THE PATCHWORK QUILT OF CLIMATE CHANGE POLICIES: AN ASSESSMENT OF VOLUNTARY AND MANDATORY GREENHOUSE GAS REDUCTION PROGRAMS

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The Patchwork Quilt of Climate Change Policies: an assessment of voluntary and mandatory greenhouse gas reduction programs

Climate change policy resembles a patchwork quilt of overlapping state, national, and international policies that vary across topic areas and policy tools. This dissertation seeks to make contributions to the understanding of the adoption and implementation of climate change policy across several types of mandatory and voluntary policy including information disclosure requirements and cap-and-trade regimes.

While much is known regarding the adoption of and effectiveness of different types of environmental policies, this dissertation seeks to fill in several gaps in this literature. I provide a quantitative approach to understanding state climate change policy adoption and find that state policy adoption reflects political resources, rather than geographic resources or regional diffusion. In a study of the experience of individual firms within the European Union Emissions Trading Scheme I discuss the uncertainty, complex production processes and transaction costs that limit firms' ability to adapt to carbon regulation. Using a difference-in-differences model to compare several cases of private voluntary and state-run mandatory approaches to climate change policy, I find that private voluntary agreements are associated with improved environmental behavior which likely reflects improved management at firms.

I conclude with observations regarding the relationship between the array of climate change policies. The variety of climate change policies is overlapping and can be complementary. State climate change policies represent laboratories of policy experimentation and demonstrate the potential implementation of national and

international regulation for parts of the economy that are not easily addressed by cap-and-trade programs. Cap-and-trade programs are useful for large point sources, but are inefficient when low-cost strategies are not implemented. Voluntary policies may help firms find low-cost abatement strategies, market themselves as environmental leaders, and help firms better cope with the complexity and uncertainty of greenhouse gas regulation. It is important that policy-makers take advantage of these comparative strengths of different types of climate change policy.

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1. Introduction: The Varied Approaches to Climate Change Policy

1.1. Summary

This chapter seeks to present several approaches to understanding climate change policy as a way to frame the several chapters that follow. I present some basic information regarding climate change as a unique environmental problem, and discuss addressing climate change policy through a policy area approach, a political jurisdiction approach, and a policy tool approach. Each of these approaches helps researchers and policymakers gain a better understanding of why policies are adopted, what policies may look like, and what their impacts might be. This discussion sets up the following chapters that discuss tradeoffs of policy design and approach, and evaluate the effectiveness and efficiency of several approaches to policy.

1.2. Climate Change as a Unique Environmental Problem

Climate change may be one of the most complex and challenging environmental problems faced by human civilization. As an environmental problem, it is extremely complex. The complexity of climate change exists across several dimensions, including the environmental and political characteristics of climate change, as well as the manner in which it is observed and experienced by humans.

1.2.1. Environmental complexity of climate change

Contributors to climate change include thousands of major actors – power plants and manufacturers - to nearly an infinite number of small actors – including individuals and households. Activities that contribute to climate change are extremely varied: they include agriculture and forestry practices, electric power generation, transportation, mining and refining fuels, and the manufacture of steel, cement, paper, glass, and chemicals.

The contributing pollutants to climate change – mainly carbon dioxide, methane, nitrogen oxides, sulfur hexafluoride, perfluourocarbons, nitrogen trifluouride, and hydrofluorocarbons – come from such a wide variety of activities and diverse actors, yet at the same time are generally not observable by individuals. Carbon dioxide and methane are colorless and odorless, making climate change much more difficult to address than environmental problems with clear and apparent causes and sources.

The causes and effects of climate change are removed by geographical location and time, removing the causes of climate change from the consequences. While greenhouse gas emissions occur largely in the industrialized states, the impacts of climate change will be most prominent in Africa and the Pacific Island regions. The most severe impacts of greenhouse gas emissions in the past and present are not likely to be experienced until several decades into the future. Further, the impacts of climate change are not experienced on a daily, monthly, or even yearly basis; rather, the impacts are observed over decades or centuries, making climate change a difficult problem to individuals to experience.

1.2.2. Political complexity of climate change

The environmental characteristics of climate change lead to political complexity. The international political environment is characterized by anarchy, making the international regulation of greenhouse gases essentially a voluntary endeavor for individual states. Because activities that contribute to climate change exist across a variety of political boundaries, and because any international regulation of greenhouse gases must be implemented by national or sub-national actors, the management of greenhouse gases exists in a complex array of local, state, and national laws, regulations, and institutions.

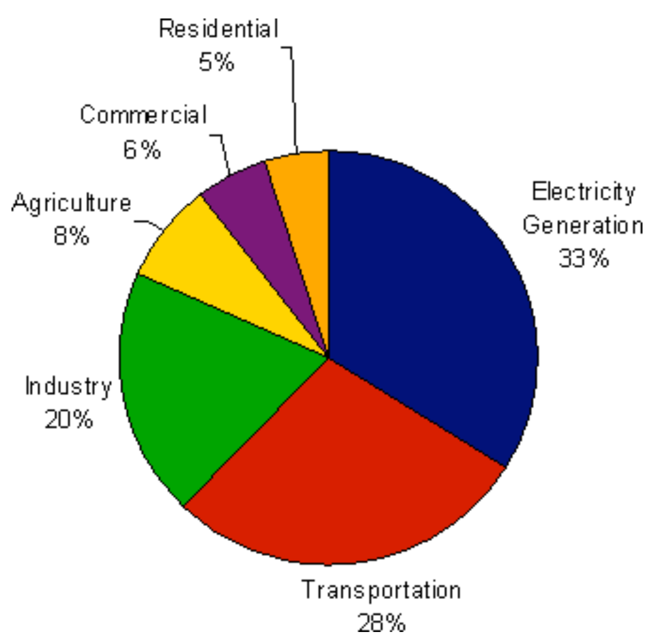
In addition to states, the international economic and political environment is characterized by an increasingly large number of non-governmental organizations, transnational organizations, and transnational corporations, which obscure the traditional role of national governing bodies and the add complexity to international action. Organizations such as the Intergovernmental Panel for Climate Change (IPCC) help coordinate scientific research and a consensus regarding the likely environmental and economic causes and impacts of climate change. The United Nations Framework Convention on Climate Change (UNFCCC) supervises clean development mechanism projects that allow the transfer of carbon credits from developing states to industrialized states. The Carbon Disclosure Project targets publicly traded firms around the globe and encourages them to disclose their carbon emissions, carbon management strategy, and carbon related risks and opportunities, as a step in promoting the improved management of greenhouse gases. And the European Emissions Trading Scheme has evolved as the first multi-national cap-and-trade regime, directly regulating large sources of carbon emissions.

The vast political and environmental complexity of climate change policy has led researchers to conclude that ultimately climate change policy will be composed of a variety of interlocking and overlapping institutions (Victor, House, & Joy, 2005). As a result of the political complexity of climate change, several different typologies have emerged as ways of understanding and categorizing approaches to climate change policy. In the next several sections, I discuss several of these typologies in order to improve understanding of the political and economic characteristics of climate change policy, and how institutions have evolved to address this environmental challenge.

