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State-level renewable electricity policies and reductions in carbon emissions

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ABSTRACT

A wide range of renewable electricity policies has been adopted at the state level in the United States, but to date there has been no large-scale, empirical assessment of the effect of these policies on carbon emissions. Such an assessment is important because scholars have pointed out that increases in renewable electricity will not necessarily lead to declines in carbon emissions. We examine the effects of a range of policies across 39 states. We find significant and robust decreases in carbon emissions associated with the introduction of public benefit funds, a form of "carbon tax" adopted by 19 states to date. Our aim in this paper is not to provide a final judgment on these policies, many of which may not have been in place long enough to show strong effects, but to shift the attention of the research community away from proximate measures such as increases in clean electricity generation and onto measurement of lower carbon emissions.

1. Introduction

Despite the hesitant pace of environmental policy at the national level, there is a proliferation of environmental policy at the state level, where "an almost stealth-like process of policy development" has been underway for over two decades (Rabe, 2004:11). Many state governments have determined that environmental policy is necessary and feasible, and have experimented with several different policy approaches, particularly on the question of facilitating alternative energy.

These state policies are surprising in many ways. For example, they are often driven by bipartisan coalitions, and, perhaps because of their lower visibility, they seem to have escaped the partisan wrangling that has limited national-level policy. Both George W. Bush and Christine Todd Whitman were pioneers of alternative energy policy at the state level, as governors of Texas and New Jersey respectively, before they went on to obstruct environmental policy at the federal level as president and head of the EPA (Rabe, 2004: 1). Texas, a state that produces reliably conservative and anti-environmental contingents at the national level, is a leader in wind energy (Rabe, 2004: 50).

Environmental policy-making at the state level is pragmatic and catholic, with many different approaches being tried. Because electricity generation accounts for 41% of all CO_2 emissions and is the largest single source of CO_2 emissions (EPA, 2011:ES-8; Carley, 2011), many states have focused their efforts on the electric power sector. One of the main sites of policy innovation has been the attempt to increase the generation of electricity from renewable sources.

Wind, solar, and hydropower are the most likely sources of renewable energy today. In order to boost the production of renewable electricity from such sources, states have experimented with a range of renewable electricity policies. One of the earliest efforts was to allow consumers to generate their own electricity from small scale renewable sources, to feed some of this small scale generation back into the electricity grid, and to charge customers only on the "net" electricity they consumed. This approach is called net metering, and is available today in forty-three states. Another series of laws has sought to create competition between electricity providers, in various ways: by mandating that electricity providers must disclose their fuel sources, to allow customers to understand where their electricity is coming from and switch sources if they so choose (fuel generation disclosure, available today in twenty-three states); by mandating outright that customers be provided choices in energy suppliers (retail choice, fifteen states); and by mandating that electricity providers allow their customers the option of purchasing more expensive electricity from alternative energy sources (mandatory green power options, eight states). Another state-level law, the public benefit fund, is a kind of carbon tax, with fees on energy usage going to support environmental efforts of various kinds. Nineteen states have adopted them. The most excitement in recent years has been around the renewable portfolio standard (RPS), a quota mandating that a certain proportion of energy be generated from renewable sources. As of today RPS has spread rapidly across the country, with 37 states having adopted them. (DSIRE, 2011; Wiser et al., 1996; Carley, 2011; Rader and Norgaard, 1996; Fischlein et al., 2010).

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To our knowledge, there has to date been no large-scale, empirical review of the effect of state-level renewable electricity policies in reducing CO_2 emissions. Because wind energy is currently the most feasible source of clean electricity, and because RPS is the most popular policy, the most sophisticated research effort in this area has been focused on assessing whether RPS policies have increased the generation of electricity from wind power. Menz and Vachon (2006) use a simple OLS regression model to show that RPS does increase wind power when the number of years a policy has been in effect is taken into account. An unpublished study by Kneifel (2008) uses fixed-effects regression and finds no effect, but Yin and Powers (2010) claim that when differences in types of RPS are taken into account RPS does have an effect even in a fixed-effect model, as do Adelaja et al. (2010). Carley (2009) finds that an RPS does increase the total availability of wind power, but does not appreciably change the overall mix of energy. Examining renewable capacity more generally, Delmas and Montes-Sancho (2011) find that RPS reduces investment in renewable capacity overall, while MGPO increases it. Shrimali and Kniefel (2011) also examine renewable energy capacity and reach mixed results, for example, that while RPS with mandatory standards have significant effects, RPS with voluntary standards do not.

