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Impacts of Renewable Portfolio Standards

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Running head: Renewable Portfolio Standards

ABSTRACT

Renewable Portfolio Standards (RPSs) are a key policy measure used by U.S. states to increase their production of renewable electricity. Economic theory shows that RPSs are not first-best policy measures for mitigating greenhouse gas emissions or solving other environmental problems. Nevertheless, they have been politically popular, in part because states hope they will help create new jobs in what they expect will be a growth industry. Research suggests that RPSs tend to be supported by Democratic legislatures in states with good solar and wind potential, are more likely in states with restructured electricity markets, and are less likely in states heavily dependent upon natural gas for electricity generation. Research also suggests RPSs have been successful at increasing renewable generation capacity, have increased the cost of electricity modestly where they have been implemented, and reduce carbon emissions at a cost roughly consistent with estimates of the social cost of carbon.

TABLE OF CONTENTS

Keywords: Renewable energy, state policy, electricity, political economy

1. Introduction

The mid 2000s witnessed widespread adoption by U.S. state governments of Renewable Portfolio Standards (RPSs) as a policy tool for promoting renewable electricity generation. An RPS ensures that a minimum amount of renewable energy (for example, wind, solar, biomass, and geothermal energy) is included in the state's portfolio of electric generating resources, and – by increasing the required amount over time – the RPS can put the electricity industry on a path toward increasing sustainability.

This new policy tool has been initiated by state governments in the absence of guiding federal regulations. The first RPS dates back to 1983, when Iowa passed the Alternative Energy Production law (revised in 1991 and 2000) requiring its two investor-owned utilities – Mid-American and Interstate Power and Light – to contract for a combined total of 105 megawatts (MW) of generation from renewable energy resources. The policy became increasingly popular in the late 1990s, and another burst of policy adoption occurred in the mid-2000s, as illustrated in Figure 1. By June 2015, 29 states and the District of Columbia had created mandatory RPS programs, and eight other states had voluntary renewable energy goals, as shown in Figure 2.

Although state RPS policies are now the principal form of support for renewable energy projects in the U.S., scholars have questioned the effectiveness and the efficiency of this policy in reducing sulfur and carbon emissions. Simulation models suggest that an RPS is not the first-best policy for achieving environmental improvements (Palmer and Burtraw 2005, Fischer and Newell 2008). Politically, an active movement to repeal or roll back RPS requirements has emerged, with Ohio having already "frozen" its RPS and West Virginia having repealed its (already weak) one.

The U.S. is not the only country to have introduced policies stipulating quantities of renewable electricity development. The European Union passed the Directive on Electricity Production from Renewable Energy Sources in 2001 and expanded it in 2007 with more aggressive targets. Various countries have adopted different approaches to implementing the requirements, some of which resemble RPS policies (Menanteau et al., 2003). In addition, in 1997 Japan set a 2012 target of 118 million KWh from renewable energy, roughly 1.35% of total generation (Nishio et al., 2006). However, the U.S. is arguably the nation that has made the most use of this policy instrument.

Given the academic and political debates around RPS policies, this is a propitious time to review what is known about them and their economic and environmental impacts. The next section reviews what economic theory has to say about the impacts of RPSs, and Section 3 discusses the history of RPS policies, with an emphasis on their goals and political motivations. Section 4 then surveys the empirical literature on the impacts of RPSs in practice. Section 5 explores the emerging political opposition to RPSs and Section 6 concludes with a discussion of needs for future research.

2. Economic Analysis of RPS Policies

Textbook economic responses to environmental externalities typically involve Pigouvian taxes that “internalize” through prices the harms business transactions would otherwise impose on third parties. In many countries, particularly in Europe, a price-based mechanism referred to as a “feed-in tariff” (FIT) is used to support renewable energy generation. A FIT guarantees a fixed price to generators of renewable electricity, thereby reducing business risks to investors but potentially shifting them to consumers (Schmalensee, 2012). To the extent that the FIT is above the price paid to other generators, it can be seen as a Pigouvian subsidy rewarding renewable generators for their lower emissions relative to fossil-fuel generation.

