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Policy Tool Interactions and the Adoption of State Renewable Portfolio Standards

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Abstract

We contribute to extant policy theory by focusing on interrelationships between existing policies and innovation. In particular, we call attention to the link between supply-side incentives and demand-side innovation, which has not been systematically investigated. Our research expectation is that supply-side policies generally will complement demand-side policy, leading to a positive impact on the adoption of demand-side innovations. We test this idea by examining adoptions of renewable portfolio standards (RPS), a demand-pull approach targeted to renewable energy generation by utilities, in the American states from 1991 to 2008. Event history models show that an index of supply-side financial incentives has a strong positive influence on RPS adoption. We do not find support for the hypothesis that this effect is contingent on in-state carbon-based energy generation. In conclusion, we argue that the study of policy adoption needs to give greater consideration to the interrelationships among policy instruments.

KEY WORDS: policy tools, renewable portfolio standards, renewable energy, tax incentives

Introduction

Studies of the diffusion of policy innovations generally focus on adoptions of a policy instrument in isolation from previously adopted policies and programs. The standard approach that focuses on internal social and political determinants as well as diffusion factors has been repeated for multiple policy types and areas. This approach facilitates the development of parsimonious explanations that are tractable for empirical testing (Berry & Berry, 1990), but it neglects the reality that policy choices are made in the context of existing policies and programs that are already in place.

In particular, this stream of research has not addressed the relationships between "supply-side" policy instruments and "demand-side" policies. Given that the distinctions between supply-side policy and demand-side policy interventions are central to both public choice and welfare economics theories (Weimer & Vining, 2004), this omission is surprising.

How do supply- and demand-side programs relate to each other? Does the existence of supply-side programs such as incentives for individuals or firms to alter behaviors facilitate or impede the adoption of demand-side programs to alter the types or qualities of products produced? For example, do tax incentives and rebate programs to consumers for energy conservation facilitate the adoption of programs to require energy producers use renewable energy sources or do these supply-side programs reduce the likelihood of demand-side innovation?

This article begins to answer this question by investigating the adoptions of renewable portfolio standards (RPS) in the U.S. states over the last 20 years. In addition to the usual suspects in terms of internal factors and diffusion, we examine

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the influence of existing supply-side incentive policies on the adoption of this innovation. We test the hypothesis that the effects of supply-side programs depend upon domestic supply of energy resources. The results confirm complementary effects. In conclusion, we discuss the implications of our findings for understanding state and local energy policy decisions and for theories of policy adoption and innovation. We then outline our ongoing theoretical and empirical research agenda for investigating relationships among policy instruments.

Renewable Portfolio Standards and State Renewable Energy Policy

The transition toward more sustainable, low-carbon states and communities requires the development and deployment of a range of new and existing energy technologies. The U.S. states are in the forefront of energy efficiency and renewable energy policy to address global climate change. Tremendous attention has been paid toward climate change policy at the national and global levels, but the federal government has done relatively little (Byrne, Hughes, Rickerson, & Kurdgelashvili, 2007). In some instances, state governments have filled this vacuum, playing a leadership role in climate protection policy (Rabe, 2004).

RPS are a relatively new instrument for promoting renewable energy. Thirty-five states and the District of Columbia have established RPS by 2009, requiring electricity providers to supply a minimum percentage or amount of customer power from a renewable source of electricity.

RPS require the retail electricity suppliers to procure a certain minimum amount of qualified renewable energy. Through setting the proportion of electricity to be generated from renewable sources with a predesigned timetable, the share of renewable energy among the whole electricity production can be incrementally increased. For example, in Massachusetts, the Department of Energy Resources has adopted an RPS that required all retail electricity providers in the state to utilize new renewable energy sources for at least 1% of the power supply in 2003; the amount increased to 4% by 2009 (DSIRE, 2010). An important feature of RPS adoption is that it could be revised to set higher standards once the previous standards were achieved, providing a steady policy instrument stimulating the development of renewables. By 2007, eleven states have revised their RPS, most of which are getting more stringent (Wiser, 2008).

The attractiveness of RPS lies in the tremendous potential payoffs for adopting states in terms of both public and private benefits. Environmental benefits can be generated by decreasing greenhouse gas (GHG) emissions and improving air quality, through increasing the percentage of renewables in the electricity portfolio (Lyon & Yin, 2010). The basic argument is that, by substituting coal and natural gas with energy from renewable sources, GHG emissions will be reduced. Although the decrease in GHG emissions could only be achieved in a scenario when the increase of overall energy demand is smaller than the increase of energy supply by renewables, the deployment of renewable energy is an option that shows much potential in mitigating GHG emissions in the long run.

