The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Regional Diffusion or Internal Determinants?

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Abstract

This paper draws upon policy innovation literature and quantitatively explains the adoption of state climate change policies, leading to a broader question—what makes states more likely to adopt policies that provide a global public good? First, existing empirical evidence relating to state climate change policy adoption is reviewed. Following this brief discussion, several analytic approaches are presented that test specific hypotheses derived from the internal determinants and regional diffusion models of policy adoption. Policy diffusion is tested as a function of the motivations, resources, and obstacles of policy change. Motivations for policy innovation include environmental conditions and demands of citizens. Resources include state financial and geographic resources, such as wind and solar potential. Obstacles include a state's reliance on carbon-intensive industries such as coal and natural gas. The results show that internal factors, particularly citizens' demands, are stronger predictors of states' policies than are diffusion effects from neighboring states.

KEY WORDS: climate change policy, energy policy, greenhouse gas policy, internal determinants, regional diffusion, renewable portfolio standards, state policy adoption, state policy innovation

Introduction

Over the past several years, while the debate has raged over climate change policy at the national and international levels, U.S. states have begun to adopt a wide variety of policies that may reduce greenhouse gas (GHG) emissions. While receiving substantial attention in the popular press, state adoption of climate change policies have been relatively ignored in the large body of climate change policy literature (Rabe, 2004).

Climate change programs are not simply cap-and-trade programs but rather can encompass a wide array of activities. State climate change policies may take a wide variety of forms including energy efficiency programs, financial incentives for renewable energy sources, financial incentives for alternative fuels, or regulations targeting the transportation or electricity-generation sectors. Climate change policies may be adopted to address a specific public bad, such as air pollution, producing a positive externality of GHG reduction. Other programs attack GHG emissions more directly, by promoting carbon accounting and methane recovery or seeking to implement a regional carbon-trading program. One specific type of energy regulation that has become increasingly popular, renewable portfolio standards (RPS), requires that a percentage of electricity generated or purchased in the state must come from renewable sources.

The heterogeneity of programs makes it unlikely that a single model can describe the adoption or effectiveness of all of these programs. Because of this heterogeneity, I focus specifically on energy efficiency and renewable energy policies, which represent a prominent sector of state policy activity to address climate change. I develop a parsimonious internal determinants model that predicts and explains the adoption of state climate change policies in the area of energy efficiency and renewable energy, based on the motivations for policy adoption, obstacles to policy adoption, and state resources.

The internal determinants model incorporates a variety of factors but does not allow me to test for regional diffusion. In order to test competing theoretical explanations of state policy adoption, I perform an event history analysis of RPS, determining whether state characteristics or regional diffusion leads states to adopt this important kind of energy regulation.

This paper draws upon policy adoption theory to explain the adoption of state climate change policies, leading to a broader question—what makes states more likely to adopt policy change, especially with policies that lead to global positive externalities? Previous studies have identified two models that explain state policy adoption.

The internal determinants model explains policy adoption as a function of state characteristics. According to this model, states innovate and adopt policies according to their endowments of attributes and resources. These attributes and resources may serve as motivations for innovation and adoption or they might be impediments toward innovation and adoption. Policy outcomes are a function of state motivation to innovate and obstacles to innovation (Mohr, 1969). In the context of climate change policy, these characteristics may include major public problems such as low air quality, important industries to the state, state energy consumption patterns, the availability of alternative energy resources, and the political ideology of the public regarding the role of government in shaping individual energy consumption choices.

The alternative model of state policy innovation and adoption is the regional diffusion model. According to this model, states view neighboring states as laboratories for policy experimentation (Elazar, 1972). State officials attend conferences and share ideas with neighboring state officials. Through these mechanisms, states emulate their neighbors by adopting similar policies.

These models of policy adoption need not be mutually exclusive. Alternative policy change models exist that incorporate a variety of internal political factors, external political factors, and policy-specific factors (Ringquist & Garand, 1999). Indeed, states may emulate their neighbors because they share similar geographical, economic, and political characteristics. Likewise, public opinion and uncertainty regarding the effects of a proposed policy or program provides an impediment toward policy adoption (Berry & Berry, 1990). The information gained by observing neighboring states serves as a resource that states can draw upon to help implement a new policy.

Over the course of this paper, I first discuss existing empirical evidence relating to state climate change policy adoption. Following this brief empirical discussion, I explain my approach in the context of state policy adoption theory and present two models that allow me to test specific hypotheses relating to the internal determinants and regional diffusion models of state policy adoption. I estimate my internal determinants model of policy adoption and provide a path analysis of this model. After a discussion of results, I present a second, more specific model that describes the adoption of RPS as an integrated model of internal determinants and regional diffusion. I conclude with a discussion of these models and provide directions for further research.

State Innovation in Climate Change Policy

Despite the enormous amount of attention paid toward climate change policy at the global and national levels, the United States has done relatively little to address climate change at the national or international levels. Under George W. Bush, the United States removed itself from the Kyoto Protocol, opting to address climate change through voluntary mechanisms. While alternative international measures are under discussion, and possible mandatory initiatives are under discussion in Congress, for the moment, it appears that the United States will address climate change on a voluntary basis and leave mandatory policy innovation to the states (Rabe, 2004). While inertia in Congress leaves little hope for a strong national policy, states have been increasingly active in promoting energy efficiency and renewable energy programs and have even begun to explore possibilities for Kyoto-style cap and trade systems. Even if the United States were to approve national legislation to address climate change, it appears that much of the foundation for reducing GHG emissions will remain at the state level. Because of this trend, the importance of understanding state policy innovation in the area of climate change has grown.

