STATE AND FEDERAL POLICY EFFECTS ON UTILITY-LEVEL RENEWABLE ENERGY ADOPTION

by

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(Under the Direction of Jeffrey D. Mullen)

ABSTRACT

Renewable portfolio standards (RPS) are important policies designed by states to increase renewable share in electricity generation. A significant amount of research has been done on the analysis of RPS. However, since many states have updated RPS, we need to re-evaluate the effectiveness of RPS. In this paper, I modify Yin and Power's and Shrimali's models and adjust their dataset to estimate how RPS and The American Recovery and Reinvestment Act of 2009 (ARRA) affect electricity capacity share. I find that RPS do not promote renewable energy deployment but ARRA does based on our results.

INDEX WORDS: Renewable energy, Renewable portfolio standards, ARRA, Energy policy

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CHAPTER 1

INTRODUCTION

1.1 Background

According to the National Aeronautics and Space Administration (NASA), the global average land and ocean temperature has increased over 1^{o}C since 1900. All but one of the 18 hottest years in NASA's 136-year record have taken place after 2001. There is no evidence that the warming trend of the past decades has recently stopped or reversed. Global warming has many serious risks for physical systems, biological systems and human and managed systems as indicated in table 1.

The greenhouse effect refers to a natural process in which the temperature of the Earth's surface increases. As solar radiation reaches the Earth's atmosphere, part of the radiation is absorbed by the land and water. The Earth radiates the sun's warmth absorbed towards space. Greenhouse gases (GHG) in the atmosphere trap some of the heat, keeping the Earth warm. Human activities like burning fossil fuels generate more GHG, trapping more heat. As a result, the Earth becomes warmer (Australian Government Department of the Environment and Energy).

Many efforts to address GHG emissions have been made at the international level. The United Nations Framework Convention on Climate Change (UNFCCC) took effect in 1994, the objective of which is to keep atmospheric concentrations of greenhouse gases at a level that does not harm the climate system (Parliament of Australia).The Kyoto Protocol took effect on 16 February 2005, as an extension of the 1992 United Nations Framework Convention on Climate

Change (UNFCCC) with the objective of combating global warming (Parliament of Australia). However, the U.S., the largest GHG emission country, refused to ratify the treaty. Another big contributor to global warming, Canada has withdrawn from the Kyoto Protocol (United Nations Climate Change). This has led to the failure of the Kyoto Protocol.

The Paris Agreement was reached at the 21st Conference of the Parties (COP21) in Paris, on 12 December 2015. Its primary objective is to reinforce the global reaction with the long-term goal of keeping the global temperature increase well below 2 degrees Celsius above pre-industrial levels and limit the increase even further to 1.5 degrees Celsius. In addition, the agreement aims to improve the capability of countries to handle the effects of global warming and keep the economy sustainable with low GHG emissions (United Nations Climate Change).

At the U.S. Federal level, President Barack Obama announced Clean Power Plan on August 3, 2015. Clean Power Plan, developed under the Clean Air Act, is new rules, or standards created by the Environmental Protection Agency (EPA) aiming to reduce carbon emissions from power plants (Union of Concerned Scientists).

On February 17, 2009, President Barack Obama signed The American Recovery and Reinvestment Act of 2009 (ARRA), an economic stimulus package enacted by the 111th United States Congress. The Energy Department invested more than $31 billion in a wide range of clean energy projects nationally (Department of Energy).

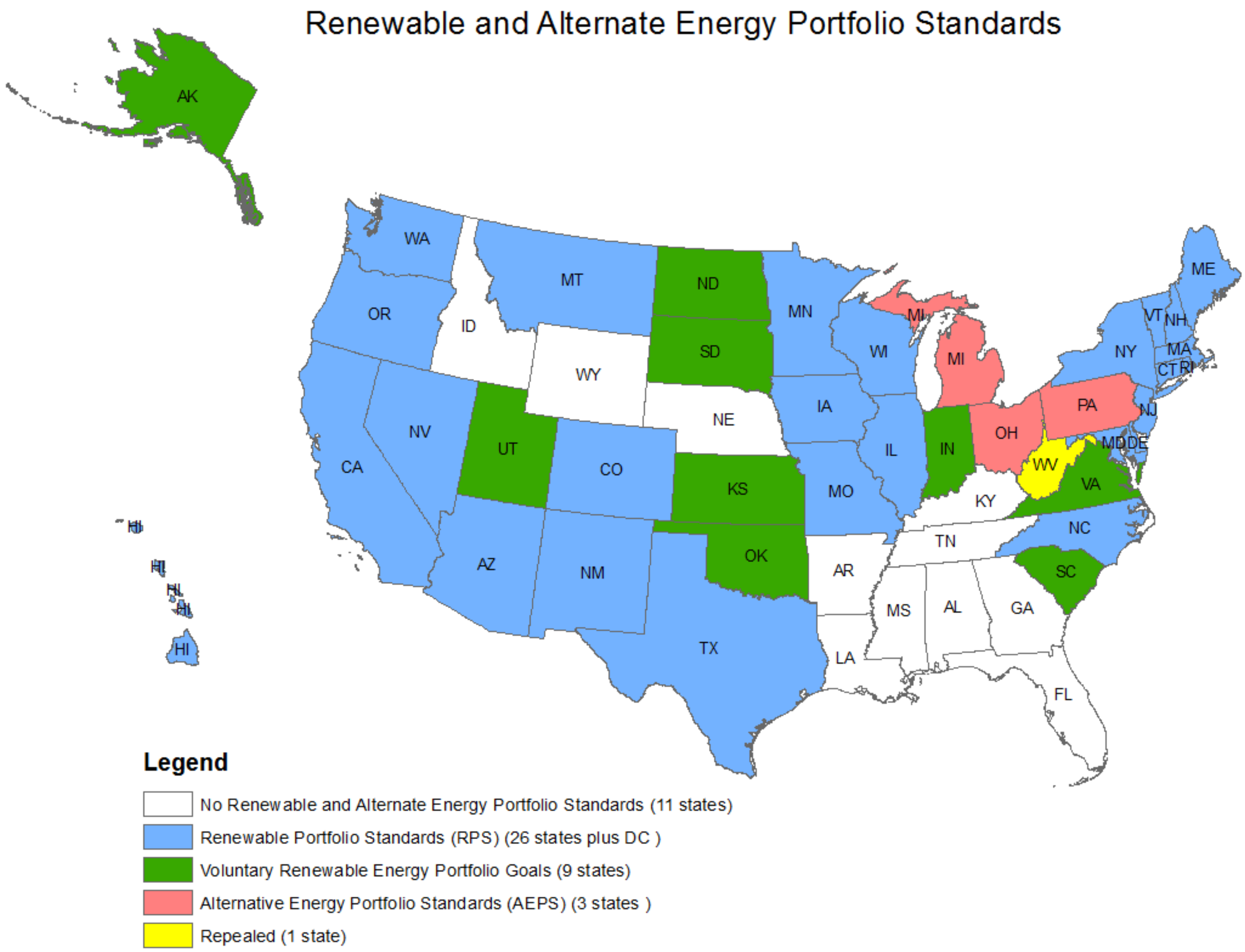
Under the Trump administration, the federal government has retreated from previous policy goals and agreements related to climate change. President Trump signed a Presidential Executive Order to repeal or stop many climate policies that have been in the process of developing for many years, including the Clean Power Plan (Union of Concerned Scientists). He has announced the withdrawal of the US from the Paris agreement on climate change to boost the economy and create more jobs.

