The Clean Power Plan: Gauging State-Level Opposition

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I.

Abstract

The Environmental Protection Agency's Clean Power Plan has generated a large amount of controversy over its mandatory carbon dioxide emissions cuts at the state level. 27 states have currently signed on to the federal lawsuit over the Clean Power plan that is currently pending, while only 18 have signed to support the EPA's position. In this paper, reasons why carbon agreements at the federal and international levels often fail are outlined. Attempted solutions by state and local governments are also discussed. Program operations and specific details of the plan are then outlined. This paper also seeks to identify reasons why states oppose the Clean Power Plan. A logistic regression with state opposition to the Clean Power Plan as the categorical respondent variable will be run. Variables that are hypothesized to be significant for the relationship include whether or not the state has a Republican Governor, the amount of coal produced in each state measured in short tons, and the percentage of each state's energy production that comes from renewable energy. After the regression was run, Republican Governor and renewable percentage production were confirmed to be extremely significant variables in explaining opposition to the Clean Power Plan. Renewable percentage made it less likely for a state to oppose the Clean Power Plan, while having a Republican Governor greatly increased the odds of a state opposing the Clean Power Plan. Coal production was not found to be statistically significant. This research leaves other questions for future research, such as examining the interactions between these variables and how that can affect opposition to the plan.

II.

Introduction

The United States Environmental Protection Agency (EPA) was established under executive order by President Richard Nixon in 1970, and ever since has been the primary federal agency that handles the crafting of environmental regulations designed to protect the environment and public health. Unsurprisingly, the regulations implemented by the agency are often subject to vehement opposition. Attempts to limit pollution, whether it be particulate matter, greenhouse gases, runoff in lakes and streams, or any other number of pollutants often find opposition in groups with vested interests in practices that cause the current level of pollution like business and corporate interests. EPA is no stranger to facing legal challenges over the rules that they issue. According to a report by the Government Accountability Office, the Environmental Protection Agency was sued and subsequently named as a defendant in a federal court case over one of their regulations approximately 155 times per year over the time period 1995-2010 (GAO 2011).

One recent regulation issued by the EPA has caused a level of controversy unseen even by the EPA, however. First proposed in 2014 and finalized in the late summer of 2015, EPA's *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*, colloquially known as the Clean Power Plan, seeks to curb emissions of carbon dioxide (CO_2) from existing power plants in the United States. EPA calculated emissions reductions goals for each state that they must ultimately meet by the year 2030. While more specific details of the plan will be laid out in later sections, it is important to note that there were not any specified mechanisms that EPA required the states to follow. In the end, how each state met their emissions reduction requirements are left to each individual state to determine what will work best for their state. Despite this, EPA has received a large amount of opposition to the rule, larger than most standard legal battles the EPA usually must fight. As of the writing of this paper, 27 states had signed on to the official condensed federal appeals court case challenging the EPA's legal authority to issue such a rule, officially titled *State of West Virginia, et al. v. United States Environmental Protection Agency, et al. (2016)*. More than half of the states suing the EPA in federal court over a single regulation is not something that happens often.

A large reason why the EPA felt the need to act on carbon dioxide emissions, despite the controversy, is the fact that other levels of government, in both the United States and worldwide, have not found much success, if any at all, when it comes to curbing the levels of greenhouse gases. Most in the academic and scientific community agree that it will take a concerted effort by a large international coalition of nations in order to seriously mitigate or reverse the trends of increasing carbon dioxide emissions and rising global atmospheric temperatures. However, international efforts to combat emissions inevitably run afoul for a variety of reasons to be discussed in later sections. Absent an international coalition, the duty to combat carbon emissions then falls to each individual nation on its own to combat. However, increasing gridlock and partisanship within the United States Congress has led to little or no serious action over the past decade when it comes to greenhouse gas regulations. So, responsibility for emissions must be taken up elsewhere. State and local governments have actually been more proactive than one might initially think in attempting to combat their local emissions. Reasons for this and attempted solutions will be discussed in later sections. Additionally, the EPA is a federal agency that is not subject to the same partisan gridlock that currently plagues Congress. While their regulations are surely to be met by political challenges, they do not have to fight tooth and nail to get them drafted and passed at all like those who fight for emissions reductions in Congress. Therefore, the EPA took action because it was necessary to do so. Outside of some concentrated state and local efforts to combat greenhouse gas emissions, international and other federal attempts to solve the problem have not been successful. EPA is not in the clear yet, however, as the Clean Power Plan has been stayed by the U.S. Supreme Court until litigation over it has been settled.

This paper will seek to address the reasons why EPA has been met with such fierce opposition to the Clean Power Plan. The literature review will highlight why federal and international attempts at carbon abatement have failed, and will seek to highlight some of the state and local efforts at solving local pollution problems, such as cap-and-trade programs and natural gas vehicles. These solutions are important because they could potentially explain why some states oppose the Clean Power Plan and why others do not: if a state has found success with a cap-and-trade system, they might be more likely to support the plan, and vice-verse. After exploring these solutions, a more detailed look into the workings and the program operation of the Clean Power Plan is offered in an attempt to better understand exactly what it is and what it would require of the states.

The research question, variables of interests, and statistical methods that can help to answer the research question are laid out next. The research question frames the analysis in a way that factors that affect state-level opposition to the Clean Power Plan can be analyzed. Variables of interest to examine will be fleshed in out detail later, but will include some variables derived from the discussion in the literature, including presence of cap-and-trade policies, natural gas and coal production by state, etc. The methods employed to answer the research question take the form of a logistic regression, in which the relationship between binary dependent variable (opposition or lack thereof to the Clean Power Plan) and a number of candidate independent variables can be assessed. The paper concludes with a presentation of the results from the regression models fitted in the analysis, and conclusions and future implications for research that can be drawn from those results.

Ultimately, whether the Clean Power Plan survives its legal challenges or not, it will take measures like it at an international scale in order to truly reverse the ever-upwardly rising carbon dioxide emissions trends currently being observed. By examining the variables that explain the opposition to the plan in the United States, future attempts at carbon abatement can keep these relationships and objections in mind and attempt to incorporate them both when fashioning climate policy and during the negotiation process.

III.

Carbon Agreements at the Federal and International Level

As the true scope of the global impacts of carbon pollution has become apparent over the last few decades, there have been several attempts to find solutions to the problem on an international level (such as the Kyoto Protocol of 1997). However, time after time these international environmental agreements (IEA's) fail to produce any measure of tangible change that will lead to a worldwide reduction of CO_2 emissions. There exists an abundance of literature on the underlying theory that explains the consistent failure of these agreements to reach a lasting solution to the problem, and why it is unlikely that an international solution will be possible without significant systemic alterations to the way that these agreements are forged.

A fundamental reason why international environmental agreements often fail is due to the fact that there are often extremely weak or no enforcement provisions whatsoever. Environmental problems like CO_2 pollution are by nature global problems; all countries contribute to carbon pollution in the atmosphere, therefore theoretically it should take a cooperative effort to solve the problem. However, the fact remains that individual states maintain autonomy over environmental affairs that take place within their own borders, and there is not an effective enforcement mechanism currently in place to force states to hold up their end of the bargain on climate agreements. Hoel (1991) summarizes the problem: since "each country's own contributions to worldwide emissions is small, there is little a country can do by itself…in the absence of suitable institutions which can make and enforce global decisions" (Hoel 56).While the United Nations has made unprecedented strides in uniting the world's states together under the guise of collective decision-making, and is responsible for the United Nations Framework Convention on Climate Change, the coalition in charge of most of the recent international work on carbon reduction, the fact remains that even the United Nations does not have the ability to police autonomous nations like China and India to ensure that they are keeping their end of the bargain under the terms negotiated in climate agreements. Without these key enforcement capabilities, a number of undesirable consequences naturally follow.

