Renewable Portfolio Standards: Good Goals, Bad Economic Policies?

Table of Contents

Abstract

Renewable portfolio standards (RPS) are relatively recent policy innovations that have primarily been implemented at the state level. Their ultimate goal is to increase the percentage of electricity generated from renewable energy sources in a predetermined time span. They effectively act as mandates on electric utility companies, which must progressively incorporate more renewable electricity generation each year under a statewide RPS policy. This aspect of RPS policies is controversial, however, with some claiming that they harm the economy by creating additional costs for utility companies and their customers. Proponents of RPS statutes counter the claim by suggesting that RPS policies actually act as a boon to the economy by providing a secure environment for future investors. They argue that investment in the new clean energy industry will promote creation of jobs and cause economic growth. I test this hypothesis using several models of ordinary least squares linear regression. In my analysis, I do not observe any significant, positive relationship between RPS policies and state economic growth. Instead, the impact of RPS policies on economic growth was negative and statistically significant. At the end of this paper, I offer reasons for why the hypothesis was proven incorrect according to my statistical analysis. I conclude that more study is needed in the years to come.

Introduction

Reasons for Implementing RPS Statutes

For the majority of the 20th- and 21st-centuries, the United States has relied primarily on fossil fuels—coal, oil, and natural gas—for its electricity needs. These fossil fuels pollute the environment with carbon dioxide and other greenhouse gases, which are thought to cause global warming, among other symptoms of climate change. Within the past few decades, electric use in the United States has skyrocketed, thereby increasing the amount of greenhouse gases that are emitted into the atmosphere and the amount of energy needed to generate electricity (Gold and Thakar 2010, 184; Duane 2010, 713).

Without much guidance at the federal level, states have begun to seek ways to reduce their carbon footprint and increase their energy security by implementing policies aimed at increasing the amount of electricity generated from renewable energy sources (Gold and Thakar 2010, 186, 188; Sovacool 2008, 242; Glenna and Thomas 2010, 857). Many researchers have identified reasons why states choose to adopt renewable energy policies—including renewable portfolio standard (RPS) statutes—and have divided them into three overarching themes. The themes include economic development, environmental protection, and energy security and fuel diversity (Brown and Mosey 2008, 3; Sovacool 208, 256; Lyon and Yin 2010, 139). The economic theory in support of enacting renewable energy policies is that the new industry will spur job creation; the environmental view is that the air quality will improve by reducing the number of greenhouse gases and other toxic chemicals that are released when fossil fuels combust; and the energy security perspective is that the state may become self-sufficient and less reliant on energy imports (Brown and Mosey 2008, 3, 4).

Renewable energy can include energy that is produced from "wind, sun, water, plant growth, and geothermic heat" (Gold and Thakar 2010, 184). In the United States, the rate of incorporation of these renewable energy types has thus far occurred slowly, however. In 2008, for example, only

8% of all electricity generated in the United States came from renewable energy sources (Gold and Thakar 2010, 184). As a result of this slow initial growth in renewable energy development and their desire to see development in renewable energy infrastructure, states have begun to implement a number of energy-related measures like energy efficiency standards, tax incentives and RPS policies. The economic impacts behind this theory are what I studied in my paper.

History and Structure of RPS Statutes

As a result of the OPEC oil embargo during the 1970s, federal and especially state legislation was passed to ensure the security of energy sources used in the United States. These programs included "tax credits, tax deductions, price subsidies, and generous utility purchase tariffs" that were used as indirect government tools to spur the development of renewable energy generation and to "reduce U.S. dependence on foreign energy resources, improve the environment, and increase energy efficiency" (Gold and Thakar 2010, 186). State RPS policies are relatively recent innovations, however, with most states not enacting such policies until the beginning of the 21st-century (Gold and Thakar 2010, 189; Wiser, Namovicz, Gielecki, and Smith 2007, 8, 12). Iowa and Maine were the earliest states to explore RPS statutes as ways to increase electricity generation from renewable sources and were the main states to have these policies before the year 2000 (Gold and Thakar 2010, 196-204). It has only been since the year 2000 that a majority of states—now almost 40 of them—has implemented either mandatory or voluntary RPS policies ("Quantitative RPS Data Project" 2012).

Essentially, RPS policies act as government mandates that require electric utility companies to generate a certain percentage of their overall electric generation from renewable sources (Glenna and Thomas 2010, 857; Sener 2010, 16). It is partly because of this nature of RPS statutes that makes them controversial in both the academic and policymaking communities (Rose and Dormady 2011, 163). In the long run, the minimum percentage of energy that must be generated from renewable sources increases, eventually leading to a higher percentage of electricity that is generated from renewable sources (Gold and Thakar 2010, 186; Duane 2010, 759; Doot, Belval, and Fountain 2007, 2).

The policy objectives behind RPS standards vary from state to state, but generally the most widely cited reasons for these policies are to "subsidize renewable energy resources, reduce utility reliance on fossil fuels, diversify energy supply, promote energy independence, create jobs, protect the environment, [and] control [for] climate change" (Gold and Thakar 2010, 189-190). Because of these broad and overarching goals, each individual RPS policy varies from state to state, especially in the details of their overall administration and compliance mechanisms (Gold and Thakar 2010, 192; Sovacool 208, 243; Sener 2010, 17; Wiser, Namovicz, Gielecki, and Smith 207, 10). Most, if not all, RPS policies do follow a similar basic model, however:

> Each defines which energy resources are "renewable" and lists which utilities must comply with RPS requirements. A utility subject to an RPS must meet its load during a specified period (the "compliance period") from sources (the "portfolio") that include a certain percentage of renewably generated electric power (the "minimum percentage"). After each compliance period, each utility must report the total amount of electric power supplied during the period and present evidence that at least the minimum percentage of that power came from RPS-eligible renewable sources. (Gold and Thakar 2010, 192)

Many states include similar renewable sources listed as eligible under their respective RPS policies, including photovoltaic (solar), biomass, hydro, and wind power. Other states may have different qualifying renewable sources that are eligible (Gold and Thakar 2010, 192-193).

