CLEAN POWER PLAN, DIRTY POLITICS:
AN EXAMINATION OF STATE REACTIONS TO CLIMATE REGULATION

by

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A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science in
Economics

Charlotte

2017

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ABSTRACT

MATTHEW MCINTYRE WITHROW. Clean Power Plan, Dirty Politics: An Examination of State Reactions to Climate Regulation. (Under the direction of DR. PETER SCHWARZ)

While carbon emissions are widely believed to be contributing to climate change, the U.S. has done little to limit the massive amounts of carbon being introduced into the atmosphere by electricity producing power plants. The Clean Power Plan (CPP) was to be the first major piece of legislation to reducing these emissions. While the plan carried estimated net benefits in the tens of billions of dollars, twenty-seven states filed a lawsuit against the Environmental Protection Agency (EPA), eventually leading to a Supreme Court Stay. This paper theoretically and empirically analyzes the incentives that influenced state-level politicians to either support the plan or sue in protest. Results suggest that political affiliations and fossil fuel electricity production are two major determinates, while the estimated benefits of climate change mitigation and the severity of state specific targets have no statistically significant effect.

DEDICATION

For my son, Elijah, who has inspired me to realize my potential and motivates me daily to be a better person.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my family for their continuous help and encouragement. I certainly could not have made it this far without the help of my mother, Marcy, and my father, Jerry. Their support through the best and, often more importantly, the worst of times, is something I am eternally grateful for.

Next, I would like to thank my advisor Dr. Peter Schwarz for his years of guidance, patience, and encouragement. In addition to sharing his enthusiasm and immense knowledge, he has always motivated me to do better, no matter what the task.

I would also like to thank the rest of the economics department for making me feel at home throughout my time at UNC-Charlotte. The enthusiasm and dedication of the faculty here has been truly astonishing, and I cannot imagine having a better grad school experience.

Finally, I would like to send my appreciation to Steffen Jenner and Solomon Hsiang for generously sharing their data for use in this project and to Joseph Cochran for helping gather data, and providing valuable feedback on new ideas.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Overview

On Tuesday, February 9th, 2016, the U.S. Supreme Court granted a stay on the Environmental Protection Agency's Clean Power Plan. This marked the likely beginning of the end for the nation's second major attempt to regulate carbon emissions. While still technically under review by the EPA under the supervision of Scott Pruitt, the Clean Power Plan (CPP) is anticipated to be either repealed, or replaced by something far more lenient.

The fate of the CPP is similar to that of the Waxman-Markey Act (WMA). Seeking to establish a cap-and-trade scheme for CO_2 emissions like that in the European Union, the WMA was passed through the U.S. House of Representatives in 2009, but never saw the floor in the U.S. Senate. At the time, there were harsh criticisms that the financial burden of climate change mitigation would fall disproportionally upon the less fortunate and the benefits would be insignificant so long as China and India, together approximately 36% of the world's annual CO_2 emissions (EDGAR, 2017), were not committed to participate. Apart from these critics, only 36% of the general public believed that there was solid evidence of climate change due to human activity (Pew Research Center, 2009).

Today, the majority of Americans both accept that human activity has an effect on global climate trends and believe that the government should play a role in regulating the emissions of greenhouse gas (GHG) (Howe 2015). In addition to changes in public sentiment domestically, the international community made it clear that they were willing to cooperate when, in 2015, nearly 200 countries met in Paris and signed a treaty pledging their support in the fight against climate change.

Meanwhile, the economics of climate change mitigation in the U.S. has taken a favorable turn. Coal fired power plants are one of the primary contributors to global GHG emissions and, in 2005, they were responsible for half of total electricity generation in the U.S. Over the last decade however, dramatic changes in the relative price of coal powered generation (compared to its substitutes) has had a substantial impact on the domestic energy mix and, consequently, emissions.

Natural gas burns cleaner and more efficiently than coal, but because of historically high prices it has typically been reserved for use in "peaker units." These units spend most of their time sitting idle, coming online only during times of high electricity demand. However, since hitting their peak in December 2005, natural gas prices in the U.S. have fallen over 75% (EIA), making it economical for new gas fired power plants to be used as base load generators. By 2015, the average annual capacity factor of natural gas combined cycle (NGCC) generators (56.3%) had surpassed coal steam generators (54.6%) (Hodge 2016).

The cost of generating electricity via renewable sources has also been decreasing over the past decade. The Levelized Cost of Electricity (LCOE) for both wind and utility scale solar power is now comparable to that of natural gas and often less than coal, even without subsidies (Lazard 2017) [1]. The decreasing costs of both natural gas and renewable generation have led to increased market shares for both sources. **Figure 1.1**

[1] A commonly used metric used to compare costs across technologies, the LCOE represents the discounted average total cost of generation per unit of electricity. However, this figure does not take intermittency into account making it somewhat misleading for renewable sources such as solar and wind.

shows how these increases correspond with an approximately 20% decrease in domestic GHG emissions over that time.

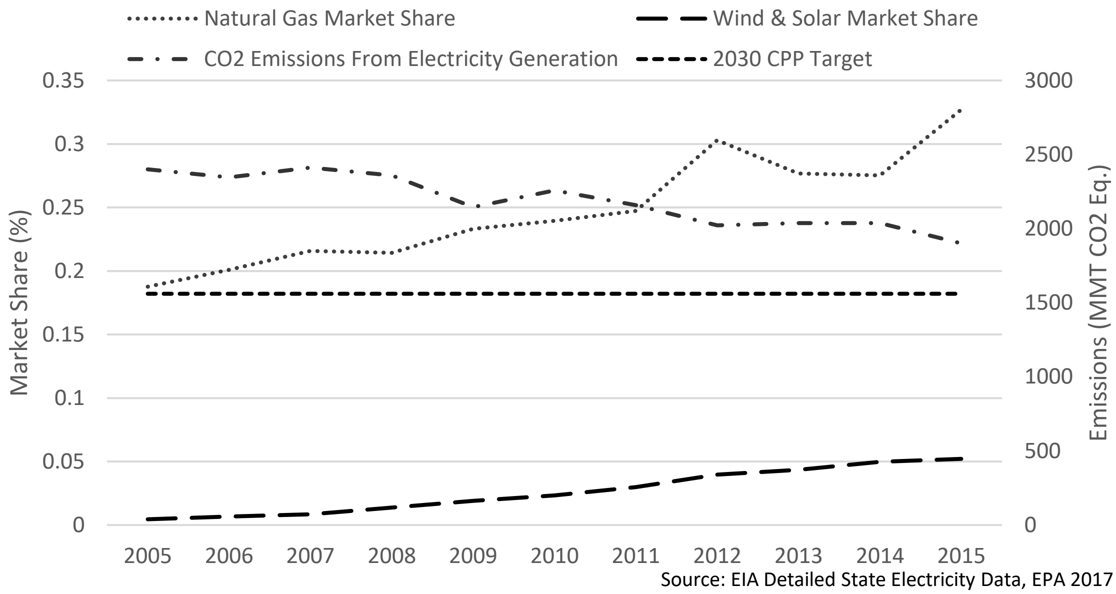

Figure 1.1: Market Share of Natural Gas, Wind, & Solar Generation with U.S. Greenhouse Gas Emissions (2005-2015)

While factors like decreasing economic cost, increased public support, and international cooperation would all suggest substantial tailwinds in favor of climate change legislation, it has once again stalled. The political arena has substantially evolved since Republican President Richard Nixon declared protection of the environment one of “those great issues facing our Nation which are above partisanship.” While environmentalism may have drawn bipartisan support in 1970, it certainly doesn’t today. By 1992, President George H. W. Bush was declaring that vice presidential nominee Al Gore was “so far out in the environmental extreme [that] we’ll be up to our necks in owls” (Sabin).

Since then, not only has environmental advocacy become a more polarized topic, but partisan conflict in general has reached an all-time high. The Partisan Conflict Index (PCI), managed by the Federal Reserve Bank of Philadelphia, tracks partisan bickering at the federal level (Azzimonti 2014). By the time the CPP was officially released, the PCI was 63% higher than it was at the time of the WMA. This increase has coincided with political debates like the debt-ceiling crisis, healthcare reform, illegal immigration, and environmental sustainability.