When abatement costs are uncertain, an emission tax (or a renewables subsidy) cannot guarantee any specific level of abatement, and a quantity constraint on emissions may be more efficient than a tax (Weitzman, 1974). A system of tradable emission permits (a “cap and trade” system) combines some of the desirable features of both taxes and quantity limits, as it provides certainty of emission reductions while allowing the burden of abatement to be allocated efficiently by market forces, so that the marginal cost of abatement is equalized across emitters (Sterner, 2003).

2.1 The Design of RPSs

An RPS is a quantity-based policy instrument. Some states, such as Iowa and Texas, frame their RPS requirements in terms of a specified number of megawatts of capacity. More commonly, however, an RPS requires that a certain percentage of power generated must come from renewable sources. It is thus a “ratio-based” policy, similar to the Renewable Fuel Standard for vehicles.

Implementation is normally accomplished by granting Renewable Energy Certificates (RECs) to generators of renewable power, and requiring load-serving entities to surrender enough RECs to cover the requisite amount of renewable generation. Regulated entities that fail to surrender enough RECS must make an Alternative Compliance Payment (ACP), a penalty which serves as an enforcement mechanism. Average ACPs are around $50/MWh, but some are as low as $10/MWh. Thus, the level of compliance with the requirements is likely to vary across states, too.

Many states impose additional restrictions, “carving out” certain amounts of power that must come from specific sources (usually solar), or offering additional credit for favored categories. These provisions may be intended to help support a nascent solar installation industry in a particular state, or to bolster an emerging solar manufacturing industry (if the RPS also requires that renewable generators must be purchased from within the state). However, these provisions also raise the cost of meeting RPS goals, since they ensure that the marginal cost of generation will not be equalized across all generation sources.

In principle, an RPS that allows unrestricted REC trading is very similar to a cap-and-trade system. In practice, however, most states restrict REC trading, e.g. by requiring that renewable generation come from in-state sources. As a result, the marginal cost of renewable generation is not equalized across sources or across states, and efficiency in encouraging renewable generation is vitiated. For example, in August of 2010 prices for solar RECs in New Jersey, Pennsylvania, Maryland, Delaware and Ohio were over $300/MWh, while unrestricted RECs in many other states were below $35/MWh (Schmalensee, 2012). These vast differences in REC prices show that the marginal cost of renewable power varies wildly across states and across generation types, and hence RPS policies cannot be minimizing the costs of increasing renewable generation.

Another design choice made by policymakers when creating an RPS is whether to allow "banking" of RECs over time. Banking encourages early adoption of renewable generation sources, and reduces the risks to investors worried about future changes in the economics of renewables. Unfortunately, most states place significant constraints on the banking of RECs, further reducing the cost effectiveness of RPS policies (Schmalensee, 2012).

2.2 Economic Efficiency of RPSs

Consistent with the foregoing comments, formal economic analysis shows that an RPS is not a first-best policy for reducing greenhouse gases (GHGs), even in its most flexible form. Palmer and Burtraw (2005) find that an RPS tends to displace natural gas as a generating fuel rather than coal, and thus is less effective at reducing carbon emissions than a direct tax on carbon emissions. They also find the economic cost of the RPS is relatively low at levels up to 15% penetration of the electricity grid, but that it rises sharply for penetration targets of 20% and above. Similarly, Fischer and Newell (2008) find that an RPS is substantially less efficient than alternative policies such as a carbon tax or a cap-and-trade system. Their method is to examine alternative policies that will lead to an equivalent amount of GHG emissions, and compare their costs. They find that a carbon tax has the lowest economic costs, and that an RPS is twice as costly as a carbon tax.[1]

The general direction of these economic conclusions is perhaps not completely surprising. Other papers have also shown that ratio-based policies tend to induce economic distortions. Indeed, over 50 years ago Averch and Johnson (1962) showed that economic regulation via a rate-of-return constraint leads regulated firms to overinvest in capital relative to labor. Similarly, a low-carbon fuel standard (which mandates a percentage of transportation fuel much come from low-carbon sources) induces increased use of low-carbon fuel, and results in unnecessarily high costs of abatement, (Holland et al., 2009). Even if the direction of the distortions identified by Palmer and Burtraw (2005) and Fischer and Newell (2008) is not surprising, however, their magnitude is large enough to be disconcerting.[2]

[1] Menanteau et al. (2003) compare the efficiency of incentive schemes in several different European countries and argue that feed-in-tariffs are more efficient than RPS requirements.