Several studies examined factors influencing renewable energy policy in the American states including state adoptions of RPS. The RPS is by far the most extensively studied policy instrument with respect to understanding the reasons underlying its adoption. Huang, Alavalapati, Carter, and Langholtz (2007) find that education, political party dominancy, and gross state product (GSP) have large impacts on the probability of RPS adoption. Lyon and Yin (2010) develop a model for the adoption of RPS using an array of policy domain-specific variables such as air quality, renewable energy interests, unemployment rate, and so on. They find that renewable energy, restructured electricity markets, and economic development matter for the adoption of RPS. With respect to the adoption of financial incentives for renewable energy, Ciocirlan (2008) finds that electric utility companies tend to oppose financial incentives, while environmentalists and renewable energy producers tend to support them. In addition, various studies have investigated the diffusion effects of state renewable energy policy, yet the results regarding the effects of policy diffusion on the adoption of RPS are inconsistent at best (Chandler, 2009; Matisoff, 2008; Stoutenborough & Beverlin, 2008).

Extant research contributes to our understanding of the RPS adoption in the states but suffers from several limitations. First, these studies used RPS and policy incentives data prior to 2007, when about 60 percent of the states had yet to adopt RPS. Their contribution is limited to explaining early adoptions of RPS. While this is important in and of itself, the results may not be generalizable to later adoptions (see Kwon, Berry, & Feiock, 2009). Second, and partly as a consequence of the limited number of adoptions, extant work may not adequately capture diffusion effects. Lastly, and most critical to this study, extant research does not account for the potential influences that other existing policies might have on the adoption of RPS. In the following sections, we outline a theoretical framework for policy adoption that takes into account the influences of these factors.

Theoretical Framework

Studies of state adoption of policy innovations have been a growth industry in the two decades since Berry and Berry's (1990) path-breaking event history analysis of state lottery adoptions. The literature focuses primarily on internal determinants and external diffusion as competing explanations for state policy adoptions. The internal determinants explanation identifies political, social, and economic characteristics of states that motivate policy adoption (Gray, 1973; Mohr, 1969; Walker, 1969), while the external diffusion explanation focuses on the influences of national or regional forces, especially adoptions by neighboring states (Berry & Berry, 1990; Mintrom, 1997). The contribution of much of the research based on this framework has been more substantive than theoretical, as the basic framework has been extended to a wide array of state policy areas. The robustness of these explanations is evidenced by the variety of domains covered by previous studies including lotteries (Berry & Berry, 1990), taxes (Berry & Berry, 1992), abortions (Mooney & Lee, 1995), school choice (Mintrom & Vergari, 1998), and many others.

The study of policy innovations and diffusions has produced important insights, but the simple framing of internal versus external determinants does not adequately capture the complexity of diffusion mechanisms that is essential for fully understanding policy innovations among state or local governments. Rather than relying on a single instrument, most policy arenas are characterized by multiple programs and instruments, which can complement and positively influence the likelihood of other policy innovations being adopted, or require shifts of resources, personnel, and expertise that reduce the likelihood of other policies being adopted.

In many policy arenas, the policy alternatives available can be classified as being supply side or demand side. For example, policies seeking to reduce carbon-based energy consumption are cast as either supply-side "supply-push" instruments, which influence the supply of renewable energy, or demand-side "demand-pull" instruments, which affect the size of the market for renewable energy (Enzensberger, Wietschel, & Rentz, 2002; Jaffe, Newell, & Stavins, 2005; Margolis, 2002).

How do other existing policies influence the adoption of a new policy innovation? Despite the prominent place that existing programs and incentives have in policy debates, they have been mostly bypassed in the theory and research on policy adoptions. Berry and Berry (2007) introduce the idea that "other policies" might influence policy adoption. Kassekert (2010) expands this idea by building on the work of Mahajan and Peterson (1978, 1985) to argue that policies can complement or substitute for each other in complex ways.

This conceptualization is consistent with Mohr's (1969) classic argument that innovation is negatively related to the obstacles to innovation, and positively related to the motivations to innovate and the resources available to overcome the obstacles. Existing policies that are complementary increase the motivation to adopt an instrument, and existing policies that are substitutes can produce obstacles to innovation or reduce the resources available to overcome obstacles.