1.3. Policy Areas and Climate Change

It is important to understand that because many varied activities that contribute to climate change, climate change policy spans a variety of policy areas, including agriculture, forestry, transportation, housing and building codes, renewable energy supply, and regulation of fossil fuel combustion for manufacturing or electricity generation (see figure below). Within each of these policy areas, policies can be enacted at the federal, state, or local levels. This section serves to detail what some of these policies look like, in order to improve understanding of the diversity of rules and regulations that already exist in order to improve greenhouse gas management.

Figure 1.1: Sources of Greenhouse Gases in the United States, all gases, 2006 (U.S. Department of Transportation, 2006)



1.3.1. Forestry and Agriculture

Land use patterns can have significant impacts on climate change – both as a source and a sink. Planting and reducing land clearing, can help serve as an important carbon sinks – at least in the short term, and improved agricultural practices – by reducing tilling - can help sequester carbon in the soil.

Between 1850 and 1998, approximate 138 gigatons of carbon (GtC) have been emitted into the atmosphere as a result of the burning of forest ecosystems, representing about one third of the increase of the total carbon emissions during that time period (IPCC, 2000). While afforestation and reforestation can be important carbon sinks and help remove and store carbon from the atmosphere, many difficulties exist that have made policy-makers wary of placing too much emphasis on carbon sequestration (IPCC, 2000). Land-use changes are reversible and impermanent - when land-use change occurs, there is no guarantee that reforested land will permanently remove carbon from the atmosphere. While methods exist that allow the measurement of all forms of carbon storage in forest ecosystems, monitoring may be costly and is currently incomplete, making the implementation sequestration policies extremely difficult (IPCC, 2000).

While afforestation and reforestation has the potential to help reduce climate change impacts, current rates of deforestation create a net balance of 44 to 83 megatons of additional carbon emissions to the atmosphere each year (MtC) among Annex I countries and 1,204 to 1,591 MtC globally per year (IPCC, 2000). IPCC estimates suggest that an additional 289 MtC per year could be sequestered through a moderate improvement in land management practices among Annex I countries, and by about 1,005 MtC per year among non-Annex I countries (IPCC, 2000).

A variety of agriculture and forestry management practices can increase sinks of carbon and other greenhouse gases, and reduce emissions to the environment, until saturation is achieved. Afforestation, reforestation, and the avoidance of deforestation improves net carbon storage for up to 90-120 years (EPA, 2006b). Improved management practices that lengthen the harvest-regeneration cycle and move towards low-impact logging increases sequestration and provides carbon storage that depends on the product life-cycle of products (EPA, 2006b). Conservation or riparian buffers prevent soil erosion and nutrient run-off into waterways; reducing tillage and allowing increased crop residue to remain in the soil after planting can increase the carbon content of soil; and improved grazing land management through rotational grazing can each improve carbon storage for up to 15-50 years (EPA, 2006b). Using crop and forestry wastes can displace the use of fossil-fuels in electricity production or fuel-intensive manufacturing processes (EPA, 2006a).

1.3.2. Transportation

Transportation in the United States represents 28% of total greenhouse gas emissions in the United States, with 97% of those emissions from the direct combustion of fossil fuels (U.S. DOT, 2008). Globally, 11,218 MtC are the result of petroleum combustion, representing 38% of global carbon emissions from fossil fuel consumption (Energy Information Administration, 2006). Transportation accounts for 48% of the increase in U.S. emissions from 1990 to 2006 and 62% of emissions are from passenger cars or from light-duty trucks and SUVs (U.S. DOT, 2008). An additional 20% of emissions are from medium and heavy-duty trucks. Aircraft and non-road transportation each account for 7% of emissions (U.S. DOT, 2008).

A variety of transportation, management, and planning strategies can be used to address greenhouse gases in the transportation sector. Alternative fuels, such as biodiesel, ethanol, electricity, propane, compressed natural gas, and hydrogen may have the potential to reduce greenhouse gas intensity. Alternative technologies to the internal combustion engine, including hybrids, plug-in hybrids, vehicle to grid, and fuel cell vehicles can reduce greenhouse gas emissions but may not be cost-effective. Improved corporate management strategies, by moving corporate fleets towards greater fuel efficiency, have the potential to both reduce costs and greenhouse gas emissions (Environmental Defense Fund, 2008). Ridesharing, transit improvements, HOV lanes, park-and-ride lots, congestion pricing, a compressed work-week, increased telecommuting, land-use planning, improved signal timing, and improvements of pedestrian and bicycle facilities can all help mitigate the contribution of transportation on greenhouse gas emissions. Improved fuel economy standards and increases in fuel taxes are other examples of policy interventions that can be employed to influence fuel use.

1.3.3. Housing and Commercial Buildings

Approximately one third of energy used in the United States is used in commercial and residential buildings, excluding appliances (Krause, 2009). When appliances are included, approximately 39 percent of energy in the U.S. is used in residential and commercial buildings (Ehrhardt-Martinez & Laitner, 2008). With increasing research suggesting that many efficiency improvements can be obtained at negative cost, increased attention has been focused on developing financial incentives and implementing regulations in order to improve the energy efficiency of homes and commercial buildings (Krause, 2009).

A variety of programs can be used to target energy efficiency. Rebates and subsidies, energy audits, labeling programs, efficiency standards, building codes, grants, loans, and certification programs are typical policies enacted in this area that can impact greenhouse gas emissions.

1.3.4. Renewable Energy Supply

Improving renewable energy supply, or replacing fossil fuel consumption with renewable energy can reduce greenhouse gas emissions across an economy. Technologies currently employed include biomass, hydropower, geothermal energy, wind energy and solar energy. Renewable energy can often be deployed at small, medium, or large scales, allowing for distributed generation for electricity, home heating, biofuels, or small-scale wind and solar generation, as well as in power plants. Renewable energy currently comprises approximately 7% of U.S. energy use, and grew 9% from 2000 to 2007 (Baldwin, 2009). Consumption of energy generated from wind, solar, and biomass grew 460%, 21%, and 20% respectively during that time frame (Baldwin, 2009).

Public policy can have significant impacts on the renewable energy supply. Denmark, for example, obtains about 25% of its energy consumption from non-hydro renewable sources (Baldwin, 2009). Spain and Germany have sharply increased their production of renewable energy, averaging 22% and 28% average annual increases in renewable energy since 2000 (Baldwin, 2009). Spain, Denmark, and Germany have renewable energy production quotas, feed-in tariffs that guarantee per kWh prices for electricity sold to the grid, and are included in the ETS, which sets a long-term price signal on carbon.