[2] Interestingly, Fischer (2010) shows that an RPS can potentially reduce electricity prices. The mechanism is that the RPS reduces demand for natural-gas fired generation, and hence can lead to a reduction in the cost of natural gas. If gas is the fuel at the margin, and electricity prices are set based on marginal cost, it is possible for the reduction in natural gas prices to produce a drop in electricity prices as well.

An additional concern about RPS policies is that they need to be carefully coordinated with other emissions policies if they are to be effective in reducing pollution. In regions with a carbon tax, such as California or the northeast states in the Regional Greenhouse Gas Initiative (RGGI), an RPS may have no impact on overall carbon emissions, because other emissions sources not subject to the RPS can profit by increasing their emissions without violating the overall cap (Moore et al., 2010).

3. The History and Politics of RPSs

Rabe (2004) was one of the first authors to recognize the importance of state RPS policies as a response to concerns about climate change. He studies a sample of states from around the United States that have adopted RPSs, and seeks to understand the political forces that led to their adoption. Among the most important factors mentioned by state policymakers in support of an RPS is that the policy creates jobs in a growth sector of the economy, so states with high unemployment rates might be expected to be especially like to adopt an RPS. "In all of the cases presented in this book, economic development has been a contributing – and, in some instances, dominating – factor behind state greenhouse gas reduction policy." (Rabe, p. 29). Because Rabe focuses on a set of case studies, however, he is not able to test such hypotheses with statistical confidence.

An RPS is not a first-best policy, but RPS policies are one of the most politically popular forms of support for renewable energy in the U.S. Thus, it is important to understand what political, social and economic factors explain state adoption of RPSs. Furthermore, measurement of the impact of RPS policies needs to take into account the factors that drove adoption, to control for the possibility that the states choosing to adopt an RPS would have achieved the same outcomes even without an RPS. There have been a number of papers that attempt to measure empirically the relative importance of various drivers of RPS adoption at the state level.

Several papers use a simple cross-sectional logit model to estimate the probability that a state has an RPS policy in place in a given year. Vachon and Menz (2006) conduct such an analysis for the U.S. in the year 2005, and find that composite measures of social and political interests were positively linked to the adoption of an RPS, while renewable potential (measured as the percent of sales that can be provided from renewable resources) was not significant. Huang et al. (2007) conduct a similar cross-sectional analysis for the year 2005, and find that states with higher gross state product, higher population growth, and higher levels of educational attainment were more likely to adopt an RPS, while states with a majority of Republicans in the legislature and with higher expenditures on natural resources were less likely to adopt.

Delmas and Montes-Sancho (2011) take a similar approach, but they use all years from find that an RPS is more likely in states with greater solar and wind potential, a higher fraction of Democratic state representatives, more environmentally-oriented federal Congressional representatives, the presence of a chapter of the American Solar Energy Society, a higher percentage of power from renewable sources, higher emissions (of SO_x, NO_X, and CO_2), higher average income, and lower unemployment rates.

The static cross-sectional logit approach can be criticized because it treats each yearly observation for a state as independent of previous years' policy. In reality, however, once an RPS policy is introduced it tends to be in place for multiple years, which means that an estimation approach with lagged dependent variables would be more appropriate. A failure to account for the intertemporal correlation of policy choices overstates the precision of empirical estimates, and can also bias coefficient estimates. Thus, most recent papers take a different econometric approach, borrowed from the technology adoption literature. These papers use a hazard rate model that takes into account which states are earlier or later adopters of RPS policy. This approach removes the state from the sample once it has adopted an RPS, thereby avoiding the problem of intertemporal correlation. (This approach is sometimes termed the "event history approach" in the political science literature.) Chandler (2009) takes such an approach for the period 1997-2008. She finds that early adoption of an RPS was more likely when a state had higher personal income and more liberal political ideology, as well as when neighboring states or other states in the same region had already adopted RPS policies.