The likely downfall of the CPP is therefore frequently blamed on simple partisan politics. However, while political factors may have played a role in its downfall, climate change mitigation remains a public good, having the potential to create economic incentives encouraging free-rider behavior. The economic benefits of climate change mitigation are also not uniformly distributed. While some regions are expected to suffer large losses due to the changing climate, others are expected to be better off (see **Figure 3.1**). This study seeks to separate two factors in the CPP's demise, economics and politics, in hopes of shedding light on potential strategies for passing beneficial legislation in the future.

The next section provides a literature review of topics related to political ideology and environmental legislation. This is followed by a comprehensive overview of the CPP in chapter two, including descriptions of noteworthy events, a summary of the legal justifications both for and against, and a review of the calculations used to obtain state emission reduction targets. Chapter Three then describes the methods and data used in this study and Chapter Four reviews the results of the research. Concluding remarks and ideas for future research are included in Chapter Five.

1.2 Literature Review:

Over the years, there have been many attempts by economists to understand the incentives that drive the voting patterns of elected officials. Fiorina (1974) develops the "Dual Constituency Hypothesis," stating that legislative voting is influenced more heavily by the preferences of a politician's supporters within an electorate. This hypothesis has been supported in several studies. Levitt (1996) estimates senators applied, on average, between two to three times the decision weight to their supporting Party constituents. Similarly, Brunner et al. (2012) examine a set of 77 instances in California from 1991 to 2008 where both the general public and state legislators voted on the same measure. They found that Democratic legislators are nine percentage points more likely to vote with their most Democratic neighborhoods, while Republican legislators are three percentage points more likely to vote with their most Republican neighborhoods. Mian et al. (2009) show that this hypothesis holds even in times of crisis; they show that the votes of Republican house members on the American Rescue & Foreclosure Prevention Act of 2008 were better explained by the mortgage default rate in Republican neighborhoods than in Democratic ones.

The role of national parties is also expected to influence politicians in their voting behavior. Poole & Rosenthal (1984) analyze the variance of liberal-conservative positions between 1959 and 1980 and find that political polarization was increasing. Rohde (1991) hypothesizes that this increase in polarization, along with a reduction in sectoral divisions within parties, has led to the strengthening of Party leadership and influence. Cox and Matthews (1991) suggest that House Parties act as "legislative cartel," heavily stacking the legislative process in favor of the majority party's interests. Akerlof (2016) expands on the role of Party politics in terms of "We Thinking." He states that this phenomenon can lead individuals to adopt group goals as their own, creating an effective solution to collective action problems.

Another view is that the ideological qualities of individual politicians are more important than those of the party as a whole. Kau and Rubin (1993) examine this hypothesis as a principle-agent problem and looked to determine whether legislators were good agents for their constituents. They find that, while legislators do not always vote in the ideological interests of their constituency, it is more likely due to the influence of private interest groups rather than ideological conflicts. Although they cannot conclude whether ideological shirking[2] is taking place, they do find that legislators that vote against their constituency are punished at the polls. Both Poole and Rosenthal (1996) and Levitt (1996) find that the individual ideology of a politician is more important than Party identity.

In contrast, ideology as a political driver is something that Stigler (1971) argues strongly against, suggesting that practically all political behavior can be explained by economic self-interest. Known as the theory of economic regulation, he suggested politicians are only expected to respond to the pressures placed on them by their constituency and special interest groups. However, Stigler's theory, along with the median voter theorem, is largely believed to be a failed hypothesis (Poole and Rosenthal, 1996, Levitt, 1996, and Rohde, 1991).

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[2] Voting in deliberate conflict with the wishes of their constituent on the basis of personal ideology

In addition to the political science literature, research on the rate of implementation for renewable portfolio standards (RPS) in the U.S. shows some of the methods used to formulate decision models involving environmental regulations. RPS regulations place obligations on electricity suppliers to generate a specific fraction of their electricity from renewable sources. Huang et al. (2007) and Lyon and Yin (2010) use logistical hazard functions as their primary modeling tools. These studies have examined gross state product (GSP), population growth rates, unemployment rates, political affiliations of state legislators, education level, resource expenditures, interest group presence, and existing generation mix as determinants in the existence, timing, and stringency of state RPS legislation.

Huang et al. (2007) find that education levels, political affiliations, state income (GSP), and state growth rate are the main determinants of RPS legislation. Lyon and Yin (2010) had similar findings but also noted that the uptake of RPS was less likely in states with higher unemployment rates, despite claims by proponents that the presence of such legislation promotes job growth. They also find that local environmental quality is not a factor in the decision to adopt RPS policies, and that states with relatively worse initial air quality are less likely to adopt a RPS.

Jenner et al. (2013) use a similar approach, but dig deeper into effects of interest groups on policymakers by compiling annual contribution data from 1998 to 2010 and separating observations into bins based on the source of the contribution. The primary variables were contributions from renewable energy interest (REI) groups, comprised of alternative energy producing firms and environmental advocacy groups, and conventional energy interest (CEI) groups, made up of traditional fossil fuel generators and producers.

The study finds that REI and CEI groups make three times more contributions to Democrats and Republicans respectfully. Additionally, statistically significant links exist between the contributions from these sources and the likelihood of a state to adopt a RPS, with REI contributions increasing the likelihood, while CEI contributions decrease it.

The incentives behind other environmental issues have also been examined. Kalt and Zupan (1984) examine the economic and ideologic drivers of Senate voting behavior on issues related to the Surface Mining Control and Reclamation Act of 1977 (SMCRA). In their study, they use benefit incidence analysis (BIA) to assess the distributional impact of the legislation, hypothesizing that states with a higher share of negatively impacted groups would be less likely to support the SMCRA and vice versa. The study uses a weighted logit technique with the dependent variable being the percentage of votes a senator took that were considered anti-SMCRA. Results found that ideology clearly played a role in the legislative process, but it was unclear whether observed ideological influences are reflections of omitted constituency variables or pure senator ideology.

An examination of the CPP itself was done by Linn et al. (2016) in response to the stay that was applied by the U.S. Supreme Court. They find that historical data show the likelihood of the court to stay a regulation is a function of the likelihood of the existing case to prevail and the likelihood that challengers will face irreparable harm while the court deliberates. While the likelihood of the case against the CPP being successful was sufficient, they find that the second condition does not hold and therefore the stay was unjustified. Changes in economic and technological developments in the natural gas industry are tracked and used to model cost estimates of the CPP through 2030, with little to no direct costs from regulation before 2025. **Table 1.1** is taken directly from their paper and shows further proof that the effects of natural gas price on the electricity market far outweighs that of environmental regulation.

Table 1.1: Effects of Recent Natural Gas Price Changes and CPP on Operating Profits of Coal- and Gas-Fired Power Plants

	Percentage change in 2012 operating profits caused by 2008–2012 natural gas price decline	Percentage change in 2030 operating profits caused by CPP
Natural gas-fired plants	70	41
Coal-fired plants	–50	–19

Source: Linn et al. (2016)

Holland et al. (2015) analyze the distributional impacts of a Cap and Trade (CAT) system to three existing CO_2 mitigation policies, the low carbon fuel standard (LCFS), direct subsidies for renewable fuels, and renewable fuel standards (RFS). Changes in consumer and producer surplus are estimated at the county level for each policy measure. CAT is found to be the most cost-effective option for CO_2 mitigation and has the lowest distributional impact of the examined policy instruments. The expected county level outcomes are then used as predictors for voting behavior in the WMA. Initial results show negative correlation between benefits of CAT and yes votes for WMA. However, once benefits of "substitute" policies, primarily RFS, are taken into account, they find positive correlation between CAT benefits and WMA, but negative correlation between RFS benefits and WMA. This suggests that politicians were holding out in favor of policies that would bring their district greater benefits at the expense of the rest of the country.

Chapter 2: The Clean Power Plan

2.1: Introduction

First proposed by the Environmental Protection Agency in June 2014, the CPP was to be the Obama administration's flagship program designed to mitigate the effects of anthropogenic climate change. While previous attempts at climate change legislation had been attempted, the CPP aimed to take advantage of sections 111(b) and 111(d) of the Clean Air Act (CAA). Certain legal interpretations of the aforementioned sections would give the EPA the authority to regulate CO_2 emissions from both new and existing power plants without the need for House and Senate approval.

