of the dependent variable or of the treatment. We do so by running regressions with leads of the dependent variable at the left-hand side of the specification or with lags of the treatment at the right-hand side. We note that the timing of the effect is mainly contemporaneous as the coefficient on party affiliation becomes smaller in magnitude (and not significant after a one time lead or lag) when increasing the number of leads in the dependent variable or of lags in the treatment. These results are available upon request.

[43] The package has explicit objectives in energy efficiency, renewable energy research and investments. It constitutes the largest federal commitment for renewable energy sources since loans and investments into renewable energy technologies are a significant part of the final provisions of the act.

[44] The LCOE of a given technology is the ratio of lifetime costs to lifetime electricity generation. LCOE from bioenergy, geothermal and wind have all been within the range of fossil fuel-fired power generation costs since 2010. Since 2014, the LCOE of solar photovoltaic has also become similar to fossil fuel generation costs (IRENA, 2019).

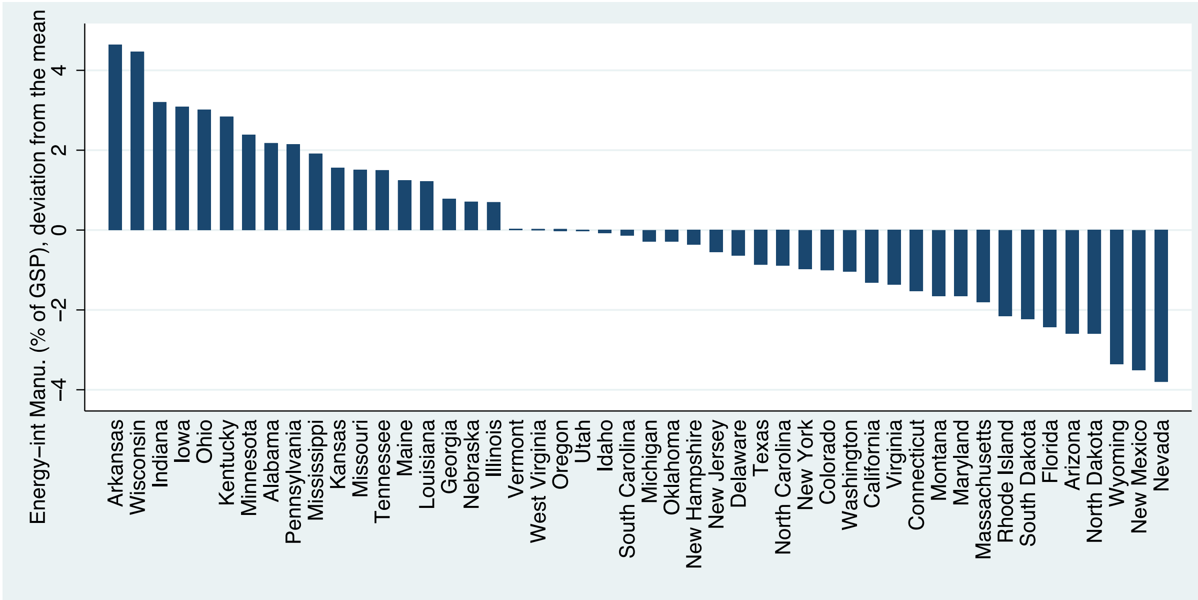

Fig. A.1. Share of energy-intensive manufacturing in total GSP (%) by state
Notes: Time-invariant GSP energy-intensive manufacturing shares are calculated as the mean over the period from 1990 to 1994. The variable is normalized to zero by detracting the sample mean. Data on total Gross State Product (GSP) and GSP from manufacturing industries are sourced from the Bureau of Economic Analysis.

politicians deviate from their partisan political leaning in response to strong economic interests representing the stakes of both the opponents and supporters of renewable energy. This could happen either because politicians respond to the political influence of economic groups and distort their policy preferences, or due to heterogeneity in politicians' baseline leanings depending on the context where they operate. We find supporting evidence that context-specific economic interests can override the main partisan ideology, potentially by conditioning their political responsiveness in specific policy areas. Interestingly, we highlight that strong economic interests tied to energy-intensive industries can hinder renewable energy penetration by influencing the behavior of politicians from parties that strongly support green agendas.

Several implications can be derived from this work. Economic groups and interests that are negatively affected by the green transition risk to hinder the effectiveness of climate actions. This is particularly relevant for policies, such as public support for renewable energy, that target long-term gains while imposing short-term costs on polluting activities. A systematic analysis of the cost-effectiveness of renewable energy programs in terms of carbon abatement is beyond the scope of this paper. Nevertheless, our work highlights the dual challenge of the green transition, which involves addressing both the global externality of pollution and securing the commitment of political actors, especially in cases where climate policies entail electoral costs.