Areas of differences do exist among states, including minimum required percentages of renewable electricity generation, compliance periods and penalties, inclusion of energy efficiency programs, and whether the renewable electricity generation must occur in the state. Many states also allow utilities to defer the need to develop their own renewable energy generation by allowing them to purchase renewable energy credits from other utility companies that have met their goal (Gold and Thakar 2010, 193-194). Some states do not strictly enforce their compliance policies either, allowing the penalties to be waived in many instances (Gold and Thakar 2010, 195). Regardless of the enforcement policies, many states with RPS have continued to revise them, often increasing the minimum compliance levels (Gold and Thakar 2010, 208). And, despite the recent economic recession, it has been suggested that "state RPS statutes remain intact and effective [at incorporating more renewable energy in statewide electricity generation]" (Gold and Thakar 2010, 210).

It is clear, therefore, that the study of RPS policies is highly relevant to modern political discourse, but as will be discussed more completely later in the Literature Review section of my paper, the exact impact of RPS policies on the economy is not well known or documented, especially at the state level. Many modeling studies have been conducted to estimate the effects of RPS policies on state economies and electricity rates, but they seem to be inconclusive. My research is pertinent to the discussion, because it tests the relationship between the implementation of RPS policies on both economic growth and electricity rates.

My paper will proceed as follows: first, I will offer an examination of the available literature on the subject and will then use current economic and environmental theories to discuss how and why environmental mandates such as RPS policies may help or hinder economic growth. Second, I will provide my statistical analysis on the subject and will analyze my results. Last, I will provide policy recommendations and conclusions concerning RPS policies and avenues for future research.

Literature Review

Much controversy exists concerning the economic impact of climate change policies in the United States. What complicates this issue is that much of the available literature seems to provide no definitive answers (Rose and Dormady 2011, 143; Fischer 2011, 102). Writing in *The Energy Journal*, researchers Rose and Dormady write that the best measurement of the effects of climate change mitigation policies is a macroeconomic indicator, including gross domestic product (GDP) and employment (2011, 144). The two researchers describe the possible effects of mitigation policies:

> If a policy option requires capital investment, such as energy-saving equipment, it makes a significant difference whether the investment funds are additive to the geographic area or whether they offset ordinary investment in plant and equipment or ordinary consumption. If they are additive (e.g., if they attract investors from outside the region or from increased savings within its boundaries without somehow reducing consumption there), they will, all other things equal, have a stimulating effect on the economy. If they displace other investment, the effect is unknown. It could be positive if this investment calls forth greater productivity increases than the investment that it displaces, but it is equally likely that it will have a neutral or negative effect (Rose and Dormady 2011, 145).

There also appears to be a "rebound effect" for energy conservation and energy efficiency standards: if the total price of electricity has decreased because of greater technological efficiency, consumers use more of it (Rose and Dormady 2011, 146).

Studies that analyze the effect of environmental mandates on economic growth often use the percent change in gross domestic product (GDP) as the dependent variable (Rose and Dormady 2011, 152). The number of studies that analyzes the relationship between RPS policies and economic growth is sparse, but there are a few case studies that have been published. One such study was conducted in the state of Illinois and was recently published by the Illinois Department of Commerce and Economic Opportunity. This study predicted that Illinois' 2006 RPS goal of achieving 16% renewable generation by 2020 would create 1800 new jobs in the renewable energy industry by 2012 and 191,000 new jobs by 2020 (Loomis and Ohler 2010, 136-137). The study, however, did not analyze the effect that the state RPS policy would have on utility rates or the overall effect Illinois' RPS policy on economic expansion in general.

It is also unclear from previous research what effects and to what extent environmental regulations have on economic performances of companies and potential investors. The traditional argument is that environmentally-oriented regulations are inefficient and slow economic growth;

both sides, however, have the backing of several academic publications (Ienciu 2009, 126-127). One recent article, published in the *International Journal of Business Research* concluded that the effects of environmental regulations differ across localities (Ienciu 2009, 129). In other words, no firm consensus has formed in the academic community about the exact relationship between environmental—specifically energy—mandates and economic growth in all states, nor has anyone conclusively proven the effect of RPS policies on electricity rates. For example, a study conducted by the National Renewable Energy Laboratory found that as a result of Illinois' increased use of wind power—partly resulting from its enactment of the RPS statute—nearly 10,000 jobs were created during construction periods and almost 500 permanent jobs were developed. The added property revenue from the wind farms was estimated to be $18 million a year (Loomis and Ohler 2010, 158). But even though it has also been shown that the number of jobs in an area that receives venture capital fundraising grow by up to 1.24%, and result in up to a 3.78% increase in aggregate income (Samila and Sorenson 2011, 338), it is unclear from previous research whether RPS standards themselves affect venture capital fundraising or have any significant effect on future investors (Lyon and Yin 2010, 134).

Similar to the results for a literature review search on the effects of RPS policies on economic growth, I could find little literature that examined the relationship between RPS policies and electricity rates. Another case study in Illinois reached inconclusive results on this subject, mainly because the [Illinois] RPS statute studied had included a price cap that would keep electricity prices from rising more than 0.5% per year. Both proponents and opponents of RPS statutes have used this finding for their respective advantages, as "proponents of the RPS suggested that the RPS would decrease prices, while opponents suggested price increases" (Loomis and Ohler 2010, 137).