States have taken numerous efforts to address climate change through a variety of policies. Indeed, every single state has at least one program designed to increase energy efficiency or promote renewable energy. Numerous states have GHG goals as well. California has led the way with AB 32, which requires a 25 percent cut in GHGs by the year 2020 (Tribble, 2007). The New England Governors released an action plan in 2001 that calls for a 10 percent reduction in GHGs below 1990 levels by 2020 (Regional Greenhouse Gas Initiative [RGGI], 2007). New York State's energy plan requires a 5 percent reduction in GHG levels by 2010 and a 10 percent decrease below 1990 levels by 2020 (RGGI, 2007). In addition, California is now considering a Kyoto-style cap and trade system to complement its stringent goals (Tribble, 2007), and the RGGI is a cooperative effort by nine mid-Atlantic and Northeastern states to establish a carbon trading program from regional power plants in order to help states reach individual goals (RGGI, 2007).

State action in climate change policy has been increasingly documented through the work of nongovernmental organizations such as the Pew Center on Global Climate Change, as well as through anecdotal evidence in the popular media. In addition, Rabe (2004), in conjunction with his work at the Pew Center, discusses the increasing state role for addressing climate change. He notes that factors encouraging climate change policies cut across traditional partisan divides and argues that state initiatives are shifting focus to what is politically, economically, and technically feasible (Rabe, 2004). Despite attention paid to the state climate change policy issue, little quantitative work has examined the adoption of these policies.

Of the dozens of studies that have been conducted regarding state policy adoption, relatively few have specifically examined climate change policy or energy policy, or other goods that might provide a global positive externality. Regans (1980) examines state adoption of energy policies, concluding that internal determinants played an important role in policy diffusion. In contrast, Freeman (1985) examines energy policy through legislators' policy decisions, through survey data, and concluded that state legislators look toward neighboring states for policy ideas.

While these two conclusions are not mutually exclusive, as discussed above, they signify a need for additional research. In particular, with the growing trend of state-led climate change policy implementation, it is increasingly important to understand when and why states choose to adopt climate change policies.

Indeed, states have pursued a wide variety of policies that have implications for climate change (Rabe, 2004). Jaffe, Newell, and Stavins (1999) and Fischer and Newell (2003) discuss the displacement of CO_2 by various energy policies. Energy efficiency programs seek to reduce the amount of electricity used by industry and consumers. Renewable forms of electricity such as solar and wind have been promoted through financial incentives as well as mandatory regulations. Alternative transportation fuels, as well as reductions in automotive traffic, have been promoted through financial incentives and mandatory regulations. Programs exist that promote reforestation, carbon accounting, no-till agriculture, methane recovery, waste to energy programs, and mandatory caps on carbon emissions from utilities.

This wide variety of programs represents a unique trend in climate change policy. Because of the varied approaches for addressing climate change policy, and because of interconnection with other salient policies, climate change policy is frequently a positive externality of other policy initiatives. For example, no-till agriculture may primarily address soil erosion but may have the effect of sequestering carbon. High occupancy vehicle lanes may primarily address traffic but may also improve air quality and reduce carbon emissions. Of the policies that address climate change, relatively few of these policies directly address carbon emissions. Nevertheless, an approach to address climate change is likely to be comprised of a large number of individual policies at all levels of government, making it important to understand why these policies are adopted (Victor, House, & Joy, 2005).

Renewable Energy and Energy Efficiency Programs

Energy efficiency and renewable energy policies adopted by the states have become increasingly popular in the past several years. While states adopted energy efficiency programs in the 1970s and 1980s to address rising energy costs and the oil embargo, the number and breadth of these programs has risen sharply in the past decade, as concerns regarding climate change and energy security have grown. This growth directly coincides with our recognition of climate change as a problem, making it reasonable to equate policies that promote energy efficiency to climate change policies.

Renewable energy programs contain financial incentives as well as regulations to promote the use of renewable energy sources. In addition to federal subsidies, many states provide tax exemptions for renewable energy equipment. They provide loan incentives for renewable energy production and rebate programs for renewable energies. Regulatory policies benefiting renewable energy sources include RPS that mandate a percentage of electricity that must be produced through renewable sources. Net metering and interconnection laws require utilities to meter and purchase renewable energy from small or even household generators. Generation disclosure laws provide consumers information regarding the energy

Table 1. A Typology of State Energy Efficiency and Renewable Energy Programs

Category of Program	Examples
Financial incentives—renewables	Tax exemptions for equipment, loan incentives, subsidies
Financial incentives—efficiency	Tax exemptions for efficiency upgrades, loan incentives, subsidies for energy audits, public benefits programs
Rules and regulations	Renewable portfolio standards, net metering, solar easements, power generation disclosure, building and construction standards

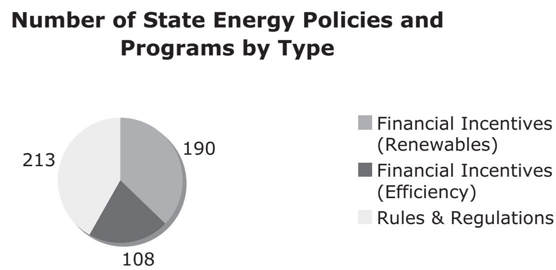

Figure 1. The Number of State Energy Policies and Programs by Type

source of purchased electricity. Solar access and easements laws provide for special property rights for solar panels.

Energy efficiency incentives and regulations also contain many provisions to bolster energy efficiency. Public benefits funds are established to promote energy efficiency throughout a state. Loans, rebates, and tax deductions are often provided to promote the purchase of energy efficient appliances. Green building programs provide incentives for resource efficient building materials and construction techniques. Building and construction codes mandate standards for energy efficiency in buildings. Table 1 describes a typology of state energy efficiency and renewable energy programs and Figure 1 demonstrates the distribution of these types of programs in the United States.

In the academic literature, many of these types of programs have been relatively ignored while several specific energy policies have garnered much attention. In particular, RPS, public benefit programs, and renewable energy programs have drawn attention from scholars. In large part, these studies focus on the variety of types of these policies, their funding (in the case of public benefits programs) and their effectiveness as a function of program characteristics.