Since the 1990s, however, states have been playing an active role in creating climate policy. Many states have adopted policies that promise to reduce their greenhouse gas releases. Twenty-six states plus the District of Columbia have adopted Renewable Portfolio Standards (RPS) and three states have adopted Alternative Energy Portfolio Standards (AEPS), mandating a certain percentage of a utility's power plant capacity or generation be derived from renewable or alternative energy sources by a given date. Some states also require that a certain percentage of the total output or percentage points of the standards be from a specific energy source, typically solar power. In contrast with RPS or AEPS states, nine states have voluntary renewable or alternate energy goals, which are not generally legally binding (Center for Climate and Energy Solutions (C2ES)).

Table 1.1 Representative Key Risks for Each Region

Region		Key Risks	
North America	Increased damage from wildfires	Heat-related human mortality	Increased damage from river and coastal urban floods
Europe	Increased damages from extreme heat events and wildfires	Increased water restrictions	Increased damages from river and coastal floods
Asia	Increased drought-related water and food shortage	Heat-related human mortality	Increased flood damages to infrastructure, livelihoods and settlements
Africa	Compounded stress on water resources	Reduced crop productivity and livelihood and food security	Vector- and water-borne diseases
Central and South America	Reduced water availability and increased flooding and landslides	Reduced food production and quality	Spread of vector-borne diseases
Australasia	Significant change in composition and structure of coral reef systems	Increased flood damage to infrastructure and settlements	Increased risks to coastal infrastructure and low-lying ecosystems
The Ocean	Distributional shift and reduced fisheries catch potential at low latitudes	Increased mass coral bleaching and mortality	Coastal inundation and habitat loss
Small islands	Loss of livelihoods, settlements, infrastructure, ecosystem services and economic stability	Risks for low-lying coastal areas	
Polar Regions (Arctic and Antarctic)	Risks for ecosystems	Risks for health and well-being	Unprecedented challenges, especially from rate of change

Source: Intergovernmental Panel on Climate Change (IPCC) AR5 SPM.08-01



Source: Center for Climate and Energy Solutions (C2ES)

Figure 1.1 Map of RPS States

1.2 Objectives

This study focuses on two primary objectives: 1) investigate the impact of Renewable Portfolio Standards (RPS) on the adoption of renewable energy electricity generation capacity; 2) compare the effect of the federal AARA on renewable energy electricity generation capacity to the effect of state-level RPS. Related to the first objective, I hypothesize that the adoption of RPS increases renewable energy electricity generation capacity within a state compared to a non-RPS state. Related to the second objective, I hypothesize that the ARRA has had a larger impact on renewable energy electricity generation capacity than the state-level RPS have had. These hypotheses are tested using data from 1991 through 2016.

1.3 Overview

The remainder of this thesis proceeds as follows. Chapter Two presents a literature review of the evaluation of U.S. energy policies. Chapter Three introduces the methodology and data. Chapter Four presents results and analysis, and Chapter Five summarizes findings and presents the conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Federal RPS

A number of Federal RPS proposals have been introduced by Congress since 1997, when the first national RPS was introduced (Nogee et al., 2007). However, none of them have been passed and become law (Wiser et al., 2007). Therefore, only a small number of studies have concentrated on national-level RPS. All of them analyze different RPS scenarios under a range of assumptions using computer modeling systems, particularly the National Energy Modeling System (NEMS), which is typically used for long-term renewables forecasts.

Most studies concentrate on the analysis of a 20 percent national RPS by 2020 under a wide range of assumptions. For several years the U.S. Energy Information Administration (EIA) and the Union of Concerned Scientists (UCS) have conducted analyses to predict the costs and benefits of different RPS proposals (Nogee et al. 2007). Clemmer et al. (1999) and Palmer and Burtraw (2004) also conducted the same type of analyses. Their results show Federal RPS would lower natural gas prices, diversify the electricity system, promote local economic development, improve the nation's energy security and reliability, and reduce global warming emissions. However, their results show different impact on the price of electricity of a 20 percent national RPS by 2020. EIA and UCS have found a 20 percent national RPS by 2020 would lower electricity prices (Nogee et al. 2007); Clemmer et al. (1999) found that it would have only a modest impact on electricity prices; Palmer and Burtraw (2004) found the RPS would raise electricity prices.

2.2 State RPS

Studies have increasingly concentrated on state-level RPS since the late 2000s as more and more states have adopted RPS. Similar to the research on federal RPS, some studies estimate the cost and benefit of state-level RPS in the future. Wiser et al. (2017) assess the electricity sector costs and environmental and health benefits, from 2015 to 2050, of current mandatory RPS policies and a potential expansion of those policies using Regional Energy Deployment System (ReEDS), providing the outlook of state RPS programs. They find the benefits of increased renewable generation used to meet RPS demand will exceed the costs including air quality benefits, greenhouse gas emission reduction benefits, and water use reduction benefits. Additionally, research on state-level RPS has various objectives, which can be classified into 3 categories in general based on the research objective.

The first is analyses of factors that influence RPS adoption. Carley and Miller (2012) examine how political and citizen ideology, electricity market factors, and socioeconomic factors influence state voluntary, weak and strong RPS policies adoption. Results show that ideological factors are more important than other drivers of policy adoption. Citizen ideology is the most significant driver of voluntary and weak policy adoption and government ideology the most significant driver of strong policy adoption. Lyon and Yin (2010) analyze the political and economic factors that contribute to RPS adoption. Their results suggest high renewable potential, a low percentage of natural gas generation, a large percentage of Democrats in a State and a low unemployment rate increase the likelihood of RPS adoption. Both articles use a logit model, which is the primary method to measure the probability of outcomes.

The second is analyses of how RPS affect the electricity prices. Fischer (2010) attempts to determine how RPS, which combine both a renewable production subsidy and a nonrenewable production tax, affect electricity prices. In particular, that study explores the role of different supply curve slopes in determining electricity market outcomes under RPS. Results suggest that lower RPS shares reduce electricity prices, while higher RPS shares increase electricity prices due to the greater cost of expanding renewable energy. Maguire and Munasib (2014) attempt to determine whether RPS in Texas increases electricity prices using the Synthetic Control Method (SCM). They find RPS is inconsequential with regard to the increase in electricity prices in Texas.