The impact on electricity rates remains unclear, because the median monthly increase was $0.46, with some rate changes ranging from an increase of $7 to a decrease of almost $5 a month

(Loomis and Ohler 2010, 159). Another previous study suggested that electricity rates would not increase by more than 1% after the implementation in RPS policies. (Wiser, Namovicz, Gielecki, and Smith 2007, 17). It is also unclear as to whether the increases in renewable energy generation were directly related to the implementation of the RPS statutes, or were a byproduct of private utility company initiative (Loomis and Ohler 2010, 165).

Part of the logic behind why one might expect electricity costs to increase after implementation of RPS policies is that the cost of renewable fuels remains higher than the cost of conventional energy (Nasiri and Zaccour 2011, 252). Furthermore, much of the discussion about the impact of RPS statutes on consumer prices of electricity or state economies has not been adequately discussed in the literature (Fischer 2010, 102). Therefore, more stringent RPS models may or may not have a negative effect on consumers' electricity bills, which in turn, may or may not have a negative effect on the economic growth rate in any given state or region. Energy efficiency policies can also interact with RPS standards, although the relationship between the two is complex and difficult to study. In general, however, energy efficiency policies affect the price of electricity by reducing the overall demand. According to the basic economic law of supply and demand, therefore, the price of electricity should decrease if supply stays constant (Fischer 2010, 112). The interaction with energy efficiency is interesting, however, as studies have been conducted which study the effect of energy efficiency policies on economic growth.

In regard to studies analyzing energy efficiency policies, the outcomes were mixed, with some yielding negative impacts on the economy and others yielding positive impacts (Rose and Dormady 2011, 161-162). Energy efficiency studies are also helpful in analyzing possible economic effects of RPS statutes because they share similar goals of reducing fossil fuel use. One study that included renewable energy as a variable used Argonne National Laboratory's "excellent AMIGA model" (Rose and Dormady 2011, 162). It concluded that mitigation policies, including implementation of renewable energy policies—potentially even RPS statutes—have only a negligible, if not positive, impact on the economy (Rose and Dormady 2011, 162).

Argument and Hypothesis

Despite the uncertainty about the relationship between RPS statutes and economic growth, environmental regulations might potentially have a variety of impacts on the economy, especially in the energy sector. These impacts include prices of electricity or other goods, consumer demand, competitiveness of utility companies, and research and development (Marcus, Aragon-Correa, and Pinkse 2011, 5). Measuring the economic impact of a certain policy in any country is a hard task, if only because an economy "consists of the interactions of millions of individual consumers and businesses, primarily through the workings of markets. The macroeconomic linkages work not only through markets for goods and services, but also through factors of production (labor, capital, and land and other natural resources)" (Rose and Dormady 2011, 144).

Nevertheless, those who favor RPS policies often state that the policies can and will create jobs, reduce carbon emissions, and—over time—reduce electricity prices (Loomis and Ohler 2010, 135; Glenna and Thomas 2010, 358; Nasiri and Zaccour 2011, 251-252). Assuming that no other states adopt RPS statutes, that the current states with RPS statutes do not decrease the minimum compliance level, and that the electric companies will abide by their states' respective RPS statutes, the EPA recently estimated that by 2025, 21% of all electrical generation from RPS states will be from renewable sources and that by 2035, nearly 17% of all U.S. electricity will be generated by renewable sources (Gold and Thakar 2010, 249). If these statistics come to fruition, it may be true that "RPS programs force[d] increased use of renewable generation" (Gold and Thakar 2010, 235). It will also mean that more Americans will be in the clean energy industry, hopefully spurring job creation and reducing the unemployment rate. As stated above, these are the positive outcomes reported in a study conducted by the Illinois Department of Commerce and Economic Opportunity

(Loomis and Ohler 2010, 136-137). Logically, this would spur economic growth in a state, as more taxes would be collected, not just on incomes, but on sales and consumption of consumer goods.

In arguing for a national RPS, Sovacool stated, "A national RPS would bring large-scale development of renewable energy and nationwide standards that would lower costs" (2008, 247). There is no reason that these benefits could not also be extrapolated to the state level. RPS statutes should be developed gradually, however, in order to provide for development of the renewable energy credit markets and increased financing in the renewable energy industry (Sovacool 2008, 250). Studies conducted at the national level have found that by implementing a national RPS statute, electricity prices would decrease about 15% per year through 2020, mainly by lowering prices of fossil fuels and making renewable energy cheaper in the future by investing now (Sovacool 2008, 252-253; Randjelovic, O'Rourke, and Orsato 2003, 242). Other studies, such as one conducted by Black and Veatch a few years ago, found that if Pennsylvania enacted an RPS statute mandating 10% minimum renewable energy portfolio by 2015, there would be "virtually no negative consequences for consumers" (Sovacool 2008, 255). Electricity rates have also been included in my analysis because they has been identified as a possible reason as to why some states may or may not enact RPS policies, mainly out of fear that if they would rise too much, the state's economy would be hurt (Lyon and Yin 2010, 144).

Despite the academic studies' findings that RPS statutes will eventually decrease electricity costs, many utility companies continue to argue that their rates would necessarily spike in the short-run; in turn, they would pass these higher rates onto consumers, perhaps weakening the economy by decreasing the amount of disposable income available to consumers (Sovacool 2008, 255). And there will be indeed some uncertain—and perhaps negative—consequences from adoption of RPS statutes, including changes in investment patterns (Sovacool 2008, 257). Critics also argue that the RPS statutes are "inefficient" drivers of economic investment in renewable energy sources (Duane

2010, 761; Michaels 2008, 81).