Supply- and Demand-Side Policy Interaction

The relationship between supply-side and demand-side policy approaches is a missing element in explanations of the adoption of state policy innovation. Specifically, we are interested in how various supply-side policies might increase or decrease the likelihood a state would adopt a demand-side policy instrument.

Theories of path dependency are consistent with our framework. Path dependency limits options because existing policies and tax incentives can alter the costs and benefits from adoption of new policy (Arthur, 1990; North, 1990, 2005). Path dependency also entrenches special interests who favor the policy into protective and organized groups. This approach is distinguished from internal determinants, in that the internal determinants are political, social, and economic factors external to the policy decisions, while the policy interaction explanation adds dynamics between different policies to the standard internal determinants and diffusion factors to explain adoption choices.

Positive policy interaction occurs when the past policy decisions of the jurisdiction increase the chance of the adoption of new policy innovation. In this sense, the positive policy interaction parallels the "increasing return" argument by historical institutionalism (Pierson, 2000).

Negative policy interaction occurs when the policies made earlier reduce the likelihood of adoption of the new policies, i.e., the past decisions crowd out the options of new policies and limit the alternatives available to the decision makers. The study of innovation diffusion often has a pro-innovation bias in that it is assumed innovations are inherently good, but if policies are substitutes or produce minimal marginal benefits in combination, the negative policy interactions may be advantageous (Kassekert, 2010).

Our research expectation is that supply-side policies generally complement demand-side policies, leading to a positive impact on the adoption of demand-side innovations. Nevertheless, the literature is unclear whether positive complementary effects or negative substitutive effects might result. If the positive relationship does not hold in all circumstances, extant theory provides little guidance to specify the conditions under which to expect negative effects.

Supply-side financial incentives are distributive in nature. The incentives are primarily in the form of tax expenditures from the state governments intended to stimulate the development of renewables. Supply-side incentives produce little conflict among the actors, as there are no clear “winners” or “losers.” In states with low levels of carbon-based industries and utilities, RPS as a demand-side policy produces minimal conflict. Due to increasing returns, the use of supply-side financial incentives facilitates a state’s future adoption of demand-side tools, when the state has a small utility sector and relies less on carbon-based energy. In this case, path dependence introduced by previous use of supply-side tools will increase the likelihood of RPS adoption.

Alternatively, in states with higher concentrations of carbon-based electric utilities, RPS becomes more of a regulatory tool that imposes costs on utilities and provides benefits to renewable energy industries. In this case, decision makers are influenced by interest group conflicts over the cost and benefit of RPS. In this situation, the previous use of supply-side tools are likely to reduce the probability of RPS adoption, because the interest groups that would be negatively affected by the RPS adoption argue that supply-side policies would be sufficient and that an RPS is not needed.

We hypothesize that the effects of supply-side policies on the adoption of demand-side tools will generally be positive, but when demand-side policy targeting energy generation imposes significant costs on utility companies, supply-side policies may be a substitute. In the case of RPS, this may be a function of the extent to which a state produces energy from in-state sources. Where states’ economies are dependent on carbon-based energy, supply-side policy instruments such as tax incentives and rebate programs act as substitutes, and reduce or reverse the positive effect on the likelihood of RPS adoption.

Hypothesis 1: The use of supply-side incentives for renewable energy will increase the likelihood a state will adopt RPS.

Hypothesis 2: The interaction of importing/exporting electricity and supply-side instruments will reduce the likelihood of adoption of RPS.

State energy policy provides an ideal venue for investigating path dependencies in state policy innovation. States are portrayed as laboratories of innovation in the new energy economy. As the national government’s role in energy and climate change lagged in the first decade of the 21st century, state and local governments in the United States took leading roles in policy innovations to bring about an energy sustainable and environmentally friendly economy. Various kinds of policy instruments have been introduced by state governments in recent decades to deal with the complicated multifaceted energy sustainability problem. RPS is one of the most frequently used state policy instruments to promote the development and use of renewable energy. Since Iowa's first adoption in 1983, 35 states have adopted RPS by 2009 (DSIRE, 2010).