The United States promotes tax credits for investment in renewable energy, as well as federal interconnection laws, and engages in green power purchasing, and many states have initiatives that provide subsidies, rebates, grants, loans, and production incentives for renewable energy. Likewise, many states have net metering, interconnection, licensing, purchasing, construction, and access laws that promote the use of renewable energy. Renewable portfolio standards, already enacted by 35 states, for example, require utilities to generate a percentage of electricity from renewable sources (DSIRE, 2009).

1.3.5. Industrial production and electricity generation

Approximately 53 percent of greenhouse gas emissions are the result of fossil fuel combustion for the purpose of electricity generation or industrial production. These point sources of production have become the recent target of legislation at the state, national, and international levels. States have chosen to regulate greenhouse gas emissions by requiring disclosure of emissions from large sources. Several states have partnered to form the Regional Greenhouse Gas Initiative (RGGI), or the Western Climate Initiative – regional cap-and-trade approaches to addressing carbon emissions. At the national level, legislation is currently being debated regarding the establishment of a national cap-and-trade system, or a carbon tax.

Internationally, the Kyoto Protocol was an attempt to establish a cap on the industrialized (Annex I) countries, while including less developed countries through a system of offset provisions. In December 2009, meetings in Copenhagen will seek to shape the direction of an international system that regulates global carbon emissions.

The European Emissions Trading Scheme caps carbon emissions across Europe, in accordance with Kyoto targets, and establishes tradable property rights at the facility level. The approximately 12,000 Facilities that are regulated are large industrial facilities, with greater than 10,000 metric tons of carbon emissions per year.

1.4. Federalism and Climate Change

A second way of understanding greenhouse gas regulation is through the political organization of regulation. In a system of international regulation of carbon, interlocking institutions will be required in order to implement carbon reduction goals at the national, state, and local levels.

International approaches to climate change include scientific collaboration through the IPCC, as well as the United Nations Framework Convention for Climate Change. Through this transnational body, the Kyoto Protocol was organized as an international cap-and-trade approach to climate change. Similarly, the Copenhagen meeting in December 2009 is expected to set the direction for international cooperation in the future.

Any international agreement regarding climate change requires national level implementation. In response to Kyoto, The ETS was formed as an EU initiative to address the major industrial sources and include offsets in agriculture and forestry, as well as efficiency improvements in countries outside of the ETS. Individual states remain responsible for addressing carbon emissions in sectors that are not covered by the ETS by promoting incentives, enacting regulations, and implementing standards.

In the United States, the federal government has ceded most authority regarding greenhouse gas mitigation to the states. While the federal government has only modest regulations and incentives across the policy areas to address climate change, a significant amount of activity has occurred at the state level (Rabe, 2002). State action on climate change allows policy experimentation, states to mimic the successful policy experiments of other states, and for each state to tailor climate change policy to its particular strengths (Matisoff, 2008).

At the local level, the United States Conference of Mayors Climate Protection Agreement and The Cities for Climate Protection campaign represent local initiatives designed to stimulate local interest and local action on climate change. While state and local policy action allows policy experimentation, it can also be used to leverage national level action and regulatory change.

1.5. Policy Instruments and Climate Change

A third manner of categorizing climate change policy is the type of action used to address greenhouse gases. Typical policy tools have been characterized as command and control based approaches, market-based approaches, or information provision approaches. Within these broad categories, regulation can be mandatory or voluntary and enacted by government or through non-governmental organizations.

1.5.1. Command and Control Approaches to Climate Change

Command and control approaches to climate change generally include mandates regarding efficiency, how something is produced, or the amount of greenhouse gases that can be emitted.

Mandates regarding efficiency can take place across many policy areas including transportation (through CAFÉ standards) or through building and appliance standards. Mandates regarding the process of production include Renewable Portfolio standards, which mandate a percentage of renewable electricity generation, land management regulations, or specific technology mandates. Regulations regarding the quantity of greenhouse gas emissions could limit specific quantities of greenhouse gas emissions for an individual facility, though in practice, these limits have been set in conjunction with market based initiatives for tradable permits.

1.5.2. Market based instruments and climate change

Market based instruments have become the favored manner in which to address climate change. Market based approaches promise reduced costs to regulation and improved flexibility for firms. Because command and control approaches often dictate how emissions reductions must be achieved, or limit reductions within one sector of the economy, command and control approaches to pollution control may be extremely costly (Portney & Stavins, 2000). Market based instruments allow firms to choose the cheapest manner of emissions reduction and equate marginal abatement costs with marginal emissions benefits (Tietenberg, 2000).

Broadly construed, market based approaches include taxes, subsidies, and cap-and-trade approaches to addressing climate change. Taxes, fees, and fines can be broad – such as a BTU or CO_2 tax, or more narrowly targeted. Carbon or BTU taxes work by setting a price on fuel use or carbon emissions, and allowing firms to decide to reduce emissions or pay a fee for the right to emit pollution.

Subsidies have been popular for encouraging the development of renewable energy, by guaranteeing a minimum price for energy supplied to the grid, tax credits and subsidies for renewable energy development, subsidies for improved land management practices, and subsidies for energy efficiency improvements.

Cap-and-trade approaches have emerged as the most popular way for countries to address climate change. By setting an economy-wide cap of carbon emissions (generally on large emitters), firms can choose the method of carbon reduction and can trade emissions property rights amongst firms (Tietenberg, 2006). This method of carbon regulation is designed to promote flexibility and innovation, while maintaining a specific carbon cap for an economy.

1.5.3. Information Provision Approaches to Climate Change Policy

While command and control and market-based incentive approaches to addressing climate change work by addressing the externalities associated with greenhouse gas emissions, information provision approaches seek to reduce information asymmetry and empower consumers and investors to improve their decision-making.

Information provision approaches can comprise of regulations that require firms to disclose total emissions, regulations that require labeling regarding the energy efficiency of a building or product, or regulations that require firms to disclose the production process of a good, such as electricity. Regulations in the United States require labeling on appliances regarding expected energy costs. The Toxic Release Inventory requires firms to disclose emissions of hazardous pollutants. Eighteen states currently require the disclosure, though not the control, of greenhouse gas emissions from major sources (EPA, 2009). A proposed rule by the EPA seeks mandatory reporting of greenhouse gas emissions by all large sources.

Improved disclosure empowers consumers to choose a product based on how it was produced and what its externalities may be. Similarly, disclosure may allow investors to choose firms that act in an environmentally sustainable manner, or choose firms that cater to consumers with environmentally sensitive preferences. From a firm perspective, improved information and measurement is the first step towards improved management, and simply improving the type and quality of information that is collected may lead to improvements in greenhouse gas management. While information disclosure has been linked with improved management of toxics, it is unclear whether lessons from toxics will apply to carbon, due to the cost of fuel, which is already considered by firms as a cost of production (Morgenstern & Pizer, 2007).