CRediT authorship contribution statement

Paolo Bonnet: Conceptualization, Methodology, Formal analysis, Software, Writing – original draft, Visualization. **Alessandro Olper:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Data description

A.1. Renewable energy outcomes

The state level of renewable installed capacity is sourced from the U.S. Energy Information Administration (EIA) which provides detailed electricity information disaggregated by state-year. The variable is constructed as the sum of the nameplate capacity of all the wind, solar, geothermal and biomass power plant units belonging to the electric power industry (i.e., electric utilities, independent, commercial and industrial producers) in a given state. In line with the literature on renewable energy diffusion, we omit hydroelectric power capacity.[45] Hydropower is a mature renewable technology whose electricity generation is already competitive in the market. Its installed capacity has been developed in the past driven by natural endowment and hydrological conditions, rather than recent public support schemes.

A.2. Manufacturing industries measures

The data on manufacturing industries are sourced from the Bureau of Economic Analysis (BEA), which provides aggregate measures for manufacturing industries of both GSP and employment for each state in each year. We mainly employ state time-invariant measures (calculated as the mean over the 4 years preceding the time window of our analysis) to address the potential endogeneity between environmental policies and changes in economic activity. An alternatively time-variant measure calculated for each state in each year is used as an additional check. The variables are normalized to zero by detracting the sample mean. Fig. A.1 and Fig. A.2 show the variability of the GSP energy-intensive manufacturing shares and GSP manufacturing shares, respectively.

Arkansas and Wisconsin are the states with the largest shares from energy-intensive industries, while the lowest shares are recorded for New Mexico and Nevada (Fig. A.1). Indiana and North Carolina have the highest contribution of the total manufacturing sector to their economies (Fig. A.2). Fig. A.3 reports the scatterplots of the energy-intensive manufacturing employment share of the total population against the GSP energy-intensive manufacturing share, both time-invariant and calculated as the mean over 1990–1994.

[45] See, for example, Carley (2009), Delmas and Montes-Sancho (2011), Cheon and Urpelainen (2013) or Verdolini et al. (2018).

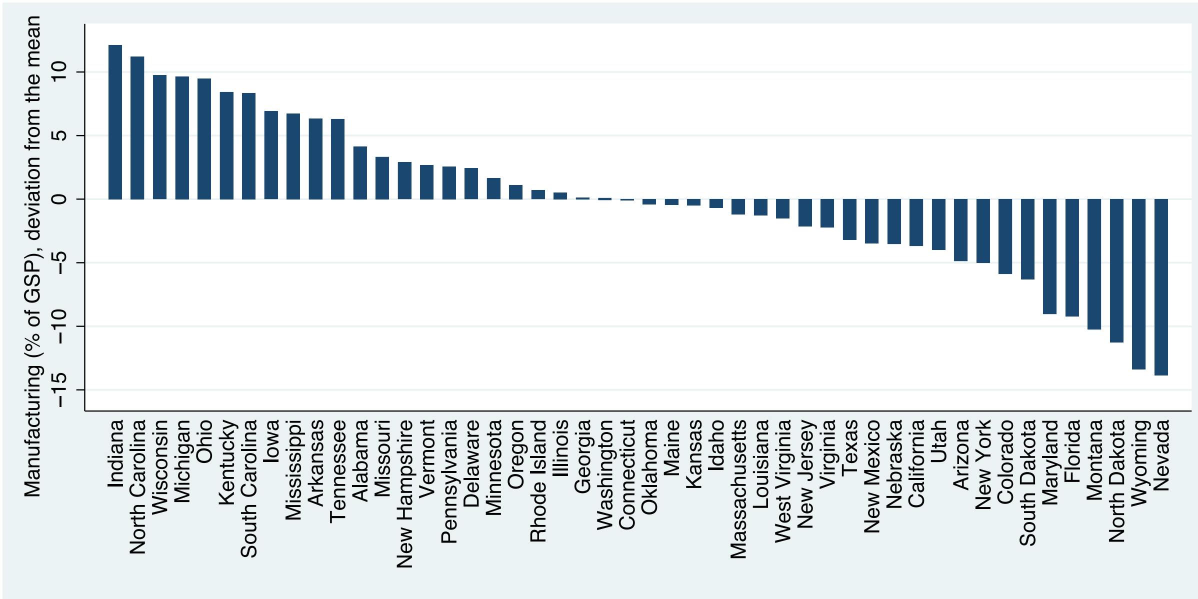

Fig. A.2. Share of manufacturing in total GSP (%) by state
Notes: Time-invariant GSP manufacturing shares are calculated as the mean over the period from 1990 to 1994. The variable is normalized to zero by detracting the sample mean. Data on total Gross State Product (GSP) and GSP from manufacturing industries are sourced from the Bureau of Economic Analysis.