Renewable Portfolio Standards and Economic Development

RPS is not a single-purpose policy instrument that only addresses climate change and renewable energy, but it is a multiple-purpose instrument that encompasses additional goals to stimulate economic development. The rationales for the adoption of RPS are based on economic development instead of climate protection in some states (Rabe, 2004). For example, the RPS legislation in Texas does not emphasize its impact on climate but instead job creation and energy supply diversity.

In the literature, it is argued that RPS can also produce substantial economic benefits to states. Rabe (2006) argues that RPS is economically beneficial to the adopting state and consistent with the goals of economic development. Wiser (2008) reports that RPS motivates renewable energy development. Yin and Powers (2010) argue that RPS is a substantive rather than symbolic policy in that RPS significantly and positively contributes to the development of renewable energy. The logical link between renewable energy development and economic development is based on the jobs created by the renewable energy industry. Studies demonstrated that renewable energy development has a great potential in creating green jobs (Wei, Patadia, & Kammen, 2010).

This aspect of the RPS policy tool requires that we should treat RPS as both a demand-side policy tool in terms of energy production and an economic incentive tool. Therefore, economic development motivations need to be accounted for in empirical models.

There are two alternative mechanisms by which economic development motivations come into play. First, we can examine whether RPS is a response to economic conditions. We can expect that states experiencing economic stress will be more likely to look for new economic development opportunities such as renewable energy development. However, the economic stress could also undermine the tax base and thus the financial capabilities of the states in stimulating renewable energy development, reducing the likelihood of using renewable energy policy.

An alternative way to examine the economic development motivation is to look at the effect of such policies on economic development. If renewable energy policy leads to job creation, then economic concern could be a driving force for the use of RPS. However, this also presents problems because of the difficulty to separate out the effects of job creation from other confounding factors. Because the latter strategy involves using RPS as an independent variable, we adopt the first strategy to examine the economic development motivation underlying RPS adoption.

Hypothesis 3: The higher the level of economic stress, the more likely a state will adopt RPS.

Research Design and Methods

Our explanation for adoption of policy innovation is tested by event history analysis (EHA). To test the hypotheses, we develop a panel data set, which covers most of the relevant policy, politics, and energy variables for the 48 continental states from 1991 to 2008, with 864 observations. The final number of observations reduces to 712, because the observations were dropped after the adoption of RPS occurred. Alaska, Hawaii, and Washington, DC, are excluded because of their uniqueness and lack of data for some control variables. The time range of 1991–2008 allows the observation of a longitudinal trend of the development of renewable energy policies.

To better measure the demand-side policies, we measure RPS in three alternative ways. The first measure is whether a state adopts RPS in a given year, a binary indicator of whether the state has RPS in a given year, with 1 indicating a state adopts RPS in that year, and 0 indicating a state has not adopted such a policy. This measure does not distinguish the levels of commitment to renewable energy, and all states that adopted renewable energy are coded as 1.

States differ from each other in their demand-side strategies, with some states adopting mandatory RPS requirement and other states adopting voluntary rules. Consequently, a second measure that we use is whether a state adopts mandatory RPS in a given year. A binary indicator is developed, with 1 indicating a state adopts mandatory RPS in that year, and 0 indicating a state adopted voluntary or no RPS.

States may also make additional demand-side commitment by specifying tiers of renewable energy goals and set the technology minimum levels (also called carve-outs). States that set technology minimum standards make additional commitment to a specific renewable technology. For example, Pennsylvania, Nevada, and Missouri, among other states, have set the minimum level of solar energy to be generated in target years. Solar energy is the most popular technology that is targeted with the technology minimum rules. Therefore, we developed a measure that captures whether a state have additional RPS tier that set minimum standards for solar energy. A binary indicator is developed, with 1 indicating a state adopts RPS with solar technology minimum requirement in that year, and 0 indicating no such requirement.

The independent variable is supply-side policy tools, which is measured by an index of states' prior use of corporate tax incentive, personal income tax incentive, and public benefit funds. The diffusion effect is taken into account by a variable that measures the percentage of neighboring states that have adopted RPS. The expectation is that the higher the percentage of neighboring states that have adopted RPS, the more likely a state will adopt this policy. These data were gathered from DSIRE web site.

The economic development concern is taken into account by including the annual state unemployment rates as a predictor. If unemployment rate is positively related to RPS adoption, then it means that higher unemployment rates lead to renewable energy efforts, indicating that renewable energy development would be used to create jobs.