The third is the impact of RPS on the renewable share, generation or capacity on which many studies concentrate. Carley (2009) uses a fixed effects model and a fixed effects vector decomposition model (FEVD) to estimate the effect of state RPS on renewable share and generation. Results show that state RPS is insignificant with regard to renewable share but has a positive effect on the increase of renewable generation. Delmas et al. (2011) explore the relationship between RPS and renewable capacity using a binary logit model in the first state regression and a tobit model in the second state regression. They find that RPS has a negative effect on renewable capacity. Yin and Powers (2010) investigate the effectiveness of state-level RPS on renewable electricity development. First, they construct a measure for the strength of an RPS, then, perform a rigorous panel data analysis based on this new measure. The results suggest that RPS policies have had a significant and positive effect on in-state renewable energy development. Allowing free trade of renewable energy credits can significantly weaken the effectiveness of an RPS, which is partly dependent on a state's existing "balance of trade" in electricity. Shrimali et al. (2015) extend Yin and Powers (2010) study by including design features like maximum effective retail rate increase (MERRI) in the model. Results show RPS stringency has a positive effect on renewable energy sources for electricity (RES-E) development. The adoption of RPS in neighboring states increases in-state renewable resource capacity. However, if trade between different states is allowed, and the trading zone becomes larger, in-state RES-E development will decrease in most states and be concentrated in a few states. This effect increases with the removal of trading restrictions.

2.3 Summary and Contributions to the Literature

With regard to the impact of RPS on electricity prices, researchers have not achieved agreement on the significance of RPS on electricity prices nor on the direction in which electricity prices travel. Similarly, studies have not reached agreement on how RPS affects renewable share or generation.

This thesis seeks to contribute to the existing literature on RPS policy following Yin and Powers (2010) model to estimate renewable share by including renewable cost, renewable potential, tax incentives and The American Recovery and Reinvestment Act of 2009 (ARRA).

CHAPTER 3

METHODOLOGY

The primary objective of this paper is to estimate the effectiveness of RPS policies on renewable energy electricity generation capacity. To do so, I use the following panel data model:

$$Y_{it} = \beta_0 + \beta_x X_{it} + \beta_p P_{it} + \beta_z Z_{it} + \beta_w W_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \tag{1}$$

where for state i at year$t$, Y_{it} is the percentage of total electricity generating capacity from non-hydro renewable sources; α_i is a state fixed effect; γ_t is a year fixed effect; β_0 is constant; X_{it} is a measure of RPS policy; P_{it} is a vector of social and economic variables; Z_{it} is a vector of RPS policy design features and other state policy incentives for renewable energy development; W_{it} represents federal policy incentive, ARRA. The dependent variable, renewable energy capacity share, is calculated from data in table EIA-860 published by the Energy Information Agency.

State and year fixed effects are included to account for state and year heterogeneity, which will lead to inconsistent estimates, if not controlled for. I use clustered robust standard errors on the error term to account for heteroskedasticity. Data for both models range from 1991 to 2016.

3.1 Measure of RPS

Because many RPS are designed so that the amount of renewable energy electricity generation capacity grows over time, I use a continuous variable *incremental share indicator*, denoted as *ISI*, rather than a dummy variable. The ISI, first proposed by Yin and Powers (2010), attempts to capture the required increase in renewable generation by RPS in terms of the percentage of all generation. *ISI* is calculated as follows:

$$ISI_{it} = \frac{NOMINAL_{it} \times COVERAGE_{it} \times SALES_{it} - EXISTING_{iT}}{SALES_{it}} \quad (2)$$

where for state i at year t with an enacted RPS in year T, $NOMINAL_{it}$ is the nominal RPS requirement—i.e., percent of electricity generation capacity mandated to be from renewable energy; $COVERAGE_{it}$ is the RPS coverage—i.e., percent of electricity generation that must meet RPS requirements[1]; $SALES_{it}$ is annual total retail electricity sales (Megawatthours); $EXISTING_{iT}$ is the existing renewable generation in the year of RPS enactment. Compared to a binary RPS variable, this variable takes account of the heterogeneity and stringency of RPS policies in different states, as well as the phasing in of a RPS policy within a state. Renewable generation data are calculated from EIA-923. Coverage is calculated from EIA-861. The nominal percentage requirement[2] is from the Database of State Incentives for Renewables & Efficiency (DSIRE). Electricity sales come from EIA-861. For Texas and Iowa, the law for nominal RPS requirement is coded in absolute capacity terms, rather than as a percentage of generation. I convert them as follows:

[1] Coverage load data of most states are extended from Shrimal's data. For some states, I use 2016 data to calculate the coverage load. The year selected does not matter since the change of coverage load is minimal between years.
[2] For Michigan, RPS policy requirements are existing renewable energy baseline plus 20%, 33%, and 50% of the gap between baseline and 10% in 2012, 2013, and 2014 respectively. I cannot find the data of the existing renewable energy baseline. Therefore, I assume the baseline is 0, and thus the nominal percentage requirements are 2, 3.3, and 5, respectively.

$$Nominal = \frac{365\ days \times 24 \frac{hours}{day} \times capacity(MW) \times\ Capacity\ factor^{3}}{retail\ sales\ (MWh)} \quad (3)$$

This is the same conversion method used by Yin and Power.

3.2 Social and Economic Variables

3.2.1 State Income

Higher income states are more likely to increase their renewable capacity since they are more capable of affording the higher electricity price, which may be caused by renewable energy development. I use median household income by state obtained from the US census.

3.2.2 Electricity Price Lagged

Electricity price may have a mixed effect on renewable generation. On one hand, high electricity prices may reflect relatively high profits, enabling investment in renewable capacity. On the other hand, high electricity prices caused by high electricity generation cost could deter the development of relatively expensive renewable generating capacity. I use annual retail electricity price by state from EIA-861.

3.2.3 Import Ratio

The import ratio variable for a given year reflects the proportion of electricity sold within a state during the previous year that was generated outside that state. A state with a high import ratio could be more inclined to develop renewable energy to alleviate energy dependence.

$$Import\ Ratio_{it} = \frac{SALES_{i,t-1} - GENERATION_{i,t-1}}{SALES_{i,t-1}} \quad (4)$$

3.2.4 League of Conservation Voters (LCV) Scores

LCV scores serve as a proxy for the importance of environmental issues to a state's elected officials. High LCV scores mean environmental issues are of greater importance which

[3] The capacity factor for Iowa is unavailable. I use 0.35, the same capacity factor as Texas, like Yin and Power (2010) did.

could lead to more renewable capacity. I collect LCV score data from the League of Conservation Voters.

3.2.5 Renewable Energy Cost

I include national-level average wind and solar cost[4] in both models. Because, these variables are state-invariant, as are the year fixed effects, they cannot be included in a model alongside year fixed effects. I believe, however, the inclusion of both in the model is important – the changing cost of wind and solar capacity over time is likely to have an impact on the development of renewable capacity, while the time fixed effects are able to account for other unobservable changes over time. To accomplish this, I create a new variable that takes account of the state-level differences in *potential* wind and solar electricity generation, weighted by the area of the state, as shown in equations 5 and 6.

$$Weighted\ Wind\ Cost_{i,t} = \frac{Wind\ Cost_t}{(Wind\ Potential_i / Total\ Area_i)} \tag{5}$$

where Wind $Cost_t$ is the national average cost per MW for wind[5] at time t as reported by Berkley Lab (2016); Wind $Potential_i$ is the sum of state i's onshore and offshore wind electricity generating capacity as reported by NREL (2012); Total $Area_i$ is the land and water area of state i measured in square miles.

$$Weighted\ Solar\ Cost_{i,t} = \frac{Solar\ Cost_t}{(Solar\ Potential_i / Land\ Area_i)} \tag{6}$$

where Solar $Cost_t$ is the national average cost per MW for solar electricity at time t as reported by Bloomberg News (2016); Solar $Potential_i$ is state i's solar electricity generating capacity as reported by NREL (2012); Land $Area_i$ is the land area of state i measured in square miles. I

[4] Solar cost is unavailable for 2016. I estimated the value using the solar cost value in 2015 and the current value assuming it decreased linearly from 2015.
[5] The value of wind cost is blank in 1991, so I use the average of 1990 and 1992.

expect renewable capacity to be negatively correlated with both the wind and solar weighted cost measures.