Lyon and Yin (2010) use a hazard rate specification 1994-2007, but use a broader spectrum of variables. They consider three possible explanations for adoption: 1) public interest welfare maximization, 2) political ideology, and 3) political pressure from special interest groups. The results provide some support for each of these factors. Consistent with the public interest, states with greater wind and solar potential are more likely to adopt RPSs. However, contrary to the claims that RPSs create more jobs, states with low unemployment rates were more likely to adopt RPSs. Political ideology turned out to be the most important driver of early RPS adoption: state legislatures dominated by Democrats were much more likely to support an RPS than are Republicans. Finally, special interest pressure matters as well: states with organized representation of renewable energy interest groups were more likely to adopt RPSs. Lyon and Yin (2010) also examine the determinants of in-state requirements in RPSs, and find these are more likely in states that had less renewable generation at the time the RPS was passed, and in states with restructured electricity markets.

Carley and Miller (2012) seek to determine whether the factors driving the adoption of "strong" RPSs (more stringent than the median state that already had an RPS) differ from those driving "weak" RPSs (less stringent than the median state). They measure stringency as the increase in percentage of renewables required by the RPS divided by the number of years to achieve it, all multiplied by the share of total generation covered. They find that state-level citizen political ideology (as measured by Americans for Democratic Action scores) is a significant predictor of weak RPS policy adoption. In contrast, "strong" policy designs are best predicted by ideology at the government level (as proxied by the so-called DW-Nominate scores).

Fowler and Breen (2013) argue that political culture affects RPS adoption, and find that states with "moralist" cultures (emphasizing the common good) are the most likely to adopt an RPS, followed by states with "individualist" cultures (emphasizing free markets) and lastly by states with "traditionalist" cultures (emphasizing elite control and paternalism). Matisoff and Edwards (2014) explore the role of interstate policy diffusion in RPS adoption using the event history approach. They find that states with large land mass, liberal politics, and worse air quality adopt

RPSs earlier. They find no evidence that there is policy diffusion across neighboring states, but they do find support for the notion that policies diffuse across states with regional and/or cultural similarities. Yi and Feiock (2012) also use an event history approach, and show that states were more likely to adopt an RPS if they had already passed supply-side policies (such as tax breaks) that support renewable electricity production.

While not strictly comparable, other studies have examined the propensity of countries in the European Union to adopt policies supporting renewable electricity, such as the Directive on Electricity Production from Renewable Energy Sources, passed in 2001 and expanded in 2007 with more aggressive targets. Jenner et al. (2012) study 27 EU countries for the period 1990 to 2010, using an approach based on Lyon and Yin (2010). They find that renewables policies were adopted earlier in countries with an established chapter of the International Solar Energy Association, with a less concentrated electric utility industry, with higher unemployment rates, and with higher solar energy potential. Perhaps the most striking difference from U.S. studies is that Europeans actually count on renewable policies to create jobs when unemployment is high, whereas in the U.S. states with low unemployment rates are more likely to adopt RPS policies.

In summary, the literature on the drivers of RPS adoption is fairly consistent in its findings. An RPS is more likely to be adopted in states with greater wind and solar potential. However, an RPS is a highly partisan form of policy that is much more strongly supported by liberal Democrats than conservative Republicans. Not surprisingly, special interest group pressure from the renewables industry helps drive RPS adoption. In the US, RPS policies are adopted in states with low unemployment rates, although in the EU countries adopt renewables policies when unemployment is high.