One consequence of the lack of enforcement documented extensively in the literature is the free-rider problem. Various studies such as Barrett (1999) and Rubio and Ulph (2007) have demonstrated that due to the lack of enforcement, countries will absolutely not comply with environmental agreements unless the benefits clearly outweigh the costs. Hoel (1994) points out that while it is often in a country's best interest in the short-run economically to not participate, a country "will usually be even better off if other countries cooperate, while it itself stays outside the agreement and pursues its own self-interest" (Hoel 259). This is often the case with international environmental agreements, especially from the point of view of developing economies whose driving force is manufacturing, one of the most pollutant-heavy industries. There is a prevailing sense of unfairness amongst these developing countries – they feel that since now-developed nations like the United States had little to no restrictions on their pollution activities when they were in the developing stages, it is not fair that they themselves are now being asked to submit to heavy regulation.

Downie (2014) identifies two reasons why international environmental agreements are notoriously unsuccessful, reasons that he deems "procedural obstacles" inherent in the process of negotiating environmental agreements. First of these is the lowest-common denominator problem. The problem stems from the previously discussed lack of enforcement mechanisms. Since carbon pollution is a worldwide problem, international attempts to address it require cooperation across a broad range of states. However, there are many states who have little interest in cooperating with an international agreement. For the agreement to succeed, these uninterested states must be persuaded to sign on to the agreements. Knowing that they have this leverage, "international and global environmental policy often represents, at least at the start, the lowest-common-denominator measures that the relevant countries are willing to accept" (Downie 2014, pg. 94). In essence, international environmental agreements can be held hostage by those states least willing to take part. The standards can only be set as high as these uninterested nations will allow them to be set; if they are made too strict they will exercise their right to not participate, scuttling the entire agreement. The other procedural obstacle that Downie discusses is the time-lag issue. Environmental issues are unique in that they often take years to manifest or reveal themselves as serious problems, and in addition the "significant time lag between the identification of an international environmental problem and the impact of international policy" (Downie 2014, pg. 95). In the case of carbon pollution, the failure of the world to make significant progress in an emissions reduction framework in the years following Kyoto does not mean that the problem is at a standstill. While gridlock prevents a treaty from taking shape, greenhouse gas emissions continue to pour into the atmosphere, worsening the problem. This is significant because "by the time a policy is put into place, the situation has often grown far worse" (Downie 2014, pg. 95). A solution to pollution that took a decade to forge is likely to be archaic and outdated by the time it is actually adopted and implemented, as the constant pollution over the course of the negotiating period has worsened the situation.

While most of the literature recognizes that it will take a coordinated, international effort to combat global carbon emissions in a serious way, this does not preclude individual nations from forging solutions to their own individual greenhouse gas emissions. On the domestic front, the United States, at least at the federal level, has not seen much more success than has been realized on the international stage. A severe economic downturn and the Obama administration's decision to prioritize health reform in its first term put many environmental issues on the backburner. Most notably, the Waxman-Markey bill that would have established a national cap and trade program (a solution that will be discussed in depth in the next section) was passed by the House of Representatives but failed to clear the Senate in 2010. Subsequent attempts at solving the problem have fallen victim to partisanship, with many killed by tying them to votes on the approval of the highly-contested Keystone XL Pipeline. The most significant legislation to pass in recent years, a bill authored by Sens. Portman (R-Ohio) and Shaheen (D-New Hampshire) that made improvements to federal energy efficiency regulations in buildings was only be able to be passed through parliamentary trickery, with the two senators forcing a voice vote deep into the night when they were the only two senators remaining on the floor of the Senate (The Hill, 2015).

While legislative inaction on the issue of carbon pollution has been well documented, the Obama administration's Environmental Protection Agency has taken a more active role in combatting CO_2 emissions from domestic sources. Over the past two years, a series of measures, the most significant of which has been termed the Clean Power Plan, have sought to curb greenhouse gas emissions in the United States by regulating power-generating electric utilities. Specifically, the Clean Power Plan sets target emissions levels of carbon dioxide from power utility plants for each state that must be met ultimately by 2030, with a series of intermediate progress checks along the way. The ultimate goal of the Clean Power Plan is a 32 percent total reduction in carbon dioxide emissions from power plants at their 2005 levels (EPA 2015). More specific details regarding the Clean Power Plan and its program operations will be discussed more heavily in the sections to come as well, however at the present moment it has been stayed by the Supreme Court until litigation surrounding its constitutionality has time to work its way through the federal courts system of the United States (Washington Post, 2015).

After many failures to reach an agreement at the international level regarding climate issues, including the widely disappointing Copenhagen talks in 2009, media accounts of the recent meeting of the UN Framework on Climate Change in Paris have told a story of success. While this news is encouraging, only time will tell if the agreement reached by the member nations there will have a meaningful impact on global carbon emissions. This fact, combined with the inability of the United States to take meaningful action at the federal level, leaves a problem that theoretically must be solved by an international coalition to state and local governments. While it is naïve to think that a global problem can be solved on a local scale, many of the steps that have been undertaken by local governments in recent years provide a solid framework that, if applied across a broad geographical range, would represent a serious attempt at tackling global carbon emissions.

IV.

State and Local-level CO_2 Abatement Solutions

Despite the either unwillingness or inability to take action on carbon dioxide emissions at the federal level in the United States, individual states have shown a willingness to take action on the issues of carbon abatement. Through a combination of attempted solutions like regional cap and trade programs, renewable portfolio standards, and alternative energy incentives states have begun to take on the work of emissions reduction that the federal government has not been able to undertake.

One approach to lowering carbon emissions popular amongst economists is carbon pricing. According to basic economic theory, firms take a variety of factors into consideration when determining how much of a good to manufacture, chief among those concerns include cost, both fixed and variable. Firms are not generally required to pay for the byproducts of their manufactured goods, namely the associated pollution that is created during the production process. Since they are not required to pay for pollution, they do not consider the costs, social or otherwise, of pollution when making business decisions, which often leads to production that causes a level of pollution much higher than is socially desirable. This is where carbon pricing comes into play: if the firms are required to pay for the carbon dioxide pollution that they emit, it is likely that they will not pollute as much. While there are a multitude of ways to put a price on carbon (including a basic carbon tax), one method that has become an increasingly popular alternative of choice for U.S. states is the method known as cap-and-trade.

While cap-and-trade first entered the mainstream of American politics in the late 1980s and early 1990s in the context of the EPA's Acid Rain Program, its origins can be traced back to the work of J.H. Dales, an economist at the University of Toronto who in 1968 authored a work entitled *Pollution, Property, and Prices* that, for the first time, fleshed out the basic tenets of a cap-and-trade program designed to lower pollution levels. The goal of cap-and-trade is to set a price on emissions of a target pollution (in this case, carbon dioxide) by establishing a market where permits that allow the holder to emit a certain amount of the target pollution (often 1 mass ton of CO_2) can be bought, sold, and traded. These permits can be distributed in a number of ways, either through initial giveaways, allocations based on previous pollution levels, or through an auction system, with the auction system becoming the most preferred option in many cap and trade systems. By simulating a free market as closely as possible, the market clearing price of pollution permits at the permit auctions represents the equilibrium price of what the private sector considers the worth of CO_2 pollution to be, a figure that government regulators are unlikely to be able to determine solely on their own. This represents the trade aspect of cap-and-trade that sets the price on pollution. Tangible emissions reductions come in the "cap" portion of cap-and-trade. Each year, a cap of permissible pollution emissions is set. Over time, this cap is lowered. The number of permits in the market matches with the cap, so over time there will be fewer and fewer permits available, forcing firms to streamline their processes to become more efficient and less polluting. According to Dales (1968), as industries grow and the number of available permits decrease, "the price of Rights will move upward," causing a decline in pollution levels.

Cap-and-trade has become an option of choice for U.S. states seeking to reduce their carbon footprints. In fact, one of the premier examples of cap-and-trade in the world has emerged in the northeastern United States. The Regional Greenhouse Gas Initiative (RGGI) is a regional cap-and-trade system that covers electric generating power utilities with a capacity of 25 megawatts or greater that was first established in 2003, and became fully operational in 2009. It consists of member states Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. At one point, New Jersey was also a member state, but Governor Chris Christie withdrew his state from the program effective at the end of the year 2011.