3.3 RPS Policy Design Features

Except for RPS market size, RPS policy design features are binary variables. Data for the policy design features defined below come directly from DSIRE.

3.3.1 Renewable Energy Certificates (RECs) Trade

Renewable Energy Certificates (RECs) represent the commodity formed by unbundling the environmental attributes of a unit of renewable energy from the underlying electricity. Generally, one renewable energy certificate equals the environmental attributes (e.g. emissions, waste discharges) of one MWh of electricity from renewable energy. Some states allow utilities to meet their RPS requirement by purchasing RECs generated outside of the state, which could weaken the effectiveness of RPS as a tool for increasing the state's renewable electricity generating capacity.

3.3.2 Penalty or Alternative Compliance Payment (ACP)[6]

A penalty or ACP is a financial punishment enforced if a utility fails to meet the RPS requirement. The impact of a penalty or ACP on renewable investment is uncertain. On one hand, a penalty may force utilities to obey the law to avoid such a penalty. On the other hand, a specific penalty gives utilities the clear ability either to choose to obey the RPS law or pay the specified penalty. The absence of a specific penalty could actually incentivize compliance as it creates uncertainty regarding the magnitude of the sanction a utility may face for non-compliance.

3.3.3 RPS Market Size (RPSMS)

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[6] If the ACP increases in subsequent years, I selected the largest penalty.

RPS market size (RPSMS) is intended to capture the effect of the regional REC trading market size in neighboring states (Shrimali et al., 2015). RPSMS is constructed as:

$$RPSMS_{it} = \frac{\sum_{a}^{A}(NOMINAL_{at} \times COVERAGE_{at} \times SALES_{at} - EXISTING_{aT}) \times TRADE_{at}}{SALES_{it}} \quad (7)$$

where A represents the number of neighboring states a to state i; $TRADE_{at}$ represents a binary variable equal to 1 if out-of-state trading is allowed and 0 otherwise; and $SALES_{it}$ represents total electricity sales. As RPSMS increases I expect the renewable capacity share to fall.

3.3.4 Neighbors with RPS

Neighbors with RPS is the percentage of neighboring states that have an RPS policy in place. I expect a positive effect on renewable capacity share.

3.3.5 The Maximum Effective Retail Rate Increase (MERRI)

MERRI captures the highest allowed percent increase in the average electricity retail rate after considering cost caps of various designs (Wiser and Barbose, 2008). Like electricity price, I hypothesize MERRI has a mixed effect on renewable generation.

3.3.6 Contracting Mechanism

Contracting Mechanism is a binary variable that indicates if a state has provisions to help with secure financing (Wiser and Barbose, 2008). I hypothesize states with contracting mechanism have a higher renewable capacity share.

3.3.7 Delivery to Regions Index (DTX)

The DTX captures the extent of flexibility to share the transmission intertie with out-of-state generators. The DTX is 0 if a state does not share interties, 0.5 if it shares interties with limitations, and 1 if it shares interties. I hypothesize states with higher values of DTX have higher renewable capacity share.

3.3.8 Delivery from Regions Index (DFX)

The DFX captures the degree of flexibility to purchase renewable energy from out-of-state generators. The DFX is 0, if a state cannot buy RECs outside, 0.5 if a state can buy RECs from a limited number of generators outside the state, and 1 if it can buy RECs anywhere outside. I expect DFX to have a negative effect on renewable energy deployment.

3.4 Other State Policy Incentives

Some states employ additional policy incentives to encourage the development of renewable electricity capacity. The variables defined below are all binary variables equal to 1 if the policy is in place and otherwise 0. The data are obtained from DSIRE.

3.4.1 Public Benefit Fund (PBF)

Public benefit funds (PBF) are state-level programs to support cost-effective energy efficiency or renewable energy programs. The funds are raised from a small charge on customer utility bills or through specified contributions from utilities (C2ES). I expect PBF to have a positive impact on renewable capacity share.

3.4.2 Net Metering (NM)

Net Metering (NM) is a billing mechanism in which renewable energy generators, typically rooftop solar panels, are connected to a public-utility power grid and surplus power is transmitted onto the grid. If net-metered, the surplus power is credited to offset the power consumed by the generator. By requiring utilities to credit surplus electricity generation by individual renewable generators, more individuals should be willing to invest in solar panels, thereby increasing the renewable capacity share. Data from EIA to construct the dependent variable, however, include only utility-scale renewable generating capacity. The ability of a utility to count surplus renewable electricity generated by homes and businesses it services toward the utility’s RPS requirement may actually reduce investment in utility-scale renewable capacity. This could cause the coefficient on net metering be negative because the dependent variable does not account for this potential substitution effect. In other words, net metering could lower the share of utility-scale capacity that comes from utility-scale renewable installations while simultaneously increasing the share of total capacity that comes from all renewable installations in a state.

3.4.3 Mandatory Green Power Option (MGPO)

Mandatory Green Power Option (MGPO) requires regulated electric utilities to offer customers the option of purchasing electricity generated by renewable resources, often at a higher price. Offering a MGPO should increase the renewable capacity share.

3.4.4 Interconnection Standards

Interconnection standards establish a standard contract between customers who want to generate electricity for sale and utilities, which lowers the transaction cost and thus should facilitate the installation of renewable energy. However, as with net metering, these non-utility scale installations are not counted in the dependent variable, so they may have a negligible or negative effect on the share of utility-scale renewable capacity.

3.4.5 Tax Incentives

Tax Incentives are state-level tax breaks (tax exemption, tax credit and tax deduction) designed to encourage the deployment of renewable energy. Some states also have an allocated budget to pay for the tax incentives. I hypothesize states with tax incentives have a high renewable capacity share.

3.5 Federal Policy Incentive

In addition to state policy, we include an important federal policy enacted on February 17, 2009. The American Recovery and Reinvestment Act of 2009 (ARRA) is an economic stimulus package that provided funding for a variety of projects, including renewable energy deployment. This is a binary variable, which is 0 before 2010, and otherwise 1. As with the wind and solar cost variables, this variable is state-invariant. To be able to accommodate the ARRA and year fixed effects, I interact the ARRA dummy with the state's total renewable potential (solar potential plus wind potential). I expect a positive effect of ARRA on renewable capacity share.