1.5.4. Voluntary Approaches to Climate Change

Voluntary approaches to climate change are not a separate policy tool; however, voluntary approaches have distinct characteristics from mandatory alternatives. Voluntary approaches can incorporate a range of policy tools. Voluntary command and control generally takes the form of a negotiated agreement between industry and government, or a unilateral initiative by industry to reduce emissions or improve environmental performance (Lyon & Maxwell, 2007). Unlike mandatory command and control regulation that may have extremely high costs of compliance, most researchers believe that firms are unlikely to undertake voluntary initiatives if they involve a high cost or if those costs are not offset by reputational gains (Khanna, 2001). Additionally, participation in voluntary policy may serve as an attempt to deflect the implementation or enforcement of more costly mandatory policy (Lyon & Maxwell, 2004).

While some market-based incentives, such as taxes, do not fit well with a voluntary approach, firms can engage in voluntary cap and trade approaches to greenhouse gas reduction. Under the Chicago Climate Exchange, firms contractually agree to participate in a cap and trade program that commits participating firms to jointly reduce one percent of greenhouse gas emissions each year. European states, such as the United Kingdom, experimented with voluntary cap and trade regimes as well, prior to the implementation of the ETS.

Finally, firms can engage in voluntary information provision approaches to addressing climate change. The Department of Energy’s 1605b program encourages corporations, government agencies, non-profit organizations, households, and other private and public entities to submit annual reports of their greenhouse gas emissions, emission reductions, and sequestration activities. The Energy Star labeling program awards top performing products with a labeling acknowledgement. The Carbon Disclosure Project, for example, encourages firms to disclose greenhouse gas emissions and carbon management strategies to investors.

1.6. Evaluating Climate Change Policy

The approaches discussed here broadly summarize the different lenses in which policy-makers and researchers have used to answer questions about climate change policy. This list of approaches helps identify research questions that will lead researchers to understand why climate change policy is adopted, whether or not it is effective, how efficient it is, and what the tradeoffs are amongst competing policy approaches. A lot of work has been conducted in the area of climate change policy – it has even generated a journal dedicated solely to the topic. Thus, it is important to be able to identify what researchers know and understand about climate change policy, and what gaps must be filled in.

Several studies have been conducted regarding why firms join voluntary environmental policies; numerous studies have looked at the design and implementation of the European Union Emissions Trading Scheme; several studies have begun to describe state and local approaches to climate change policy; and lessons from the experience in other environmental policy areas, such as sulfur dioxide and the broader literature regarding voluntary initiatives can inform policy debates regarding climate change.

This dissertation seeks to fill in several gaps in this literature. First, I provide a quantitative approach to understanding state climate change policy adoption. Second, while several studies have examined the effectiveness of specific mandatory or voluntary environmental programs, few (if any) studies have compared the empirical results of mandatory and voluntary approaches to policy, or have compared the impacts of different policy instruments within voluntary policy. Third, I examine private voluntary approaches to climate change policy, which may provide different insight and impacts from public voluntary agreements, which have received most of the attention in the academic literature. Fourth, I seek to uncover the motivations for and implications of firm decision-making under cap-and-trade regulation.

In order to accomplish these goals, I present a series of chapters that each focus on a different aspect of climate change policy. I have attempted to order the chapters in order to tell a coherent story regarding the adoption, design, and impact of different types of climate change regulation. However, each chapter is designed to stand on its own as well.

Chapter two describes state approaches to climate change policy – seeking to explain whether states take advantage of their geographical resources when developing climate change policy. This paper links state developments in energy efficiency and renewable energy with climate change policy, and will give readers a better understanding of state action and climate change policy. It also provides a strong quantitative approach to explaining state adoption of climate change policies, which had been missing from the academic debate regarding climate change.

The second paper (chapter 3) examines the micro-foundation of the EU experience in more detail. Using firm interviews, I describe firm decision-making in regulated firms in the EU and highlight how uncertainty, transaction costs, and the bounded rationality of decision-makers in firms impacts firm behavior. This analysis helps researchers and policymakers understand how firms respond to cap-and-trade regulation – especially when observed behavior does not match theoretical expectations from the rational model. This research highlights firm difficulties in maximization under uncertainty and under complex cap-and-trade regulations and suggests modifications to cap-and-trade regulation and implementation as ways to minimize difficulties with this policy instrument.

The third paper (chapter 4) compares the effectiveness and efficiency of two voluntary approaches to addressing climate change policy – the Chicago Climate Exchange, a cap-and-trade approach, and the Carbon Disclosure Project, an information provision approach. Using a unique dataset from which I was able to calculate carbon dioxide emissions from fossil fuel combustion, I am able to measure plant-level emissions reductions associated with voluntary program participation, and I am able to measure the costs in achieving those emissions reductions.

The fourth paper (chapter five) compares the effectiveness and efficiency of mandatory and voluntary information disclosure programs. The Carbon Disclosure Project serves as a voluntary information disclosure program while several states, such as Wisconsin, have implemented mandatory carbon reporting. Using a unique dataset with plant level data, I am able to calculate the carbon dioxide emissions from fossil fuel combustion from powerplants in the United States, and calculate the impact of voluntary and mandatory information disclosure programs.

Chapter 6 examines the comparative impact of voluntary and mandatory programs, and propose several directions for further research, based on the evidence presented in this dissertation and other research in this area.

I conclude with a short discussion of how these pieces fit together to give a better understanding of climate change policy effectiveness.

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2. The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Regional Diffusion or Internal Determinants?

2.1. Abstract

This paper draws upon policy innovation literature and quantitatively explains the adoption of state climate change policies, leading to a broader question – what makes states more likely to adopt policies that provide a global public good? First, existing empirical evidence relating to state climate change policy adoption is reviewed. Following this brief discussion, several analytic approaches are presented that test specific hypotheses derived from the internal determinants and regional diffusion models of policy adoption. Policy diffusion is tested as a function of the motivations, resources, and obstacles of policy change. Motivations for policy innovation include environmental conditions and demands of citizens. Resources include state financial and geographic resources, such as wind and solar potential. Obstacles include a state's reliance on carbon intensive industries such as coal and natural gas. The results show that internal factors, particularly citizens' demands, are stronger predictors of states' policies than are diffusion effects from neighboring states.

2.2. Introduction

Over the past several years, while the debate has raged over climate change policy at the national and international level, U.S. states have begun to adopt a wide variety of policies that may reduce greenhouse gas (GHG) emissions. While receiving substantial attention in the popular press, state adoption of climate change policies have been relatively ignored in the large body of climate change policy literature (Rabe, 2004).

Climate change programs are not simply cap and trade programs, but rather, can encompass a wide array of activities. State climate change policies may take a wide variety of forms including energy efficiency programs, financial incentives for renewable energy sources, financial incentives for alternative fuels, or regulations targeting the transportation or electricity generation sectors. Climate change policies may be adopted to address a specific public bad, such as air pollution, producing a positive externality of GHG reduction. Other programs attack GHG emissions more directly by promoting carbon accounting and methane recovery, or seeking to implement a regional carbon-trading program. One specific type of energy regulation that has become increasingly popular, Renewable Portfolio Standards (RPS) requires that a percentage of electricity generated or purchased in the state must come from renewable sources.