Wiser and Langniss (2001) provided an early assessment of the Texas RPS, concluding that the program has generated significant new wind power, in part because of outstanding wind resources, long-term retail contracting, and economies of scale as a result of the large RPS (Wiser & Langniss, 2001). Following this assessment, a study of U.S. RPS noted the variability of RPS and attempted to discern how characteristics of these standards may impact effectiveness (Wiser, Porter, & Grace, 2004). Bird and his colleagues (2003) discuss the development of wind power in the United States, attributing the development of this renewable resource in large part to the proliferation of RPS.

Providing an overview of public benefits programs, Bolinger and Wiser (2001) discuss the funding of public benefits programs in the United States as well as numerous case studies expanding on efforts in individual states.

While this is not a complete overview of the literature regarding renewable energy and energy efficiency programs, it demonstrates the type of research that has been conducted regarding energy efficiency and renewable energy programs. Research has discussed these programs in relation to climate change policy, and these policies have been evaluated individually. This paper quantitatively assesses motivations for adoption of energy policies and climate change programs. While RPS have been evaluated qualitatively, they have not been evaluated quantitatively with respect to motivations for adoption or effectiveness.

Approach and Theory

In this section, I briefly discuss the two major perspectives for state policy adoption theory. After this review, I lay out my approach with a discussion of my modeling choice and the measurement of the two dependent variables employed by the models. Third, I detail specific testable hypotheses in the context of state climate change policy, as well as the measurement of the independent variables used to test these hypotheses.

Policy Adoption Theory

State policy adoption theory has been generally characterized by two perspectives. The internal determinants model explains state policy adoption as a function of state political and economic characteristics (Canon & Baum, 1981; Glick, 1981; Gray, 1973; Regans, 1980; Walker, 1969). This model is generally tested through cross-sectional regressions, and considerable empirical evidence has supported this theory.

Within this model, there are several different strategies for isolating the political and economic characteristics that lead to policy adoption by states. Typically, the dependent variable is a measure of how early a state adopts a policy among a group of potential adopters, or whether a state has adopted a policy. Nevertheless, some methodological problems are associated with this cross-sectional approach. Because policies are adopted over a long time period, some policies become more temporally removed from the measurement year of the independent variables. Depending on the temporal variation of the explanatory characteristics, results can be problematic (Berry & Berry, 1990).

The other major school of policy diffusion research has focused on regional diffusion of state policies, as states are likely to observe policy experimentation by their neighbors and implement successful policies in their own state (Berry, 1994; Berry & Berry, 1990; Canon & Baum, 1981; Mintrom, 1997; Walker, 1969). According to this research program, bureaucrats attend regional conferences and share ideas with neighboring states much more frequently than they do with distant states. Programs such as the RGGI or the Western States Climate Change Initiative exemplify the regional diffusion hypothesis.

The state-of-the-art approach for testing both regional diffusion and internal determinants is an event history analysis, which uses panel data to combine both the cross-sectional approach of the internal determinants model and the regional diffusion approach (Berry, 1994; Berry & Berry, 1990; Mooney, 2001). This approach recognizes the previous observations and contributions of a variety of researchers who have acknowledged that policy diffusion is a function of motivations to implement policy change, resources to allow policy change, and obstacles that can prevent policy change (Elazar, 1972; Mohr, 1969; Walker, 1969).

Approach

In order to address the research question—what motivates states to adopt climate change policies—I measure two different dependent variables and employ two models.

I test the internal determinants model by measuring the absolute number of energy efficiency and renewable energy policies adopted by each state between 1990 and 2007. This cross-sectional analysis allows me to test the motivations for policy adoption across an entire class of state climate change policies, giving a better understanding of how internal determinants may affect the adoption of many types of state climate change policies. While the absolute number of policies is not a measurement of overall policy strength, it is a measurement of regulatory activity and an indicator of how much policy activity takes place in the states. Unfortunately, this modeling choice does not allow me to test the regional diffusion model of policy adoption against the internal determinants model.

In order to test the internal determinants model of state policy adoption against the regional diffusion model, I conduct an event history analysis. To complete this, I must limit the analysis of climate change policies to one specific type of policy. *For the event history analysis, I measure whether a state adopts a renewable portfolio standard in each year between 1997 and 2005.* A more complete discussion regarding specific choices in measurement and estimation will follow in the specific discussion for each model.

Independent Variables and Hypotheses

In the federal system, states have the freedom to experiment and implement innovative policies that take advantage of their specific attributes, leading to the internal determinants model of state policy adoption. Because climate change policy is embedded within transportation policies, energy policies, and land use policies, I expect that states are motivated to adopt policies in order to address other state problems. In this context, climate change action is a positive externality of action addressing other public bads. In the area of energy efficiency, I expect that the motivation for energy efficiency and renewable energy adoption will primarily be because of the motivation to improve air quality and reduce criteria air pollutants. I employ two different measurements of air quality in this work. The first measurement is simply the total state criteria air pollutant emissions per capita in 1990 as a proxy for state air quality in 1990.[1] Second, using the AIR reporting database on the Environmental Protection Agency's website, and census information regarding county populations, I calculate the average percentage of a state's population living in a nonattainment area for the six major criteria air pollutants.[2] I expect that the greater the percentage of a state's population that is living in areas of poor air quality, the greater the likelihood of the adoption of renewable energy programs.

H1: States with lower air quality will implement more energy efficiency and renewable energy programs and policies.

Other attributes of states may provide impediments to policy adoption. Special interest groups—especially those representing powerful industries—may hold considerable sway over state policy-making efforts. In contrast to the interest group liberalism model, which posits that a wide variety of special interests will tug at national policy (Lowi, 1979), a smaller number industry groups may hold considerable sway over policy-making efforts at the state level (Ringquist & Garand, 1999). In the context of energy policy, I expect that states that have a greater reliance on carbon-intensive industries will be less likely to implement energy efficiency and renewable energy policies. In particular, in the United States, the majority of electricity production is derived from the combustion of coal and natural gas. States that produce coal and natural gas should be less inclined to implement energy efficiency and renewable energy policies in order to protect local industries. In contrast, a state may anticipate future mandatory regulations from the national level and attempt to act early. However, in the time frame of this study, mandatory action does not seem to be a credible threat. The two measurements I use to measure a state's dependency on carbon-related industry are carbon intensity and natural gas and coal production. The carbon dioxide intensity of a state is measured in tons per thousand of real 2000 chained dollars of Gross State Product (GSP). Carbon dioxide emissions data were collected from the Energy Information Agency (Energy Information Administration, 2007). Coal and natural gas production was collected from the Energy Information Agency and is measured in thousands of BTU/capita (Energy Information Administration, multiple years).