Table 3.2 provides summary statistics for each variable used in the regression models. I will update and adjust the data and then compare the results with those of Yin and Power's and Shrimali's models. The form of their models is identical to equation (1) but the independent variables are different. Table 3.3 demonstrates the independent variables in both models.

3.6 Comparing Models

I do not use R-square to compare different models since the R-square value will not decrease if more variables are added. Instead, I use Akaike information criterion (AIC) and Bayesian information criterion (BIC) to the comparison. The lower the value, the better the model.

$$R^2 = 1 - \frac{RSS}{TSS} \tag{8}$$

where *RSS* is the residual sum of squares and *TSS* is the total sum of squares.

$$AIC = -2\ln(maximum\ likelihood) + 2k \tag{9}$$

$$BIC = -2\ln(maximum\ likelihood) + k\ln(n) \tag{10}$$

where *k* is the number of the estimated parameters and *n* is the number of the observations.

Table 3.1 Explanatory Variables for the Model

	Renewable Capacity Share
Measure of RPS	ISI
Social and Economic Variables	State Income
	Electricity Price Lagged
	Import Ratio
	LCV Scores
	Weighted Wind Cost
	Weighted Solar Cost
RPS policy Design Features	RECs Trade
	Penalty or ACP
	RPSMS
	Neighbors with RPS
	MERRI
	Contracting Mechanism
	DTX
	DFX
Other State Policy Incentives	Public Benefit Fund (PBF)
	Net Metering (NM)
	Mandatory Green Power (MGPO)
	Interconnection Standards
	Tax Incentives
Federal Policy Incentive	ARRA

Table 3.2 Summary Statistics

	Obs	Mean	Std Dev	Min	Max	Unit
Renewable Capacity Share	1,350	5.72	6.43	0	37.7	% (0-100)
Incremental Share Indicator (ISI)	1,300	1.02	3.08	0	25.47	% (0-100)
RECs Trade	1,350	0.16	0.37	0	1	Binary
Penalty or ACP	1,350	0.11	0.32	0	1	Binary
Penalty or ACP (continuous)	1,350	4.36	15.56	0	110	$/MWh
RPS Market Size	1,350	7.32	26.41	0	307.46	% (0-∞)
Neighbors with RPS	1,350	25.44	31.94	0	100	% (0-100)
MERRI	1,350	0.06	0.23	0	1	% (0-1)
Contracting Mechanism	1,350	0.08	0.26	0	1	Binary
DTX	1,350	0.03	0.14	0	1	0-0.5-1
DFX	1,350	0.05	0.19	0	1	0-0.5-1
State Income	1,350	55.4	8.86	33.32	81.02	1000$
Import Ratio	1,300	-24.06	57.66	-303.55	82.75	% (-∞-100)
Electricity Price lagged	1,300	8.19	3.26	3.37	34.04	Cents/kWh
Total Area	1350	75.88	96.13	1.55	663.27	$1000Mile^2$
Land Area	1350	70.75	85.15	1.05	571.95	$1000Mile^2$
Wind Cost	1350	1.95	0.44	1.34	3.08	$/W
Solar Cost	1350	4.78	2.62	0.25	8	$/W
Wind Potential	1350	1	1.25	0	6.65	PWh
Solar Potential	1350	8	10.5	0.02	62.2	PWh
Weighted Wind Cost	1,350	21.52	92.79	0.01	845.75	$\frac{\$/W}{GWh/Mile^2}$
Weighted Solar Cost	1,350	0.16	0.36	0	3.21	$\frac{\$/W}{GWh/Mile^2}$
LCV Score	1,350	46.81	27.76	0	100	0-100 index
Mandatory Green Power Option (MGPO)	1,350	0.08	0.27	0	1	Binary
Public Benefit Fund (PBF)	1,350	0.23	0.42	0	1	Binary

Net Metering (NM)	1,350	0.5	0.5	0	1	Binary
Interconnection Standards	1,350	0.38	0.48	0	1	Binary
Tax Incentives	1,350	0.65	0.48	0	1	Binary
Tax Budget	1,350	0.06	0.24	0	1	Binary
ARRA x Renewable Potential	1,350	2.33	7.03	0	68.8	PWh

Table 3.3 Independent Variables of Yin and Power's and Shrimali's Models

	Yin and Power	Shrimali
Same Variables	ISI	ISI
	RPSMS	RPSMS
	LCV	LCV
	Import Ratio	Import Ratio
	Electricity Price lagged	Electricity Price lagged
	State Income	State Income
	MGPO	MGPO
	PBF	PBF
	NM	NM
	REC Trade	REC Trade
	Penalty	Penalty
Different Variables	Interconnection Standards	Contracting Mechanism
	Import Ratio x ISI	MERRI
	REC Trade x ISI	DTX
	Penalty x ISI	DFX
		Neighbors with RPS

CHAPTER 4

RESULTS

4.1 Introduction

Chapter 4 displays the results of different models. Section 4.2 displays the results of Yin and Power's model. Section 4.3 displays the results of Shrimali's model. Section 4.4 summarizes and explains the results.

4.2 Results of Yin and Power's Model

4.2.1 Data from 1993-2006

In this section, I re-estimate Yin and Powers' (2010) model using two datasets and report the parameters in Table 4.1. First, I use the same data as Yin and Powers (2010) (referred to as the "original" model). I then adjust the dataset with updated values (referred to as "adjusted" model). Next, I add some new variables to the adjusted model (referred to as "modified" model). Since publication in 2010, the sources of some of the data, DSIRE and EIA, have made adjustments to the values of several of the variables in the original dataset. Specifically, the calculation of the dependent variable, Renewable Capacity Share (RCS), uses EIA-860 for data on the two components of that variable – renewable capacity and total capacity. When I use the data currently reported by EIA, I obtain different RCS values than those used by Yin and Powers. The RCS values I calculate, however, are identical to those used by Shrimali et al. (2015).

Data for four explanatory variables – incremental share (ISI), renewable energy credits trade (REC Trade), penalty for non-compliance (Penalty), and state income levels (State Income)

– have also been adjusted. The adjustment to ISI was done because the RPS Nominal and Staring Date values provided by DSIRE have been updated; the dataset used to estimate the adjusted model is based on the most recent information. Since the ISI data are different, variables derived from ISI such as ISI x Penalty are also different. State Income data, obtained from the US Census, are also different due to updated values. The value of Import Ratio Data in the adjusted model dataset is the same as in the original model dataset, but I use percentage unit (1-100) instead of (0-1). Public benefits fund (PBF) data are the same as in the original model dataset with the exception of Hawaii because the policy starting dates I pick in DSIRE are different from the original ones, but the starting date of Hawaii is identical to that of Shrimali's data. Other variables data (NM, MGPO, Interconnection standards, Electricity Price Lagged, and LCV) are identical to those in the original model.