The heterogeneity of programs makes it unlikely that a single model can describe the adoption or effectiveness of all of these programs. Because of this heterogeneity, I focus specifically on energy efficiency and renewable energy policies, which represent a prominent sector of state policy activity to address climate change. I develop a parsimonious internal determinants model that predicts and explains the adoption of state climate change policies in the area of energy efficiency and renewable energy, based on the motivations for policy adoption, obstacles to policy adoption, and state resources.

The internal determinants model incorporates a variety of factors but does not allow me to test for regional diffusion. In order to test competing theoretical explanations of state policy adoption, I perform an event history analysis of renewable portfolio standards (RPS), determining whether state characteristics or regional diffusion leads states to adopt this important kind of energy regulation.

This paper draws upon policy adoption theory to explain the adoption of state climate change policies, leading to a broader question – what makes states more likely to adopt policy change, especially with policies that lead to global positive externalities? Previous studies have identified two models that explain state policy adoption.

The internal determinants model explains policy adoption as a function of state characteristics. According to this model, states innovate and adopt policies according to their endowments of attributes and resources. These attributes and resources may serve as motivations for innovation and adoption or they might be impediments towards innovation and adoption. Policy outcomes are a function of state motivation to innovate and obstacles of innovation (Mohr, 1969). In the context of climate change policy, these characteristics may include major public problems such as low air quality, important industries to the state, state energy consumption patterns, the availability of alternative energy resources, and the political ideology of the public regarding the role of government in shaping individual energy consumption choices.

The alternative model of state policy innovation and adoption is the regional diffusion model. According to this model, states view neighboring states as laboratories for policy experimentation (Elazar, 1972). State officials attend conferences and share ideas with neighboring state officials. Through these mechanisms, states emulate their neighbors by adopting similar policies.

These models of policy adoption need not be mutually exclusive. Alternative policy change models exist that incorporate a variety of internal political factors, external political factors, and policy specific factors (Ringquist & Garand, 1999). Indeed, states may emulate their neighbors because they share similar geographical, economic, and political characteristics. Likewise, public opinion and uncertainty regarding the effects of a proposed policy or program provides an impediment towards policy adoption (F. Berry & Berry, 1990). The information gained by observing neighboring states serves as a resource that states can draw upon to help implement a new policy.

Over the course of this paper, I first discuss existing empirical evidence relating to state climate change policy adoption. Following this brief empirical discussion, I explain my approach in the context of state policy adoption theory and present two models that allow me to test specific hypotheses relating to the internal determinants and regional diffusion models of state policy adoption. I estimate my internal determinants model of policy adoption and provide a path analysis of this model. After a discussion of results, I present a second, more specific model that describes the adoption of renewable portfolio standards as an integrated model of internal determinants and regional diffusion. I conclude with a discussion of these models and provide directions for further research.

2.3. State Innovation in Climate Change Policy

Despite the enormous amount of attention paid towards climate change policy at the global and national levels, the United States has done relatively little to address climate change at the national or international levels. Under George W. Bush, the United States removed itself from the Kyoto Protocol, opting to address climate change through voluntary mechanisms. While alternative international measures are under discussion, and possible mandatory initiatives are under discussion in Congress, for the moment, it appears that the United States will address climate change on a voluntary basis, and leave mandatory policy innovation to the states (Rabe, 2004). While inertia in Congress leaves little hope for a strong national policy, states have been increasingly active in promoting energy efficiency and renewable energy programs, and have even begun to explore possibilities for Kyoto-style cap and trade systems. Even if the United States were to approve national legislation to address climate change, it appears that much of the foundation for reducing greenhouse gas emissions will remain at the state level. Because of this trend, the importance of understanding state policy innovation in the area of climate change has grown.

States have taken numerous efforts to address climate change through a variety of policies. Indeed, every single state has at least one program designed to increase energy efficiency or promote renewable energy. Numerous states have greenhouse gas goals as well. California has led the way with AB 32, which requires a 25 percent cut in greenhouse gasses by the year 2020 (Tribble, 2007). The New England Governors released an action plan in 2001 which calls for a 10 percent reduction in greenhouse gasses below 1990 levels by 2020 (Regional Greenhouse Gas Initiative, 2007). New York State's energy plan requires a 5 percent reduction in greenhouse gas levels by 2010 and a 10 percent decrease below 1990 levels by 2020 (Regional Greenhouse Gas Initiative, 2007). In addition, California is now considering a Kyoto-style cap and trade system to complement its stringent goals (Tribble, 2007), and the Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by nine mid-Atlantic and northeastern states to establish a carbon trading program from regional power plants in order to help states reach individual goals (Regional Greenhouse Gas Initiative, 2007).

State action in climate change policy has been increasingly documented through the work of non-governmental organizations such as the Pew Center on Global Climate Change, as well as through anecdotal evidence in the popular media. In addition, Rabe (2004), in conjunction with his work at the Pew Center, discusses the increasing state role for addressing climate change. He notes that factors encouraging climate change policies cut across traditional partisan divides and argues that state initiatives are shifting focus to what is politically, economically, and technically feasible (Rabe, 2004). Despite attention paid to the state climate change policy issue, little quantitative work has examined the adoption of these policies.

Of the dozens of studies that have been conducted regarding state policy adoption, relatively few have specifically examined climate change policy or energy policy, or other goods that might provide a global positive externality. Regans (1980) examines state adoption of energy policies, concluding that internal determinants played an important role in policy diffusion. In contrast, Freeman (1985) examined energy policy through legislators' policy decisions, through survey data, and concluded that state legislators look towards neighboring states for policy ideas. While these two conclusions are not mutually exclusive, as discussed above, they signify a need for additional research. In particular, with the growing trend of state-led climate change policy implementation, it is increasingly important to understand when and why states choose to adopt climate change policies.

Indeed, states have pursued a wide variety of policies that have implications for climate change (Rabe, 2004). Jaffe, Newell and Stavins (1999), as well as Fischer and Newell (1999, 2003) discuss the displacement of CO_2 by various energy policies (Fischer & Newell, 2003; Jaffe, Newell, & Stavins, 1999). Energy efficiency programs seek to reduce the amount of electricity used by industry and consumers. Renewable forms of electricity such as solar and wind have been promoted through financial incentives as well as mandatory regulations. Alternative transportation fuels, as well as reductions in automotive traffic have been promoted through financial incentives and mandatory regulations. Programs exist that promote reforestation, carbon accounting, no-till agriculture, methane recovery, waste to energy programs, and mandatory caps on carbon emissions from utilities.

This wide variety of programs represents a unique trend in climate change policy. Because of the varied approaches for addressing climate change policy, and because of interconnection with other salient policies, climate change policy is frequently a positive externality of other policy initiatives. For example, no-till agriculture may primarily address soil erosion, but may have the effect of sequestering carbon. High occupancy vehicle lanes may primarily address traffic, but may also improve air quality and reduce carbon emissions. Of the policies that address climate change, relatively few of these policies directly address carbon emissions. Nevertheless, an approach to address climate change is likely to be comprised of a large number of individual policies at all levels of government, making it important to understand why these policies are adopted (Victor, House, & Joy, 2005).