Section 111(b) of the CAA gives the EPA clear authority to regulate any form of emissions from new stationary power plants that "cause, or contribute significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." The significant portion of the CPP, however, relies on the more ambiguous language used in section 111(d). This section states that when regulating a new pollutant, the EPA is to "prescribe regulation under which each state shall submit a plan which establishes standards of performance for any existing source of any air pollutant…to which a standard of performance under this section would apply if such existing source were a new source." The CPP was merely the "prescription" given by the EPA to states, which were then obligated to formulate their own plan to regulate CO_2 emissions.

The period in which the CPP regulations would apply were to span from 2020-2030, in which time, CO_2 emissions from electricity generating power plants would be expected to decrease 32% relative to 2005 levels. Over the course of the decade, each state would face three decreasing interim targets with a final goal in place at the end of the period. The interim goals would act more as benchmarks rather than strict targets. States would be permitted to converge towards their final target at whatever rate best suited their circumstances, so long as their average annual emission levels between 2022 and 2029 were less than or equal to the mean of the three interim goals. **Figure 2.1** shows an example of how a state could hypothetically invest less in an abatement program early on, and more towards the end of the program, so long as on average it meets its goal.

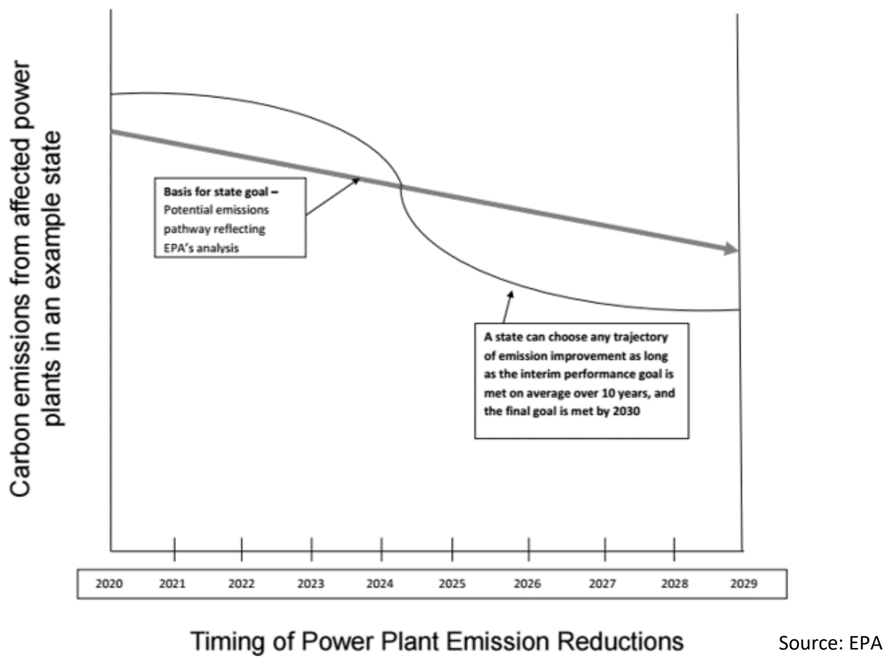

Figure 2.1: Hypothetical Abatement Trajectory Relative to EPA Targets

2.2: Building Blocks

Emission targets were established to represent the Best System of Emission Reduction (BSER), as determined by the EPA. The BSER was constructed using the following three building blocks:

- Building block 1: Improve the heat rate of existing coal-fired power plants
- Building block 2: Increase generation from low-emission natural gas combined cycle (NGCC) power plants
- Building block 3: Increase the capacity of zero-emission renewable sources

Acknowledging that power plants often operate on a regional level, state specific targets were assigned using a top down approach. The EPA analyzed the three North American Electric Reliability Corporation Interconnections, which are made up of the eastern and western regions as well as the region regulated by the Electricity Reliability Council of Texas (ERCOT).

There are two categories of fossil units for which the EPA assigned standards; Fossil Steam, made up of oil, gas and coal generation, and natural gas combined cycle (NGCC), which uses exhaust heat from one or more natural gas combustion turbines to power a secondary steam turbine. The first step in setting state targets was to aggregate all unit-level data up to the regional level, generating an average heat rate value for both categories of fossil fuel. Then, the three building blocks outlined in the BSER could be applied to the average heat rate values using a set of assumptions that the EPA determined to be reasonable.

Building block 1 aims to reduce emissions by improving the efficiency of existing fossil steam units (primarily coal). In the CPP, the EPA refers to a unit's heat rate, which is the number of British Thermal Units (Btus) required for a power plant to produce one kilowatt hour (kWh) of electricity. By decreasing heat rate, less fuel is required to generate a fixed quantity of electricity, and consequently, fewer emissions are generated.

The method used to determine the heat rate target for each region was called the "efficiency and consistency improvement under similar conditions" approach. The EPA started with hourly, unit-specific data spanning from 2002-2012 (the latest year for which the EPA had data at the time of the initial proposal) and separated each observation into a bin characterized by the average ambient temperature and capacity factor at the corresponding time and location from which the observation was derived. With 168 bins in total, a benchmark hourly gross heat rate (GHR) was set at the 10th percentile value in each bin. Next, a "consistency factor" of 30 was chosen, representing a hypothetical percent reduction in the heat rate gap between a given bins benchmark GHR and that of another observation in the bin.

Comparing the generation-weighted average GHR of the original aggregated data to that which has had the consistency factor applied is what yielded the target GHR reductions attached to building block one. The approach led to the conclusion that, through the application of best practices and equipment upgrades, fossil steam units were, on average, capable of decreasing GHR by 2.1% in the west, 4.3% in the east, and 2.3% in the ERCOT interconnection. Many other analytical processes, such as the "best historical performance" approach, suggest that greater GHR reductions could be reasonably accomplished. However, the overall methodology adopted by the EPA mandated that the most conservative option, identified by a reasonable analytical approach, be the one chosen. Other methods used estimated GHR reduction targets between 0.5 and 2.6 percentage points higher than those described above.

Building-block one applies primarily to coal-fired plants, and seeks to make them more efficient. Building block two, on the other hand, is not directly concerned with efficiency, but rather the generation mix. Here the CPP seeks to shift generation from coal to a resource that is already much cleaner and efficient; natural gas (NG). When burned, NG emits between 40% and 50% less CO_2 than coal per Btu of fuel. Not only is the fuel itself cleaner, but it is also converted to electricity more efficiently. In 2015 the average operating heat rate for a NGCC power plant (7,665 Btu/kWh) was 25% lower than that of an average coal fired plant (10,059 Btu/kWh). Combining these two factors, a kWh of electricity generated in a NGCC plant will, on average, produce 50-60% less CO_2 compared to a coal-fired plant.

The EPA again turned to historical data to determine a target capacity factor that they would consider reasonable. Analyzing data on all domestic NGCC units, the EPA found that 15% operate at a 75% net summer capacity factor on an annual basis and up to 30% operate at a 75% level on a seasonal basis. The EPA considers this to be sufficient evidence that the national average net summer capacity factor could reasonably increase to between 75-80%. Continuing with the methodology of choosing the more conservative target, building block two adds a 75% target summer capacity factor for NGCC power plants to the BSER list[3]. This figure is roughly equivalent to a 70% capacity factor calculated using nameplate capacity rather than summer capacity, which is typically lower[4]. With the average annual capacity factor of NGCC power plants in 2015 standing at 56.3%, the CPP target represents a nearly 25% increase in utilization.

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[3] The EPA used average net summer capacity for building block one in response to public comments after the initial proposal.

[4] Nameplate capacity is the maximum output in standard test conditions (STC), whereas summer capacity reflects the maximum output during times of peak summer demand. Because generators run less efficiently at higher temperatures, summer capacity will be lower than the nameplate capacity.