Table 4.1 Results of Yin and Power's model 1993-2006

	Yin ori	Yin adj	Yin mod
ISI	0.996*** (0.225)	***-8.383*** ***(6.109)***	***-9.596*** ***(6.128)***
RPSMS	1.122 (4.19)	*-0.001* *(0.014)*	0 (0.015)
LCV	-0.002 (0.004)	*0.007* *(0.005)*	*0.007* *(0.005)*
Import Ratio	2.151** (0.855)	0.019*** (0.007)	0.02*** (0.007)
Electricity Price lagged	-0.067 (0.11)	-0.231 (0.176)	-0.207 (0.163)
State Income	0.005 (0.023)	0.028 (0.018)	0.03 (0.018)
MGPO	2.53*** (0.485)	3.076*** (0.424)	3.027*** (0.428)
PBF	-0.198 (0.417)	-0.012 (0.448)	*0.018* *(0.45)*
NM	-0.729* (0.42)	**-0.413** **(0.291)**	**-0.396** **(0.291)**
Interconnection Standards	0.505 (0.511)	0.296 (0.344)	0.282 (0.351)
Penalty	-1.886 (1.2)	*0.012* *(1.044)*	*0.063* *(1.015)*
REC Trade	1.52 (1.023)	0.255 (1.005)	0.24 (0.994)
Taxbreak			-0.001 (0.283)
Weighted Solar Cost			0.748 (0.984)
Weighted Wind Cost			0 (0.002)
Import Ratio x ISI	-1.259*** (0.456)	-0.014*** (0.004)	-0.014*** (0.004)
REC Trade x ISI	-1.467*** (0.467)	***8.438*** ***(6.114)***	***9.648*** ***(6.134)***
Penalty x ISI	0.82 (0.72)	*-0.652* *(0.537)*	*-0.783* *(0.552)*
Taxbreak x Taxbudget			0.797 (1.157)
State Effects	yes	yes	yes
Year Effects	yes	yes	yes

State Clusters (robust)	yes	yes	yes
Time Frame	1993-2006	1993-2006	1993-2006
N	700	700	700
R-Square	0.407	0.326	0.331
AIC	1745	1870.141	1872.619
BIC	1872.431	1997.571	2018.254

Robust standard errors in parenthesis.
*significant at 10%. **significant at 5%. ***significant at 1%

The updated data affect the parameter estimates, causing changes in sign, magnitude and statistical significance. Importantly, the results of the original model show that the incremental percentage mandated by RPS increase by 1 percentage point will result in about a 1 percentage point increase in renewable capacity share, but the coefficient on the Incremental Share Indicator becomes negative and not significant in the adjusted and the modified model. Net metering (NM) also becomes insignificant but the results of the original model suggest that states which have net metering laws have a 0.73 less percentage point of renewable capacity share. The results of the original model suggest that the incremental percentage mandated by RPS increase by 1 percentage point will result in a 1.47 percentage point decrease in renewable capacity share in the states allowing REC trade than those prohibiting REC trade, but this variable becomes positive and insignificant in the adjusted and the modifies model. This is because our data for some key variables are different from the original. The results of the original model suggest that the electricity import ratio increases by 1 percentage point will result in about a 2 percentage point increase in renewable capacity share, but in the adjusted model and the modified model, the magnitude falls to about 0.02. It also shows that the electricity import ratio increases by 1 percentage point will result in a 1.3 percentage decrease in renewable capacity share if ISI increase by 1 percentage point, but this magnitude falls to 0.01 in the adjusted and the modified model. The results of the original model suggest that states which have mandatory green power option (MGPO) will results in a 2.5 percentage point increase in renewable capacity share but in the adjusted and the modified model the magnitude rises to 3. According to our results, state RPS policy has not contributed to the deployment of renewable energy. REC Trade does not weaken the impact of RPS.

4.2.2 Data from 1993-2016

In this section, I extend the time range of the dataset in 4.2.1 from 2006 to 2016. The first column displays the results of the adjusted model, the second column displays the results of the modified model, and the third column displays the results of the modified model with the ARRA.

MGPO is significant in the modified models. The results suggest that states which have mandatory green power option (MGPO) will results in about a 3 percentage point increase in renewable capacity share. Import Ratio, State Income, Net Metering, and Penalty x ISI are significant in all models. The results suggest that the electricity import ratio increases by 1 percentage point will result in about a 0.04-0.05 percentage point increase in renewable capacity share. State income increases 1000 dollars will result in a 0.2-0.3 percentage point increase in renewable capacity share. States which have net metering laws have a 2 percentage point less of renewable capacity share than those without net metering laws. The incremental percentage mandated by RPS increase by 1 percentage point will result in a 0.5-0.7 percentage point decrease in renewable capacity share in the states having a financial punishment compare to those without a financial punishment. The results of the modified model with the ARRA show that once the ARRA started, the renewable potential increase by 1 PWh will result in a 0.17 percentage point increase in renewable capacity share.

Table 4.2 Results of Yin and Power's model 1993-2016

	yin adj	yin mod	yin arra
ISI	0.056 (0.491)	0.123 (0.557)	*-0.093* *(0.69)*
RPSMS	0.012 (0.011)	0.012 (0.011)	0.011 (0.009)
LCV	0 (0.02)	*-0.002* *(0.019)*	*-0.006* *(0.018)*
Import Ratio	0.043* (0.023)	0.047** (0.02)	0.042** (0.021)
Electricity Price lagged	-0.067 (0.171)	*0.004* *(0.161)*	*0.084* *(0.142)*
State Income	0.265*** (0.069)	0.277*** (0.066)	0.245*** (0.066)
MGPO	3.244 (1.954)	**3.101*** **(1.846)**	**3.33*** **(1.768)**
PBF	0.763 (0.945)	0.919 (0.948)	0.846 (0.919)
NM	-2.237** (1.057)	-2.099* (1.049)	-2.353** (1.012)
Interconnection Standards	0.32 (1.011)	0.232 (1)	0.16 (0.984)
Penalty	-0.575 (1.493)	-0.306 (1.547)	-0.28 (1.241)
REC Trade	1.48 (1.533)	1.28 (1.551)	1.585 (1.367)
Taxbreak		0.67 (1.09)	0.729 (1.045)
Weighted Solar Cost		2.449 (1.526)	1.12 (1.684)
Weighted Wind Cost		-0.001 (0.002)	0.001 (0.002)
arraxrenewablepotential			0.17** (0.067)
Import Ratio x ISI	0 (0.002)	*0* *(0.002)*	0.001 (0.002)
REC Trade x ISI	-0.115 (0.452)	-0.188 (0.519)	-0.023 (0.661)
Penalty x ISI	-0.72*** (0.141)	-0.648*** (0.161)	-0.505*** (0.159)

Taxbreak x Taxbudget		0.052 (1.701)	-0.186 (1.651)
State Effects	yes	yes	yes
Year Effects	yes	yes	yes
State Clusters (robust)	yes	yes	yes
Time Frame	1993-2016	1993-2016	1993-2016
N	1200	1200	1200
R-Square	0.563	0.57	0.601
AIC	6134.733	6123.133	6035.662
BIC	6328.156	6336.916	6254.535

Robust standard errors in parenthesis.
*significant at10%. **significant at5%. ***significant at1%.