2.3.1. Renewable Energy and Energy Efficiency Programs

Energy efficiency and renewable energy policies adopted by the states have become increasingly popular in the past several years. While states adopted energy efficiency programs in the 1970's and 1980's to address rising energy costs and the oil embargo, the number and breadth of these programs has risen sharply in the past decade, as concerns regarding climate change and energy security have grown. This growth directly coincides with our recognition of climate change as a problem, making it reasonable to equate policies that promote energy efficiency to climate change policies.

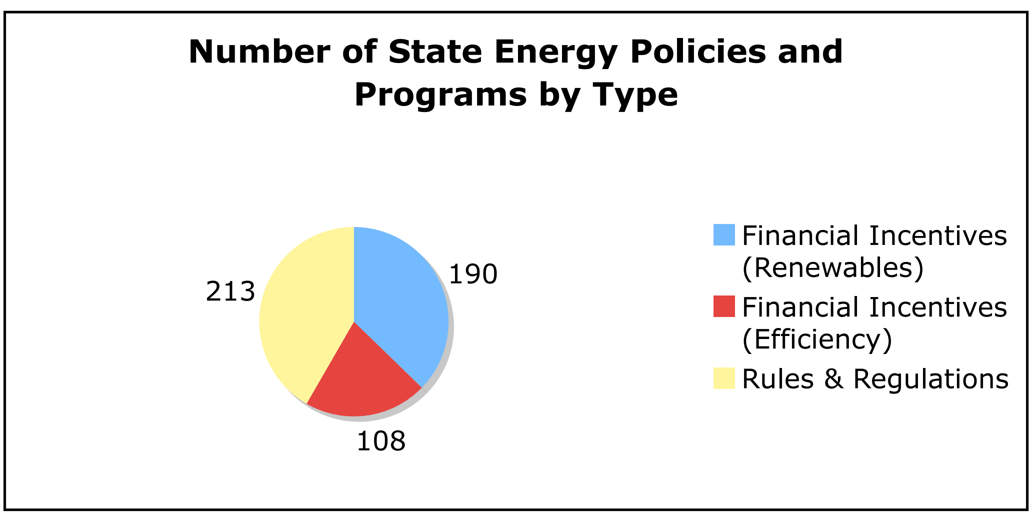
Renewable energy programs contain financial incentives as well as regulations to promote the use of renewable energy sources. In addition to federal subsidies, many states provide tax exemptions for renewable energy equipment. They provide loan incentives for renewable energy production, and rebate programs for renewable energies. Regulatory policies benefiting renewable energy sources include renewable portfolio standards (RPS) that mandate a percentage of electricity that must be produced through renewable sources. Net metering and interconnection laws require utilities to meter and purchase renewable energy from small or even household generators. Generation disclosure laws provide consumers information regarding the energy source of purchased electricity. Solar access and easements laws provide for special property rights for solar panels.

Energy efficiency incentives and regulations also contain many provisions to bolster energy efficiency. Public benefits funds are established to promote energy efficiency throughout a state. Loans, rebates, and tax deductions are often provided to promote the purchase of energy efficient appliances. Green building programs provide incentives for resource efficient building materials and construction techniques. Building and construction codes mandate standards for energy efficiency in buildings. Table 1 describes a typology of state energy efficiency and renewable energy programs and figure 1 demonstrates the distribution of these types of programs in the United States.

Table 2.1: A Typology of State Energy Efficiency and Renewable Energy Programs

A Typology of State Energy Efficiency and Renewable Energy Programs	
Category of Program	Examples
Financial Incentives – Renewables	Tax exemptions for equipment; loan incentives, subsidies
Financial Incentives – Efficiency	Tax exemptions for efficiency upgrades, loan incentives, subsidies for energy audits, public benefits programs
Rules and Regulations	Renewable portfolio standards, net metering, solar easements, power generation disclosure, building and

Figure 2.1: The Number of State Energy Policies and Programs by Type



In the academic literature, many of these types of programs have been relatively ignored while several specific energy policies have garnered much attention. In particular, RPS, public benefit programs and renewable energy programs have drawn attention from scholars. In large part, these studies focus on the variety of types of these policies, their funding (in the case of public benefits programs) and their effectiveness as a function of program characteristics(Bird, et al., 2003; Langniss & Wiser, 2003; Rader, 2000; Wiser, Porter, & Grace, 2005). Research has discussed these programs in relation to climate change policy, and these policies have been evaluated individually. This paper quantitatively assesses motivations for adoption of energy policies and climate change programs. While RPS standards have been evaluated qualitatively, they have not been evaluated quantitatively with respect to motivations for adoption nor effectiveness.

2.4. Approach & Theory

In this section, I briefly discuss the two major perspectives for state policy adoption theory. After this review, I lay out my approach with a discussion of my modeling choice and the measurement of the two dependent variables employed by the models. Third, I detail the specific testable hypotheses in the context of state climate change policy, as well as the measurement of the independent variables used to test these hypotheses.

2.4.1. Policy Adoption Theory

State policy adoption theory has been generally characterized by two perspectives. The internal determinants model explains state policy adoption as a function of state political and economic characteristics (Canon & Baum, 1981; Glick, 1981; Gray, 1973; Regans, 1980; Walker, 1969). This model is generally tested through cross-sectional regressions and considerable empirical evidence has supported this theory.

Within this model, there are several different strategies for isolating the political and economic characteristics that lead to policy adoption by states. Typically, the dependent variable is a measure of how early a state adopts a policy among a group of potential adopters, or whether or not a state has adopted a policy. Nevertheless, some methodological problems are associated with this cross-sectional approach. Because policies are adopted over a long time period, some policies become more temporally removed from the measurement year of the independent variables. Depending on the temporal variation of the explanatory characteristics, results can be problematic (F. Berry & Berry, 1990).

The other major school of policy diffusion research has focused on regional diffusion of state policies, as states are likely to observe policy experimentation by their neighbors and implement successful policies in their own state (F. Berry, 1994; F. Berry & Berry, 1990; Canon & Baum, 1981; Mintrom, 1997; Walker, 1969). According to this research program, bureaucrats attend regional conferences and share ideas with neighboring states much more frequently than they do with distant states. Programs such as the Regional Greenhouse Gas Initiative or the Western States Climate Change Initiative exemplify the regional diffusion hypothesis.

The state of the art approach for testing both regional diffusion and internal determinants is an event history analysis, which uses panel data to combine both the cross-sectional approach of the internal determinants model, and the regional diffusion approach (F. Berry, 1994; F. Berry & Berry, 1990; Mooney, 2001). This approach recognizes the previous observations and contributions of a variety of researchers who have acknowledged that policy diffusion is a function of motivations to implement policy change, resources to allow policy change, and obstacles that can prevent policy change (Elazar, 1972; Mohr, 1969; Walker, 1969).