The third building block sets targets for zero-emission renewable energy generation (REG) to replace what is currently coal-fired power. Rather than efficiency or capacity factor, this building block sets regional targets for annual capacity additions. As existing REG capacity does not serve to decrease CO_2 emissions from current levels, target levels were set for incremental REG additions. Additionally, in the context of the CPP, REG technologies include only utility-scale solar PV, concentrating solar power (CSP), onshore wind, geothermal, and hydropower. Notable omissions from this list are distributed energy resources (DERs), including rooftop solar (RTS), because of evaluation, measurement, and verification issues; and offshore wind, as there had not been "clear evidence of technical feasibility and cost-effectiveness [in the U.S.]" at the time of the initial proposal[5].

The EPA's first step in calculating REG targets was to calculate the five-year (2008-2012) annual average and maximum capacity changes for the REG technologies listed above. Expected future capacity factors are applied to each REG technology using estimates from the National Renewable Energy Laboratory's (NREL) Annual Technology Baseline (ATB) model. The EPA uses the following equation to calculate two generation levels using the expected capacity factors (θ_i) and their corresponding five-year average and maximum capacity additions (ΔCap_i).

$$\Delta REG_i = \theta_i \left(\Delta Cap_i\right) 8760$$

Table 2.1 shows the results from the preceding equation. The incremental REG level derived using the five-year average value is then applied to years 2022 and 2023

[5] While not included in the calculation of building block three, incremental RTS and offshore wind capacity would still help states meet their targets under the CPP.

while the remaining years of the compliance period are assigned a target derived from the five-year maximum value. After calculating a “base case”, representing expected incremental REG deployment in the absence of the CPP up to year 2021, the EPA set an aggregate REG target of 706,030,112 MWhs by 2030. A series of integrated planning models (IPMs) could then be used to specify interconnection-specific targets subject to a variety of constraints, including terrain variability, land use exclusions, system reliability constraints, etc.

Table 2.1: Historical Capacity Changes and Associated REG Levels

	Assumed future capacity factor (percent)	Five-Year average capacity change (MW)	Generation associated with five year-average capacity change (MWh)	Maximum annual capacity change (MW)	Generation associated with maximum annual capacity change (MWh)
Utility-Scale Solar PV	*20.7*	*1,927*	*3,494,268*	*3,934*	*7,133,601*
CSP	*34.3*	*251*	*754,175*	*767*	*2,304,590*
Onshore Wind	*41.8*	*6,200*	*22,702,416*	*13,131*	*48,081,520*
Geothermal	*85.0*	*142*	*1,057,332*	*407*	*3,030,522*
Hydropower	*63.8*	*141*	*788,032*	*294*	*1,643,131*
Total Generation	*N/A*	*N/A*	*28,796,222*	*N/A*	*62,193,363*

Source: EPA Clean Power Plan

The IPMs assigned the majority of the REG target to the eastern interconnection (438 TWhs), with the western (161 TWhs) and ERCOT (107 TWhs) splitting the remainder more evenly.

2-3: Establishing CPP Targets

While states have several different compliance options, they are all rooted in the category-specific emission rate requirements which are calculated using the targets derived in the three building blocks. Emission rate targets are calculated at the regional level, and following previously mentioned methodology, the most lenient rates are selected for use as a federal standard.

To calculate the federal category-specific emission rate targets, fossil steam (coal, oil, and gas) generation and total NGCC generation were aggregated to the regional level along with corresponding emission levels. Generation and emission levels were adjusted for units that were either under construction or under operation for only a portion of 2012 (the last year for which data are available). A baseline emission rate for each category is calculated based on the historical data, as shown in the equations below, and is then adjusted with respect to each of the three building blocks summarized in **Table 2.2**.

$$Baseline\ Emission\ Rate_{Fossil\ Steam} = \frac{Coal\ Emissions + Oil\ \&\ Gas\ Emissions}{Coal\ Gen + Oil\ \&\ Gas\ Gen}$$

$$Baseline\ Emission\ Rate_{NGCC} = \frac{NGCC\ Emissions}{NGCC\ Gen}$$

Table 2.2: Summary of Building Block Targets

	BB1 – Heat Rate Improvement (HRI) for Coal Fleet	**BB2** - TWh of Total NGCC Generation at 75 % Utilization, (Amount of NGCC Generation Potential Incremental to Baseline)	**BB3** - Incremental RE Potential (TWh)
Eastern Interconnection	4.3%	988, (253)	438
Western Interconnection	2.1%	306, (108)	161
Texas Interconnection	2.3%	204, (66)	107

Source: EPA, Clean Power Plan

The adjustment for building block one applies only to the fossil steam rate and is reflected by adjusting *Coal Emissions*, from the baseline fossil steam rate, downward by the region-specific HRI target while leaving the denominator unchanged. This is done by taking the product of *Coal Emissions* and one minus the HRI target.

Next, building block three is applied to the generation levels of both fossil steam and NGCC. Because the CPP assumes that incremental REG replaces baseline fossil fuel generation, its effects on emission rate targets must be calculated prior to building block two[6]. Additionally, it is assumed that incremental REG will replace either fossil steam or NGCC generation in proportion to their share of baseline generation in the region. For example, the eastern interconnection has a baseline fossil fuel generation total of 2,039,224 GWhs, of which 64% comes from fossil steam and 36% comes from NGCC. Therefore, of the targeted 438,445 GWhs of incremental REG, 280,515 GWhs (64%) will be apportioned to replace fossil steam while the remaining 157,929 GWhs (36%) is assigned to NGCC.

Once incremental REG has been accounted for, the final adjustments can be made to generation levels. Building block two is applied by increasing generation in NGCC plants to reflect an increase to an average net summer capacity factor of 75%. The corresponding increase in NGCC generation would be assumed to displace fossil steam. For instance, continuing the example in the eastern interconnection, the difference between the post building block two NGCC generation levels, and the potential generation at 75% net summer capacity factor, is 411,250 GWhs. This potential NGCC generation is assumed to be shifted away from fossil steam so long as there is a sufficient quantity remaining post building block 3.

Having completed the adjustment targets from all the building blocks, the category-specific emission rate requirements can be calculated using the equations presented below. Although these rates do not carry much meaning themselves, they will later be used to determine state specific targets.

[6] BB2 assumes increased capacity factors at NGCC plants replaces coal generation, but that effect is not calculated until the effects of incremental REG on NGCC capacity factors are calculated.

$$Regional\ Emission\ Rate_{Fossil\ Steam}$$
$$= \frac{(Adj.Fossil\ Steam\ Gen * Adj.Fossil\ Steam\ Rate) + (Incr.NGCC\ Gen * Baseline\ NGCC\ Rate)}{(Adj.Fossil\ Steam\ Gen + REG\ Replacing\ Fossil\ Steam\ Gen + Incr.NGCC\ Gen)}$$

$$Regional\ Emission\ Rate_{NGCC} = \frac{(Adj.NGCC\ Gen * Baseline\ NGCC\ Rate)}{(Adj.\ NGCC\ Gen + REG\ Replaceing\ NGCC\ Gen)}$$

Once calculated, the least stringent regional rate for each category is selected to represent the federal 2030 rate standard. **Table 2.3** shows the results from each region, the eastern interconnection yielding the least stringent values for each category. This same technique is used to generate federal rate targets for each year of the compliance period. The interim goal is derived by averaging the rate targets generated by the model in years 2022-2029.

Table 2.3: Category-Specific Regional Rates

	Adjusted Rates	
Region	Fossil Steam Rate (lb/MWh)	NGCC Rate (Ib/MWh)
Eastern Interconnection	1,305	771
Western Interconnection	360	690
ERCOT Interconnection	237	697

The conversion of the federal rate targets, both interim and final goals, are converted to state rates by taking a weighted average of the category specific rates, from **Table 2.3**, according to the baseline generation mix. For example, North Carolina is located in the Eastern Interconnection and its baseline mix is approximately 68% fossil steam and 32% NGCC, the final statewide rate-based performance goal could be calculated as follows:

$$Emission\ Rate_{NC} = 0.68\ (1{,}305) + 0.32\ (771)$$

What remains after calculating the state specific rate-based goal is the conversion to an equivalent mass-based goal, which limits total quantity of CO_2 emissions rather than the average emissions rate. This calculation is split into two components. The first component is straightforward; baseline generation is multiplied by the corresponding rate target, resulting in the total emissions that would result from 2012 levels of generation in final rate compliance. The second component uses quantified emissions from additional fossil fuel generation that would be associated with meeting the full incremental REG potential from building block three, while maintaining the state specific rate-based goal.