H2: States that have higher carbon-intensive economies will be less likely to adopt renewable energy and energy efficiency programs.

H3: States that produce more coal and natural gas will be less likely to adopt renewable energy and energy efficiency programs.

State policy adoption is a function of political and economic resources as well. The political-economic characteristics of a state may be many of the most important causes of policy change at the state level (Ringquist & Garand, 1999). Specifically, wealthier states may be more apt to partake in policy experimentation due to the ability to implement costly public programs. Second, the ideological position of the citizens of a state is often the most important determinant and functions as a political resource of state policy action (Ringquist & Garand, 1999). In the context of state energy policies, I expect that states with a higher income level will be more likely to implement climate change policies. I also expect that states with more liberal citizen bases will be more likely to support government intervention to change energy consumption behavior and thus will lead to more energy programs. I approximate state financial resources using GSP per capita. This figure was calculated using Bureau of Economic Analysis Data for GSP (Bureau of Economic Analysis, 2006) and population data from the Census Bureau (U.S. Census Bureau, 2007). Data are measured in real 2000 chained U.S. dollars per capita. I estimate the ideology of a state's citizens using Berry and others' citizen ideology index, which seeks to measure the mean position on a liberal-conservative continuum of the "active electorate" in a state, which is scaled from 0 (conservative) to 100 (liberal) (Berry, Ringquist, Fording, & Hanson, 1998). This measurement also functions as a proxy for other political characteristics of states, such as the party control of the state legislature, and is preferred over other measurements of state liberalism because it is a continuous, dynamic longitudinal measure of the mean state ideology. In addition it is sensitive to the difference between a minimal and overwhelming legislative majority and variation in parties' ideological positions across states. This index is constructed by weighting the ideology of the district's incumbent by the support they received and adding it to the weighted ideology of the state's average opposition party representatives.

H4: States with greater income per capita are more likely to adopt energy efficiency and renewable energy programs.

H5: States with more liberal citizens are more likely to adopt energy efficiency and renewable energy programs.

In addition to state political and economic resources, states have unique geographical resources that may allow them to pursue more renewable energy programs. In particular, high amounts of wind and solar resources should allow states to pursue a greater number of renewable energy programs and may encourage a state to pursue more energy efficiency programs as well. Wind potential is measured as the total percentage of U.S. electricity consumption that could be produced by state wind generation. This calculation assumes the utilization of all high-quality wind at 30 meters hub height, with 25 percent efficiency and 25 percent losses (Elliot & Schwartz, 1993). Solar potential is coded as annual average global radiation for each state ($kWh/M^2/day$).[3]

H6: States with higher wind generation capacities are more likely to adopt energy efficiency and renewable energy programs.

H7: States with higher solar generation capacities are more likely to adopt energy efficiency and renewable energy programs.

In order to test regional diffusion against the internal determinants model of state policy adoption, I measure the percentage of neighboring states that have adopted a renewable energy portfolio standard. Neighboring states serve as a laboratory for policy experimentation. Neighboring states may have many similar political, geographic, and economic characteristics and serve as a resource for states considering policy change. As the percentage of neighboring states that have adopted a policy increases, I expect that a state is more likely to adopt a policy. Indeed, a simple glance at the states that have adopted RPS seems to indicate regional clustering as indicated in Figure 2. Nevertheless, many states that are geographically close also have similar internal characteristics. Statistical analysis will allow me to separate the independent effects of internal characteristics and regional diffusion.

H8: States are more likely to adopt a particular energy policy if the neighbors of that state have already adopted a similar policy.

In order to test these competing theories, I will employ two models to test these hypotheses on all state renewable energy policies and energy efficiency programs

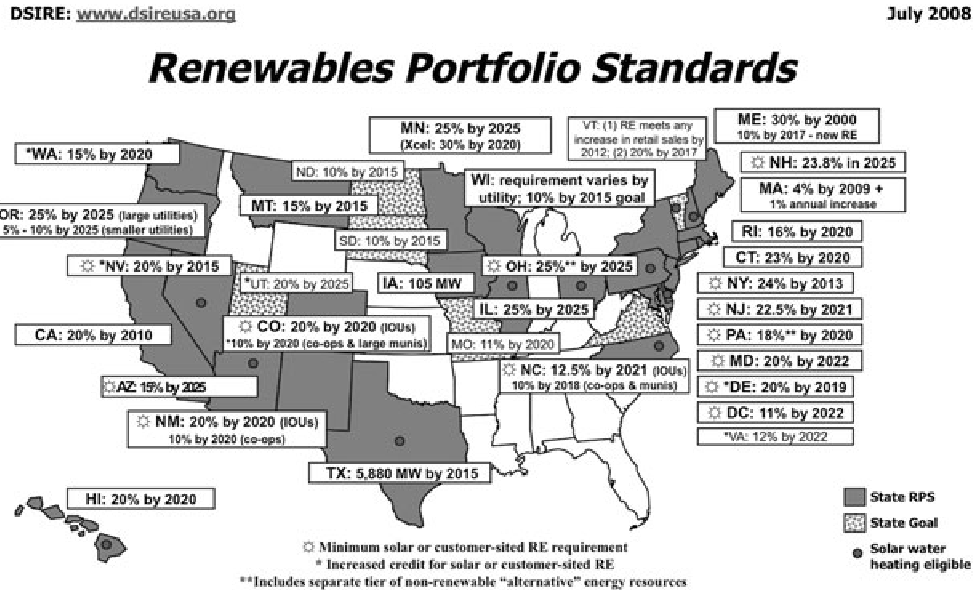

Figure 2. Map of state Renewable Portfolio Standards
Source: N.C. Solar Center at NCSU and DSIRE—http://www.dsireusa.org

and on a smaller subset of RPS policies. First, I use a cross-sectional analysis to determine which characteristics of the internal determinants model most importantly influence the adoption of state climate change policies. This cross-sectional analysis allows me to gauge relative policy activity among the states and look at a time period long enough to establish cause-and-effect relationships in the policy process (Mazmanian & Sabatier, 1989). This model will also establish the external generalizability of second part of the study and perform a path analysis establishing causal effects. Because of the heterogeneity of the types of policies included in this cross-sectional study, I cannot test for regional diffusion using this model, and there may be concerns of internal validity.