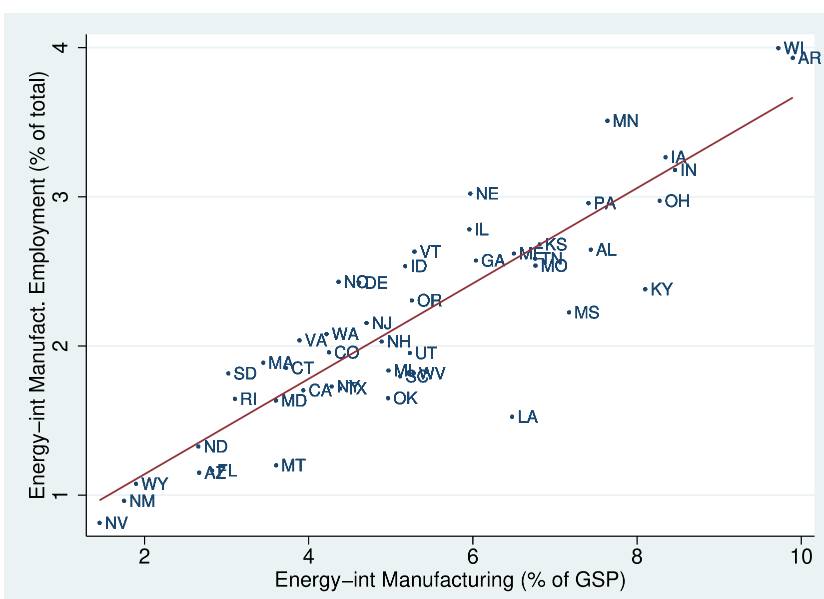

Fig. A.3. Correlation between GSP energy-intensive manufacturing shares and employment shares of energy-intense industries
Notes: Each point corresponds to a U.S. state. Time-invariant measures of GSP energy-intensive manufacturing share and employment share (% of total population) of energy-intense industries are calculated as the mean over the period from 1990 to 1994. Data on total state population, employment from the manufacturing industries, total Gross State Product (GSP) and GSP from manufacturing industries are sourced from the Bureau of Economic Analysis.

Table A.1
Summary statistics.

	Mean	SD	Min.	Max.	Obs.
ln (Renew. Capacity)	5.270	1.665	−1.833	9.241	704
ln (Hydro Capacity)	6.187	1.799	0.693	9.950	683
ln (Fossil Capacity)	9.167	1.215	4.913	11.534	704
ln (Nuclear Capacity)	7.880	0.788	6.333	9.528	467
Democrat	0.432	0.496	0	1	704
GSP Energy-int. Manu. (Time-inv.)	0	2.040	−3.803	4.641	704
GSP Energy-int Manu. (Time-var.)	0	2.235	−3.240	16.408	704
Empl. Energy-int. Manu. (Time-inv.)	0	0.732	−1.367	1.815	704
GSP Manu. (Time-inv.)	0	6.444	−13.848	12.119	704
Empl. Manu. (Time-inv.)	0	2.593	−5.109	5.123	704
Wind potential (Time-inv.)	0	1.669	−3.776	3.117	704
Solar potential (Time-inv.)	0	0.117	−0.292	0.292	704
Ren. Endowment (Time-inv.)	0	1.682	−3.841	3.256	704
RPS	0.327	0.469	0	1	704
ln(Electricity use per capita)	2.668	0.527	1.485	4.526	704
ln(Population)	15.204	0.979	13.104	17.435	704
ln(Real personal income per capita)	9.738	0.159	9.348	10.257	704
Percentage population over 65	12.774	1.629	8.500	18.600	704
Percentage population between 5 and 17	18.157	1.352	14.958	24.838	704

Notes: The sample time span is from 1995 to 2010. Data on installed capacity for renewables, hydropower, fossil fuels and nuclear are sourced from the U.S. Energy Information Administration. Data on governors' political parties are taken from Dave Leip's Atlas of U.S. Elections. Data on Gross State Product (GSP), GSP manufacturing sector, GSP energy-intensive industries and relative employment levels are sourced from the Bureau of Economic Analysis. Data on wind and solar renewable endowment are from the National Renewable Energy Laboratory. Information about state Renewable Portfolio Standards is compiled from the Lawrence Berkeley National Laboratory. Data on electricity use come from the U.S. Energy Information Administration. Data on state population and personal income are from the Bureau of Economic Analysis. Data on state age characteristics are from the Census Bureau.