Regardless, one study at Berkeley Lab estimated that more than 50% of all new wind energy projects between 2001 and 2006 were in response to implementation of state RPS policies (Wiser, Namovicz, Gielecki, and Smith 2007, 14). But in addition to this short-term achievement, renewable portfolio standards do hold significant promise for "long-term investment and financing" (Wiser, Namovicz, Gielecki, and Smith 2007, 16). Investors can be expected to invest in states with renewable energy standards, at least in the long-run (Sovacool 2008, 247). Government-mandated regulations also help to ensure that investments will have time to grow and offer reward for investors (Marcus, Aragon-Correa, and Pinkse 2011, 5).

Thus, a mandate that ensures investors of some future need for renewable energy will provide enough certainty for investors to increase capital flow into states that have created these RPS mandates, which will create economic value while reducing environmental risks (Duane 2010, 763; Randjelovic, O'Rourke, and Orsato 2003, 251). I tend to agree with this view and wish to test the idea that "the RPS approach has therefore effectively created enormous new markets for renewable generation that could theoretically ensure enough market sales and project development to nurture a strong, economically viable renewable energy industry for the next decade" (Duane 2010, 760). In general, entrepreneurship and venture capital investment are thought to benefit employment growth and increase expansion of GDP (Minniti 2008, 780; Samila and Sorenson 2011, 338).

Therefore, my hypothesis is that RPS policies, especially mandatory ones, do not hurt economic growth in states that have adopted such policies. In fact, mandatory RPS policies may help bolster economic growth because of the reasonably secure and consistent market that will be necessary for energy consumption in the future, allowing for investors to direct capital into states with mandatory RPS policies. This will create jobs and stimulate economic growth. I also conjecture that states that have more stringent RPS policies and with longer records of support for RPS policies benefit more economically because of investors who will be more willing to invest in a state when there is guaranteed time during which they can reap financial rewards. As my secondary hypothesis, I believe that higher electricity rates do have a significantly negative impact on economic expansion, but that RPS policies do not have a measurable effect on electricity rates.

Research Design

Sample

The data sample was a panel set, including data from all 50 states from 2000 through 2010. All states were included in the study in order to have a baseline of the states that do not or did not have a RPS statute during the 2000 to 2010 time span. This is helpful because fluctuations in the economy can be a result of many different variables, not just the implementation of a RPS policy in a state. Therefore, the inclusion of other states in the study acts as a control variable.

Variables

I included two dependent variables in this study: percent change in state GDP per capita, which was the primary dependent variable, and electric rates. The percent change in state GDP per capita is simply GDP per capita of one year minus the GDP per capita of the previous year, divided by the GDP per capita of the previous year. It is then multiplied by 100. GDP per capita is the total output of a state divided by the population. I used the dataset collected by the Bureau of Economic Analysis (BEA), which chained the state GDP per capita to 2005 dollars and had also calculated percent change in GDP per capita. In order to lag the variables to control for the passage of time and help to show causality among the variables, the percent change in GDP per capita was used. The electricity rate is the average price of electricity in a given state, measured in cents per kilowatt hour. The data used was from the U.S. Energy Information Administration. Both of these variables were included to measure possible effects of the implementation of RPS policies on both economic growth in the state and electricity prices.

As for independent variables, I included three different variables reflecting different aspects of RPS statutes: the mere presence of a RPS statute in the state, whether the RPS was mandatory or voluntary, and how stringent the policy was in increasing the minimum level of renewable energy generation required. The presence of a RPS policy and the type (mandatory versus voluntary) were dummy variables in my model. States without RPS policies in a given year were coded as 0, while states that had a RPS policy implemented were coded as 1. Similarly, states with mandatory RPS policies in any given year were coded as a 1, while states without mandatory RPS policies in any given year were coded as a 0. Coding for voluntary RPS policies was identical to that described for coding for mandatory RPS policies.

Stringency was an interval variable with the minimum percentage of renewable energy generation entered for each year a state had a mandatory RPS statute implemented. Stringency of an RPS policy was based primarily on the DSIRE classification of mandatory RPS policies at the state level. For the purposes of this analysis, I only included "Tier 1" minimum requirements, which are generally the renewable energy generation requirements for the largest utility companies. While all states have Tier 1 minimum requirements, the overall number of tiers varies across states, which is why I only used Tier 1 minimum requirements in my research (Wiser, Namovicz, Gielecki, and Smith 2007, 11). Duration of the RPS statute was calculated as a fourth independent variable, in order to ascertain whether the length of time of the policy had any long-term effects on the economy of the state or on electricity rates. This variable was determined by adding the number of years a state had had a RPS policy enacted since the during the 2000 to 2010 time span. Iowa and Texas were dropped from the analysis in models 2 and 4, which studied the effects of mandatory and voluntary RPS statutes and stringency of RPs statutes, respectively. This is because Iowa and Texas have RPS policies that do not mandate a minimum percentage of electricity be generated by renewable sources; rather, these two states measure renewable generation in megawatt hours, not in percentages like most other states with RPS statutes.

Last, I included the percentage of high school graduates in a state as a control variable, as it has been demonstrated in prior literature that a more educated workforce is positively correlated with state economic growth (Reed 2009, 687, 693). This variable was recorded using data from the U.S. Census Bureau, which divided the total number of people with a high school education in a state by the total number of residents in a state. As stated above, the percent change in GDP per capita also acted as a control variable in my study to allow for possible causal inferences to be made. The presence of a national recession was controlled for per information published by the National Bureau of Economic Research. Years in which the United States nationally was in a recession for more than six months were coded as a 1, while all other years were coded as a 0. Other variables that have been found to be significant in determining state economic growth—such as working age population, the amount of electricity generated from renewable energy sources, and amount of venture capital invested in states—were difficult to find or too expensive to utilize (Reed 2009, 687, 693). Therefore, they were omitted from my statistical analysis.