Second, using a cross-sectional time-series model, I narrow my focus to RPS and test the regional diffusion explanation against the internal determinants model using an event history analysis. While the first model provides external generalizability, this second model provides more internal validity. The time-series model approximates unit homogeneity by reducing the sample to RPS and accounts for alternative theoretical explanations, such as regional diffusion. Using both models allows us to gain a much clearer understanding of the causes of state climate change policy innovation.

Estimation of the Internal Determinants Model

For the internal determinants model, independent variables were measured from 1990 for each of the contiguous 48 states. The 1990 baseline represents the date that the first Intergovernmental Panel on Climate Change report was released, concluding that global climate change was likely caused by human behavior. Beginning in 1990, state agencies have kept track of GHG emissions and their efforts to combat them. Using data from 1990 also establishes temporal antecedence. While several policies were adopted prior to 1990, the vast majority of policies have been adopted since 1990, removing the effects that these policies may have had on the independent variables (such as air quality). While it is difficult to attribute the incidence of policies in 2004 to characteristics measured in 1990, for the most part, many of these characteristics have not changed dramatically since 1990, and public policy literature recommends a period of longer than ten years to evaluate major policy change (Sabatier & Jenkins-Smith, 1999).

Alaska and Hawaii are excluded because they have no neighboring states and cannot have a regional diffusion effect. In addition, Alaska has a variety of characteristics that make it unique. In particular, its enormous oil industry makes it an outlier with respect to gross state product, political ideology, and other measures. Finally, these two states were not included in the study of wind potential, making data incomplete for these two states.

For each of the contiguous states, the number of energy efficiency programs and renewable energy programs was collected from the Database of State Incentives for Renewable Energy (Interstate Renewable Energy Council, 2006). These programs are divided into three categories: financial incentives for renewables; financial incentives for energy efficiency; and rules, regulations, and policies. These categories will be used to test the robustness of the model for the different types of energy programs.

Our internal determinants model serves to estimate the independent effects of seven characteristics on the number of energy policies a state has adopted to address carbon dioxide emissions.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_7 X_7 + \varepsilon$$

This model can be estimated as a negative binomial count model or as an ordinary least squares (OLS) regression. Because the counts range from two programs in a state to 30 programs in a state, it may not be necessary to use a count model. In addition, with only 48 states to consider, OLS offers a variety of benefits over maximum likelihood regression, because of the large-n assumptions required of maximum likelihood. Because MLE is only asymptotically unbiased, a sample size of 48 with seven regressors is not likely sufficient. Instead, however, I use bootstrapping, a resampling method that allows for consistent, unbiased parameter estimates for MLE from a small sample (Mooney & Duval, 1993). I estimated the model with both an OLS and a bootstrapped negative binomial specification, generating similar results. In addition, two specifications of each estimation technique are presented in Table 2 in order to demonstrate the effects of creating a renewables index from the solar density and wind potential variables by adding the z-scores of each of the state's solar densities and wind potentials.

Because the dependent variable is a sum of three different counts, it is necessary to check the robustness of the model for each of the three types of state energy programs or regulations. I ran bootstrapped negative binomial models for each of the three different counts: renewable energy financial incentives, energy efficiency financial incentives, and energy rules and regulations. I dropped wind potential and solar potential as explanatory variables for energy efficiency financial

Table 2. Two Models Regressing State Characteristics on Total Number of Energy Policies. Parameter Estimates Are Shown, with Standard Errors in Parentheses (48 Observations).

Model	OLS	OLS	Neg-bin Bootstrap (500 reps)	Neg-bin Bootstrap (500 reps)
F-statistic	7.15***	8.42***		
Wald chi squared			37.48***	43.46***
R^2	0.56	0.55		
GSPPC	0.2e–04 (0.2e–04)	0.2e–03 (0.2e–03)	0.3e–04 (0.3e–04)	0.2e–04 (0.2e–04)
CO_2 intensity	−2.25 (1.90)	−4.60 (2.57)*	−0.204 (.359)	−0.412 (0.316)
Coal & gas PC	1.06e07 (9.51e–07)	2.8e–07 (8.93e–07)	−3.38e–08 (3.97e–07)	−2.13e–08 (3.31e–07)
Criteria air pollutants PC	5.54 (3.10)*	4.34 (2.25)*	0.576 (0.456)	0.508 (0.336)
Citizen ideology	0.357 (0.075)***	0.370 (0.07)***	0.031 (0.007)***	0.031 (0.007)***
Solar density	1.82 (1.87)		0.166 (0.192)	
Wind potential	−0.089 (0.155)		−0.0058 (0.025)	
Renewables index		1.88 (1.85)		0.173 (0.196)
Constant	−25.25 (12.92)*	−22.67 (12.00)*	−1.09 (1.62)	−957 (1.34)

*represents significance at the $\alpha = 0.1$ level; **represents significance at the $\alpha = 0.05$ level; ***represents significance at the $\alpha = 0.01$ level.

incentives, and energy rules and regulations, returning consistent results across the three counts.[4]

Discussion of Internal Determinants Model

The OLS model produces a surprisingly large amount of explanatory power. The full model is highly significant as a whole, with an F-statistic of 7.15 and an R^2 values of 0.56, representing that 56 percent of the variation in the number of state energy efficiency and renewables programs can be explained through these seven explanatory variables. Combining the solar density and wind potential variables into a renewables index does not have much of an effect on results.