2.4.2. Approach

In order to address the research question – what motivates states to adopt climate change policies, I measure two different dependent variables and employ two models.

I test the internal determinants model by measuring the absolute number of energy efficiency and renewable energy policies adopted by each state between 1990 and 2007. This cross-sectional analysis allows me to test the motivations for policy adoption across an entire class of state climate change policies, giving a better understanding of how internal determinants may affect the adoption of many types of state climate change policies. While the absolute number of policies is not a measurement of overall policy strength, it is a measurement of regulatory activity, and an indicator of how much policy activity takes place in the states. Unfortunately, this modeling choice does not allow me to test the regional diffusion model of policy adoption against the internal determinants model.

In order to test the internal determinants model of state policy adoption against the regional diffusion model, I conduct an event history analysis. To complete this, I must limit the analysis of climate change policies to one specific type of policy. *For the event history analysis, I measure whether a state adopts a renewable portfolio standard in each year between 1997 and 2005.* A more complete discussion regarding specific choices in measurement and estimation will follow in the specific discussion for each model.

2.4.3. Independent Variables and Hypotheses

In the federal system, states have the freedom to experiment and implement innovative policies that take advantage of their specific attributes, leading to the internal determinants model of state policy adoption. Because climate change policy is embedded within transportation policies, energy policies, and land use policies, I expect that states are motivated to adopt policies in order to address other state problems. In this context, climate change action is a positive externality of action addressing other public bads. In the area of energy efficiency, I expect that the motivation for energy efficiency and renewable energy adoption will primarily be due to the motivation to improve air quality and reduce criteria air pollutants. I employ two different measurements of air quality in this work. The first measurement is simply the total state criteria air pollutant emissions per capita in 1990 as a proxy for state air quality in 1990.[1] Second, using the AIR reporting database on the Environmental Protection Agency's website, and census information regarding county populations, I calculate the average percentage of a state's

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[1] Data for non-attainment counties are not available for the 1990 baseline, while total emissions are not available through 2005. Thus, for the cross-sectional model explaining total energy policy adoptions we use total criteria air pollutants per capita from the National Emissions Inventory (Environmental Protection Agency, 2007a). For the event history analysis of renewable portfolio standards, we use the county non-attainment database, which more accurately represents a state's motivation to adopt RPS standards (Environmental Protection Agency, 2007b).

population living in a non-attainment area for the six major criteria air pollutants.[2] I expect that the greater the percentage of a state's population that is living in areas of poor air quality, the greater the likelihood for the adoption of renewable energy programs.

> *H_1: States with lower air quality will implement more energy efficiency and renewable energy programs and policies.*

Other attributes of states may provide impediments to policy adoption. Special interest groups – especially those representing powerful industries – may hold considerable sway over state policymaking efforts. In contrast to the interest group liberalism model, which posits that a wide variety of special interests will tug at national policy (Lowi, 1979), a smaller number industry groups may hold considerable sway over policy-making efforts at the state level (Ringquist & Garand, 1999). In the context of energy policy, I expect that states that have a greater reliance on carbon intensive industries will be less likely to implement energy efficiency and renewable energy policies. In particular, in the United States, the majority of electricity production is derived from the combustion of coal and natural gas. States that produce coal and natural gas should be less inclined to implement energy efficiency and renewable energy policies in order to protect local industries. In contrast, a state may anticipate future mandatory regulations from the national level and attempt to act early. However, in the time frame of this study, mandatory action does not seem to be a credible threat. The two measurements I use to measure a state's dependency on carbon-related industry are

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[2] The six major criteria air pollutants include NO_x, SO_2, CO, Pb, 1 hour Ozone, and PM-10. The standards for 8-hour Ozone and PM-2.5 do not come into effect until after the range of this study.

carbon intensity and natural gas and coal production. The carbon dioxide intensity of a state is measured in tons per thousand of real 2000 chained dollars of Gross State Product (GSP). Carbon dioxide emissions data was collected from the Energy Information Agency (Energy Information Administration, 2007). Coal and natural gas production was collected from the Energy Information Agency and is measured in thousands of BTU/capita (Energy Information Administration, (multiple years)).

> *H_2: States that have higher carbon intensive economies will be less likely to adopt renewable energy and energy efficiency programs.*
>
> *H_3: States that produce more coal and natural gas will be less likely to adopt renewable energy and energy efficiency programs.*

State policy adoption is a function of political and economic resources as well. The political-economic characteristics of a state may be many of the most important causes of policy change at the state level (Ringquist & Garand, 1999). Specifically, wealthier states may be more apt to partake in policy experimentation due to the ability to implement costly public programs. Second, the ideological position of the citizens of a state is often the most important determinant and functions as a political resource of state policy action (Ringquist & Garand, 1999). In the context of state energy policies, I expect that states with a higher income level will be more likely to implement climate change policies. I also expect that states with more liberal citizen bases will be more likely to support government intervention to change energy consumption behavior and thus will lead to more energy programs. I approximate state financial resources using GSP per capita. This figure was calculated using Bureau of Economic Analysis Data for GSP (Bureau of Economic Analysis, 2006), and population data from the Census Bureau (U.S. Census Bureau, 2007). Data are measured in real 2000 chained U.S. dollars per capita. I estimate the ideology of a state's citizens using Berry and others' citizen ideology index, which seeks to measure the mean position on a liberal-conservative continuum of the "active electorate" in a state, which is scaled from 0 (conservative) to 100 (liberal) (W. D. Berry, Ringquist, Fording, & Hanson, 1998). This measurement also functions as a proxy for other political characteristics of states, such as the party control of the state legislature, and is preferred over other measurements of state liberalism because it is a continuous, dynamic longitudinal measure of the mean state ideology. In addition it is sensitive to the difference between a minimal and overwhelming legislative majority, and variation in parties' ideological positions across states. This index is constructed by weighting the ideology of the district's incumbent by the support they received and adding it to the weighted ideology of the state's average opposition party representatives.

> *H_4: States with greater income per capita are more likely to adopt energy efficiency and renewable energy programs.*
>
> *H_5: States with more liberal citizens are more likely to adopt energy efficiency and renewable energy programs.*

In addition to state political and economic resources, states have unique geographical resources that may allow them to pursue more renewable energy programs. In particular, high amounts of wind and solar resources should allow states to pursue a greater number of renewable energy programs and may encourage a state to pursue more energy efficiency programs as well. Wind potential is measured as the total percentage of U.S. electricity consumption that could be produced by state wind generation. This calculation assumes the utilization of all high quality wind at 30 meters hub height, with

25 percent efficiency, and 25 percent losses (Elliot & Schwartz, 1993). Solar potential is coded as annual average global radiation for each state (kWh/M^2/day).[3]

> *H_6: States with higher wind generation capacities are more likely to adopt energy efficiency and renewable energy programs.*
>
> *H_7: States with higher solar generation capacities are more likely to adopt energy efficiency and renewable energy programs.*

In order to test regional diffusion against the internal determinants model of state policy adoption, I measure the percentage of neighboring states that have adopted a renewable energy portfolio standard. Neighboring states serve as a laboratory for policy experimentation. Neighboring states may have many similar political, geographic and economic characteristics, and serve as a resource for states considering policy change. As the percentage of neighboring states that have adopted a policy increases, I expect that a state is more likely to adopt a policy. Indeed, a simple glance at the states that have adopted renewable portfolio standards seems to indicate regional clustering as indicated in figure 2. Nevertheless, many states that are geographically close also have similar internal characteristics. Statistical analysis will allow me to separate the independent effects of internal characteristics and regional diffusion.