4.3 Results of Shrimali's Model

4.3.1 Data from 1991-2010

In this section, I re-estimate Shrimali's (2015) model using two datasets and report the parameters in Table 4.3. First, I use the same data as Shrimali's (2015) (referred to as the "original" model). I then adjust the dataset with updated values (referred to as "adjusted" model). Next I add some new variables to the adjusted model (referred to as "modified" model).

Data for incremental share (ISI) has been adjusted for two reasons: first, the RPS Nominal and Staring Date values provided by DSIRE have been updated; second, the method by which I calculate ISI is different from Shrimali's (2015) but is the same as Yin and Power's (2010).[7] State Income data, obtained from the US Census, are adjusted only for inflation. The value of Import Ratio Data is different from that of Shrimali's (2015) but identical to Yin and Power's (2010). Neighbors with RPS is different because the RPS start dates I selected and the total number of neighbor states that I include of some states are different.[8] Binary variables (MGPO, NM, PBF) are adjusted due to updated information and the different starting dates I

[7] Shrimali's ISI data are close to the nominal share since the requirement share is a percentage but the existing share is a proportion in the process of their calculation of ISI. In addition, Shrimali's ISI data do not include IA and TX since the nominal percentage requirement is coded in absolute capacity terms, so we add them as Yin and Power did.
[8] First, I do not include DC as a neighbor of Maryland and Virginia. Second, I consider Michigan and Illinois, the border of which is on a lake, as neighbors.

selected. Penalty is a continuous variable in Shrimali's model, but I use Alternative Compliance Payment (ACP) values rather than Solar Alternative Compliance Payment (SACP) which is typically for solar energy. Other variables (LCV, renewable generation, RCS, total electricity sales, electricity price, MERRI, DTX, DFX, Contracting Mechanism, REC Trade) are identical to Shrimali's data.[9]

[9] Electricity sales, LCV, and electricity price data are slightly different than Shrimali's but such difference is negligible.

Table 4.3 Results of Shrimali's model 1991-2010[10]

	sml ori	sml adj	sml mod
ISI	0.287**	***-0.061***	***-0.083***
	(0.115)	***(0.072)***	***(0.07)***
RPSMS	-0.09***	***0***	***0.001***
	(0.029)	***(0.018)***	***(0.017)***
LCV	0.01	**0.013***	**0.015***
	(0.008)	**(0.008)**	**(0.008)**
Import Ratio	0.031***	0.032**	0.034**
	(0.011)	(0.015)	(0.014)
Electricity Price lagged	-0.181	**-0.26****	-0.17
	(0.137)	**(0.113)**	(0.123)
State Income	0.103**	0.086**	0.099**
	(0.046)	(0.039)	(0.039)
MGPO	4.264***	3.147**	2.97**
	(1.543)	(1.306)	(1.281)
PBF	0.118	0.716	0.729
	(0.454)	(0.538)	(0.541)
NM	-1.139**	**-0.783**	**-0.801**
	(0.47)	**(0.51)**	**(0.504)**
Contracting Mechanism	-1.705**	**-0.878**	**-0.911**
	(0.685)	**(0.81)**	**(0.795)**
Penalty	0.001	0.005	0
	(0.002)	(0.032)	(0.032)
MERRI	-1.905***	-1.681*	-1.577*
	(0.676)	(0.923)	(0.919)
DTX	0.465	*-0.731*	*-1.047*
	(1.204)	*(1.875)*	*(1.802)*
DFX	-5.859***	-4.058**	-4.099**
	(1.475)	(1.868)	(1.886)
REC Trade	2.507***	**0.781**	**0.982**
	(0.764)	**(1.224)**	**(1.183)**
Taxbreak			0.137
			(0.555)
Weighted Solar Cost			2.58***
			(0.896)
Weighted Wind Cost			-0.004***
			(0.001)

[10] Maine is dropped as an outlier because its natural gas capacity increased greatly in 2000, coinciding with its adoption of RPS (Shrimali et al. 2015).

Taxbreak x Taxbudget			-1.097* (0.606)
Neighbors with RPS	0.023** (0.01)	**0.015** **(0.01)**	**0.018** **(0.011)**
State Effects	yes	yes	yes
Year Effects	yes	yes	yes
State Clusters (robust)	yes	yes	yes
Time Frame	1991-2010	1991-2010	1991-2010
N	980	980	980
R-Square	0.481	0.451	0.472
AIC	3761.131	3816.094	3787.131
BIC	3932.195	3987.159	3977.746

Robust standard errors in parenthesis.
*significant at 10%. **significant at 5%. ***significant at 1%.

The results of the original model show that the incremental percentage mandated by RPS increases by 1 percentage point will result in about a 0.3 percentage point increase in renewable capacity share, but the coefficient on the Incremental Share Indicator becomes negative and not significant in the adjusted and the modified model. In the original model, the results show the RPS market size increases by 1 percentage point will result in a 0.1 percentage point decrease in renewable capacity share, but in the adjusted and the modified models, this variable becomes positive and insignificant. Net metering (NM) and Contracting Mechanism also become insignificant but the results of the original model suggest that states which have net metering laws and contracting mechanism have a 1.1 and 1.7 less percentage point of renewable capacity share, respectively. REC Trade and Neighbor with RPS are not significant, but the results of the original model suggest that states allowing REC trade will lead to a 2.5 more percentage point of renewable capacity share. The percentage of neighboring states having an RPS policy in place increases by 1 percentage point will cause a 0.02 percentage point increase in renewable capacity share. The results of the original model show that states which have mandatory green power option (MGPO) will results in about a 4 percentage point increase in renewable capacity share, but in the adjusted and the modified model, the magnitude fall to 3. LCV becomes significant. The results of the adjusted and modified models suggest the increase of LCV score by 1 point will result in a 0.013 and 0.015 percentage point increase in renewable capacity share. Electricity Price lagged becomes significant in adjusted model with the results showing the increase of electricity retail price last year by 1 cent/kWh will result in a 0.26 percentage point decrease in renewable capacity share. Import ratio, state income, MERRI and DFX are significant in all the models. The results suggest that the electricity import ratio increases by 1 percentage point will result in about a 0.03 percentage point increase in renewable capacity share, and that state income increases 1000 dollars will result in a 0.1 percentage point increase in renewable capacity share. The results of the original model suggests the highest possible percent increase in the average retail rate of electricity increases by 1 percentage point will result in a 0.019 percentage point decrease in renewable capacity share, but in the adjusted and modified model, this value is 0.017 and 0.016, respectively. The results of the original model suggests allowing any generators outside to sell RECs into the states results in a 5.9 percentage point decrease in renewable capacity share, but in the adjusted and the modified model the value falls to 4.1. The results in the modified model shows that the weighted wind cost and solar cost increase by 1 $\frac{\$/W}{GWh/Mile^2}$ will cause a 0.004 percentage point decrease and 2.58 percentage point increase in renewable capacity share, respectively. The states having tax breaks with tax budgets have a 1.1 percentage point less of renewable capacity share than the states having tax breaks without tax budgets.