4. Empirical Findings on the Impacts of RPSs

The literature on the impacts of RPSs has focused on three main questions. First, to what extent does an RPS actually lead to an increase in renewable energy development? Second, to what extent does an RPS lead to an increase in electricity prices? Third, what are the environmental impacts of RPS policies? The literature on the consequences of RPS policies has proven to be more contentious than the literature on the causes of RPS policies. This is in part because some papers have used simplistic measures of RPS stringency. It may also be due in part to the fact that most studies on the impact of RPSs have not accounted for the endogeneity of state decisions to adopt RPSs in the first place. This is an issue to which we will return at the end of the section.

4.1 Renewable Energy Development

One might think it odd to question whether a policy designed to support renewable energy development supports renewable energy development. However, some states provide very weak penalties to utilities that fail to meet RPS requirements, so compliance may be poor. In addition, states may pass RPS requirements that they are already on track to meet or in fact have already met.[3] For example, Maine passed an RPS in 1999 requiring that 30% of power come from renewable sources, including hydroelectric sources, but its percentage of renewable power at the time the law was implemented was actually higher than 30% (Yin and Powers, 2010). Thus, the question of whether an RPS actually brings forth more renewable investment than would have happened anyway is an interesting one. Indeed, some authors, such as Michaels (2007) and Delmas and Montes-Sancho (2011) argue that RPS policies are largely symbolic, and have no real impact on renewables deployment.

Most empirical studies find that RPS policies are positively correlated with renewable energy investment. Carley (2009) finds that a dummy variable for presence of an RPS policy has a significant and positive effect on total generation from renewable sources but no significant effect on the percentage of renewable generation out of the total electricity generation mix.[4] Ohler and Radusewicz (2010) focus on the state of Illinois, and argue qualitatively that its RPS has encouraged mostly wind generation and has raised awareness of problems with the transmission grid.

Yin and Powers (2010) argue that it is crucial to account for the fact that RPS policies often do not cover all utilities in the state, and are often passed by states that have already made significant progress towards meeting the stated goals. Thus, they introduce a new measure of RPS stringency that accounts for both these factors. (Thus, they treat Maine's 30% RPS as having an incremental stringency of 0%.) It turns out that using the correct measure of stringency makes an enormous different in empirical results. Using a simple dummy variable for RPS adoption, their panel-data analysis fails to find any impact of RPS adoption on the percentage of in-state generating capacity that comes from renewable sources. Using the nominal RPS requirement as an independent variable actually suggests that RPS policies have a negative impact on the percentage of capacity from renewable sources, as also found by Shrimali and Kniefel (2011). However, using their measure of RPS stringency, they find a significant impact of RPS passage on in-state renewable electric capacity. Furthermore, when they account for the possibility of meeting RPS requirements via the "free trade" of Renewable Energy Certificates (RECs), they find an almost 1-for-1 relationship between RPS stringency and deployment. Thus, they demonstrate the great importance of using nuanced measures of RPS design. Interestingly, they find a substitution effect between RPS requirements and "free trade" of Renewable Energy Credits (RECs). That is, allowing RPS requirements to be met through acquisition of RECs from other states can significantly weaken the impact of an RPS on in-state renewables investment. Thus, the combination of the above two policies should be used with caution.

Fischlein and Smith (2013) delve further into the heterogeneity in RPS designs, and characterize in detail how state RPSs differ. They argue that an RPS will induce a higher share of renewable energy generation if it is stringent, has strong penalties for non-compliance, and allows flexibility in meeting the goal. They conduct a preliminary empirical test of these hypotheses

[3] For example, Maine passed an RPS in 1999 requiring that 30% of power come from renewable sources, including hydroelectric sources. Its percentage of renewable power at the time the law was implemented was actually higher than this. http://programs.dsireusa.org/system/program/detail/452 .

[4] She states in a footnote that the results are not changed significantly when using the nominal value of the RPS requirement instead of a dummy variable for presence of an RPS.

using data from 2008, and including both in-state and out-of-state generation. They find that utilities with more demanding goals, voluntary green power programs and/or REC trading have a higher share of renewable generation. States with deregulated wholesale markets have a lower share of renewable generation, as do states that require in-state generation of renewables. Surprisingly, the strength of non-compliance penalties has no significant effect.