We also included several control variables. Data on import and export of state electricity were gathered from Energy Information Administration. The most updated versions of the indices of citizen and government ideology (Berry, Ringquist, Fording, & Hanson, 1998) were collected from Richard Fording's web site. Interest groups are measured by the number of renewable energy nonprofit organizations in a state for a given year, which was coded from the database of *National Center for Charitable Statistics*. The selection mechanism of commissioners of

Table 1. Dependent and Independent Variable Explanations and Data Sources

Variable	Explanation	Source
Dependent variable		
Renewable portfolio standard (RPS) adoption	Dummy, 1: with RPS; 0: without RPS	DSIRE (2010)
Independent variables		
Supply-side policy	Index of corporate, personal tax incentives, and public benefit funds	DSIRE (2010)
Diffusion	Percentage of neighboring states that have adopted RPS	DSIRE (2010)
Unemployment rate	Percent unemployed in a state	BLS (2011)
Control variables		
Net import of electricity from other states	Unit: Million Btu	EIA (2011)
Citizen and government ideology	Index scores	Berry et al. (1998)
Green energy interest group	Counts	NCCS (2011)
Elected vs. appointed commissioners	Dummy. 1: elected commissioner; 0: appointed commissioner	Cavazos (2003)
Solar energy potential	Unit: Percent days of sunshine	Census Bureau
Wind energy potential	Unit: Miles per hour	Census Bureau
Population density	Unit: Number of people per square mile	BEA (2011)
Per capita income	Unit: Dollar	BEA (2011)

Table 2. Descriptive Statistics

Variable	Observation	Mean	Standard Deviation	Min	Max
Renewable portfolio standards (RPSs)	712	0.042	0.201	0	1
Mandatory RPS	712	0.035	0.184	0	1
RPS with solar tier	712	0.021	0.144	0	1
Supply-side policy	712	0.506	0.815	0	3
Diffusion	712	0.115	0.196	0	1
Unemployment rate	712	5.187	1.405	2.2	11.3
Net import of electricity	712	1.329	4.996	−29.537	43.611
Citizen ideology	712	47.359	13.770	8.449	95.972
Government ideology	712	46.196	25.851	0	97.917
Green energy interest group	712	3.546	3.866	0	35
Elected vs. appointed commissioners	712	0.372	0.484	0	1
Solar energy potential	712	57.048	7.883	38.904	81.096
Wind energy potential	712	9.147	1.653	5.800	12.900
Population density	712	157.775	205.321	2.156	1056.375
Per capita income	712	25,979.450	6236.341	13,208	48,608

the state public utility regulatory commissions was coded from the study of Cavazos (2003). It is coded as a dummy variable, with 1 denoting elected commissioner of public utilities regulatory commission, and 0 denoting appointed commissioner. Other relevant variables include state population density, state per capita income, solar power potential, and wind power potential in a state. Specific measures and data sources are listed in Table 1. Table 2 provides descriptive statistics for all these variables.

Our explanations for RPS adoption are tested by six event history models. The first model estimates the effect of supply-side policy on the adoption of RPS without the interaction of importing/exporting electricity and supply-side instruments. The second model estimates the parameters with the interaction term. The third model estimates the effect of supply-side policy on the adoption of mandatory RPS without interaction term. The fourth model adds the interaction term to model three. The last sets of models estimate the effect of supply-side policy on the adoption of RPS with technology minimum requirement for solar energy, fifth model without interaction term, and sixth model with interaction term. Estimation is done by treating the probability of failure as conditional on survival, previous use of policy tools, and various other control variables.

The three most frequently applied link functions for the EHA models are Logit, Probit, and Cloglog (Box-Steffensmeier & Jones, 2004). We use Cloglog because of its better treatment of rare events (Buckley & Westerland, 2004). The model assumes the underlying hazard is flat with respect to time (Box-Steffensmeier & Jones, 2004), i.e., the hazard rate that a state will adopt the renewable energy policy tool is assumed to be constant over time. A constant hazard rate assumes that the adoption of RPS is constant across time after controlling for the covariates in the model.

A second issue with the analysis is how to correct standard errors for the repeated measurements across the states. Time dependence generally results in underestimation of standard errors (Beck & Katz, 1997). Two measures will be adopted simultaneously to account for temporal dependence. First, we will correct the standard errors by applying robust standard errors clustered on the unit of analysis (state). Second, following Beck, Katz, and Tucker (1998), we will first create temporal dummies for each period and then use cubic spline smoothing functions to smooth the temporal dummies. Three equally spaced splines will be created and then incorporated into the model. In this way, the temporal dependence can be tested and controlled.