4.3.2 Data from 1991-2016

In this section, I extend the time range of the dataset in 4.3.1 from 2010 to 2016 using the same model. Also, I adjusted REC Trade due to updated information. The first column displays the results of the adjusted model, the second column displays the results of the modified model, and the third column displays the results of the modified model with ARRA.

Import Ratio is significant in the modified model and the modified model with ARRA. The results show that the electricity import ratio increases by 1 percentage point will result in about a 0.04 percentage point increase in renewable capacity share. Electricity Price lagged, MGPO, Penalty, and Weighted Solar Cost are significant in the modified model with ARRA. The results suggest that the increase of electricity retail price last year by 1 cent/kWh will result in a 0.26 percentage point decrease in renewable capacity share. States which have mandatory green power option (MGPO) will results in about a 3 percentage point increase in renewable capacity share. The financial punishment increase 1 \$/MWh will lead to a 0.04 percentage point decrease in renewable capacity share. The weighted solar cost increase by 1 $\frac{\$/W}{GWh/Mile^2}$ will cause a 2-3 percentage point increase in renewable capacity share. State Income, NM, Neighbors with RPS, and DFX are significant in all models. The results show that state income increases 1000 dollars will result in a 0.2-0.3 percentage point increase in renewable capacity share. States which have net metering laws have a 2 percentage point decrease in renewable capacity share. The percentage of neighboring states having an RPS policy in place increases by 1 percentage point will cause a 0.03-0.05 percentage point increase in renewable capacity share. Allowing generators outside to sell RECs into the states without limitation results in a 6-8 percentage point decrease in renewable capacity share. The results of the modified model with the ARRA show that once the ARRA started, the renewable potential increase by 1 PWh will result in a 0.2 percentage point increase in renewable capacity share.

Table 4.4 Results of Shrimali's model 1991-2016[11]

	sml adj	sml mod	sml arra
ISI	-0.091	-0.106	-0.151
	(0.128)	(0.122)	(0.12)
RPSMS	0.015	0.017	0.022
	(0.018)	(0.018)	(0.016)
LCV	-0.001	-0.003	-0.008
	(0.018)	(0.017)	(0.016)
Import Ratio	0.036	**0.042****	**0.039****
	(0.024)	**(0.019)**	**(0.019)**
Electricity Price lagged	0.036	0.183	**0.256***
	(0.175)	(0.17)	**(0.143)**
State Income	0.251***	0.267***	0.226***
	(0.059)	(0.056)	(0.053)
MGPO	3.275	3.123	**3.362***
	(2.204)	(2.058)	**(1.922)**
PBF	1.04	1.125	0.909
	(0.895)	(0.87)	(0.851)
NM	-2.036**	-1.895**	-2.19***
	(0.834)	(0.782)	(0.736)
Penalty	-0.017	-0.019	**-0.043***
	(0.035)	(0.034)	**(0.024)**
REC Trade	0.884	0.721	0.966
	(1.389)	(1.359)	(1.24)
Taxbreak		0.153	0.045
		(1.046)	(0.99)
Weighted Solar Cost		3.37***	2.098*
		(1.121)	(1.149)
Weighted Wind Cost		0	0.002
		(0.002)	(0.002)
arraxrenewablepotential			0.199***
			(0.072)
Taxbreak x Taxbudget		-0.191	-0.381
		(1.611)	(1.591)
Neighbors with RPS	0.034*	0.04*	0.045**
	(0.02)	(0.02)	(0.02)
DFX	-7.758***	-7.962***	-6.162**
	(2.819)	(2.791)	(2.942)

[11] Maine is dropped as an outlier because its natural gas capacity increased greatly in 2000, coinciding with its adoption of RPS (Shrimali et al. 2015).

DTX	-1.806	-2.684	-5.112
	(2.893)	(3.294)	(3.351)
MERRI	-0.713	-0.674	-0.115
	(1.752)	(1.722)	(1.638)
Contracting Mechanism	-0.985	-0.78	-0.016
	(1.217)	(1.117)	(1.055)
State Effects	yes	yes	yes
Year Effects	yes	yes	yes
State Clusters (robust)	yes	yes	yes
Time Frame	1991-2016	1991-2016	1991-2016
N	1274	1274	1274
R-Square	0.567	0.58	0.622
AIC	6464.694	6433.746	6303.829
BIC	6675.841	6665.493	6540.725

Robust standard errors in parenthesis.
*significant at 10%. **significant at 5%. ***significant at 1%.

4.4 Summary and Explanation

Based on AIC and BIC value, the modified model with ARRA is the best one. The results show that RPS does not have a positive effect on renewable development. Import Ratio is positive and significant, which means states with higher dependence on the importation of electricity are more motivated to develop renewable energy. State Income is significant and has a positive effect on renewable capacity share, meaning that states with higher income have a higher share of renewable capacity. MGPO is significant and positive, which means MGPO is effective on renewable development. However, different from other binary variables, only 8 states have MGPO. More research needs to be done to identify the effectiveness of such an incentive. Contradicted to the hypothesis, Net Metering is negative and significant, suggesting states with net metering mechanism have a lower renewable capacity share than those without net metering. Weighted Solar Cost is positive and significant. Penalty x ISI is negative and significant, suggesting RPS policy with penalty is less effective than that without penalty. ARRA is positive and significant. Since ARRA took effect, renewable capacity share has increased.

Identical to Shrimali's results, DFX is negative and significant, and Neighbors with RPS is positive and significant, suggesting that states with higher flexibility in terms of importing electricity generated by renewable sources from other states have a lower share of renewable capacity; states with a higher share of neighbor states which have adopted RPS tend to have a higher percentage of renewable capacity.

CHAPTER 5

CONCLUSION

Previous studies have not reached agreement on how RPS, as a key policy in the U.S. to increase renewable share in electricity generation, affect the renewable energy deployment. As time has passed, many states have adjusted their RPS goals.

This paper further explores the effectiveness of RPS based on Yin and Power's (2010) and Shrimali's (2015) study. In this paper, I adjust Yin and Power's (2010) and Shrimali's (2015) data, add new variables to their models, and compare the results of different models. I then extent the data to 2016 and make comparisons between different models.

Based on the results, I find Yin and Power's and Shrimali's finding RPS increase renewable share is not robust to updated data or adjustments to the model. RPS does not have a positive effect on renewable development. It is because some RPS states do not obey the law or the renewable capacity share in some non-RPS states such as Wyoming has increased recently, washing out the effectiveness of RPS. Instead, since ARRA went into effect, renewable capacity share has increased. ARRA elasticity of renewable capacity share is 0.15 for Yin and Power's updated model and 0.18 for Shrimali's updated model, respectively. This means after ARRA being in place, renewable potential increases by 1 percentage point will result in a 0.15 percentage point and 0.18 percentage point increase in renewable capacity share. Net Metering is negative and significant. One possible explanation is NM captures substitution effects between non-utility and utility scale installation since the dependent variable is utility renewable capacity share not including consumer electricity generation (Shrimali, 2015). Against my hypothesis, Weighted Solar Cost is positive and significant. A possible explanation is the opportunity cost of land is higher in smaller states. For given potential, a large state has a higher weighted cost compared to a small state.

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