There has been much less research effort on the question of whether these policies are reducing carbon emissions, however, and some critics have argued that renewable energy will not contribute to that goal. Again, the most consistent research focus has been on RPS. Palmer and Burtraw (2005) do find that an RPS would reduce carbon emissions, but they also note that it would likely do more to reduce the use of clean but costly natural gas than cheap, dirty coal. They suggest that a simple cap on carbon emissions would be a more cost-efficient policy. Michaels (2008), in a sharp and multi-pronged critique of RPS, supports this view, noting that wind power's intermittent availability "means that [it] will largely displace gas-fired generation that can adjust output on short notice" (87). Unlike gas units, coal plants "will remain base-loaded and operating at almost all times" (87). This may compromise the ability of renewable energy to reduce carbon emissions, and even if renewable electricity is increasing, carbon emissions may not be decreasing. Michaels therefore suggests abandoning RPS and moving to more direct means such as caps on emissions.

Hogan (2008) provides a limited empirical assessment of the issue in case studies of Colorado, Connecticut, California, and Minnesota. He finds that only Minnesota appeared to have any decline in power sector CO_2 emissions after implementing an RPS (119). In accordance with the reasoning of Palmer and Burtraw as well as Michaels, Hogan notes that Minnesota was the only one of the four states where the marginal generation, which wind displaces, is predominantly coal-fired (119).

Other scholars have assessed emission effects with simulated models but reach conflicting conclusions. For instance, Kydes (2007) shows that a 20% non-hydroelectric RPS could reduce carbon dioxide emissions by around 16.5%. But the EIA has conducted a simulation suggesting a national RPS of 10% would reduce carbon emissions by only 3%–7% (EIA, 2002). Carley (2010) finds that individual state policies are only minimally effective if nearby states do not adopt similar policies.

While the existing research is informative, there is a need to supplement this work with multivariate empirical analysis of the effect of state-level renewable electricity policies on carbon emissions to date.

2. Methods and design

In this study we examine the effect of state-level renewable electricity policies on carbon emissions by state. Our approach is to compare carbon emissions in the electric power sector over time in states that have passed renewable electricity policies to carbon emissions in states that have not done so, controlling for factors that might independently affect carbon emissions in order to isolate the effect of the policy. We construct time-series panel data and employ a fixed-effects regression model that allows us to control for unobserved heterogeneity between the states. Our unit of measure is the state-year, and we have data on 468 state-years.

Our main model is

$$CO_2 = \alpha_1 + \beta_1\ \text{policy} + \beta_2\ \text{pop} + \beta_3\ \text{pcGDP} + \beta_4\ \text{pcgen} + \beta_5\ \text{exports} + \varepsilon \tag{1}$$

where CO_2 is a measure of carbon emissions, *policy* is a measure of renewable electricity policy in the state, *pop* is state population, *pcGDP* is per capita gross domestic product in the state, *pcgen* is per capita generation of electricity from all sources in the state, and *exports* is a measure of exports of total electricity to other states. We also include state fixed effects in the model.

Table 1 shows the specific definitions and sources of our variables, Table 2 presents summary statistics, and Tables 3a–d present bivariate correlations for variables entered into the same model. While some of the bivariate correlations shown in the tables are relatively high (>0.5), we also conducted variance inflation factor analysis for all models, and do not find multicollinearity in any of the models. The VIF analyses are not given here, but can be found in the full calculations presented online.[1]

Our independent variable for renewable electricity policy is measured in four different ways. We first test whether the simple presence or absence of a policy (coded as a binary) is associated with an effect on carbon emissions. We do this in two ways, first as the presence of any policy, and then as the presence of one of the six specific policies (net metering, retail choice, fuel generation disclosure, mandatory green power options, public benefit funds, renewable portfolio standards). However, Menz and Vachon (2006) argue that experience with a policy may also affect its success. It may be the case that as consumers become more familiar with the policy and begin to respond to it more clear effects are seen. For renewable portfolio standards in particular, years of experience with a policy may be significant because the standards are written to become gradually more stringent over time. We thus conduct separate estimations using the number of years the policy has been in effect in the state as the measure of *policy*. Again, we do this in two ways, first as a measure of aggregate experience with any policy, and second as experience with any one of the six specific policies. For the variable of experience with any policy, if a state had two or more policies in one year each of these policies would contribute one year of experience to the measure. For example, if a state had both net metering and public benefit funds in 1998, this would count as two years of policy experience. Our reasoning was that a state that has experience with two different policies is more experienced with renewable electricity policy in general than a state that has experience with one policy, and a cumulative measure more appropriately reflects this experience and differentiates between states with different levels of policy effort.

This leads to four measures for the independent variable: presence of any policy; presence of one of six specific policies; number of years experience with any policy; and number of years experience with one of six specific policies. To avoid multicollinearity, we do not enter any of these four ways of measuring

[1] All data and calculations are available in a supplement available online at: doi:10.1016/j.enpol.2012.02.024.