Methodology

The models were run using ordinary least squares (OLS) regression in the SPSS software package. A total of six models were run, with the first four studying the effects of the presence of RPS statutes, the type of RPS statutes, the duration of RPS statutes, and the stringency of RPS statutes on economic growth as measured by percent change in GDP per capita. Another model was used to determine whether there is a statistically significant relationship between electricity rates and the percent change in GDP per capita, while the last model used studied the relationship between RPS policies and electricity rates. Because previous literature had found education to be a significant determinant of economic growth in states, I controlled for the variable in all five models in which percent change in GDP per capita was the dependent variable. The presence of a national recession was also controlled for in all of the models run.

Results

Six different models were used in my analysis; the first five estimated the effects of RPS policies and electricity rates on economic growth, as measured by percent change in GDP per capita. The sixth model that I used studied the relationship between RPS statutes and electricity rates, which was also a central aspect of my argument (Table 1).

Two control variables were included in the first five models, in which percent change in GDP per capita was the dependent variable. These control variables were the presence of a national recession and the percentage of a state's population with a high school education or higher. In all five models, the presence of a national recession was found to have a significant negative effect on the economic growth rate of a state ($p<0.01$). However, the percentage of the population with a high school education or higher was not found to be significant in any of the models, and in most cases was even associated negatively with economic growth.

Based on the estimation sample and holding all else constant, the presence of a RPS policy in a state was negatively and significantly correlated to percent change in GDP per capita (p-value=0.1, 90% confidence). On average, states with RPS policies tend to experience 0.07% less annual GDP growth than states without such policies. In model 2, I differentiate between mandatory and voluntary RPS statutes. When the effects of the two types of policy are estimated separately, it becomes clear that the negative effect of RPS on economic growth is driven by mandatory policies. Based on this sample and holding all else constant, the presence of a mandatory RPS appears to reduce GDP growth by 0.09% (significant at the 95% level), while the effect of voluntary RPS on the economy is statistically null.

A negative effect on economic growth was also seen in model 3, which estimated the effects of the duration of RPS policies on percent change in GDP per capita. According to the model, the length of time that state RPS statutes have existed decreases economic growth by 0.133% (significant at the 99% level). What is striking about this finding is that even though duration of RPS policies has a significant effect on state economies, the stringency of the RPS statute does not appear to have any significant effect. This relationship was estimated in model 4, which showed that more stringent RPS policies might have a negative effect on state economies, but the relationship is statistically insignificant.

Models 5 and 6 studied the effect of electricity rates on state economic growth and the effect of RPS statutes on electricity rates. In model 5, I observed a negative effect of the electricity rate on economic growth, implying that higher electricity rates hinder economic expansion (significant at the 90% level). When linked to whether this may be why RPS policies also negatively impact the economic growth of a state, however, there appears to be no significant relationship. This was estimated in model 6, which showed that even though the presence of RPS policies may positively affect electricity rates, the relationship is not statistically significant.

Discussion

When reviewing the results of the six regression models included in my analysis, I must conclude that my hypothesis was incorrect. RPS policies appear to have a negative impact on the economic growth of states that enact them, supporting the part of the literature that environmental—and in this case, energy—mandates do negatively and significantly affect the economy. While much of the negative effect of RPS policies is due to mandatory policies, the stringency of such policies does not appear to affect the economy, which at face value seems illogical. However, upon further reflection, the effect of the stringency of RPS policies on economic growth may not be significant because of the relatively small minimum amounts of renewable energy that have so far been required of utility companies or of investors in clean energy (Table 2). If this is the case, then most electric utility companies would not have yet had to raise rates significantly in order to offset expensive investment in renewable fuel sources. Therefore, the impact on electricity rates might not have had a chance to materialize in the dataset that I was able to compile. Additionally, a significant increase in the amount of jobs needed to install and maintain more clean energy equipment and infrastructure may not have occurred to have a positive significant impact on the economy.

One part of my argument that was also incorrect was my proposition that states that had implemented RPS policies for longer periods of time would witness greater amounts of investment in jobs and economic growth. However, this was not found to be the case; model 3 estimated that for every year a RPS statute had been in place, percent change in GDP per capita decreased by 0.133% (Table 1). This may be due to the fact that the recession was not completely controlled for by the dummy variable I used, therefore making policies that had been enacted for longer periods of time through the 2007-2009 recession to have a more negative effect in my model.

The link between higher electricity rates and economic growth was significant in my model, with higher electricity rates correlating to negative economic growth. While this was an important middle link in my argument and hypothesis as to why RPS statutes can affect economic growth in states that have adopted such policies, the presence of RPS statutes does not appear to significantly impact utility rates (Table 1). Again, however, this may be explained by recognizing that several years may need to pass before RPS statutes have a significant effect on utility rates.