RGGI operates over the course of three year “control periods.” Companies have until the end of the three years to obtain the requisite number of permits for their carbon emissions over that same period. The first control period began in January 2009 and ended at the conclusion of 2011. The second control period lasted from 2012 to 2014, and the third control period is currently underway. The cap was set at 91 million tons of aggregate CO_2 emissions over the nine states per year at the beginning of 2014. This cap is scheduled to decrease by 2.5% each year until 2020, when the data available will allow regulators to set a new, more appropriate cap (RGGI 2015). The literature on whether or not RGGI has been working is mixed. Much of the existing literature must be taken with a grain of salt, as it was either paid for or produced by an entity with a vested interest in seeing the program either succeed or fail. Both electricity prices and carbon emissions in the region have been falling since RGGI was adopted in 2009. Most independent analyses reach the same conclusion: it is likely that RGGI has helped contribute to this decline, but the driving factor for these declines was the economic recession and the resultant drop in electricity demand (Acadia Center 2015). Cap-and-trade for carbon pollution does not just exist in the northeastern United States. California in 2012 became the first state to fully implement its own independent cap-and-trade program. Additionally, as mentioned earlier, cap-and-trade was a central component of the Clean Air Act Amendments of 1990 that sought to combat acid rain pollution in the U.S., a program that most observers agree worked remarkably well. While it is unfortunate that economic factors such as the recession may be masking the true effects of cap-and-trade in the northeastern United States, it appears as if cap-and-trade has had the baseline level of success needed to stay in places where it has already been adopted, and may become an attractive option for other states to adopt in the coming years.

Another option that has become increasingly popular across a wider range is a policy solution known as the renewable portfolio standard (RPS). The central feature of the RPS is to require public utilities within the state to generate a designated portion of their power from alternative energy sources. Currently, 37 states and D.C. have adopted some form of an RPS, with 8 of those 37 being suggested targets, not necessarily restrictive mandates. Most of the states that have not adopted an RPS are states in the Deep South, with a few northwestern states like Wyoming and Idaho holding out as well (NCSL 2015).

Rabe (2007) discusses the various program designs that an RPS can take. While all states define what they consider to be "renewable energy," all consider basics like solar and wind energy to count towards renewable production. One of the biggest divides in program operations amongst states is the standards themselves. Most states require some percentage of the total electricity generated to come from renewable energy, but other states require a fixed amount of energy to be produced from renewables, no matter the total amount of electricity produced (Iowa and Texas are two examples of states that do this). Rabe identifies Texas, Pennsylvania, Colorado, Nevada, and Massachusetts as states that have experienced a particular success in their RPS programs. Rabe also discusses some challenges that have come to face RPS standards across states, chief of which has been the growth of competitive special interests representing each of the various energy sources, all seeking to get preferential treatment for their specific energy source. Another problem identified has been "double counting" – as states begin to collaborate and work together to reach their renewable goals, they from time to time will count renewable electricity generation from one state in other states involved in the partnership as well, defeating against the entire purpose of the original legislation.

The conventional wisdom of most of the previous literature was that RPS adoption was more of a symbolic gesture than a real attempt at greenhouse gas reduction, and that RPS standards are far too costly given the benefits that they incur (Michaels 2007; Kniefels 2007; Fischer and Newell 2008). However, this is not a unanimous view. Yin and Powers (2009) used an economic technique known as differences-in-differences regression to demonstrate that "on average, RPS policies have had a significant and positive effect on in-state renewable energy development." Ultimately, while the mere passage of an RPS is not an automatic guarantee that renewable, cleaner energy will become more abundant, it is an important first step for many states to start moving away from carbon-heavy energy sources like oil and coal.

As discussed so far, individual states have shown willingness to take action on pollution abatement solutions where the federal government is either unable or unwilling to do so. However, when discussing a point-source pollution like carbon dioxide, it is often most efficient for the most local form of governments to go about solving the problems, as they are the governmental bodies most closely integrated into the local communities and economies. In fact, due to the concerns such as local health problems and deleterious economic impacts on local communities, "local governments can be most effective in controlling pollutants that originate at stationary power sources, industrial processes, or solid waste disposal plants located within their territorial limits" (Zollinger 1972). Over the past several decades, local governments have indeed made progress on pollution issues, despite their relative lack of resources.

One area where local governments have made considerable progress is in public transportation and municipal government fleets in urban areas. Public transportation in itself, no matter whether powered by traditional petroleum sources or alternative energy, helps to considerably reduce pollution emissions due to the fact that it takes automobiles off of the road. One way in which cities have been able to accelerate the pollution abatement accrued from public transportation is to begin the conversion of their municipal fleets to cleaner-burning alternative fuel vehicles, most often vehicles that run off compressed natural gas (CNG). Independent studies by researchers at Argonne National Laboratory have shown that greenhouse gas emissions from CNG range from 6 to 11 percent lower than the greenhouse gas emissions from the equivalent amount of standard gasoline.

Michaelis (1995) identified municipal fleets as a promising sector into which alternative fuel vehicles was likely to expand and outlined several reasons why. Most important of these is the fact that fleets such as buses travel predictable routes and return to the same station at the end of each day. One of the chief concerns of switching over to alternative fuel vehicles such as CNG-powered units, especially for private users, is the lack of necessary infrastructure (i.e. CNG fueling stations) that exist across the United States. While certain states such as California, Texas, and Oklahoma have a sizable number of fueling stations (AFDC 2016), other states have little to no CNG infrastructure whatsoever, so purchasing a CNG-powered car for private use makes little sense for private consumers in these states. However, municipal fleets such as city bus systems, county vehicles, and other government fleets are perfect targets for CNG expansion, as they travel a similar route each day. With minimal infrastructure, cities can support an alternative-fuel transportation fleet that is centered on just one or two fueling stations.

The state of Oklahoma provides a valuable case study on the benefits that can be realized from alternative fuel fleets, specifically CNG fleets. As the fourth largest producer of natural gas in the United States according to the Energy Information Administration, Oklahoma has a natural advantage over other states when it comes specifically to CNG use. The city of Norman is one municipality that has benefited from the adoption of CNG vehicles in their municipal fleets. Rosenthal et al. (2012) note three notable benefits that the city of Norman has realized after switching over to CNG vehicles. The first is cost savings, with an annual projected saving in fuel costs of $60,000. The second is a reduction in noise pollution, a secondary but not unimportant benefit in municipalities (CNG vehicles are notably quieter than vehicles that run on standard internal combustion engines). The third and primary benefit is, as expected, notable reductions in pollution emissions, with lower greenhouse gas emissions and up to 94% decreases in particulate matter recorded in the city's air. Norman is not alone in their adoption of CNG, as county administrators have begun taking up CNG vehicles as a cost-saving measure as well (NewsOK 2015). Both of the states' major universities (University of Oklahoma and Oklahoma State University) have adopted CNG vehicles in their fleets. In addition, the two largest metropolitan areas in the state, Oklahoma City and Tulsa, have begun adding some CNG buses to their fleets, as well as their respective school districts (NewsOK 2015). While transitioning over to natural gas, a fossil fuel, is not going to solve the global issues of climate change, it does lead to positive impacts in greenhouse gas emissions reductions in local communities, and Oklahoma has demonstrated that. While natural-gas vehicles do not make sense in all areas of the country, they are a viable option for those areas that have the proven reserves and infrastructure capabilities.

Another way in which local governments have begun tackling air pollution issues is through a mechanism known as a council of governments (COG). COGs are defined as "multiservice entities with state and locally-defined boundaries that deliver a variety of federal, state, and local programs while continuing to function as a planning organization" (Wolf & Bryan 2009). In his seminal work on COG's, political scientist Nelson Wikstrom identifies the important roles that COGs play in regional planning and cooperation, and finds that COGs that operate in a voluntary manner are those that are generally more successful in encouraging "interlocal cooperation" (Wikstrom 1977). COGs have grown in numbers since they were first conceived in the 1950s, and the National Association of Regional Councils (NARC) estimates that of the 39,000 various municipal governments in the United States, 35,000 of them participate in a council of government of some kind (NARC 2016).