Results and Discussion

Diagnostics were performed to examine the distribution of residuals and leverage values. The sign and significance of the coefficients are robust to deletions of states with high leverage values.[1] The results of the six different model specifications are provided in Table 3. The difference between the models 1, 3, and 5 and models 2, 4, and 6 are that the latter models test the interaction hypothesis (hypothesis 2). Simple p-values can be misleading for interaction terms because the standard *t*-tests assume independence, and interactions by definition violate this assumption. A joint test of net electricity imports, tax incentives, and the interaction term was also conducted and the interaction hypothesis was inconclusive in model 2 and model 4. Therefore, the discussion of the results will focus on models 1 and 3.

The primary variable of interest is the index of supply-side energy policy for renewable energy. Consistent with our hypothesis, supply-side policies have a strong, positive, and significant influence on demand-side RPS policy adoptions, regardless of different measures of RPS policies. In the first model, converting the coefficient into an odds ratio, we determine that the odds that states adopt RPS are 1.817 times greater for each financial incentive policy they have previously adopted. In the second model, the effect of supply-side policy on the adoption of mandatory RPS policies is even stronger. The odds that states adopt mandatory RPS are two times greater for each financial incentive policy they have previously adopted. This is reasonable in that voluntary RPS is not as strong as mandatory RPS and is probably symbolic. Then previously adopted supply-side policies are sufficient for

Table 3. Determinants of State Adoption of Renewable Portfolio Standards (RPSs)

Independent Variable	Model 1 DV: RPS	Model 2 DV: RPS (interaction)	Model 3 DV: Mandatory RPS	Model 4 DV: Mandatory RPS (interaction)	Model 5 DV: RPS with solar tier	Model 6 DV: RPS with solar tier (interaction)
Supply-side policy	0.597** (0.239)	0.540** (0.245)	0.695** (0.281)	0.645** (0.291)	0.930*** (0.328)	1.167*** (0.416)
Diffusion	1.108 (0.744)	1.111 (0.742)	0.523 (0.819)	0.533 (0.827)	−0.244 (0.908)	−0.172 (0.864)
Unemployment	−0.444** (0.182)	−0.477** (0.191)	−0.124 (0.220)	−0.148 (0.222)	−0.383 (0.348)	−0.337 (0.331)
Net imports of electricity	−0.029 (0.057)	−0.058 (0.089)	−0.018 (0.058)	−0.045 (0.112)	0.022 (0.055)	0.074* (0.043)
Net imports of electricity × supply-side policy	—	0.016 (0.030)	—	0.014 (0.038)	—	−0.033** (0.013)
Citizen ideology	0.080*** (0.020)	0.082*** (0.021)	0.063*** (0.024)	0.065** (0.026)	0.044 (0.035)	0.044 (0.035)
Government ideology	0.006 (0.010)	0.008 (0.010)	0.015 (0.011)	0.016 (0.011)	0.023* (0.014)	0.020 (0.014)
Green energy interest group	0.057 (0.054)	0.060 (0.053)	0.002 (0.058)	0.005 (0.058)	−0.082 (0.072)	−0.096 (0.075)
Elected vs. appointed commissioners	−0.957* (0.540)	−0.990* (0.538)	−1.172 (0.753)	−1.184 (0.745)	−2.888* (1.618)	−3.023* (1.702)
Solar energy potential	0.075* (0.040)	0.078* (0.040)	0.090* (0.047)	0.092** (0.046)	0.102 (0.072)	0.110 (0.072)
Wind energy potential	0.180 (0.151)	0.185 (0.157)	0.114 (0.176)	0.115 (0.180)	—	—
Population density	−0.003** (0.001)	−0.003** (0.001)	−0.003* (0.001)	−0.003* (0.001)	−0.002 (0.002)	−0.003 (0.002)
Per capita income	0.0001* (0.00008)	0.0001* (0.00008)	0.0002** (0.0001)	0.0002** (0.0001)	0.0003*** (0.0001)	0.0003*** (0.0001)
Spline 1	0.001 (0.017)	0.001 (0.018)	−0.007 (0.019)	−0.006 (0.019)	−0.002 (0.022)	−0.002 (0.021)
Spline 2	0.006 (0.024)	0.006 (0.024)	0.016 (0.026)	0.016 (0.026)	−0.020 (0.030)	0.020 (0.029)
Spline 3	−0.009 (0.014)	−0.009 (0.030)	−0.013 (0.015)	−0.014 (0.015)	−0.023 (0.018)	−0.023 (0.017)
Constant	−15.810*** (4.612)	−15.609*** (4.585)	−18.841*** (5.561)	−18.632*** (5.528)	−18.326** (8.007)	−19.938*** (7.604)
Log pseudolikelihood	−77.280	−77.086	−71.871	−71.742	−46.965	−46.481
Observations	712	712	712	712	712	712