Because the CPP applies the more conservative rate of the eastern interconnection, potential incremental REG goes unrealized in the other two regions. The second component of the mass-based goal is obtained by calculating the minimum incremental REG required to meet federal rate targets and subtracting it from the full potential building block three numbers. As seen in the following equations, the conversion to a mass-based goal is completed by combining the first and second components.

$$Comp1_i = (Emission\ Rate\ Goal_i * 2012\ Gen_i)$$

$$Comp2_i = Emission\ Rate\ Goal_i * (Potential\ REG_i - Minimum\ REG_i) * 2$$

$$Mass\ Goal_i = Comp1_1 + Comp2_i$$

The mass-based goal could therefore be less strict in terms of an overall emissions rate, but restricts the amount of overall incremental generation that would be available to states during the compliance period.

2-4: Legal Factors

The events surrounding the CPP were set in motion on June 25, 2013, when President Obama issued a memorandum to the EPA, directing them to take action addressing carbon pollution from both existing and proposed power plants, using authority granted under sections 111(b) and 111(d) of the CAA. The CPP was formulated over the following year and on June 18, 2014, the EPA set forth its initial proposal. As the EPA was in the process of receiving more than 4 million comments in regard to the proposal, industry members attempted to take immediate action against the rule, filing a claim in the D.C. Circuit. This claim was dismissed as premature; however, it did give the EPA an opportunity to preview the challenges that would eventually be brought before it once the CPP had been finalized.

On August 3rd, 2015, the EPA released the final rule of the CPP. The final rule included many substantive changes from the proposed rule in an attempt to appease the concerns of those who commented on the initial proposal. The most meaningful change to the rule, however, was in the interpretation of section 111(d) of the CAA.

When the CAA was making its way through the legislature in 1990, both the Senate and House passed amendments to section 111(d) that were ultimately passed into law, but never reconciled. The Senate amendment would exclude the regulation of pollutants from a list published under the CAA in section 112(b). The House amendment, on the other hand, excluded the regulation of pollutants emitted from source categories already regulated under section 112 of the CAA.

In the initial proposal of the CPP, the EPA argued that the Senate version of section 111(d) allowed for the regulation of CO_2 as it was not among the list of pollutants listed in the CAA. The House version, however, would not allow for the regulation from power plants because they were already being regulated under section 112, albeit for forms of pollution other than CO_2. The proposed rule claimed that the ambiguity created in the conflicting versions of the CAA gave the EPA the option to conform to either version of law. Because the CPP met the requirements of the Senate version of the law, the EPA claimed legal authority required to enact the CPP.

In the final rule, the EPA maintained that the Senate amendment was clear and unambiguous in allowing the regulation of CO_2 emissions from existing power plants. Their interpretation of the House amendment, however, had changed. In the initial rule, they had conceded that the House version would preclude the regulation of CO_2, but they now stated that the amendment was "ambiguous and subject to numerous possible readings" (Final Document 64,713). This view relied heavily on distinguishing the meaning within the context of the CAA, rather than the literal language of the amendment. While the House amendment states literally that the EPA does not have the authority to regulate existing power plants, the final rule of the CPP argues that, much like the Senate version, the purpose of the House amendment was to avoid duplicative regulation. The conclusion was that the two competing versions of section 111(d) were reconcilable, rather than contradictory, and both versions would therefore support the EPA's move to regulate CO_2 emissions from existing power plants.

Despite the justifications put forth by the EPA, the final rule of the CPP was met with resounding opposition. On October 26th, 2015, the D.C. Circuit consolidated the numerous challenges from states, federal government agencies, and industry groups (Goldberg). In an unprecedented move, the Supreme Court answered the plea of the plaintiffs by issuing a stay for the CPP while the case was still being heard in the D.C. Circuit. The Supreme Court stay prevented implementation of the plan from moving forward until the outcome of the legal proceedings could be determined. This would become a moot point when, on March 28th, 2017, President Trump signed an executive order, directing the EPA to review the CPP, and if appropriate, suspend, revise, or rescind the plan. The EPA, under the leadership of Scott Pruitt, is expected to have a proposal for a revised version of the CPP in the fall of 2017. However, it is not clear what direction the revised plan will take given the presiding administration's stance on climate change.

Chapter 3: Methodology

As mentioned previously, the purpose of this paper is to determine the extent to which the political affiliation of state lawmakers played a role in state's decisions to either oppose or support the clean power plan. Statistical analysis is performed using a cross-sectional data set comprised of political and economic variables for each of the 47 states affected by the CPP. Alaska, Hawaii, and Vermont were exempt from regulation under the CPP and were omitted from the data[7].

3.3: Probit Model

These models seek to determine the contributing factors in states' decisions surrounding the CPP. Party affiliation and cost/benefit are the primary variables under consideration, while a host of other variables are included at one stage or another.

The general format of the probit models are:

$$\Pr(Sueing_i = 1 | Observed\ Vars_i) = \Phi$$

$$(\alpha + \delta_j Political\ Motivators_{i,j} + \gamma_j Cost\ Proxies_{i,j} + \beta Benefit\ Proxy_i + \theta_j X_{i,j} + \epsilon_i)$$

One or more variables from section 3.2 are used for *political motivators, cost proxies*, and *benefit proxy*, while $\theta_j X_{i,j}$ represents a vector of control variables that do not clearly fit into one of the three preceding categories. Many of these are other energy industry variables that do have clear implications on costs, while others are state statistics, such as income, that are included purely as controls.

[7] While they hypothetically could have opposed the CPP, they could not legally enter as a plaintiff in the lawsuit against the EPA. Hawaii and Vermont publicly supported the CPP, while Alaska withheld judgement.

3.2: The Data

The data were compiled with information from a variety of sources. The dependent variable in nearly all specifications is *suing*, which equals one if the state was part of the suit against the EPA in opposition to the CPP, and zero otherwise. Variables that distinguished between states that publicly supported the CPP and those that neither supported nor opposed the plan were also collected.

The independent variables generally fall into one of two categories, political or economic. The following sub-sections describe the variables based on the category they have been assigned. A full table of summary statistics is provided in **Appendix A-1**, as not all of the variables in the data set are described in this section.

4-2(a): Political Variables

All Party affiliation data were gathered from 2015; the year in which the suit was filed against the EPA. Because it is not clear what actors were the primary decision makers, several variables needed to be considered to represent political affiliation. The first was the affiliation of the governor, followed by a set of variables related to the proportion of Republicans and Democrats in the state Senate and House[8]. These variables were generated to represent the percentage of Republicans in the combined state legislatures (*p*_rep) and a dummy equal to one if Republicans control the governorship as well as the House and Senate (*trifecta*). As shown in **Table 3.1**, Republicans controlled

[8] Nebraska has a unicameral legislature and therefore has blank values where state House and Senate mix is considered

the majority of state legislative branches and maintained a trifecta (control of all three branches) in nearly half of states.

Table 3.1: Political Affiliation Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
gov	1=RepGov	0.6696	0.48	0	1
sendem	Total(#)	16.91	9.00	4	39
senrep	Total(#)	23.11	8.28	5	40
housedem	Total(#)	47.80	29.94	9	160
houserep	Total(#)	64.22	36.05	11	239
p_rep	% of Total	0.5789	0.16	0.14	0.86
trifecta	1=RepTrifecta	0.4783	0.51	0	1

In addition to pressure from political parties, it is assumed that politicians are subject to pressure from their donors. The most up to date and relevant campaign finance information was found at *followthemoney.org*. For each state, total lifetime contribution data was gathered for each governor at the time of the suit against the EPA. Contributions are given in total and by industry sector. For this analysis, the variable *prop_energycont* was generated by dividing contributions from the energy and natural resources (ENR) industry sector by total lifetime contributions. This controls for both the length of a politician's career and the size of the state, but does not consider the timing of the contributions.