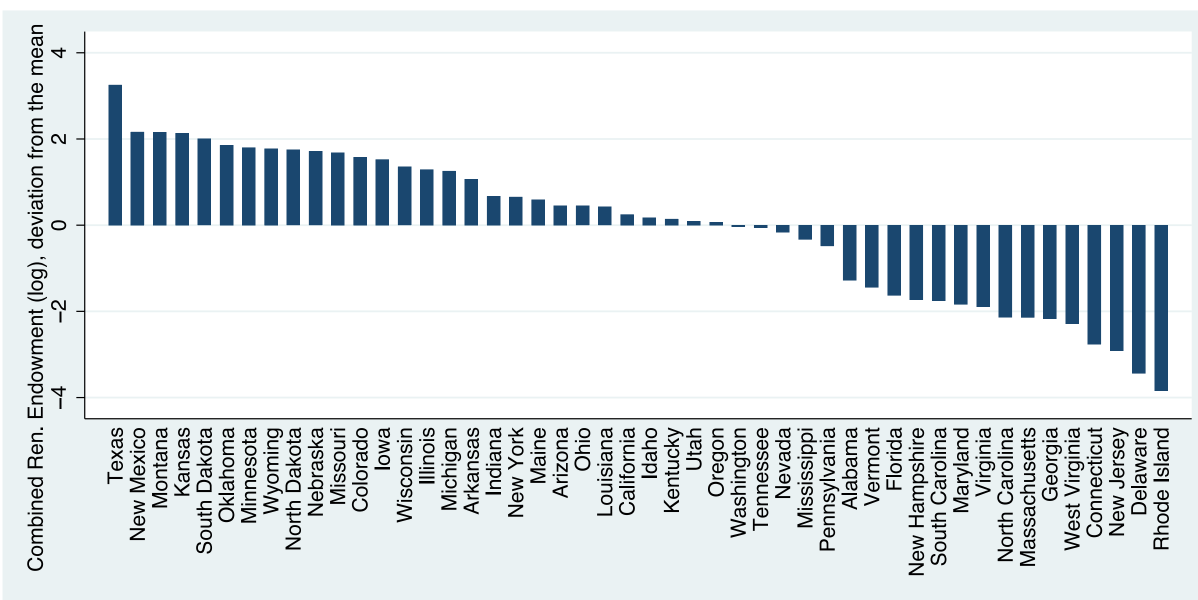

Fig. A.4. Natural renewable endowment by state
Notes: Time invariant combined indicator of wind and solar endowment by state. The variable is expressed in log and normalized to zero by detracting the sample mean. Data on wind and solar potential are sourced from the National Renewable Energy Laboratory.

A.3. Natural renewable endowment measures

Wind potential is defined as the potential capacity (in MW) that could be installed from the development of the available land area.[46] The data is provided aggregated at the state level by the U.S. Department of Energy (WINDExchange online platform) based on the wind potential estimates of the National Renewable Energy Laboratory (NREL).[47] Solar potential is measured as annual average daily total solar resource (in kWh/m2/day) It represents the potential of solar panels given daily solar radiation and land area.[48] The data are sourced by state from the solar radiation database of the National Renewable Energy Laboratory (NREL).[49]

[46] The available land is calculated (in km2) as the total land area with a gross capacity factor for wind turbines of 35% and greater at 110 hub heights. Exclusion criteria for available land are applied including environmental criteria (e.g., national parks, conservation areas, national monuments) and land-use criteria (e.g., airfields, urban, wetland areas, non-ridge crest forests, areas with slope).

[47] NREL estimates for wind speed are averages over 2007–2013

[48] Solar resource is recorded over surface cells of 0.1 degrees in both latitude and longitude and using fixed flat plate systems tilted towards the equator (i.e., they reproduce the functioning of solar panels).