Councils of government allow local, state, and even the federal government to work together on a variety of issues that they might not be able to tackle otherwise, and pollution is one of these issues. Wolf & Bryan (2009) note that COGs increasingly play "a role in the planning and review of programs, particularly with regards to transportation and the environment." In fact, NARC, the association that represents COGs at the federal level in Washington D.C., identifies the environment, including alternative and renewable energy development, as one of the top three goals that all COGs share, along with economic development and public transportation. Notable environmental programs that COGs have undertaken in the past include air quality monitoring systems, drinking water testing and monitoring, and the administration of the Department of Energy's Clean Cities program, which provides federal investment that is used for helping municipalities become more environmentally friend and energy efficient. A large component of this program includes investment in alternative fuel vehicles like the CNG vehicles discussed previously. Again, since COGs are voluntary associations, it is unlikely that sweeping reforms in pollution control will derive from them. However, the cooperation amongst and across all levels of government in combatting environmental issues has risen to a level that would have been unthinkable just a few decades ago.

Alternative fuel vehicles and COGS are two viable solutions to helping urban regions tackle their pollution issues. While it is important to tackle pollution in urban regions due to the deleterious effects of concentrated pollution, it is troubling to note that not much headway has been made in combatting rural pollution. While there are some signs that rural electric co-operatives (traditionally a bastion of coal-powered plants due to cost concerns) may be starting to invest in solar energy (Roberts 2016), it has been much more difficult to effectively reduce rural sources of greenhouse gases such as agriculture and the aforementioned rural electric co-operatives.

V.

The Clean Power Plan

On August 3, 2015, the Environmental Protection Agency released its "Carbon Pollution Emissions Guidelines for Existing Stationary Sources: Electric Utility Generating Units." Colloquially known as the Clean Power Plan, it represented the most comprehensive attempt at carbon dioxide that the United States government had ever undertaken. While it became an instant political controversy, with some states suing before the final text had even been released, the questions of just what exactly the Clean Power Plan is and what it would require of states need to be answered.

The legal authority for the Clean Power Plan, as claimed by the EPA, is Section 111(d) of the Clean Air Act. Section 111(d) gives the EPA Administrator the authority to establish 'standards of performance' for any existing source for any air pollutant, and also require states to submit plans for how they intend to meet these newly imposed standards. The EPA, claiming this authority, issued the Clean Power Plan as an attempt to combat carbon dioxide pollution from existing stationary sources. The EPA ultimately decided to regulate emissions from two categories of electric generating units (EGU's) – fossil-fuel fire electric steam generating units, and natural gas-fired combined cycle generating units. The former category most often includes coal and oil-fired power plants, the most common types (EPA 2015). Consistent with the approach outlined in Section 111(d) of the Clean Air Act, EPA did not choose to proscribe certain methods of emissions reductions or required technological upgrades to power plants within states (part of a category of regulation known as command-and-control regulation). Rather, EPA chose to set benchmark interim and final goals for each state to reach, but are not told how they have to get there. The amount of autonomy given to states is near absolute; all they are told is how much they need to reduce their emissions by, and then they have complete control over the way that they see best fit to do so. This is important because there is evidence in environmental policy literature that well-designed regulation that leaves some flexibility in how the standards are met can actually increase efficiency and competitiveness, a phenomenon known as the Porter Hypothesis (Ambec et. al. 2011). While the Porter Hypothesis is indeed just that, a hypothesis, EPA saw fit to follow its model and let states devise their own solutions to carbon emissions, rather than being told what to do by federal regulators who may not know what would work best for each state.

The specifics of the Clean Power Plan are as follows. EPA regulators, using past data and studies on carbon dioxide, determined a best system of emissions reductions (BSER) for each state. Based off of this, EPA set emissions reductions targets in three forms for states to reach: "A rate-based state goal measured in pounds per megawatt hour (lb/MWh); A mass-based state goal measured in total short tons of CO_2; and a mass-based state goal with a new source complement measured in total short tons of CO_2" (EPA 2015). States were originally required to submit their intended plans for compliance to EPA by September 2016, with an extension until 2018 available in some circumstances. It is important to note that the Clean Power Plan applies only to the contiguous 48 states; Alaska and Hawaii were not included under the Clean Power Plan's authority. The states must meet the interim goals that were established for them over the period from 2022 to 2029, and from 2030 onwards must meet the final goals that were established under the plan. The ultimate goal of the Clean Power Plan is to achieve a 32 percent reduction in CO_2 emissions from their 2005 levels.

While EPA did not force any sort of compliance mechanisms on the states, it did make recommendations for each state through the BSER system. Called building blocks, EPA set three recommendations for states to reach their emissions targets (EPA 2015). The first building block is the improvement of the heat rate of existing coal-powered plants so that the intensity of carbon emissions during electricity generation is weakened. The second building block is the shifting of electricity production away from high-polluting coal-fired plants and towards lower-polluting natural gas-fired plants. The third and final building block is the substitution of electricity production generated from zero-emission sources like wind and solar for electricity production from coal-fired plants. All three building blocks together follow the general theme of moving the nation's electricity production away from its traditional, heavy reliance on coal-fired plants and towards new sources of electricity generation. Interestingly enough, while it did not include it as an official building block, EPA has strongly encouraged the states to adopt or join emissions trading schemes, like the previously discussed Regional Greenhouse Gas Initiative.

On February 9, 2016, the Supreme Court of the United States issued a stay of the Clean Power Plan while its legality was still up for question in the court system. This means that states do not have to meet any requirements that would have been imposed on them until the cases surrounding the Clean Power Plan have been resolved. All of the separate suits against the EPA over the Clean Power Plan have been consolidated into one case at the Federal Court of Appeals level. Oral arguments are currently scheduled for the summer of 2016 in the D.C. Circuit Court of Appeals, with an appeal to the Supreme Court no matter the outcome very likely. Currently, 18 states have signed on to help the EPA defend the plan, while 27 states have joined the suit against the EPA. Five states have not taken an official stance on the regulation yet.

VI.

Research Question

Now that the Clean Power Plan has been discussed in detail, the question of why and how it has become such a politically-charged regulation can be fleshed out. As mentioned earlier, of the fifty American states, 27 have joined the lawsuit against the EPA, 18 have signed on as proponents of the Clean Power Plan, and 5 have not yet taken an official action for or against the regulation at the state level. As a reminder, Alaska and Hawaii are not required to comply with CPP, although Hawaii is one of the 18 states that has signed on in favor (Alaska is one of the five "neutral" states). The 18 states that have joined with the EPA are New York, California, Connecticut, Delaware, Hawaii, Illinois, Iowa, Maine, Maryland, Minnesota, New Hampshire, New Mexico, Oregon, Rhode Island, Vermont, Washington, Massachusetts, and Virginia. The 27 states suing the EPA are West Virginia, Texas, Alabama, Arkansas, Colorado, Florida, Georgia, Indiana, Kansas, Louisiana, Michigan, Mississippi, Missouri, Montana, Nebraska, New Jersey, Ohio, South Carolina, South Dakota, Utah, Wisconsin, Wyoming, Kentucky, Arizona, North Carolina, Oklahoma, and North Dakota (*State of West Virginia, et al. v. United States Environmental Protection Agency, et al. (2016)*).

Using this framework, the research question that this paper will attempt to answer is "What factors explain a state's opposition to the Clean Power Plan?" The dependent variable, which is official state reaction to the Plan (oppose or not oppose) is a categorical dependent variable that lends itself to analysis using logistic regression methods. A more detailed outline of the methods employed and a list of independent variables and their theoretical reasons for being included the model will be given in the following sections.

VII.