Nevertheless, despite the strong significance of the model as a whole, it is necessary to examine the individual parameter estimates. As expected, GSP per capita and citizen's ideology are positively correlated with an increase of climate change programs. The measurement of citizen ideology is the only significant variable at the 0.05 or 0.01 levels, suggesting that citizen preferences drive state policy decisions more than geographic, environmental, or political characteristics.

As citizen ideology increases by approximately three points in the Berry and others index, a state is likely to implement one more climate change mitigation program. This parameter estimate supports our hypothesis earlier that states with more liberal populations are more likely to adopt climate change policies, indicating the high salience of energy issues with the public.

The positive correlation of GSP per capita indicate that, as expected, as government institutions become more liberal, and as wealth increases, states are likely to implement more climate change mitigation programs.

The parameter estimate for carbon dioxide (CO_2) intensity is negative, though is only statistically significant in the reduced-form OLS regression. This supports the hypothesis that states may seek to protect carbon-intensive industry, rather than encourage them to reduce carbon dioxide in order to meet expected carbon emissions requirements.

In these two model specifications, coal and natural gas production does not appear to be correlated with energy efficiency programs. This lack of significance for this parameter is likely due to the strong collinearity between coal and natural gas production and carbon dioxide (CO_2) intensity. If either CO_2 intensity or coal and gas per capita are dropped from the model, either variable becomes statistically significant and negative, demonstrating states' desires to protect local industries and a decrease in the likelihood of implementing climate change mitigation programs, all other factors remaining constant. A path analysis conducted below will illuminate the extent to which coal and gas production may have an indirect effect on state energy program adoption. These findings support the idea that state policy adoption is heavily influenced by political considerations.

These results suggest that states may adopt climate change policies in order to address other environmental concerns; however, results for this parameter are not robust across the two specifications. In the OLS specification, the parameter estimate on criteria air pollutants is large, positive, and significant, with a p-value of 0.08 and a parameter estimate indicating that a one ton increase of criteria air pollutants per capita leads to an increase of 5.5 energy policy programs. The negative binomial specification, while positive, is not statistically significant at any reasonable alpha value.

The negative parameter estimate for wind potential is surprising, and these estimates and low *t*-statistics indicate that wind potential may be nearly independent of energy legislation. Wind potential may be unrelated to climate change policies because of the types of states that have wind potential. Frequently, these states are rural, sparsely populated states, putting the wind resources geographically removed from load centers. States such as North and South Dakota are outliers in this group with huge amounts of wind potential that dwarf other states' wind potentials; however, these states have few climate change policies. Even with our controls for the other economic and political factors, these states are likely to drive the results for the wind potential parameter. Nevertheless, these results demonstrate that states with high wind potentials do not seem to be taking advantage of this abundant energy resource.

The positive parameter estimate for solar density suggests that, in contrast to wind potential, states with high solar potential may be taking advantage of their geographic endowments. However, this result is not significant at a reasonable alpha value.

A renewables index was created in order to aggregate solar density and wind potential, in order to reduce downward bias introduced by using both measurements to predict average effects across states. This measure is positive across both models, though not statistically significant.

The statistical insignificance of many of the parameters, coupled with the highly significant model and high R^2 indicates that many of these variables—and in particular the CO_2 intensity, criteria emissions, and coal and gas production measurements—may be capturing similar concepts. Indeed, when constructing this model, other related variables such as environmental groups per capita and energy consumption per capita were dropped in order to reduce this collinearity and improve the statistical significance of the variables that remained included in the model. Even with this reduced-form model, other variables could be dropped to further improve the hypothesis tests.

Nevertheless, the high explanatory power of the model and low statistical significance of the explanatory variables seems to indicate that not one of these measurements is particularly responsible for state adoption of climate change policies but rather that these factors work together as a whole to generate support for state climate change policies. Further, while individual correlation statistics between the number of climate change policies and any one of these explanatory variables is quite high, the model as a whole works much better and is much better theoretically justified.

Path Analysis of the Internal Determinants Model

Multiple regression may not be the best empirical tool in which to analyze policy outcomes as it only allows us to determine the direct effects of each variable on the dependent variable. As discussed above, many of these variables are highly correlated and are likely causally related. In particular, coal and gas production likely determines carbon dioxide intensity and criteria air pollutants emissions. Carbon dioxide intensity and gross state product likely have an effect on criteria air pollutants. Single-equation regression techniques do not allow us to measure these causal relationships or the indirect effects that these relationships have on the dependent variable. In addition, the use of a single-equation regression technique does not allow the researcher to compare the relative influence of the independent variables when these variables are causally related. For these reasons, the model is also operationalized as a set of path analytic equations.

In the path analysis, wind potential, solar density, citizen liberalism, gross state product, and coal and gas production are treated as exogenous variables. Wind potential, solar density, and fossil fuel production are largely determined geographically. Citizen liberalism and gross state product are exogenous in the sense that no other variables in the model are causally related to these variables. Carbon dioxide intensity is assumed to be partially determined by coal and gas production. Criteria air pollutants are assumed to be partially determined by coal and gas production, carbon dioxide intensity, and gross state product.

Using a path analysis, I can determine the extent to which each of these variables has an indirect effect on the dependent variable and in turn allow me to determine the total effect each variable has on the dependent variable. The path analysis, described in Table 3, supports some of my earlier hypotheses. If I consider the total effects of coal and gas production and carbon dioxide intensity on the number of energy policies, the total standardized parameter coefficient estimates are negative. Indeed this path diagram also emphasizes some strong relationships between the variables in the model. For example, a single standard deviation increase in coal and gas production leads to a 0.738 standard deviation increase in carbon dioxide intensity and a 0.273 standard deviation increase in criteria air pollutants. The only major shift in total effects from direct effect is a change in gross state product, due to a large, negative, indirect effect through criteria air pollution.