[49] NREL estimates for solar radiation are averages over 1998–2009

Wind and solar potential are time-invariant measures since both of them are defined as state annual averages calculated using data over multiple years. We assume them to be constant across time and independent from the year-span used as measurement benchmark. This assumption is not much of a concern given that these kinds of climatic variables do not significantly deviate from their annual means over decades. These variables are expressed in logs and as deviations from the sample mean. Fig. A.4 shows the cross-state variation of the combined indicator of solar and wind potential. Higher scores equal higher levels of natural renewable endowment which, in turn, is assumed to attract the interests of clean energy producers. Prominent examples of abundance in natural renewable resources are states characterized by windy lands (i.e., mainly due to the presence of mountains and hills) and located in Southern sunny areas (e.g.,Texas and New Mexico). North-East states (e.g., Rhode Islands, Delaware and New Jersey) display, instead, the lowest levels of renewable energy potential.

A.4. Summary statistics

The sample of the main regressions consists of 704 state-year observations. The number of observations is lower than all the state-years combinations (i.e., 768) for two reasons. First, we are focusing on the competition between Democrats and Republicans and we are not considering states ruled by governors from third parties (i.e., 16 state-years observations in our sample). Second, by using a logarithmic transformation of the dependent variable, we drop the pairs with zero values in installed capacity (i.e., 48 state-years observations for renewable installed capacity). In Section 6.2, we address this limitation by employing alternative empirical specifications that deal with zero values without simply dropping them.

Appendix B. Robustness checks

B.1. Robustness checks tables

Table B.1
RDD, renewable capacity and governor's party affiliation, 1995–2010.

	Dependent variable: ln (Renew. capacity)					
	(1)	(2)	(3)	(4)	(5)	(6)
Democrat	0.535***	0.301	0.570***	1.407***	0.684***	0.426*
	(0.200)	(0.255)	(0.136)	(0.168)	(0.199)	(0.248)
Democrat × GSP Energy-int Manu. (Time-inv.)					−0.219***	−0.226***
					(0.069)	(0.070)
Democrat × Ren. Endowment (Time-inv.)					0.373***	0.362***
					(0.108)	(0.107)
State F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Estimation	parametric	parametric	non-parametric	non-parametric	parametric	parametric
Polynomial order	I	II	I	II	I	II
Bandwidth	global	global	6.809	6.809	global	global
Observations (above/below cutoff)	400/304	400/304	100/105	100/105	400/304	400/304

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: The table reports results of estimating Eq. (3) through a RDD, concerning the relationship between renewable installed capacity and political party affiliation. The running variable is the Democratic governor's *margin of victory* in a statewide election: the value 0 is the cutoff point for the discontinuity in the incumbency status (the treatment). Column (1) and column (2) report the results from the parametric linear and quadratic RD regressions, respectively. For *non-parametric* estimations in columns (3) and (4), results are local bias-corrected RD estimates implemented with the RDROBUST package by Calonico et al. (2017). All *non-parametric* regressions use a *triangular kernel*, robust non-parametric standard errors and a MSE-optimal bandwidth. Columns (5) and (6) report the results from a parametric heterogeneous RD allowing for interacting the Democrat dummy with energy-intensive manufacturing and renewable endowment.
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

Table B.2
Placebo test, 1995–2010.

	ln (Hydro capacity)	ln (Fossil capacity)	ln (Nuclear capacity)
	(1)	(2)	(3)
Democrat	0.00737	0.00451	0.00774
	(0.0146)	(0.0159)	(0.00475)
Democrat × GSP Energy-int. Manu. (Time-inv.)	−0.00442	−0.000698	0.00313
	(0.00450)	(0.00809)	(0.00192)
Democrat × Ren. Endowment (Time-inv.)	−0.00404	−0.0101	−0.00394
	(0.0103)	(0.0107)	(0.00309)
Controls	Yes	Yes	Yes
State F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Observations	720	752	488
R2	0.998	0.991	0.998

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: Placebo tests are performed by replacing the dependent variable with: installed capacity for hydropower (column 1), installed capacity for fossil fuels (gas, oil and coal) (column 2) and installed capacity for nuclear (column 3). All the control variables described in Section 4 are included.
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

Table B.3
Alternative empirical specifications, 1995–2010.