Table 3.2: Campaign Contribution Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
prop_energycont	% of Cont.	3.72	3.78	0.09	15.85
demcont	% of Cont.	2.11	2.54	0.14	10.64
repcont	% of Cont.	4.55	4.07	0.09	15.85

Because of the broad variety of interests that fall under the category of (ENR), this study uses interaction terms to include any difference in effect between contributions made to Democrats rather than Republicans. **Table 3.2** shows the difference in the mean proportion of ENR contributions to Democratic (*demcont*) and Republican (*repcont*) Governors[9]. Overall, ENR contributions made up 3.72% of governor's campaign contributions. While this study could not differentiate fossil fuel and renewable interest group contributions, Jenner (2013) finds that the former was more likely to contribute to Republicans, while the later was more likely to contribute to Democrats.

The final political variable reflects public sentiment regarding the CPP. Howe et al. (2015) used survey data to establish a series of climate opinion statistics based on geographic location. Questions were sorted into four categories: beliefs, risk perceptions, policy support, and behaviors. The two variables included in this study both fell under the "policy support" category and were based on the following questions:

How much do you support or oppose the following policies?

1. Regulate carbon dioxide (the primary greenhouse gas) as a pollutant…

   and

2. Set strict carbon dioxide emission limits on existing coal-fired power plants to reduce global warming and improve public health. Power plants would have to reduce their emissions and/or invest in renewable energy and energy efficiency. The cost of electricity to consumers and companies would likely increase.

[9] The zero values generated in the interaction terms are omitted from table 5 to provide a meaningful mean comparison

Two variables, *regulate* and *regcoal*, were defined as the proportion of respondents that selected either strongly support or somewhat support as their answers for questions one and two respectively. **Table 3.3** shows that the majority of responses in each state showed support for both forms of CO_2 regulation.

Table 3.3: Public Opinion Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
regulate	% Agree	73.44	3.4	66.42	80.61
regcoal	% Agree	66.93	5.34	55.25	78.71

3.2(b): Economic Variables

The primary economic variables serve as proxies for more detailed cost and benefit data. Two options are used to estimate costs. First is the stringency of the CPP target (*target*) taken as the required percent reduction in CO_2 emissions, relative to 2013 levels, for a state to meet its mass-based goal. While the cost of compliance for two states with similar *target* values could differ substantially, this study assumes that the cost of compliance would be strongly correlated with the stringency of the target. As shown in **Table 3.4**, the magnitude of state targets varies greatly, with the least stringent target allowing an increase of emissions of up to 43.8% and the most stringent requiring a 56% reduction.

The second proxy for costs makes use of state fossil fuel statistics. States that rely heavily on fossil fuel generation, particularly coal, for their electricity would likely face greater costs to come into compliance with the CPP. Three variables are created following this assumption, per capita coal (*coalgen*) and natural gas generation (*gasgen*), as well as a combination of the two (*ffgen*); all of which are measured in MWhs/person.

These data are sourced from the Energy Information Association (EIA) and are the most up to date statistics (2013) that would have been available to state legislators at the time of the CPP decision.

Table 3.4: Economic Cost Proxy Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
target	%CO_2 Reduction	0.6696	0.48	0	1
coalgen	MWh/person	16.91	9.00	4	39
gasgen	MWh/person	23.11	8.28	5	40
ffgen	MWh/person	47.80	29.94	9	160
coal_ext	Tons/person(mil.)	64.22	36.05	11	239
gas_ext	Ft^3/person(mil.)	0.4783	0.51	0	1

The production (extraction from the earth) of fossil fuels is also considered, as legislation discouraging fossil fuel generation would be expected have effects on the coal mining industry (*coal_ext*). While the effects of the CPP on the natural gas industry (*gas_ext*) are not as clear, they are generally considered alongside the coal industry for simplicity. Resource extraction variables are measured in millions of short tons and millions of cubic feet respectively. The variance in these statistics is very high, with a large number of states not producing any fossil fuel resources and a select few producing a great deal.

Variables used to measure benefits of climate change mitigation are measured in avoided cost. Estimates for these variables use data that come from a 2017 study by Solomon Hsiang et al. that estimates potential damage from climate change in the United States at a county level. As shown in **Figure 3.1**, damages are estimated as a percent of county GDP in years 2080-2099.

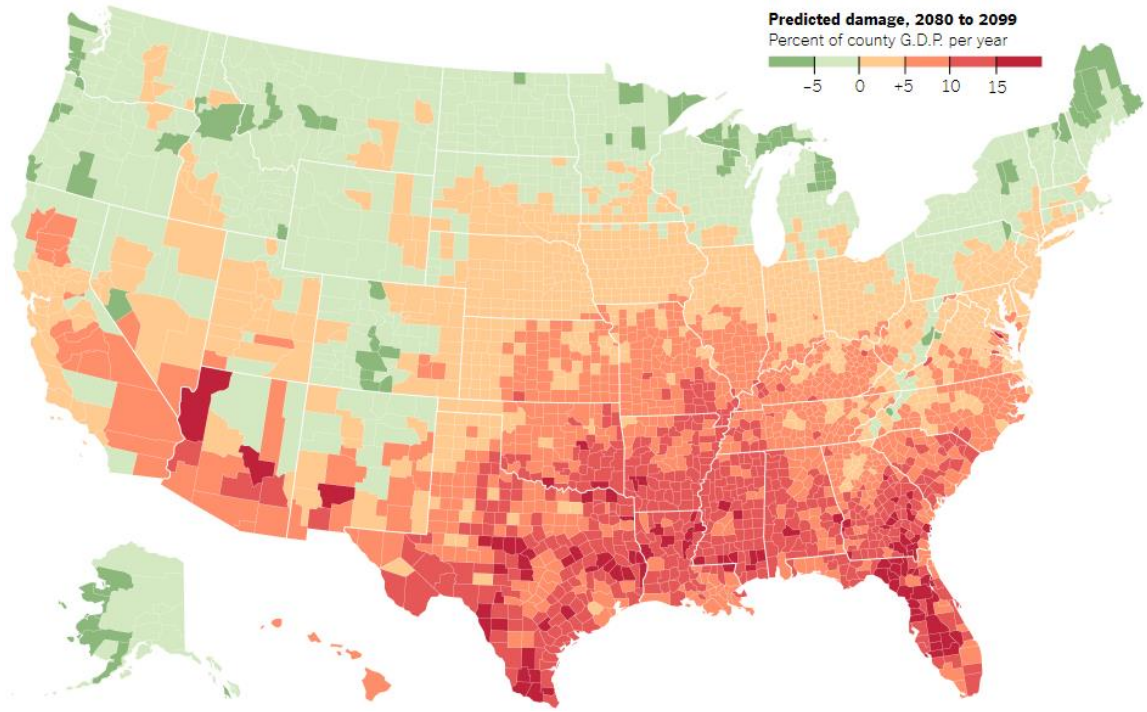

Figure 3.1: Estimated Damage from Climate Change in the U.S. Source: Hsiang et al. 2017

County level data was then aggregated to the state level by implementing a population weighted average of each county. These damages are expressed as a percentage of state GDP (*benefit_pct*), change in per capita income (*benefit_pc*), and nominal change in state GDP (*benefit_gsp*)[10]. The data do not need to be discounted under the assumption that county incomes would increase at the same rate as any hypothetical discount rate. Note that the minimum values for all benefit measures in **Table 3.5** are negative because much of the northern part of the country is expected to benefit from the effects of a warming climate.

[10] 2012 population and income data are used in unit conversions where necessary

Table 3.5: Economic Benefit Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
benefit_pct	-%Δ in GSP	0.0294	0.037	-0.0279	0.1154
benefit_pc	$/person	1152.38	1431.83	-1105.23	4762.53
benefit_gsp	$(bil.)	10.19	18.99	-4.97	92.18

To preserve degrees of freedom in the analysis, cost and benefit values are combined to generate a relative net benefit (*rnb*) variable. This would create a measure of relative value of the CPP compared to other affected states. To generate equivalent cost and benefit variables, this study considers states' relative share of total U.S. emissions reductions and nominal avoided damages (*benefit_gsp*) relative to U.S. GDP. As shown in the following equations, a state's *rnb* under the CPP would then be calculated by subtracting relative costs from relative benefits.

$$benefitshare_i = \frac{benefit\_gsp_i}{\sum_{i=1}^{47} benefit\_gsp_i}$$

$$costshare_i = \frac{target_i * 2013Emissions_i}{\sum_{i=1}^{47} target_i * 2013Emissions_i}$$

$$RNB_i = benefitshare_i - costshare_i$$

Table 3.6 displays the summary statistics for the preceding equations. Negative cost and benefit share values occur in states that have already met their CPP mass-based targets or are expected to experience net benefits of climate change.