Delmas and Montes-Sancho (2011) point out that RPS policies are not adopted in a vacuum, so estimation of the impact of these policies may be biased if the political selection process is ignored. Indeed, they argue that once the selection process is considered, RPS policies are merely symbolic political gestures, and have no impact at all. The authors employ a Heckman-style two-stage model of RPS impacts, with the first stage estimating the adoption of an RPS, and the second stage estimating the impact of the RPS (the presence of an RPS is measured simply by a dummy variable). Their first-stage model produces results similar to those of Lyon and Yin (2010). States with better wind and solar resources are more likely to adopt an RPS, as are states with more liberal (i.e., Democratic) legislatures, states with lower unemployment rates, and states with a staffed chapter of the American Solar Energy Society (ASES). Unlike Lyon and Yin (2010), however, they find that restructuring had no significant impact on RPS adoption. The second-stage of the model uses estimated probabilities of adopting an RPS as an independent variable. The authors find that once selection is accounted for, "RPS has proven to have a negative effect on investments in renewable capacity." This is somewhat misleading, however, because they find that RPSs have a significant and positive effect for investor-owned utilities (IOUs), which account for the largest share of generation; furthermore, some states only impose their RPS on IOUs.

Although the use of a two-stage model is laudable, its implementation suffers from some methodological issues that call its findings into question. In the first stage model, the authors run a logit estimation of probability of adopting an RPS each year, which appears to assume that the RPS is up for reconsideration each year. In reality, however, most states commit to an RPS for a period of years, which is exactly what motivates researchers to use a hazard rate approach that removes a state from the sample once a policy has been introduced. Another concern is that the first-stage model includes the percentage of power from renewable sources, which is an endogenous function of prior periods' RPS policy decisions. This raises the chance that the model's results will be biased, and will understate the impact of the RPS on renewable capacity. A similar concern arises in the second-stage model, which includes the percentage of generation from renewables as an independent variable, despite the fact that it is endogenously determined with capacity additions. Overall, then, while the paper's findings are provocative, they need to be confirmed by other papers using more robust empirical methods before policymakers can rely upon them.

4.2 Electricity Prices

As demonstrated by Fischer (2009), it is possible for an RPS to either raise or lower electricity prices, depending upon the elasticity of demand and the elasticity of supply of natural gas, among other factors. Thus the impact of RPSs on electricity prices is an important empirical question.[5]

On balance, the empirical literature suggests that electricity prices increase following an RPS adoption, but estimates of the magnitude of the effect vary widely. Kydes (2007) uses the Department of Energy's National Energy Modeling System (NEMS) to simulate the impact of a 20% federal RPS and finds that electricity prices rise about 3% on average as a result. Lamontagne (2013) uses panel data regression techniques for the period 1990-2010 to estimate the impact of RPS policies in practice, and finds that states with an RPS have approximately a 20% higher all-retail electricity price than states that do not have an RPS. She also finds that in states with an RPS, electricity prices rise 5% per year relative to states with no RPS, rising to 10% per year after the policy is in place for a decade. These papers only examine state-level variation, however, with potentially large utility-level variations left unexplored. Tra (2015) investigates the effect of the RPS on residential and commercial electricity rates at the utility level for the period 1990-2012. He finds that a dummy variable for presence of a state RPS is associated with about a 3% increase in average residential and commercial electricity rates. However, he also finds that if RPS stringency is measured by mandated nominal renewables share, then RPS stringency has no significant effect on prices once state-by-year fixed effects are included in the model.

An alternative approach to analyzing the effect of an RPS is to develop a detailed simulation model that solves the electricity dispatch problem for a specific utility system with and without the RPS requirement. Johnson and Novacheck (2015a, b, c) conduct such an analysis for the state of Michigan, exploring the cost to consumers of increasing the share of renewables in the generation mix from the current 10% to 25%. They find that the average consumer would pay $2.60 more per month in the year 2030 as a result of the expanded RPS, an increase of 3% (Johnson and Novacheck, 2015a).