Lastly, although the effects tend to be relatively small, mandatory RPS statutes do have a significant and negative effect on economic growth. This fact is a refutation of my hypothesis that even though RPS policies are environmental mandates, an increase in investment would still occur in states that have adopted such mandatory measures, thereby spurring job creation and economic growth. There are three possible explanations as to why my hypothesis was proven incorrect by my statistical analysis, the first being that there has not been enough time to see the impacts of renewable energy investment in states that have adopted mandatory policies. The second reason that my hypothesis might have been proven incorrect is coupled with the first possible reason: one of the most severe economic recessions in the United States occurred during the time period that most states adopted and implemented RPS statutes. The recession might have made it difficult for investors to increase their investments in renewable energy from 2008 through at least 2009, if not until more recently. Therefore, because many states had not implemented policies before 2007, it could be true that investment was limited, thereby also limiting the positive benefits of investment, including job creation and economic growth. The third and perhaps most practical reason explaining why my hypothesis was wrong is simply that [mandatory] RPS statutes have a small negative impact on the economy. As previous research has concluded, environmental mandates can act as barriers to economic growth. Although RPS policies are not strictly environmental mandates, they can be viewed as such, and may thus be reflecting an inherent nature of environmental policies. Indeed, in the *Energy Law Journal*, Professor of Economics Michaels writes:

> As environmental policy, an RPS is inefficient by every economic standard. It is a costly measure whose effects on emissions are uncertain, difficult to integrate with existing environmental regulation, and needlessly disruptive of generation investments intended to comply with anticipated emissions rules… As macroeconomic or industrial policy, a national RPS cannot possibly 'create' net increases in employment and rural areas that it will 'revitalize' seldom need the help." (2008, 81).

In terms of the robustness of my model, I would like to have included more control variables. But due to a lack of time and the difficulty in finding adequate data for control variables that I would have included, I was omitted them from my study. Additionally, the datasets needed to study the effect of RPS policies on investment rates cost more than what I could afford. The education of a state was still included, nonetheless, to act as a control variable, as states with educated populations tend to perform better economically than states with fewer educated persons.

In the models I ran, though, high school education was not estimated to be a significant variable on economic growth rates, which is somewhat strange given the conclusions reached by other authors (Reed 2009, 693). Nonetheless, education was still controlled for in my study. The other main control in my study was the presence of a national recession, which was a dummy variable and included in my study for the 2001 and 2007-2009 recession. My incorporation of the presence of a national recession sought to control for national economic growth as measured by GDP, which might also affect state economic expansion. Lastly, by using the percent change in GDP per capita, I also attempted to control for any lag-time that would occur between implementation of RPS policies and their effects on economic growth. One last control variable that should have been included is the presence of other state policies aimed at increasing renewable energy generation.

Conclusion

Because of lack of consensus in the academic community about the relationship between RPS policies and economic growth, I developed my own estimation models in an attempt to prove that RPS policies might, over time, positively affect the economies of states that have adopted the policies because of their potential to spur financial investment, thereby creating jobs and growing the economy. None of my models showed my hypothesis to be correct, however, with most of them suggesting a negative relationship between RPS policies and economic growth. Part of my argument was also that electricity rates have a significant and negative effect on economic growth; this was proven to be true according to model 5. In model 6, however, the relationship between RPS policies and electricity rates was studied and showed that RPS policies do not significantly effect electricity rates. This impels the question: if RPS policies do not cause electricity rates to rise—which in itself causes a decline in economic growth—then by what other mechanisms would RPS policies hurt economic growth?

As stated previously, most RPS policies have not been in place for a long period of time.

Indeed, the fact that the majority of them were enacted within a couple of years of the 2007-2009 recession might explain why my argument and hypothesis were wrong. If investors did not have the capital or appetite for risk during the implementation of RPS policies, there would be, of course, no job creation or economic growth. Furthermore, because the latest macroeconomic data available was for the 2009-2010 period, the effects of recession were most likely still resonant in my sample.

Nevertheless, because of the recent upsurge in enactment of RPS policies across the country, the interaction between energy mandates and economic growth is still an important issue that needs to be studied. A lack of consensus in the academic community means that policymakers are unable to formulate strong and cost-effective policies. Thus, although I may have conducted my research at a time too early to effectively study the impacts of RPS policies on state economies because of the lack of sufficient data in time, this topic should still be researched in other areas, including how RPS policies affect private equity and venture capital investments in the renewable energy industry. If I could expand my study, it would be to examine how RPS policies, along with other state energy-related policies, impact the flow of investment capital into states. This might be a more direct measure of how RPS policies actually affect state economic growth, rather than examining the effect electricity rates on the economy.

Despite these shortcomings, my project was useful to the knowledge on the subject. Through my statistical analysis, I was able to show that mandatory RPS models negatively affect change in GDP per capita. I was also able to demonstrate that higher electricity prices do have a significant and negative effect on the economy. Therefore, while I believe that RPS policies should continue to be studied for possible positive effects on the economy, based on my research, I cannot support their implementation, especially if policymakers' goals include economic growth through RPS policies. Although I did not study other types of energy policies, I would recommend that other innovative policies are considered if policymakers place alternative energy development high on their priority list, and policymakers definitely should continue to investigate ways to encourage sustainable development and use of renewable energy, whether through tax credits or other incentives (Wiser, Namovicz, Gielecki, and Smith 2007, 14). These areas promise significant future economic, environmental, and security returns if the investment is made now. But as it pertains to my research, RPS statutes may not be the most cost-effective way to achieve these goals.

Appendix

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Presence of RPS	**-0.073†** (0.114)					0.038 (0.390)
Mandatory RPS		**-0.094**** (0.039)				
Voluntary RPS		0.038 (0.397)				
Duration of RPS			**-0.133***** (0.004)			
Stringency of RPS				-0.096 (0.556)		
Presence of national recession	**-0.184***** (0.000)	**-0.188***** (0.000)	**-0.173***** (0.000)	**-0.173***** (0.000)	**-0.0190***** (0.000)	**-0.322***** (0.000)
Percent of population with a HS education	-0.029 (0.522)	-0.038 (0.408)	-0.047 (0.301)	-0.047 (0.301)	-0.028 (0.541)	
Percent change GPD per capita						
Electricity rate					**-0.076*** (0.096)	
N (sample size)	500	500	474	64	500	500
R-squared	0.050	0.056	0.066	0.023	0.051	0.099