Table 3.6: Relative Net Benefit Summary Statistics

Variable	Units	Mean	Std. Dev	Min	Max
benefitshare	% of Benefits	0.021	0.394	-0.01	0.19
costshare	% of Reductions	0.021	0.025	-0.01	0.10
rnb	%Ben-%Cost	-0.00012	0.421	-0.057	0.193

Chapter 4: Results

4.1: Probit Regression

Given only a cross section of 47 states, a necessary first step was to reduce the number of variables considered in the analysis. The probit regression model was constructed in segments, in a fashion similar to that of a forward stepwise estimation[11]. Model estimates are numbered M1-M13 so they can be easily referenced throughout the section. Stars are used to represent the significance level of the parameters in the tables.

Political variables were the first to be entered into the model. Party affiliation of the governor (*gov*) was chosen as the primary political variable over the proportion of Republicans in the state legislature (*p_rep*) and the trifecta indicator (*trifecta*) for several reasons. Due to the nature of the opposition towards the CPP, it is not clear what actors within a state government were primarily responsible for the stance. Some state governors, however, have certainly been outspoken about their opposition to the CPP (Neuhauser 2015), which suggests significant involvement. Additionally, political contribution variables used in the model were directly tied to the governors, rather than the state government as a whole.

Energy contributions are added to the model following the party affiliation variable. When considered alone, as in M2 (**Table 4.1**), *prop_energycont* yields a parameter that is not statistically different from zero (t-stat = 0.85). However, when the effects are split by Party affiliation, starting in M3, the estimated effect of *prop_energycont* becomes consistently significant for states with Democratic governors.

[11] Heteroskedasticity consistent standard errors were used in all model iterations

The positive sign that accompanies the parameter for *demcont* may also be somewhat surprising. When splitting the *prop_energycont*, it was suspected that ENR contributors to Democratic politicians would lean towards renewable resources (Jenner 2013), encouraging support of climate legislation like the CPP. However, the data show that Democratic governors who took a larger share of their money from ENR resources were more likely to oppose the CPP, while it did not influence Republican support.

Table 4.1: Determining Relevant Political Variables

	M1	M2	M3	M4	M5
Against					
gov	1.041**	0.920**	2.732****	2.746****	2.726****
prop_energycont		0.0579			
demcont			0.855**	0.792***	0.843***
repcont			0.00702	-0.115*	-0.0687
regulate				-0.319***	
regcoal					-0.165**
Constant	-0.489	-0.624*	-2.211****	21.69***	9.170*
Observations	47	47	47	47	47
Pseudo R-squared	0.107	0.125	0.240	0.460	0.398

* $p<0.10$, ** $p<0.05$, *** $p<0.01$, **** $p<0.001$

The last strictly political variables are those concerning the public opinion of CO_2 regulation. Both *regulate* (M4) and *regcoal* (M5) are statistically significant and carry the expected signs. It is interesting that the more relevant survey response variable, *regcoal*, which asked specifically about regulating existing coal plants, was not as significant as *regulate*, which was based off the much broader question of general CO_2 regulation.

Building upon M4, cost variables are added one or two at a time[12]. Being the most direct proxy for the cost of CPP compliance, *target* is tested first in M6 (**Table 4.2**), but the estimated parameter is statistically insignificant. This unexpected result is robust, appearing in a variety of modeling procedures. Examining the data, this could help explain how four states, Florida, Mississippi, New Jersey, and South Dakota, were still against the CPP, even though they had already met their 2030 emissions targets.

Table 4.2: Determining Relevant Cost Variables

	M6	M7	M8	M9
Against				
target	0.0114			
ffgen		0.252***		
coal_genpc			0.245***	
ng_genpc			0.265*	
lncoal				0.384*
lngas				0.203
Constant	20.94**	12.22	12.66	14.93
Observations	47	47	47	24
Pseudo R-squared	0.473	0.611	0.611	0.694

* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001

On the other hand, models using fossil fuel electricity generation as cost proxies, as in M7 and M8, consistently have positive and statistically significant parameters. However, while we may have expected the coefficients for natural gas and coal generation to be different given the expected effects of the CPP (Linn 2016), a Wald test suggests that the parameters are statistically equal. The combined variable, *ffgen*, is therefore a more appropriate variable to use in this situation.

[12] M4 parameters are omitted from table 4.2.

Unlike the generation variables, the fossil fuel extraction variables, given in logs as *lncoal* and *lngas* in M9, are weakly significant at best[13]. These statistics almost certainly had an influence on state decisions regarding the CPP, but the small sample size prevents the model from isolating any potential effects that they may have had. One would have expected the coal extraction variable to have had a positive influence on the probability of opposing the CPP. Natural gas extraction, however, could have hypothetically gone either direction.

The remaining variable category is the economic benefit measure, as defined by the potential for avoided climate change damages. The results suggest that states acted in a way that completely disregarded the potential costs (and benefits) of climate change to their state. Both Hsiang et al. (2017) and Barreca (2012) estimate positive net effects of climate change in much of the northern part of the country, while the south stands to face the negative effects of a warming climate. This impact is generally the opposite of the geographic tendencies for those that either oppose or support the CPP.

Adding the benefit measure to the previous models led to insignificant results across the board, so results from those regressions are not shown. However, **Table 4.3** shows results from regressions using only the benefit variables. The positive coefficients in M10-M12 suggest that states with larger benefits of climate change mitigation would be more likely to sue in opposition to the CPP. The only coefficient with what we would expect to be a proper sign is the relative net benefit variable in M13.

[13] 5% significance level in a one-tailed t-test

Holland et al. (2015) has comparable results when analyzing the effect of benefits on voting patterns of House Representatives on the WMA. Their unexpected sign was due to omitted variable bias, as the sign flipped when they controlled for the expected benefits of substitute policy measures. That could also be the issue here, but it is also possible that states are simply not considering benefits in their decisions.

Table 4.3: Decision Variable Regressed on Benefits

	M10	M11	M12	M13
Against				
benefit_pct	17.59***			
benefit_pc		0.000412***		
benefit_GSP			0.0199	
rnb				-1.128
Constant	-0.259	-0.232	0.0123	0.188
Observations	47	47	47	47
Pseudo R-squared	0.143	0.123	0.040	0.001

* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001

Next, several probit models are tested with variables that did not fit clearly into any of the previously defined categories. These include non-fossil fuel energy statistics, existing electricity regulations, historical electricity prices, and state GDP figures. Variables in this group were considered different from the others because they could conceivably fit into either category, or their role as economic variables could not clearly be defined as a cost or benefit[14].

Of these variables, the only one that was even weakly significant was per capita solar power generation. As discussed in section 2.2, existing non-fossil fuel generation is

[14] Summary Statistics for these variables can be found in Appendix A-1

not considered in the calculations of state targets, therefore it would have little effect on a cost-benefit calculation for a state considering actions regarding the CPP. Because solar power has historically been much more expensive than wind, hydroelectric, and nuclear generation, it is likely more prolific in states that offer more generous subsidies. It is therefore possible that the *solar* variable is more political than economic. Because it is only weakly significant and its relationship to the outcome variable is not fully understood, it is omitted from the final model.

Table 4.4: Final Probit Regression Results

```
Probit regression                               Number of obs     =         47
                                                Wald chi2(7)      =      19.72
                                                Prob > chi2       =     0.0062
Log pseudolikelihood = -12.072073               Pseudo R2         =     0.6234
```

against	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
gov	4.789354	1.526071	3.14	0.002	1.798309	7.780399
repcont	-.2376268	.0818249	-2.90	0.004	-.3980007	-.077253
demcont	1.25668	.4019619	3.13	0.002	.4688491	2.044511
regulate	-.2327014	.1264166	-1.84	0.066	-.4804734	.0150706
ffgen	.3232906	.1541266	2.10	0.036	.0212079	.6253732
target	-.0179244	.0195163	-0.92	0.358	-.0561757	.0203269
benefit_pc	.0000236	.0002432	0.10	0.923	-.0004531	.0005003
_cons	11.40567	10.13135	1.13	0.260	-8.451407	31.26275

Note: 0 failures and 3 successes completely determined.