Table 3. Direct Effects and Total Effects of Variables on Energy Policy Adoption

Variable	Direct Effect	Total Effect
Coal and gas production	0.02	–0.02
Carbon dioxide intensity	–0.252	–0.191
Criteria air pollutants	0.343	0.343
Gross state product	0.19	–0.19
Wind potential	–0.096	–0.096
Solar density	0.128	0.128
Citizen liberalism	0.749	0.749

Event History Analysis Model

Data for the event history analysis model were collected beginning in 1997, which coincides with the first adoption of a RPS by Massachusetts (though it did not go into effect until 2001). This model explains the likelihood that a state will adopt an RPS in a given year. In addition to the explanatory variables representing state characteristics, a variable was coded explaining the percentage of states that share a border with each state that had adopted an RPS in that year or earlier. Data have not been released past 2005 for many of the explanatory variables of the states.

For this model, the adoption of an RPS standard in each state is coded as a "1" for the year of adoption and "0" if the RPS standard has not been adopted. Once a state adopts a policy, it drops out of the data set. This coding indicates that a particular policy can only be adopted once for each state (although it can be renewed or strengthened). It is estimated with a probit model as each state has a probability of adopting a RPS, given the characteristics of the state. This process assumes that at any given time after 1997 states are considering the possibility of adopting a RPS and will adopt it once a certain threshold is exceeded.

This model can be described as:

$$P = \left(e^{\alpha+\beta_1 X_1+\beta_2 X_2 \ldots+\beta_8 X_8+\varepsilon}\right) / \left(1+e^{\alpha+\beta_1 X_1+\beta_2 X_2 \ldots+\beta_8 X_8+\varepsilon}\right)$$

This model was estimated using a probit maximum likelihood regression, with a time counter in order to help control for time-related drift and robust standard errors to control for additional geographic or temporal heteroskedasticity.[5] Two specifications are presented in Table 4 in order to demonstrate the effects of creating a renewables index from the solar density and wind potential variables.

Discussion of Event History Analysis Model

The event history analysis model demonstrates strong support for the internal determinants model but no support for the regional diffusion model. Both models provide similar results, with citizen liberalism, solar density, the criteria pollutant index, and the time counter control statistically significant and in the expected directions. In addition, model 2 demonstrates significance for the carbon dioxide intensity parameter in the expected directions. All other parameters are in the expected directions, with the exception of gas and coal production per capita.

According to model 1, the expectation that a state will adopt a renewable portfolio standard in the year 2001 (the median year in the sample), with all factors held at

Table 4. Robust Probit Parameter Estimates, with Robust Standard Errors in Parentheses, Regressing State Characteristics and Regional Diffusion on Renewable Portfolio Standards Adoption (374 Observations); Dependent Variable = RPS Adoption (374 Observations)

Model	Model 1	Model 2
Wald Chi^2	34.96***	33.11***
Pseudo R^2	0.28	0.27
Neighboring states	–0.215 (0.57)	–0.196 (0.57)
CO_2 intensity	–0.290 (0.25)	–0.436 (0.24)*
GSPPC	0.3e–4 (0.2e–04)	0.3e–04 (0.2e–04)
Wind potential	0.023 (0.16)	
Solar density	0.628 (0.33)*	
Renewables index		0.237 (0.11)**
Criteria pollutant index	1.69 (0.82)**	1.81 (0.81)**
Gas and coal per capita	2.41e–08 (4.06e–08)	4.36e–08 (4.32e–08)
Citizen liberalism	0.052 (0.01)***	0.050 (0.01)***
Timecounter	0.131 (0.07)*	0.131 (0.07)*
Constant	–8.88 (2.39)***	–5.83 (1.27)***

*represents significance at the $\alpha = 0.10$ level; **represents significance at the $\alpha = 0.05$ level; ***represents significance at the $\alpha = 0.05$ level.

their means, is 0.1 percent. Varying citizen liberalism by one-half of a standard deviation on either side of the mean leads to states with low citizen liberalism adopting a RPS at a rate of <0.1 percent and states with high citizen liberalism adopting an RPS at a rate of 0.4 percent demonstrating that a one standard deviation change in citizen liberalism more than quadruples the probability of a state adopting an RPS.

The effect of resources and other motivations for RPS adoption is much more muted. Using the same methodology, and varying solar density, wind potential, or the criteria pollutant index from one-half of a standard deviation below the mean, to one-half of a standard deviation above the mean, holding all other factors at their means, leads to an increase in the probability that a state adopts an RPS standard from 0.1 percent to 0.2 percent, doubling the probability of RPS adoption. Varying GSP per capita by one standard deviation does not have a substantial effect on the predicted probability of RPS adoption. Varying the carbon dioxide intensity leads to a decrease in the expected probability of RPS adoption from 0.2 percent to 0.1 percent, halving the probability of RPS adoption. These changes in expected probability from a one standard deviation change in each of the independent variables demonstrates that individually each of these factors only has a moderate effect on RPS policy adoption; however, in concert, these factors can dramatically increase the probability of RPS adoption.

Combining the measures of solar density and wind potential in order to remove downward bias results in a positive and statistically significant relationship between a renewable energy potential index and RPS at the $\alpha = 0.05$ level. Similarly to the cross-sectional model discussed earlier, citizen liberalism is perhaps the strongest predictor of state policy adoption, consistently indicating that states with more liberal citizens are more likely to expand the role of government in order to address energy consumption patterns. Indeed, in earlier iterations of this model with data ending in 2003, the liberalism index was the only consistently statistically significant predictor of RPS adoption, indicating that over time, environmental, geographic, and political-economic characteristics have increased in their ability to explain RPS adoptions by states.

The positive and statistically significant coefficient on the criteria pollutant index demonstrates that states with poor air quality are much more likely to consider RPS as a method of improving their air quality, indicating that states may pursue climate change policies in order to address other social problems.