4.3 Environmental Impacts

There has been relatively little attention paid to the environmental impacts of RPS policies, perhaps because the measurement challenges are serious.

Carley (2011) builds a two-state simulation model of electricity dispatch, using the AURORAxmp package widely used by regulatory commissions, to simulate policies in Utah and Arizona, two neighboring states. She considers a suite of policies including an RPS, a demand-side management (DSM) program, renewable energy tax incentives, and a carbon capture and sequestion (CCS) policy, which makes it difficult to identify the effect of the RPS. She finds that isolated state policies raise electricity prices by over 30%, but state coordination can reduce the increase to roughly 20% while also reducing greenhouse gas emissions substantially.

[5] Huisman et al. (2013) use the experience with hydropower to argue that an increase in renewable power supply is likely to reduce electricity prices, but as the authors acknowledge this evidence is at best indirect.

Prasad and Munch (2012) provide a preliminary test for the period 1997-2008 of whether state-level carbon emissions are lower in states with an RPS or other policies that support renewable generation. They find very weak policy effects in general, but that a public benefits fund does lead to significant reductions of carbon emissions. In addition, they find that states with an RPS that has been in place longer have lower carbon emissions. Unfortunately, they are unable to control for inter-state transfers of renewable generation, i.e. through trading of RECs. Future work should attempt to take this into account, to update the sample period, and to control for whether a state is part of a carbon cap-and-trade system such as the one in California or the Regional Greenhouse Gas Initiative (RGGI) in the northeastern states whose compliance period began in 2009.

Johnson (2014) estimates the implicit cost of carbon abatement due to RPS policies. He performs a two-stage regression in which the first stage estimates how renewable electricity prices (system marginal prices + REC prices) are affected by RPS requirements, and the second stage estimates how renewable capacity responds to renewable electricity prices. He concludes that the cost of abatement via an RPS is at least $11/ton and possibly at high as $160/ton, which he points out is well above the prices of carbon permits in RGGI, where were around $3.00/ton in 2009.

Johnson and Novacheck (2015b) estimate the implicit cost of reducing greenhouse gas emissions via the RPS using a detailed simulation model of unit dispatch in Michigan. They find that it is between $28 and $34 per ton of CO_2 without government subsidies (Johnson and Novacheck, 2015b), which is with the range of estimates from Johnson (2014). However, the effectiveness of an RPS in mitigating carbon emissions is significantly reduced if existing coal plants are forced to retire early, as could happen due to the EPA's Clean Power Plan (Johnson and Novacheck, 2015c).

5. Political Opposition and the Future of RPSs

As discussed above, the passage of RPS policies has tended to be a partisan affair, supported by Democrats and opposed by Republicans. Utilities have also entered the political battle on occasion, sometimes using artificial grassroots lobbying groups, known as "astroturf groups" or simply front groups, to try and block RPS proposals.[6] Since 2014, conservatives have been organizing attacks on existing RPS laws in an attempt to weaken or repeal them altogether.[7] In particular, the American Legislative Exchange Council (ALEC), a conservative policy shop, has crafted model legislation to repeal RPS requirements, and distributed its proposed bill to sympathetic state legislators around the country. Advertising to repeal RPSs has been funded by Americans for Prosperity, a group funded by the Koch brothers, who hold some of the biggest investments in fossil fuels in the U.S. and Canada.[8] The anti-RPS bills were introduced in Arizona, Colorado, Ohio, New Mexico and New Hampshire in 2014, but none passed.

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[6] http://energy.umich.edu/news-events/news/2015/09/01/umeis-tom-lyon-front-groups-play-growing-and-dangerous-role-energy

[7] Stokes (2013) reports that Ontario's feed-in tariffs have also been experiencing political attacks.

[8] http://americansforprosperity.org/kansas/article/americans-for-prosperity-launches-statewide-tv-radio-to-repeal-rps/

Ohio imposed a two-year "freeze" on its 2008 RPS requirement in 2014, and created a committee to study the impact of the RPS and recommend whether to repeal it. RPS opponents crowed that West Virginia had become the first state to actually repeal its RPS in early 2015.[9] In reality, however, the state's 2009 law was never really a renewable portfolio standard since it counted as "alternative energy" a wide range of sources that included natural gas, "clean coal," and incinerated tires.