In the final model, shown in **Table 4.4**, the political affiliation of the governor (*gov*) is still strongly significant. Both contribution variables are now significant, although both carry the opposite sign that we expected and *repcont* was not significant when it was tested originally in M3 (**Table 4.1**). Had *demcont* not been consistently significant throughout the modelling process, neither would have been included.

The public opinion variable, *regulate*, is only weakly significant here, but carries the sign we would expect and has been consistent throughout. The last remaining significant variable in the model is *ffgen*, which again is statistically equivalent to including both coal- and NG-fired electricity generation in the model. The remaining variables, *target* and *benefit_pc*, were included in the final model because they have little to no effect on the other parameters and their insignificance is worth highlighting. The results of the final probit regression in **Table 4.4** are generally robust to changes in model specification, with the signs, magnitude, and significance of variables being relatively consistent.

Because the probit model specification is non-linear, variable coefficients are not representative of the marginal effects. Instead, marginal effects are dependent on the value of all the regressors in the model and can be measured at any level. The most common methods evaluate the marginal effects at the mean (MEM) (**Table 4.5)**, and average marginal effects (AME) (**Table 4.6**), using the following equations:

$$MEM_j = \phi\left(x'\hat{\beta}\right) * \hat{\beta}_j$$

$$AME_j = \frac{1}{N}\sum_{i=1}^{N} \phi\left(\bar{x}'\hat{\beta}\right) * \hat{\beta}_j$$

While the MEM is generated using only one calculation, the AME calculates the marginal effect at each value of x and takes the average over the entire sample.

Table 4.5: Marginal Effects at the Mean Using the Final Probit Specification

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
gov*	.970513	.04595	21.12	0.000	.880454	1.06057	.659574
repcont	-.0440027	.02863	-1.54	0.124	-.10011	.012104	3.00178
demcont	.2327063	.12516	1.86	0.063	-.012609	.478021	.7194
regulate	-.0430906	.04207	-1.02	0.306	-.12554	.039358	73.4394
ffgen	.0598655	.02165	2.77	0.006	.017439	.102292	11.6176
target	-.0033192	.00245	-1.35	0.176	-.008123	.001485	11.7162
benefi~c	4.37e-06	.00005	0.10	0.923	-.000085	.000093	1152.38

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table 4.6: Average Marginal Effects Using the Final Probit Specification

against	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
gov	.5887837	.0658446	8.94	0.000	.4597307	.7178368
repcont	-.0337232	.0090224	-3.74	0.000	-.0514067	-.0160397
demcont	.1783437	.052084	3.42	0.001	.0762609	.2804264
regulate	-.0330242	.0159373	-2.07	0.038	-.0642607	-.0017876
ffgen	.0458803	.0193428	2.37	0.018	.0079691	.0837915
target	-.0025438	.0027537	-0.92	0.356	-.007941	.0028534
benefit_pc	3.35e-06	.0000344	0.10	0.923	-.0000642	.0000709

Coefficients now represent the expected change in likelihood of a state to sue, given a one-unit change in the corresponding variable. A notable difference between the two estimates is that the MEM method controls for the fact that the *gov* variable can only hold two values, zero and one, while the AME method treats it the same as any other variable. The resulting marginal effects for the *gov* variable are 0.97 with MEM and 0.59

with AME[15]. These results suggest that the political affiliation of the governor is often the deciding factor in a state's decision to oppose or support the CPP.

[15] The estimated marginal effect at the mean for *gov* is 0.887 when calculated without controlling for the fact that it is a dummy variable.

Chapter 6: Conclusion

This thesis has examined probit models as a way of explaining reactions to the CPP. While the public goods nature of climate change mitigation has the potential to encourage free-riding based on economic interests, the results of this study suggest that ideology has played a bigger role in states decisions to either support or oppose the CPP. Although most of the material focuses attention on the increased propensity of Republican controlled states to oppose the legislation, it should be noted that the inverse is true for states held by Democrats. That is to say that one could either say a Republican state was ~60% more likely to sue, or a Democrat led state was ~60% less likely to sue.

The most surprising findings in this research were the results that showed benefits of climate change mitigation as an irrelevant variable in the decision-making process. While the effect was negated when controlling for other variables, benefit data modelled on its own suggested that states with greater potential damages from climate change were more likely to oppose the CPP, while states that faced potential benefits were more likely to support it. However, this can partially be explained by the fact that many environmental goods are not included in the state GDP data that were used to measure benefits.

It is an important aspect of public policy to carefully analyze the costs and benefits of proposed legislation and make use of that information in the decision-making process. This research suggests that the prospects of implementing a successful strategy to mitigate climate change are slim, regardless of how economically sound it may be. It could be more helpful to work towards ways of mitigating the expected damages of climate change, rather than trying to avoid it all together. This could be accomplished by providing financial assistance to those who experience losses in the future, or delving into the realm of geoengineering, which would attempt to counteract the effects of global warming by artificial means. One such practice is solar radiation management (SRM), which would involve releasing chemicals into the atmosphere to reflect a portion of global solar radiation back into space.

Alternatively, the threat of emissions reduction targets could impact the actions of firms before any actual mandates are applied. Future research could be used to determine whether state specific targets included in the CPP influenced state CO_2 emissions while the plan was being implemented. If states took precautionary actions prior to implementation of the plan, new strategies could be implemented that could influence emissions whether or not the plan was eventually passed into law.

There is general consensus (Cook et al. 2016) that climate change is an issue and, one way or another, society will need to deal with it. Unfortunately, when and how we deal with it will more likely rely on the political climate of the time, rather than the pursuit of economic efficiency.

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APPENDIX: SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
against	47	.5744681	.4997687	0	1
gov	47	.6595745	.4789752	0	1
p_rep	46	.5788539	.1615754	.1441441	.8555556
sendem	46	16.91304	9.003274	4	39
senrep	46	23.1087	8.279099	5	40
housedem	46	47.80435	29.9404	9	160
houserep	46	64.21739	36.05546	11	239
pop	47	6711359	7239437	584153	3.88e+07
emis_pc	47	9.857018	12.92225	.8158272	79.12211
gasgen	47	3.92885	3.528715	.2289292	15.11493
coal_ppc	47	17.67726	93.87522	0	643.2775
net_export	47	13.74841	94.44157	-14.06184	642.041
ffgen	47	11.61761	12.14376	2.288424	75.54751
cf_genpc	47	4.849957	3.452421	.0261246	12.5528
wind_solar	47	1.128224	1.834341	0	8.79765
wind	47	1.079241	1.851517	0	8.79765
solar	47	.0489828	.1285236	0	.5837785
nuc	47	2.358984	2.663469	0	10.9998
reduction	47	-7.842399	9.353786	-36.61134	3.686841
benefit_pc	47	1152.378	1431.828	-1105.227	4762.53
benefit_gsp	47	10.191	18.98622	-4.970125	92.18016
benefit_pct	47	.0293603	.0371147	-.0279173	.1154578
ben_share	47	.0211552	.0394129	-.0103173	.1913541
cost_share	47	.0212766	.025377	-.0100025	.0993274
benefitcost	47	-.0001214	.0421292	-.0579229	.1926333
miners_pth~d	47	.6187441	2.043918	0	11.35833
regulate	47	73.43936	3.402294	66.421	80.606
regcoal	47	66.92723	5.340474	55.252	78.707
energycont	47	844898.8	1748360	14155	1.19e+07
prop_energ~t	47	3.721179	3.780765	.0929012	15.84998
demcont	47	.7193997	1.770924	0	10.64014
repcont	47	3.001779	3.945993	0	15.84998

coal_ext	47	1.90e+07	5.70e+07	0	3.76e+08
gas_ext	47	548408	1461195	0	8663333
price	47	12.66085	2.898619	9.09	20.94
rps	47	.5744681	.4997687	0	1
gsp	47	47916.68	8857.732	31633	67305
trifecta	47	.4680851	.5043749	0	1
target	47	11.71623	20.05397	-43.84204	56.02334