The positive coefficients on wind potential and statistically significant coefficient on solar density and the subsequent statistically significant and positive coefficient on the renewables potential index is an encouraging sign that states consider their geographic characteristics when making policy adoption decisions. In contrast to the cross-sectional model presented earlier, this model demonstrates a closer link between state resources and policy tool choice.

Most strikingly, perhaps, is the lack of support for the regional diffusion model. While a glance at a map might and existing policy adoption theory may lead one to believe that states adopt policies in clusters, imitating their neighbors, this model does not provide any support for this hypothesis. Indeed, the sign on neighboring states is negative, though not statistically significant. Earlier iterations with data through 2003 also returned a negative correlation between neighboring states adoption and the state's likelihood of adopting an RPS. The lack of support for the regional diffusion model may be because of two reasons. First, neighboring states are also similar in many geographic, political, and economic factors as well. Thus, while regional diffusion takes place, it takes place due to the similar political, geographic, and economic factors of a state, rather than due to the imitation of one's neighbors. Second, it is possible that energy policies, and other types of policies that generate global public goods, rely less upon regional diffusion and more upon internal characteristics of states than policies that involve other types of public programs, suggesting that the regional diffusion explanation for policy innovation is limited to certain types of policies.

Directions for Future Research

While this study has provided a thorough analysis of the internal determinants model, and tested this model against the regional diffusion model, the time frame studied here is short. The data conclude with 2005 data, which include the adoption of RPS by 20 states but exclude the adoption of RPS by an additional five to ten states. It would be helpful to extend the time frame to include more RPS adoptions in order to determine if regional diffusion is present at a later point in the policy process. Measurements of concepts such as "renewable potential" can be improved and refined. Future measurements may be able to use wind density, rather than wind potential, and include the potential of other renewable resources such as geothermal and biomass.

This study also does not account for the different types, or strengths, of RPS or the different types of energy and climate change policies. In the cross-sectional study, energy policies are simply counted, without regard to a policy's scope or strength, in order to give a general picture of policy activity. In the event history analysis, states either adopt or do not adopt an RPS. There is no room in this methodology to consider modifications or strengthening of an RPS. Methodological developments that would allow for tracking the strength of RPS over time, by state, would be a major development. Finally, while this study determines why states adopt energy-related climate change policies, and in particular, RPS, there is the need to quantitatively assess whether these have effects on a state's air quality, renewable electricity generation, or carbon dioxide emissions.

Conclusion

Literature regarding the state policy adoption has focused on two perspectives. The internal determinants model, which characterizes state policy adoption as a function of its internal characteristics, and regional diffusion, in which states are laboratories for experimentation, and successful policies are mimicked by neighboring states. These two models help determine the veracity of two perspectives regarding state policy adoption. These results demonstrate that state characteristics drive climate change policies, rather than regional diffusion, and suggest that the regional diffusion hypothesis ought to be reexamined.

In addition, these models are substantively significant regarding the implications of state climate change policy, which is the major driver of mandatory climate change policy in the United States. States appear to adopt climate change policies for a variety of reasons including the desire to curb harmful criteria air pollutant emissions, supporting the view that carbon dioxide mitigation may be seen as a positive externality of other types of policies. States also tailor their policies to match their particular characteristics. States with high wind potential tend to adopt RPS. States with solar potential adopt solar easements. Nevertheless, despite the variation among states in the types of climate change policies they adopt, we can generally predict which states will be more likely to adopt further measures to address climate change. In general, states with more liberal populations, higher per capita emissions of criteria air pollutants, more renewable potential, and less carbon dioxide intensive industry make more attempts to curb GHG emissions.

This paper emphasizes the political nature of energy policy adoptions but provides an optimistic view towards policy adoption aligned with environmental goals and geographic resources. Across the two models, citizen liberalism, the strength of industry, measured in carbon dioxide intensity; renewable resources; and air quality all served as statistically significant predictors of RPS policy adoption. While the most powerful explanation for the adoption of RPS is citizen liberalism—or the willingness of citizens to use government to expand the powers of government—there is support for states adopting policies appropriate for its geographical characteristics or in order to address public bads such as air pollution. In addition, these results suggest that regional diffusion of policies may vary with the intended effects of a policy. If a policy promotes a global public good, such as reduced carbon emissions, its adoption may be more dependent on internal determinants and political ideology than on regional diffusion mechanisms.

This area of research begins to open a pathway for exploration of how and why different states adopt varying types of climate change policies. While this study attempted to address RPS standards, one of the most prevalent and prominent climate change policies, there are many more policies that deserve attention. In addition, this study only looked at energy efficiency and renewable energy policies.

There are many other types of climate change policies that deserve attention including forestry, transportation, agriculture, and direct-emissions control policies, which can be addressed through a similar theoretical framework. In addition to continued exploration regarding the adoption of these policies, it becomes increasingly important to assess their effectiveness and whether state policy adoption will have impact on states' carbon emissions.

Notes

1 Data for nonattainment counties are not available for the 1990 baseline, while total emissions are not available through 2005. Thus, for the cross-sectional model explaining total energy policy adoptions I use total criteria air pollutants per capita from the National Emissions Inventory (Environmental Protection Agency, 2007a). For the event history analysis of RPS, I use the county nonattainment database, which more accurately represents a state's motivation to adopt RPS standards (Environmental Protection Agency, 2007b).

2 The six major criteria air pollutants include NO_x, SO_2, CO, Pb, 1 hour Ozone, and PM-10. The standards for eight-hour Ozone and PM-2.5 do not come into effect until after the range of this study.

3 These data were received from the EPA directly via personal communication. It is based on the 1961–2000 National Solar Radiation database from the National Renewable Energy Laboratory, Golden, Colorado.

4 I attempted to expand the population to include other types of climate change policies, and while the model as a whole was significant, if the population was reduced to these individual segments, the model would not have been robust for the transportation policy segments.

5 The estimation with regular standard errors did not produce significantly different results. The robust standard errors are used to reduce concerns of heteroskedasticity and autocorrelation from the time-series results.

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