	OLS estimations ln(Renew. capacity + 1)				PPML estimations Renew. capacity				First difference Δ ln(Renew. capacity)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Democrat	0.384**	0.441***	0.378**	0.439***	0.475***	0.460***	0.474***	0.455***	
	(0.163)	(0.157)	(0.164)	(0.158)	(0.117)	(0.115)	(0.117)	(0.117)	
Democrat × GSP Energy-int. Manu. (Time-inv.)		−0.173**		−0.194***		−0.0798		−0.0914	
		(0.0714)		(0.0694)		(0.0594)		(0.0604)	
Democrat × Ren. Endowment (Time-inv.)			0.135	0.182			0.144**	0.157**	
			(0.125)	(0.130)			(0.0664)	(0.0647)	
Δ Democrat									0.282***
									(0.0900)
Δ Democrat × GSP Energy-int. Manu. (Time-inv.)									−0.0759
									(0.0585)
Δ Democrat × Ren. Endowment (Time-inv.)									0.149**
									(0.0642)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	752	752	752	752	752	752	752	752	690
R2	0.815	0.820	0.816	0.822					0.133
Pseudo R2					0.890	0.891	0.892	0.894	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: Columns from 1 to 4 report the results obtained from replacing, in Eq. (1) and Eq. (2), the dependent variable with ln(Renewable installed capacity + 1). Columns from 5 to 8 show the results of the Poisson Pseudo Maximum Likelihood estimation with installed renewable capacity (not in logs) as dependent variable. Interactions terms are GSP energy-intensive manufacturing share and combined natural renewable endowment. Column 9 reports results from Eq. (2) expressed as first difference. All the control variables described in Section 4 are included.
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

Table B.4
Renewable capacity, governor's party affiliation and interactions, extended panel, 1995–2018.

	Time period: 1995–2018 dependent variable: ln (Renew. capacity)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Democrat	0.0316	0.0588	0.0349	0.0690	0.0674	0.0540	0.0710	0.0340	0.0456
	(0.118)	(0.118)	(0.119)	(0.120)	(0.116)	(0.117)	(0.118)	(0.119)	(0.117)
Democrat × GSP Energy-int. Manu. (Time-inv.)		−0.0940		−0.112*					
		(0.0645)		(0.0657)					
Democrat × Ren. Endowment (Time-inv.)			0.0680	0.104					
			(0.0727)	(0.0753)					
Democrat × GSP Manu. (Time-inv.)					−0.0442**				
					(0.0183)				
Democrat × Empl. Energy-int. Manu. (Time-inv.)						−0.262			
						(0.167)			
Democrat × Empl. Manu. (Time-inv.)							−0.129***		
							(0.0466)		
Democrat × Wind Potential								0.0564	
								(0.0731)	
Democrat × Solar Potential									2.409*
									(1.312)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1075	1075	1075	1075	1075	1075	1075	1075	1075
R2	0.771	0.773	0.771	0.774	0.775	0.773	0.777	0.771	0.775

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: The table reports OLS results for estimating Eq. (2) using an extended time period covering the years 1995 to 2018. All the control variables described in Section 4 are included.
Standard errors (in parentheses) are clustered at state-electoral level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

B.2. RDD sensitivity to bandwidth

The nonparametric RD analysis presented in Section 6.1 is based on a baseline bandwidth that is optimally computed by the data-driven bandwidth selector of the estimator by Calonico et al. (2017). We test the sensitivity of our results to alternative bandwidth choices.[50] Indeed, the bandwidth choice defines how "close" are the elections we are

[50] To test the validity of the RD design, we also perform a manipulation test of a local polynomial density estimation, as proposed and implemented via the RDDENSITY package by Cattaneo et al. (2018). The test presents a value of 0.567 for the discontinuity of the density variable (i.e., the margin of victory) around the cutoff with a p-value = 0.571, which suggest to not reject the null hypothesis of no discontinuity (i.e., there is no statistical proof of manipulation in the running variable). Thus, the test's results seem to support the RDD assumption that the observations around the cutoff are not self-selected into treatment and control units.