Discussion of Variables and Hypotheses

Now that the research question has been defined, the independent variables that will be used to measure CPP opposition can be identified. First, the dataset used is one that the author compiled from a combination of sources including the U.S. Census Bureau, the Environmental Protection Agency, the Department of Energy, and Energy Information Administration. The experimental unit is the 50 states. Washington D.C. was excluded as its extremely small geographic size and other factors (such as that it is mostly all residential or business land) make it substantially different enough from the population (states) that it was not chosen to be included.

The response or dependent variable is each state's opposition or lack thereof to the EPA's Clean Power Plan, denoted in the dataset as 'cppopp.' Opposition or lack thereof was determined in the following way: if the Governor, Attorney General, State Legislature, or state-owned power utility had signed on the official condensed lawsuit against CPP that is currently pending in the D.C. Circuit Court of Appeals, then they were categorized as in opposition to the plan, and coded as a 1. If any of those officials or a combination had signed on to the same lawsuit in support of CPP, they were categorized as in support of the plan, and coded as a 0. Five states have not currently issued any sort of official governmental response to the plan (Alaska, Idaho, Nevada, Pennsylvania, and Tennessee). These five states were coded as a 0 in the dataset as well. This decision was made because of the purpose of the analysis. The research question that the analysis seeks to answer is what factors explain opposition to the Clean Power Plan. Therefore, support and neutral were included in a single category, not opposed. Originally, the plan was to drop Alaska and Hawaii from the dataset, as the plan does not apply to those two states. However, since Hawaii has chosen to support the plan even though it does not apply to them, the two states were left in the dataset. Nine independent variables were selected to be included in the dataset. A short description, as well as theoretical underpinnings for each follows:

State Population 2015 – The official Census Bureau estimate of each state's population as of July 1st, 2015. The variable was included as a demographic variable for use later. Are small states more likely to oppose or support the plan? Does population size make a difference?

Median Income 2013 – The official Census Bureau three year average (2011-2013) estimate of the median household income in each state. Theoretically, poorer states should be more likely to oppose the plan, as there is the potential for higher utility costs which would hit the poorest consumers hardest.

Renewable Percentage – The percentage of each state's energy mix that comes from "renewable energy" as defined by the Department of Energy. The latest figures that could be obtained were from 2009. States that already produce a large portion of their energy from renewable sources should be more likely to support the plan, as it would not require much effort on their part to cut back on emissions. Conversely, they might be more likely to oppose the plan because they have already cut their emissions through these renewable sources, and may find it harder to make further cuts.

Coal Production 2014 – Coal production by State in the year 2014, as measured in short tons. The data comes from the Energy Information Administration (EIA). Coal states should be the most vehemently opposed to the plan, as one of the explicitly stated goals of the plan is to shift U.S. electricity production away from coal-fired plants.

Carbon Dioxide Emissions 2013 – Carbon dioxide emissions by each state in 2013, measured in million metric tons. This data comes from the EIA as well. This variable was included for similar reasons as the renewperc variable. High emissions states may be more likely to oppose the plan, but they also may be more likely to support it because it will be easier for them to find ways to cut back as compared to states who may have already cut their emissions by a substantial amount.

Natural Gas Production – Natural Gas Marketed Production in the year 2014, measured in million cubic feet. This data also comes from EIA. Natural gas producing states could gain from the plan, as it wants to move away from coal and towards alternative sources like natural gas. However, many natural gas states are also known as oil and coal states who may oppose the plan.

Renewable Portfolio Standards – A categorical variable to measure whether or not the state has some form of a renewable portfolio standard in place. From the literature review, an RPS is an important step but not a foolproof one towards cutting emissions. A state was coded as a 1 if it has adopted such a standard, and a 0 if it has not.

Cap and Trade – A categorical variable to measure whether or not the state has adopted a form of cap and trade. So far, only 11 states have ever tried cap and trade, and 10 currently have it in place (the nine RGGI states in the Northeast plus California). Given that cap and trade is often pushed as a potential solution by the EPA itself, states that have adopted it may be more likely to support the EPA's plan. A state was coded as a 1 if it is part of a cap and trade program, and a 0 if it is not.

Republican Governor – A categorical variable to measure whether or not the governor of the state in question is a Republican or not. Given that the plan was formulated and put into place by a Democratic administration, states that have a Republican serving as their chief executive officer should in theory be more likely to officially oppose the plan. A state was coded as a 1 if their current governor is a Republican, and a 0 if their governor is not a Republican. There is currently one independent Governor in the U.S., Bill Walker of Alaska. Since Mr. Walker's political history is a bit muddled when it comes to party affiliation (he has run as a Republican in the past, but his running mate from the last election was a Democrat), it was chosen to code him as 0. Therefore, a 1 represents a Republican governor and a 0 represents not a Republican governor, not necessarily a Democratic one. If there was more than one current Independent governor, a third category for the variable would have been created, however given the fact that there is only one it did not seem feasible to create a new category for just one observation.

Based off of the theoretical reasons for including each variable, the following specific hypotheses were formulated in order to test the research question. Each will be answered by the analysis to follow.

1. Republican Governor will be the most significant independent variable for explaining Clean Power Plan Opposition. Since the Clean Power Plan is inherently political in nature, having a Republican as a state's chief executive officer should make it significantly more likely to oppose the Clean Power Plan.
2. Additionally, since an explicitly stated goal of the Clean Power Plan is to move U.S. electricity production away from coal-fired plants, heavy coal-producing states should be much more likely to oppose the plan as well. Therefore, Coal Production in 2014 will be another significant independent variable.
3. Renewable percentage will be another significant independent variable. Since the Clean Power Plan wants to make states produce more from renewable sources, states that already do should be less likely to oppose the plan, since they already do so.

VIII.

Outline of Statistical Methods Employed

The data lends itself to analysis using a series of methods known as logistic regression. Logistic regression was first developed by statistician David Cox in 1958 (Cox 1958), and was developed as on offshoot of ordinary least squares regression (OLS) techniques. Specifically, the purpose of logistic regression is to handle cases where the response variable is a categorical variable. OLS regression techniques were developed with continuous response variables in mind, but oftentimes the dependent variable in question is not continuous. With logistic regression, the response variable can be binary or multinomial, as long as it is categorical. One common application of logistic regression include examining the effects of a number of variables on the presence or absence of a disease. In this case, the response variable is a dichotomous categorical variable – a state's opposition or lack thereof to the EPA's Clean Power Plan.

The regression equation calculated from a logistic regression for a model with n independent variables and response variable Y can be represented in the following manner:

$$Logit(Y) = b_0 + b_1X_1 + \cdots + b_nX_n$$

Logistic regression is a subcategory of a larger group of linear models known as the generalized linear model (GLM). In the statistical package R, generalized linear models can be neatly summarized and analyzed using the `glm` command.

The steps of the logistic regression to be carried out will progress in the following way:

1. First, the data will be imported and cleaned for analysis. The command `as.factor()` is used in R to specify that certain variables are to be treated as factor/categorical variables, as the default in R is to treat all variables as continuous, even if coded as 0/1 dichotomous variables.

2. Next, the data must be examined for potential relationships and or problems. This is done by creating simple box and whisker plots for each of the continuous independent variables against the response. For the categorical independent variables, contingency tables against the response will be generated.
3. The model specification process will be initiated. The initial model will be an additive model with all independent variables included. Other models of interest will be examined in order to test the hypotheses laid out in the previous section.
4. Next, the "best possible model" will be identified using the process of stepwise regression. Stepwise regression methods determine the "best" possible model by adding and subtracting candidate variables from the model and calculating a specified criteria (Efroymson 1960). The criteria that will be used to determine the "best" model is Akaike's Information Criterion, or AIC (Akaike 1973). It is extremely useful as a comparative measure to choose between models based on their relative quality. Models with a lower AIC score are considered to be better fits of the true relationship.
5. Next, the model will be tested for its overall significance. This can be done by using a chi-square test on the difference between the null and residual deviances of the models.
6. The last step of the analysis will be to convert the coefficients of the estimated model into what is known as an odds ratio for ease of interpretation. The coefficients that R will report are given in terms of log odds. Log odds can be converted to an odds ratio by exponentiating the log odds coefficient. For example, if we convert a log odds coefficient to the odds ratio and it comes out to, say 4.5, that would mean that the presence of that independent variable (if categorical) or a 1 unit increase in the variable (if continuous) makes it 4.5 times more likely that a state will be opposed to the Clean Power Plan.