*p < .10; **p < .05; ***p < .01 (two-tailed)
Robust standard errors are given in parentheses.
DV, dependent variable.

state governments if they want to make symbolic stances on renewable energy issues. After taking out voluntary RPS states, we do find a stronger relationship between supply-side policies and demand-side policies.

In the last two models, we try to estimate the influence of supply-side policies on the use of RPS with solar tier. Even though the interaction term in model 6 is significant, interpretation of the coefficient needs to take into account other factors. The interpretation of interaction terms in nonlinear models is complicated, and it is not correct to only interpret the signs and significance of the interaction term. We use a strategy that calculates the marginal effects of supply-side policies on the use of RPS with solar tier, when electricity import variable is set at different values and other covariates are set at their means. The marginal effects are insignificant for all values of electricity import, indicating that the interaction term has no empirical meaning, even though it is statistically significant. Our discussion then focuses on model 5.

In model 5, we find a much stronger effect of supply-side policies on the adoption of RPS, compared with the previous models. This is because states that adopt RPS with solar tier are more committed to the demand-side strategy, and the complementary effect would be stronger if the demand-side strategy is assumed to be more effective by policy makers. Converting the coefficient into an odds ratio, we determine that the odds that states adopt RPS are 2.534 times greater for each financial incentive policy they have previously adopted.

The effect of economic condition on the use of demand-side instrument is not robust to different specifications, with the coefficient negatively significant in the first model and insignificant in models 3 and 5. This suggests that the economic concern may not be a driving force for the use of RPS policies, after controlling for the effects of other covariates. Moreover, even though economic stress may make RPS policies an appealing alternative, fiscally stressed financial conditions of the state governments could prevent them from doing so.

We do no find statistically significant results for the diffusion effects. Citizen ideology is positively significant in models 1 and 3, and government ideology is positively significant in model 5. This indicates that a more liberal ideological orientation in a state is associated with the use of RPS policies. The last variable of interest is the impact of solar and wind energy potential. While we do not find significant effects of wind energy potential, we do find some support for effect of the solar energy potential. However, the coefficient of solar energy potential is statistically significant in models 1 and 3, but not in model 5, which models the use of RPS with solar tier. This might indicate that the physical potential of renewable energy matters when states make initial decisions regarding the use of demand-side strategy, but it does not predict the states' further commitment to such strategy.

Conclusions

Studies of the adoption of policy innovation have increased rapidly over the last two decades, but the theoretical and empirical models upon which they are based have not progressed at a similar pace. This article contributes to extant theory by investigating interrelationships between existing policies and innovation. In particular, this study focuses on the link between supply-side incentives and demand-side innovation. We find support for our hypothesis that supply-side policies generally will have complementary effects that increase the likelihood of demand-side policy innovation. We do not find support for the hypothesis that economic development is driving the adoption of RPS.

Future research in this area will begin by developing a more precise measure of tax incentive usage. Currently, we use a sum of binary indicators for different tax incentive policies. We plan on gathering data concerning the amounts each state spends on the different tax incentives to measure the exact impact of the separate policies.

A second avenue of future research is to model multiple sustainable energy policies simultaneously. In this article, we hypothesize that tax incentives are precursory to the adoption of RPS. Numerous other policies such as smart grids, Leadership in Energy and Environmental Design (LEED) standards, and other green inducements can be adopted by state governments, and these policies may be complements, substitutes, or contingent upon the previous set of policies adopted. This research clearly demonstrates the impact of previous tax policy choices. The next step for scholars of state energy policy is to incorporate a more comprehensive set of energy policies.

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Note

1 Five states have leverage values higher than 0.3. These states are: Arizona (0.47), Connecticut (0.32), Florida (0.31), New Hampshire (0.34), and Oregon (0.34).

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