Table 1. A statistical analysis of my data, with economic models that were estimated using OLS. Coefficients from the regression model and their significance values are displayed, respectively. † = p<0.15, * = p<0.10, ** = p<0.05, *** = p<0.01

State	Year								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Arizona					1.25	1.425	1.575	1.70	2.0
California			14.00	15.00	16.00	17.00	18.00	19.00	20.00
Colorado						2.88	4.80	4.80	4.80
Connecticut					2.00	3.50	5.00	6.00	7.00
Delaware							1.00	1.989	2.986
Hawaii									10.00
Illinois								1.50	3.00
Maine							1.00	2.00	3.00
Maryland					1.00	1.00	2.00	2.00	3.00
Massachusetts			1.50	2.00	2.50	3.00	3.50	4.00	4.93
Montana							5.00	5.00	10.00
Nevada				5.70	5.70	8.55	8.55	11.40	11.40
New Hampshire								0.50	1.00
New Jersey				0.74	0.983	2.037	2.924	3.84	4.685
New Mexico					5.00	6.00	6.00	6.00	6.00
New York					0.425	0.425	0.593	2.144	2.120
Ohio								0.246	0.49
Pennsylvania						1.499	1.499	1.993	2.508
Rhode Island						1.00	1.50	2.00	2.50
Wisconsin					3.55	3.55	3.55	3.55	5.55

Table 2. The minimum percent of renewable energy generation required by electric utility companies in states with mandatory RPS policies.

Bibliography

Akin, Mustafa Seref. 2011. "Does Venture Capital Spur Patenting? Evidence from State-Level Cross-Sectional Data for the United States." *Technology & Investment* 2(4): 295-300.

Booth, Douglas E. 1995. "Economic Growth and the Limits of Environmental Regulation: A Social Economic Analysis." *Review of Social Economy* 53(4): 553-573.

Brown, Elizabeth, and Gail Mosey. 2008. "Analytic Framework for Evaluation of State Energy Efficiency and Renewable Energy Policies with Reference to Stakeholder Drivers." *National Renewable Energy Laboratory*.

Brown, Elizabeth and Sarah Busche. 2008. "State of the States 2008: Renewable Energy Development and the Role of Policy." *National Renewable Energy Laboratory*.

Buckman, Greg. 2011. "The effectiveness of Renewable Portfolio Standard banding and carve-outs in supporting high-cost types of renewable electricity." *Energy Policy* 39: 4105-4114.

Carley, Sanya. 2012. "Energy demand-side management: New perspectives for a new era." *Journal of Policy Analysis & Management* 31(1): 6-32.

Carley, Sanya. 2011. "The Era of State Energy Policy Innovation: A Review of Policy Instruments." *Review of Policy Research* 28(3): 265-294.

Chen, Chung-Chiang. 2011. "An analytical framework for energy policy evaluation." *An International Journal* 36(10): 2694-2702.

Commins, Nicola, Séan Lyons, and Marc Schiffbauer. 2011. "Climate Policy & Corporate Behavior." *Energy Journal* 32(4): 51-68.

Cory, Karlynn S. and Blair G. Swezey. 2007. "Renewable Portfolio Standards in the States: Balancing Goals and Rules." *Electricity Journal* 20(4): 21-32.

Doot, David T., Paul N. Belval, and Lynn M. Fountain. 2007. "State Mandates Most Effective So Far in Renewable Portfolio Standards." *Natural Gas & Electricity* 23(12): 1-7.

Doris, Elizabeth, Joyce McLaren, Victoria Healey, and Stephen Hockett. 2009. "State of the States 2009: Renewable Energy Development and the Role of Policy." *National Renewable Energy Laboratory*.

Doukas, H., K.D. Patlitzianas, A.G. Kagiannas, and J. Psarras. 2008. "Energy Policy Making: An Old Concept or a Modern Challenge?" *Energy Sources Part B: Economics, Planning & Policy* 3(4): 362-371.

Duane, Timothy P. 2010. "Greening the Grid: Implementing Climate Change Policy through Energy Efficiency, Renewable Portfolio Standards, and Strategic Transmission System Investments." *Vermont Law Review* 34(4): 711-780.

"Electricity Detailed Data Files." 2012. *U.S. Energy Information Administration* http://www.eia.gov/electricity/ (9 April 2012).

Endrud, Nathan E. 2008. "State Renewable Portfolio Standards: Their Continued Validity and Relevance in Light of the Dormant Commerce Clause, the Supremacy Clause, and Possible Federal Legislation." *Harvard Journal on Legislation* 45(1): 259-286.

Figge, Frank and Tobias Hahn. 2005. "The Cost of Sustainability Capital and the Creation of Sustainable Value by Companies." *Journal of Industrial Ecology* 9(4): 47-58.

Fischer, Carolyn. 2010. "Renewable Portfolio Standards: When Do They Lower Energy Prices?" *Energy Journal* 31(1): 101-119.

Glenna, Leland L. and Robert Roy Thomas. 2010. "From Renewable to Alternative: Waste Coal, the Pennsylvania Alternative Energy Portfolio Standard, and Public Legitimacy." *Society & Natural Resources* 23(9): 856-871.

Gold, Ivan, and Nidhi Thaker. 2010. "A Survey of State Renewable Portfolio Standards: Square Pegs for Round Climate Change Holes?" *William & Mary Environmental Law & Policy Review* 35(1): 183-268.

Gompers, Paul A., Josh Lerner, Margaret M. Blair, and Thomas Hellmann. 1998. "What Drives Venture Capital Fundraising?" *Brookings Papers on Economic Activity. Microeconomics* 1998: 149-204.

Grant, Melanie. 2011. "Where Are They Now? A Look at the Effectiveness of RPS Policies." *Brigham Young University Law Review* 28(3): 265-294.