IX.

Results

The logistic regression analysis was run in the statistical package R. The full code used to produce all output and results can be found in the Appendices section of the paper. First, the data was imported, cleaned, and all categorical variables were identified in the script.

The next step of the analysis was to produce the boxplots of each continuous independent variable and contingency tables of each categorical independent variable against the response to look for trends. All boxplots and tables can be found in the Appendices. After examining the plots, it appeared that median income, renewable percentage, carbon dioxide emissions, cap and trade, and Republican Governor were variables with a clearly visible difference between states that oppose and do not oppose the Clean Power Plan. With median income and renewable percentage, states that opposed the Clean Power Plan had a clearly visible lower value on both variables than did states that do not oppose the Clean Power Plan. In fact, the median value of renewable production percentage for states that oppose the Clean Power Plan is lower than even the first quartile value for states that do not oppose the Clean Power Plan. From the carbon dioxide emissions boxplot, it appears that CO_2 emissions are significantly higher in states that oppose the Clean Power Plan. With cap and trade, all 10 states that have adopted some form of it do not oppose the Clean Power Plan, while 27 out of the 40 states that have not adopted it oppose the Clean Power Plan. Of the 31 states with Republican Governors, 22 of them oppose the Clean Power Plan. Of the 19 states with non-Republican Governors, only 5 oppose the Clean Power Plan. While none of these variables have been proven statistically or practically significant yet, it is important to look for these trends in the data before the actual models are specified. These results also lend credence to hypotheses 1 and 3 laid out in the previous section, that Republican Governor and Renewable Percentage will be important variables in the model.

The first model that was tested was an additive model that contained all of the candidate independent variables. The output for this model, denoted `glm1` in the R script, is provided in the Appendices section. For this model, the only variable that is statistically significant is the renewable percentage variable (log-odds coefficient estimate=-.0376, z=-2.126, p-val=0.0335). While it was expected that renewable percentage would be significant, it is surprising that no other variables were found to be statistically significant. The AIC for this model was 53.532. The next model that was specified was a model containing only renewable percentage. While it is not generally advised to drop all non-significant variables and re-run the model, doing so allowed us to confirm that renewable percentage is a statistically significant variable, even on its own. The output for this model, `glm2`, can be found in the Appendices section as well. The AIC for this model was 61.082, which is higher than the first model we tested. Therefore, while renewable percentage is an important variable for our relationship, our model needs more variables to properly explain the relationship.

Next, stepwise regression was used to determine the "best" possible model in terms of AIC, a criteria that measures model quality by instituting a penalty for models that overfit the relationship. Running the stepwise regression ran models of all combinations of candidate independent variables. The output for the final model is given in the Appendices section, and the rest has been redacted due to space concerns. The model that the stepwise regression suggests as the best model is one that includes renewable percentage, cap and trade, and Republican Governor. This model, henceforth noted as `glm3`, has an AIC of 44.64, significantly lower than the other two models tested so far.

From this model, we see that the two statistically significant variables are renewable percentage (log odds coefficient estimate=-0.03287, z=-2.638, p-val=0.00833) and Republican

Governor (log-odds coefficient estimate=1.88158, z=2.108, p-val=0.03501). Both of the p-values are below the standard alpha=0.05 level for significance, meaning that we can reject the null hypothesis and have evidence to show that they are statistically significant to the relationship.

Next, we can test for the significance of the overall model using a chi-square test. This can be done by subtracting the residual deviance from the null deviance given in the output, giving us our chi-square statistic. The degrees of freedom on our test are derived by subtracting the residual degrees of freedom from the null degrees of freedom, leaving 3 degrees of freedom. The associated p-value from a chi-square value of 32.351 and 3 degrees of freedom, as calculated in R, is 0.0000004413. The extremely low p-value allows us to reject the null hypothesis that there is no statistically significant relationship, and to conclude that the overall model is significant.

Finally, the coefficients on the renewable percentage and Republican Governor variables will be converted to an odds ratio for ease of interpretation. Before the specific results are interpreted, it is important to note: An odds ratio of 1 means that a change in the independent variable causes no change in the odds of the dependent variable (opposition to Clean Power Plan). An odds ratio of less than 1 means that a one unit increase in the variable (if continuous) or the presence of the variable (if categorical) makes it less likely that a state will oppose the Clean Power Plan. An odds ratio of more than 1 makes it more likely that a state will oppose the Clean Power Plan.

The odds ratio for renewable percentage is 0.9676673, and the odds ratio for Republican Governor is 6.563886. These numbers can be interpreted in the following way. An odds ratio of 0.9676673 means that for a one percent increase in the percentage of a state's energy production that comes from renewables, states become slightly less likely to oppose the Clean Power Plan than they would have been otherwise, based on the fact that the odds ratio is near 1. This conclusion matches with the fact that the log-odds coefficient estimate is negative. For Republican Governor, the odds ratio is 6.563886. This means that the presence of a Republican Governor makes a state approximately 6.564 times more likely to oppose the Clean Power Plan than a state that does not have a Republican governor, an odds ratio that is quite large.

Before the analysis was completed, it was noted that coal production, a variable that was hypothesized to be one of the most important for the explanation of the relationship has not appeared in any of the models so far. Going back to the original additive model, coal production's coefficient was not found to be statistically significant (z=.275, p-val=.7834). An additional model was specified to test for the significance of coal production on its own, without other variables that may be masking its effect. However, this model again showed no statistical significance on the coal production variable (z=1.406, p-val=0.160).

X.

Conclusions

Now that the data has been analyzed and models tested for their significance, conclusions on the research question and the hypotheses can be drawn. As a reminder, the research question around which the entire analysis was framed is "What factors explain a state's opposition to the Clean Power Plan?"

The first hypothesis posited that Republican Governor would be the most important variable in explaining a state's opposition to the Clean Power Plan. This hypothesis was supported by the analysis. Republican governor was statistically significant in both the model on its own and in the "best" model with the lowest AIC. It appears that political concerns do play a major role here. Despite all other characteristics of a state provided for in this analysis, just simply having a Republican Governor makes a state about 6.5 times as likely to oppose the Clean Power Plan. This is not necessarily a negative finding. It may be that Republican Governors are truly representing the will of their constituents by taking this position on the Clean Power Plan. This raises further questions for research and analysis in the future, such as how the interaction between Republican Governors and other factors like public opinion for and against the Clean Power Plan correlate with one another.

The second hypothesis posited that coal production would be another significant variable for explaining state opposition to the Clean Power Plan. This hypothesis was not supported at all by the analysis. Coal production was not found to be a statistically significant variable in any of the models that were specified. This finding was of interest, because the theoretical reasons behind why the hypothesis was made still stand true. Coal miners and coal executives are steadfast opponents to the plan, so why would this trend not follow through on the state level? The best way to answer this question was just to return to the original data. The likely reason for the lack of significance on the coal production variable was the fact that there are quite a few states that produce no coal whatsoever, yet still oppose the Clean Power Plan for a variety of other reasons (Michigan, Florida, Georgia, and North Carolina are just a few). In addition, two of the largest coal producing states, Illinois and Alaska, either support or have not taken a position on the Clean Power Plan. So, while it is true that many of the heaviest coal producing states (Kentucky, West Virginia, Montana, etc.) do oppose the Clean Power Plan, the presence of no-coal states opposing the plan and the presence of Illinois and Alaska's lack of opposition were likely enough to mask any sort of statistical significant relationship from appearing in the models. Therefore, while it was not statistically significant within the context of the logistic regression model run in this analysis, it is potentially still a practically significant variable in explaining why some, but not all states, oppose the Clean Power Plan.