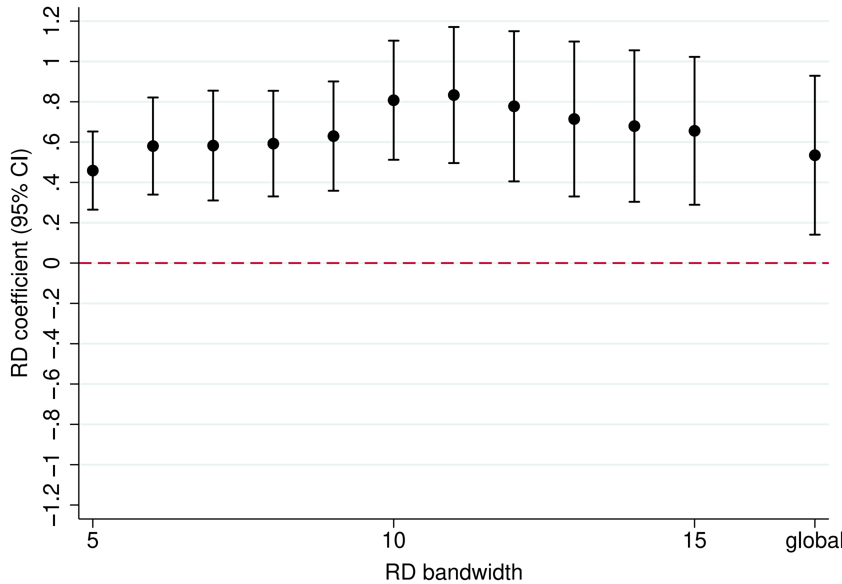

Fig. B.1. RD sensitivity to bandwidth choice
Notes: The figure shows a coefficient plot from estimating Eq. (3) through a RDD using different bandwidths. Point estimates are obtained from local linear bias-corrected RD estimations implemented with the RDROBUST package by Calonico et al. (2017), using a *triangular kernel* and robust non-parametric standard errors. The coefficient of the *global* regression is obtained from a global RDD regression with a linear polynomial of the forcing variable. Outcome variable is renewable installed capacity. 95% confidence intervals.

focusing on, defining the sample of our regressions. Fig. B.1 plots RD coefficients from the local linear regressions for a variety of bandwidths, showing that the results do not depend on the bandwidth selection. However, there is an important remark regarding the application of a RDD analysis to our context. One possible drawback of our RDD analysis is that due to the limited sample size we consider elections with a sufficiently large number of observations around the cutoff in our sample, by focusing on elections with marginal victories of at least of 5%. The limited time window and sample of our analysis are constrained by the policy context of the research question. State renewable energy policies are either relatively recent and, in the U.S. context, have overlapped with federal programs after 2010 (see Section 6.2). Indeed, the sample of our main analysis consists of approximately 700 state-year observations. This is a relatively small sample for conducting a RDD analysis, which is typically data-demanding and requires a large number of observations around the discontinuity. In our case, the sample size does not allow us to focus on what the literature typically considers highly competitive elections, such as electoral races with candidates' marginal victories of 0.5%, 1% or 2%. For instance, if we narrow the margin to 2%, our sample around the cutoff decreases to 47 observations (23 below and 24 above the cutoff), which is insufficient for meaningful estimations. Due to data limitations and the inability to fully meet the data requirements of a RDD approach, we present our DiD estimates as the primary results of this analysis. We use the RDD approach to better assess the robustness of the treatment effect. Nevertheless, our RDD results suggest that the DiD estimates are not influenced by treatment endogeneity.

B.3. Environmental voting score

We augment our analysis by looking at roll call votes on federal environmental initiatives by congress members elected in different U.S. states.[51] In Fig. B.2, we show the average voting scores over the period 1995–2010 by electing state.[52] Following a similar theoretical argument as presented in this paper, we explore whether environmental voting scores by congress members elected in different states is correlated with state-level renewable energy capacity. We expect that those states whose congress representatives have a greener voting behavior are more advanced in terms of renewable energy transition, and, more broadly, environmental performance. For example, these politicians may actively promote their green political agenda at the federal level to benefit their home districts. Yet, they may exert influence on local politics and institutional actors. In Table B.5, we show that the results observed for governors also apply to congressional voting scores, despite the differences in context. While governors oversee state-level environmental policies, congressmen' environmental scores are derived from their votes on federal legislation. Thus, the positive effect (column 1 and 2) of environmental voting score on state renewable energy policies may be interpreted as an indirect spillover effect. Interestingly, as shown in column (3), we find significant coefficients associated with the interaction terms with energy-intensive manufacturing (negative) and renewable energy potential (positive). Even if state-elected congressmen actively support environmental legislation at the federal level, context-specific anti-renewable interests could still hinder the transition to renewable energy at the state level. Conversely, natural renewable endowment appears to facilitate this transition.

Appendix C. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.eneco.2023.107259.

[51] We thank an anonymous reviewer for suggesting us to also look at federal roll call votes.

[52] The data on roll-call votes on environmental bills by senators and house representatives elected in U.S. states are collected by the League of Conservation Voters (LCV). We use the dataset provided by Kim and Urpelainen (2017a). Annual environmental voting scores (on a scale of 0 to 100) are calculated as the ratio of pro-environment votes to the total votes cast by congressmen elected in various U.S. states. LCV selects the relevant environmental legislative initiatives and codes each congress member's vote as pro-environmental or anti-environmental voting. We build the variable *Environmental Voting Score* by collapsing votes by year and state of election, and by averaging house and senate voting scores.