Hargadon, Andrew B. and Martin Kenney. 2012. "Misguided Policy? Following Venture Capital into Clean Technology." *California Management Review* 54(2):118-139.

Hurlbut, David. 2008. "State Clean Energy Practices: Renewable Portfolio Standards." *National Renewable Energy Laboratory*.

Ienciu, Ionel A. 2009. "Environmental Performance Versus Economic Performance." *International Journal of Business Research* 9(5): 125-131.

Loomis, David G. and Adrienne Ohler. 2010. "Are Renewable Portfolio Standards a Policy Cure-All? A Case Study of Illionois's Experience." *William & Mary Environmental Law & Policy Review* 35(1): 135-182.

Lowry, William R. 2008. "Disentangling Energy Policy from Environmental Policy." *Social Science Quarterly* 89(5): 1195-1211.

Lyon, Thomas and Haitao Yin. "Why Do States Adopt Renewable Portfolio Standards? An Empirical Investigation." *Energy Journal* 31(3): 133-157.

Marcus, Aflred, J. Alberto Aragon-Correa, and Jonatan Pinkse. 2011. "Firms, Regulatory Uncertainty, and the Natural Environment." *California Management Review* 54(1): 5-16.

Michaels, Robert J. 2008. "National Renewable Portfolio Standard: Smart Policy or Misguided Gesture?" *Energy Law Review* 29(1): 79-119.

Minniti, Maria. 2008. "The Role of Government Policy on Entrepreneurial Activity: Productive, Unproductive, or Destructive?" *Entrepreneurship Theory and Practice* 32(5): 779-790.

Nasiri, Fuzhan and Georges Zaccour. 2010. "Renewable Portfolio Standard Policy: A Game-theoretic Analysis." *INFOR* 48(4): 251-260.

Newell, Peter, Nicky Jenner, and Lucy Baker. 2009. "Governing Clean Development: A Framework for Analysis." *Development Policy Review* 27(6): 717-739.

Nostrand, James M. Van and Anne Marie Hirschberger. "Climate Change and the Future of Energy: Implications of a Federal Renewable Portfolio Standard: Will It Supplement or Supplant Existing State Initiatives?" *The University of Toledo Law Review* 41: 853-875.

Polatidis, Heracles, Dias A. Haralambopoulos, Giussepe Munda, and Ron Vreeker. 2006. "Selecting an Appropriate Multi-Criteria Decision Analysis Technique for Renewable Energy Planning." *Energy Sources Part B: Economics, Planning & Policy* 1(2): 181-193.

"Quantitative RPS Data Project." 2012. *DSIRE: Database of State Incentives for Renewables & Efficiency* http://www.dsireusa.org/rpsdata/index.cfm (3 April 2012).

Randjelovic, Jelena, Anastasia R. O'Rourke, and Renato J. Orsato. 2003. "The Emergence of *Green* Venture Capital." *Business Strategy and the Environment* 12: 240-253.

Reisinger, William T. 2010. "Climate Change the Future of Energy: Federal and State Renewable Portfolio Standards: Conflict or Harmony?" *The University of Toledo Law Review* 41: 877-887.

Reed, W. Robert. 2009. "The Determinants of U.S. State Economic Growth: A Less Extreme Bound Analysis." *Economic Inquiry* 47(4): 685-700.

Rose, Adam, and Noah Dormady. 2011. "A Meta-Analysis of Climate Change Policy in the United States." *The Energy Journal* 23(2): 143-165.

Rossi, Jim. 2010. "The Future of Energy Policy: A National Renewable Portfolio Standard: The Limits of a National Renewable Portfolio Standard." *Connecticut Law Review* 42(5): 1425-1450.

Samila, Sampsa, and Olav Sorenson. 2011. "Venture Capital, Entrepreneurship, and Economic Growth." *Review of Economics & Statistics* 93(1): 338-349.

Sener, Adil Caner. 2011. "Redefining Renewable Portfolio Standards: The Value of Installed Renewable Capacity." *Electricity Journal* 24(1): 14-20.

Sovacool, Benjamin K. 2008. "A Matter of Stability and Equity: The Case for Federal Action on Renewable Portfolio Standards in the U.S." *Energy & Environment* 19(2): 241-261.

Sovacool, Benjamin K., Barkenbus, Jack N. 2007. "Necessary but Insufficient: State Renewable Portfolio Standards and Climate Change Policies." *Environment* 49(6): 20-30.

"The 2012 Statistical Abstract." 2012. *United States Census Bureau* http://www.census.gov/compendia/statab/ (3 April 2012).

Thomson, Vivian E. and Vicki Arroyo. 2011. "Upside-down cooperative federalism: climate change policymaking and the states." *Virginia Environmental Law Journal* 29(1): 1-61.

"U.S. Business Cycle Expansions and Contractions." 2012. *The National Bureau of Economic Research* http://www.nber.org/cycles.html (16 April 2012).

Valentine, Scott Victor. 2011. "Emerging symbiosis: Renewable energy and energy security." *Renewable & Sustainable Energy Reviews* 15(9): 4572-4578.

Victor, David G. and Kassia Tanosek. 2011. "The Crisis in Clean Energy: Stark Realities of the Renewables Craze." *Foreign Affairs* 90(4): 112-120.

Wiser, Ryan, Christopher Namovics, Mark Gielecki, and Robert Smith. 2007. "The Experience with Renewable Portfolio Standards in the United States." *Electricity Journal* 20(4): 8-20.

Wolff, Franziska, and Norma Schönherr. 2011. "The Impact Evaluation of Sustainable Consumption Policy Instruments." *Journal of Consumer Policy* 34(1): 43-66.