The lack of significance on the coal production variable illustrates some of the flaws inherent with statistical analysis and an overreliance on data alone. If one were just to rely on the data and the resulting analysis alone, they would not find coal a significant variable for explaining Clean Power Plan opposition. In most cases, it is best to not rely solely on quantitative or qualitative analysis. A mixture of the two can generally allow one to make solid conclusions while also further exploring trends that may not be as evident in the data.

Another set of issues that arise when studying states is that there only fifty of them, meaning that the power of any statistical tests that are run is lower due to the fact that is difficult to make strong conclusions off of such a small sample size. If the sample size, n, was 500, or 5,000, it would be more appropriate to make stronger conclusions about the data, and trends that may be masked by smaller n samples (like coal production's relationship to Clean Power Plan opposition) would be much more likely to be detected with a larger sample size. Promising trends in quantitative research that seek to address this problem include sampling from the existing data and simulating new data with a larger n, so that stronger conclusions can be formed.

The final hypothesis posited that renewable percentage would be another important variable in explaining state opposition to the Clean Power Plan. This hypothesis was supported by the analysis. Renewable percentage was a statistically significant variable in all models specified, and its odd ratio of less than 1 confirms the hypothesis that states with higher levels of renewable energy production would be less likely to oppose the Clean Power Plan. Since the Clean Power Plan is an attempt to move states over to renewable production, states that already have high levels of renewable energy production are indeed less likely to oppose the plan as it would not be a significant burden to them.

Ultimately, the two most significant variables in explaining opposition were renewable percentage and Republican Governor. While other variables such as coal production and natural gas production did not have as much of a significant relationship as expected, there is potentially still the chance that the variables remain practically important for those assessing support and opposition for the Clean Power Plan. For those who wish to move past the protracted legal and political stalemate surrounding the Clean Power Plan, it is important to note that a state's political leanings and its renewable energy production are two of the dominant driving factors in determining a state's stance towards the plan. Ultimately, if the regulation is to ever move forward in a successful manner, it will take a good-faith, concerted effort by all parties involved to reach a common goal of emissions reductions. Bridging the vast differences between states on this issue will be impossible unless there is first an attempt to step into the role of the opposition, and understand why they believe what they do in the first place.

XI.

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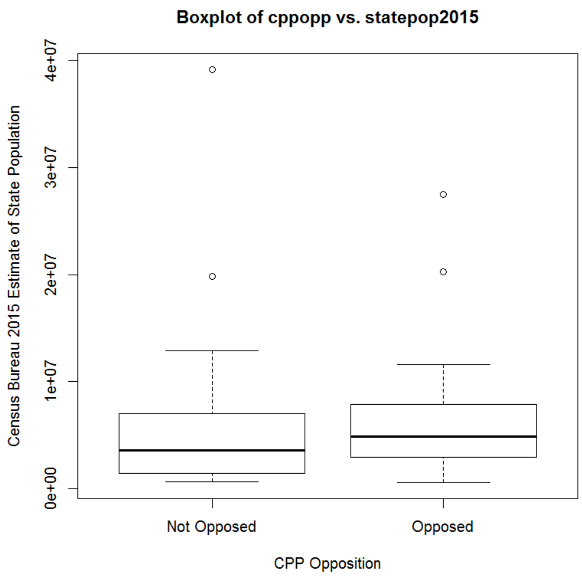
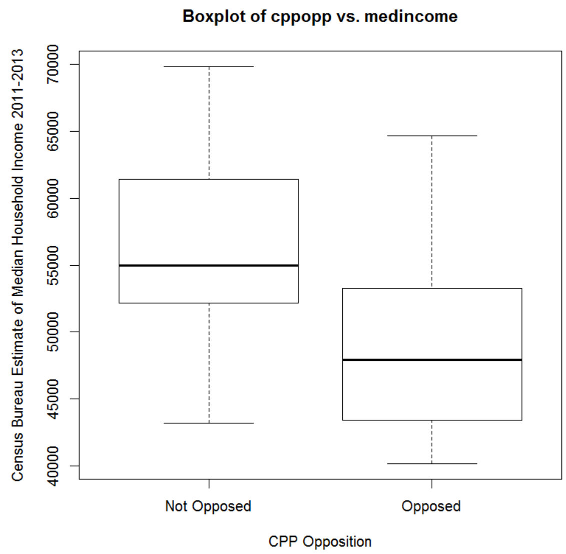
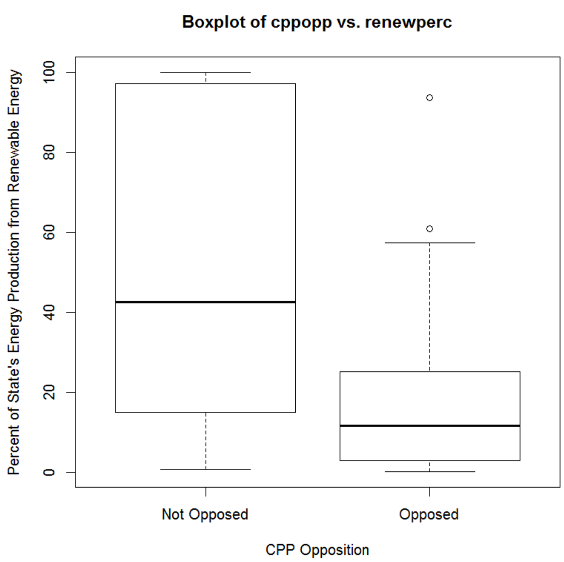
XII.

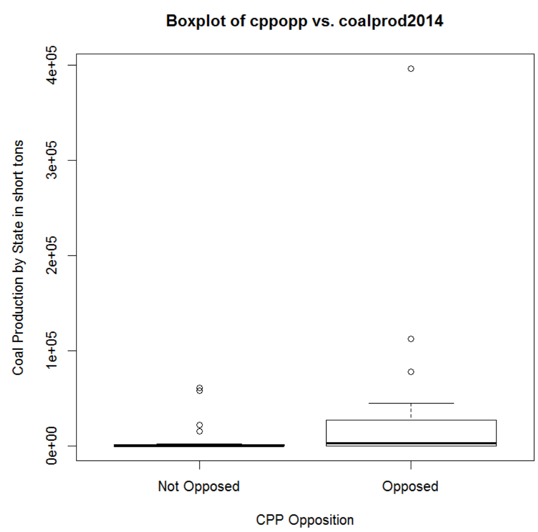
Appendices

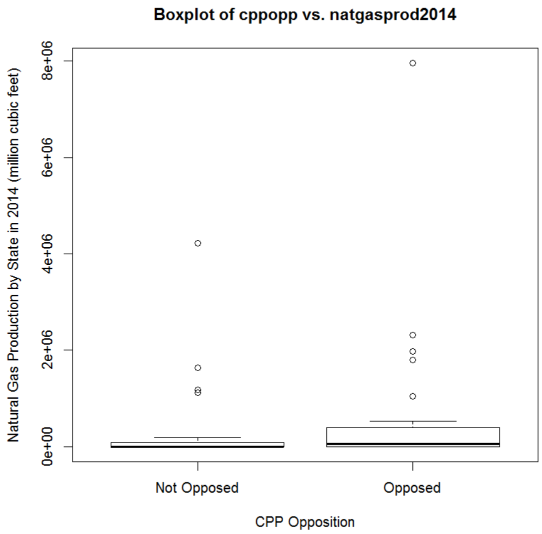
Appendix A – Boxplots of Continuous Independent Variables against Response