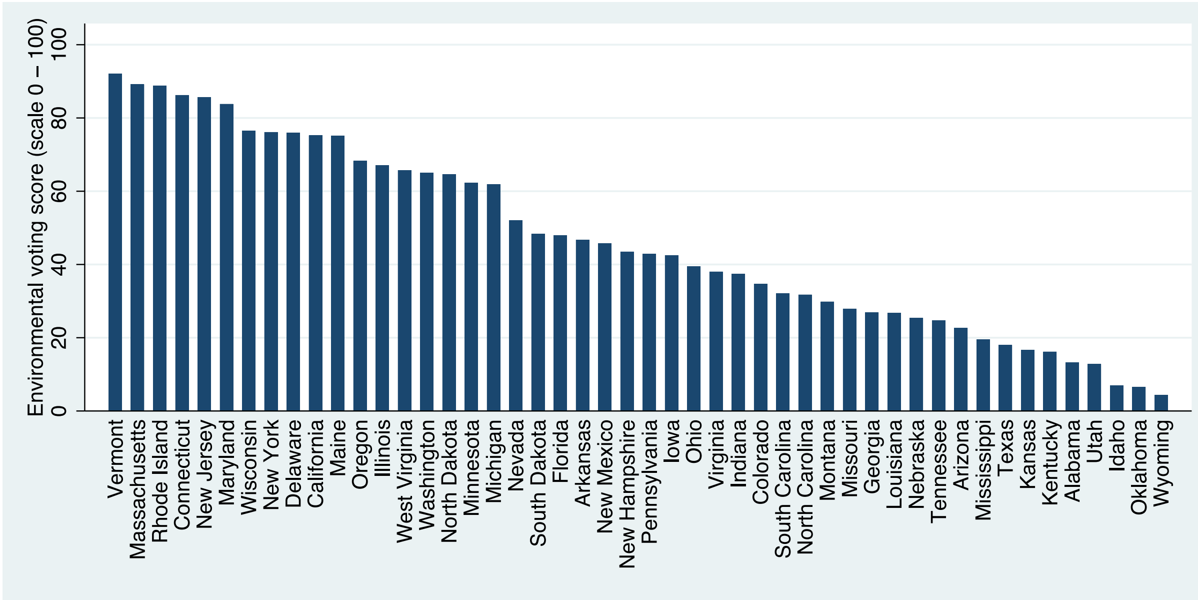

Fig. B.2. LCV environmental voting score by state, 1995–2010

Notes: Voting score on environmental bills by senators and house representatives elected in US states. Data on roll-call votes on environmental issues are collected by the League of Conservation Voters (LCV). We use the dataset provided by Kim and Urpelainen (2017a). Annual environmental voting scores (on a scale of 0 to 100) are calculated as the ratio of pro-environment votes to the total votes cast by congressmen elected in various U.S. states. LCV selects the relevant environmental legislative initiatives and codes each congress member's vote as pro-environmental or anti-environmental voting. The graph shows the average of house and senate voting scores over the period 1995–2010 from members elected in different U.S. states.

Table B.5
Renewable capacity, environmental voting score and interactions, 1995–2010.

	Dependent Variable: ln (Renew. Capacity)		
	(1)	(2)	(3)
Environmental voting score	0.0116***	0.00863**	0.00652**
	(0.00427)	(0.00362)	(0.00330)
Environmental voting score × GSP Energy-int. Manu. (Time-inv.)			−0.00480***
			(0.00147)
Environmental voting score × Ren. Endowment (Time-inv.)			0.0124***
			(0.00201)
Controls	No	Yes	Yes
State F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Observations	720	720	720
R2	0.762	0.789	0.808

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Notes: Column (1) reports results from replacing the party affiliation dummy of Eq. (1) with the indicator of environmental voting scoring. Annual environmental voting scores (on a scale of 0 to 100) are calculated as the ratio of pro-environment votes to the total votes cast by congressmen elected in various U.S. states and are derived by the dataset provided by Kim and Urpelainen (2017a). In column (2), we add the baseline control variables. Column (3) reports results from interacting environmental voting scoring with the GSP energy-intensive manufacturing share and the combined renewable endowment, similar to specification of Eq. (2).
Standard errors (in parentheses) are clustered at state-electoral term level. * denotes significance at 10%. ** denotes significance at 5%. *** denotes significance at 1%.

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