Many of the opinion pieces promoting RPS repeal rely on studies produced by Utah State University's Institute for Political Economy (IPE).[10] The IPE studies rely on simplistic models that blame RPSs passed just before the financial crisis of 2008 for the economic damage that followed the financial crisis (Simmons, et al., 2015). Although the research conflates the impacts of RPSs with those of the financial crisis, and is hence unreliable, the reports have been completed for Colorado, Kansas, Michigan, North Carolina, and Ohio, and have provided useful ammunition for conservative activists aiming to repeal RPS policies. The IPE is not transparent about its funding sources, but acknowledges that some funding comes from the Charles Koch Charitable Foundation, suggesting that oil and gas interests are threatened by RPSs –-which is consistent with the empirical literature mentioned above.

As of this writing, the effort to repeal RPS policies has gotten the most traction in states that either never had a real RPS or were among the last to adopt one. It remains an open question as to how far this political battle will ultimately go.

6. Conclusions and Needs for Future Research

Renewable Portfolio Standards are a key policy measure used by U.S. states to increase their production of renewable electricity. Economic theory shows that they are not first-best policy measures for mitigating greenhouse gas emissions or solving other environmental problems. Nevertheless, they have been politically popular, in part because states hope they will help create new jobs in what they expect will be a growth industry. The evidence suggests that on balance RPSs are supported by Democratic legislatures in states with good solar and wind potential, are more likely in states with restructured electricity markets, and are less likely in states heavily dependent upon natural gas for electricity generation. The evidence also suggests that these policies have been successful at increasing renewable generation capacity, and have increased the cost of electricity modestly where they have been implemented. Viewed as a carbon mitigation strategy, an RPS appears to reduce emissions at a cost that is roughly consistent with estimates of the social cost of carbon, suggesting that it is not a terribly inefficient policy, although it is only second-best.

Although there is a substantial literature on RPSs, many questions remain. From a methodological perspective, impacts research must go beyond simply treating all RPSs as the same, and needs to account for the nuances of different RPS policies, as recent work has begun

[9] http://insideclimatenews.org/news/20150205/wva-new-gop-majority-defangs-renewable-energy-law-never-had-bite

[10] See, for example, http://www.cincinnati.com/story/opinion/2015/07/08/opinion-repeal-renewable-energy-mandates/29876271/

to do. More fundamentally, analyses of the effects of RPSs should account for the fact that RPS adoption is not imposed exogenously from afar, but is chosen through the political process. The endogeneity of RPSs has not been reflected in most studies of their impacts, and is an important area for future work.

Somewhat surprisingly, there has been relatively little empirical analysis of the environmental benefits of RPS policies. To produce reliable results, of course, econometric studies of this sort will need to address the challenges mentioned above. Engineering-economic analyses of system dispatch are an underutilized but promising alternative approach.

Political economic research has shown that RPS policies are strongly driven by political ideology at the state level, as well as interest-group pressures. Thus, it should not be surprising that RPSs may face political attacks when state politics change, or when fossil fuel interest groups grow more threatened. Given the political pushback that RPS policies are receiving of late, this type of policy should be an excellent testbed for studying the role of ideology and interest-group politics in influencing public policy.

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Related Resources

Database of State Incentives for Renewables and Efficiency http://www.dsireusa.org/

Figure 1: The Adoption of RPS: 1994-2015

1994	MN					
1995						
1996	AZ					
1997	NV	MA	ME			
1998	WI	CT				
1999	TX	NJ				
2000						
2001	IL					
2002	NM	CA				
2003						
2004	CO	HI	MD	NY	PA	RI
2005	DE	DC	MT	VT		
2006	WA					
2007	OR	MO	NC	NH		
2008	MI	OH				

Note: Iowa adopted its RPS in 1983. No states have adopted an RPS since 2008.

Figure 2: RPS Requirements in the US as of 2015