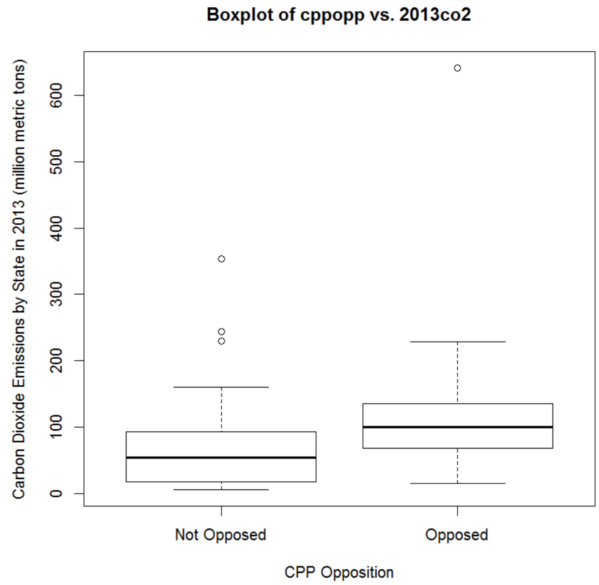









Boxplot of cppopp vs. natgasprod2014
Natural Gas Production by State in 2014 (million cubic feet)
0e+00
2e+06
4e+06
6e+06
8e+06
Not Opposed
Opposed
CPP Opposition


Boxplot of cppopp vs. 2013co2
Carbon Dioxide Emissions by State in 2013 (million metric tons)
0
100
200
300
400
500
600
Not Opposed
Opposed
CPP Opposition

Appendix B – Tables of Categorical Independent Variables against Response

cppopp	rps	
	No	Yes
Not Opposed	3	20
Opposed	10	17

cppopp	capandtrade	
	No	Yes
Not Opposed	13	10
Opposed	27	0

cppopp	repubgov	
	Not a Republican	Republican
Not Opposed	14	9
Opposed	5	22

Appendix C – Summary Output from Selected Models

```
> summary(glm1)
Call:
glm(formula = cppopp ~ statepop2015 + medincome + renewperc +
    coalprod2014 + X2013co2 + natgasprod2014 + rps + capandtrade +
    repubgov, family = binomial, data = data)

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)     3.785e+00  3.813e+00   0.993   0.3208
statepop2015   -2.013e-07  2.105e-07  -0.956   0.3389
medincome      -6.814e-05  6.800e-05  -1.002   0.3163
renewperc      -3.076e-02  1.447e-02  -2.126   0.0335 *
coalprod2014    2.482e-06  9.030e-06   0.275   0.7834
X2013co2        1.805e-02  1.685e-02   1.071   0.2840
natgasprod2014 -7.627e-07  6.802e-07  -1.121   0.2622
rps1            2.038e-01  1.001e+00   0.204   0.8387
capandtrade1   -1.825e+01  3.132e+03  -0.006   0.9953
repubgov1       1.514e+00  1.010e+00   1.499   0.1339
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 68.994  on 49  degrees of freedom
Residual deviance: 33.532  on 40  degrees of freedom
AIC: 53.532

> summary(glm2)
Call:
glm(formula = cppopp ~ renewperc, family = binomial, data = data)

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  1.23061    0.45545   2.702  0.00689 **
renewperc   -0.03195    0.01077  -2.965  0.00302 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 68.994  on 49  degrees of freedom
Residual deviance: 57.082  on 48  degrees of freedom
AIC: 61.082

> thesis.glm.step <- step(glm0, list(lower=cppopp ~ 1,
upper=cppopp~statepop2015+medincome+renewperc+coalprod2014+X2013co2+natgaspro
d2014+rps+capandtrade+repubgov))
…
…
(Output redacted as all possible models were tested, final model is shown)

Step:  AIC=44.64
cppopp ~ capandtrade + renewperc + repubgov
```

```
                 Df Deviance    AIC
<none>                36.643 44.643
+ medincome       1   35.188 45.188
+ natgasprod2014  1   36.417 46.417
+ statepop2015    1   36.482 46.482
+ rps             1   36.574 46.574
+ coalprod2014    1   36.641 46.641
+ X2013co2        1   36.642 46.642
- repubgov        1   41.524 47.524
- renewperc       1   45.397 51.397
- capandtrade     1   47.773 53.773
```

> summary(glm3)

```
Call:
glm(formula = cppopp ~ capandtrade + renewperc + repubgov, family = binomial,
    data = data)

Coefficients:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)     0.61758    0.72035   0.857  0.39126
capandtrade1  -19.63592 2943.75958  -0.007  0.99468
renewperc      -0.03287    0.01246  -2.638  0.00833 **
repubgov1       1.88158    0.89250   2.108  0.03501 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 68.994  on 49  degrees of freedom
Residual deviance: 36.643  on 46  degrees of freedom
AIC: 44.643
```

> summary(glm4)

```
Call:
glm(formula = cppopp ~ coalprod2014, family = binomial, data = data)

Coefficients:
               Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.207e-01  3.277e-01  -0.368    0.713
coalprod2014  2.203e-05  1.566e-05   1.406    0.160

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 68.994  on 49  degrees of freedom
Residual deviance: 65.276  on 48  degrees of freedom
AIC: 69.276
```

Appendix D – Full R Script

```
#Derek Wietelman
#Thesis Code

#Set-Up
data <- read.csv("thesisdata1.csv", header=TRUE)
data$cppopp <- as.factor(data$cppopp)
data$rps <- as.factor(data$rps)
data$capandtrade <- as.factor(data$capandtrade)
data$repubgov <- as.factor(data$repubgov)
summary(data)
attach(data)
levels(cppopp) <- c("Not Opposed", "Opposed")
levels(rps) <- c("No", "Yes")
levels(capandtrade) <- c("No", "Yes")
levels(repubgov) <- c("Not a Republican", "Republican")

#Examining Data Part 1 - Boxplots of Continuous Independent Variables vs.
Response Variable
plot(statepop2015~cppopp, main="Boxplot of cppopp vs. statepop2015",
xlab="CPP Opposition", ylab="Census Bureau 2015 Estimate of State
Population")
plot(medincome~cppopp, main="Boxplot of cppopp vs. medincome", xlab="CPP
Opposition", ylab="Census Bureau Estimate of Median Household Income 2011-
2013")
plot(renewperc~cppopp, main="Boxplot of cppopp vs. renewperc", xlab="CPP
Opposition", ylab="Percent of State's Energy Production from Renewable
Energy")
plot(coalprod2014~cppopp, main="Boxplot of cppopp vs. coalprod2014",
xlab="CPP Opposition", ylab="Coal Production by State in short tons")
plot(X2013co2~cppopp, main="Boxplot of cppopp vs. 2013co2", xlab="CPP
Opposition", ylab="Carbon Dioxide Emissions by State in 2013 (million metric
tons)")
plot(natgasprod2014~cppopp, main="Boxplot of cppopp vs. natgasprod2014",
xlab="CPP Opposition", ylab="Natural Gas Production by State in 2014 (million
cubic feet)")

#Examining Data Part 2 - Contingency Tables of Categorical Independent
Variables vs. Response Variable
table(cppopp, rps)
table(cppopp, capandtrade)
table(cppopp, repubgov)

#Initial Model Specifications
glm1 <-
glm(cppopp~statepop2015+medincome+renewperc+coalprod2014+X2013co2+natgasprod2
014+rps+capandtrade+repubgov, family=binomial, data=data)
summary(glm1)
glm2 <- glm(cppopp~renewperc, family=binomial, data=data)
summary(glm2)

#Stepwise Regression
glm0 <- glm(cppopp ~ 1, family=binomial, data=data)
summary(glm0)
```

```
thesis.glm.step <- step(glm0, list(lower=cppopp ~ 1,
upper=cppopp~statepop2015+medincome+renewperc+coalprod2014+X2013co2+natgaspro
d2014+rps+capandtrade+repubgov))

glm3 <- glm(cppopp~capandtrade+renewperc+repubgov, family=binomial,
data=data)
summary(glm3)

#Testing Models for Significance
#glm1
68.994-33.532
49-40
1-pchisq(35.462, 9)
#glm2
68.994-57.082
49-48
1-pchisq(11.912, 1)
#glm3
68.994-36.643
49-46
1-pchisq(32.351, 3)

#Log Odds to Odds Ratio
coef(glm1)
exp(coef(glm1))
coef(glm2)
exp(coef(glm2))
coef(glm3)
exp(coef(glm3))

#One Final Model
glm4 <- glm(cppopp~coalprod2014, family=binomial, data=data)
summary(glm4)
```