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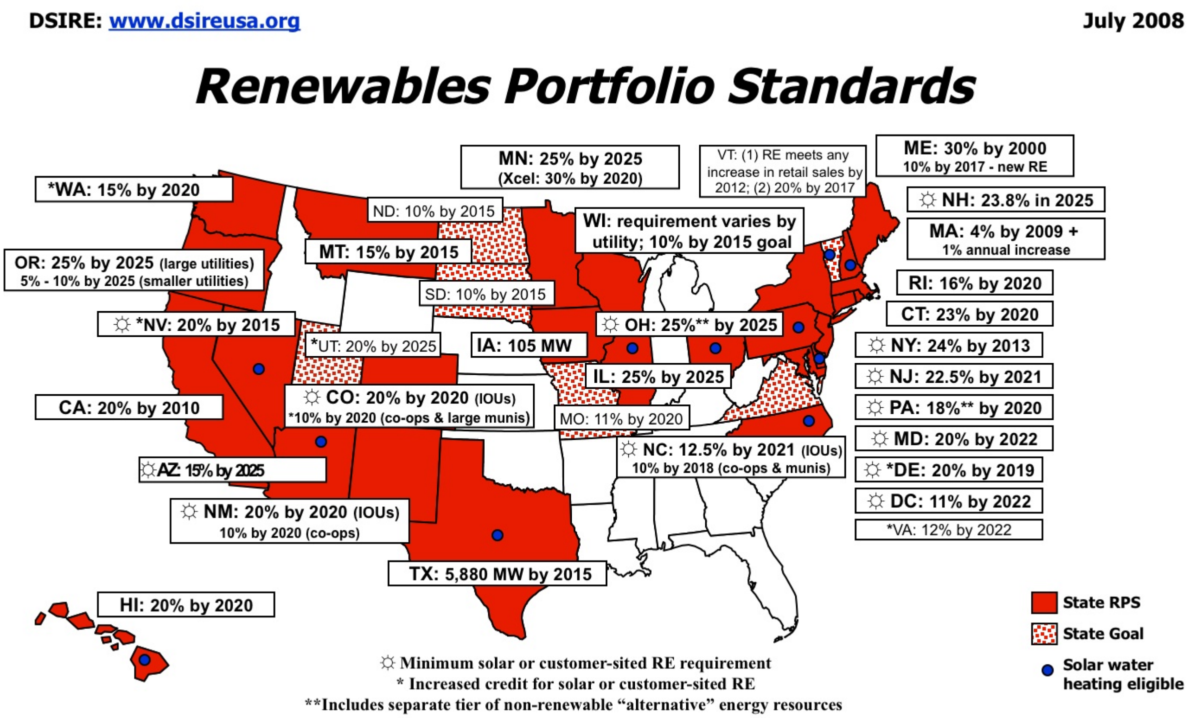
[3] This data was received from the EPA directly via personal communication. It is based on the 1961-2000 National Solar Radiation database from the National Renewable Energy Laboratory, Golden, Colorado.

Figure 2.2: Map of state Renewable Portfolio Standards



(source: N.C. Solar Center at NCSU and DSIRE - www.dsireusa.org)

H_8: States are more likely to adopt a particular energy policy if the neighbors of that state have already adopted a similar policy.

In order to test these competing theories, I will employ two models to test these hypotheses on all state renewable energy policies and energy efficiency programs and on a smaller subset of RPS policies. First, I use a cross-sectional analysis to determine which characteristics of the internal determinants model most importantly influence the adoption of state climate change policies. This cross-sectional analysis allows me to gauge relative policy activity among the states and look at a time period long enough to establish cause and effect relationships in the policy process (Mazmanian & Sabatier, 1989). This model will also establish the external generalizability of second part of the study and perform a path analysis establishing causal effects. Because of the heterogeneity of the types of policies included in this cross-sectional study, I cannot test for regional diffusion using this model, and there may be concerns of internal validity.

Second, using a cross-sectional time series model, I narrow my focus to renewable portfolio standards and test the regional diffusion explanation against the internal determinants model using an event history analysis. While the first model provides external generalizability, this second model provides more internal validity. The time series model approximates unit homogeneity by reducing the sample to RPS standards and accounts for alternative theoretical explanations, such as regional diffusion. Using both models allows us to gain a much clearer understanding of the causes of state climate change policy innovation.

2.5. Estimation of the Internal Determinants Model

For the internal determinants model, independent variables were measured from 1990, for each of the contiguous 48 states. The 1990 baseline represents the date that the first Intergovernmental Panel on Climate Change report was released, concluding that global climate change was likely caused by human behavior. Beginning in 1990, state agencies have kept track of greenhouse gas emissions and their efforts to combat them. Using data from 1990 also establishes temporal antecedence. While several policies were adopted prior to 1990, the vast majority of policies have been adopted since 1990, removing the effects that these policies may have had on the independent variables (such as air quality). While it is difficult to attribute the incidence of policies in 2004 to characteristics measured in 1990, for the most part, many of these characteristics have not changed dramatically since 1990, and public policy literature recommends a period of longer than 10 years to evaluate major policy change (Sabatier & Jenkins-Smith, 1999).

Alaska and Hawaii are excluded because they have no neighboring states, and cannot have a regional diffusion effect. In addition, Alaska has a variety of characteristics that make it unique. In particular, its enormous oil industry makes it an outlier with respect to gross state product, political ideology, and other measures. Finally these two states were not included in the study of wind potential, making data incomplete for these two states.

For each of the contiguous states, the number of energy efficiency programs and renewable energy programs was collected from the Database of State Incentives for Renewable Energy (Interstate Renewable Energy Council, 2006). These programs are divided into three categories: financial incentives for renewables, financial incentives for energy efficiency, and rules, regulations and policies. These categories will be used to test the robustness of the model for the different types of energy programs.

Our internal determinants model serves to estimate the independent effects of seven characteristics on the number of energy policies a state has adopted to address carbon dioxide emissions.

$$Y=\alpha+\beta_1X_1+\beta_2X_2\ldots\ +\beta_7X_7+\varepsilon$$

This model can be estimated as a negative binomial count model, or as an ordinary least squares regression. Because the counts range from two programs in a state to 30 programs in a state, it may not be necessary to use a count model. In addition, with only 48 states to consider, OLS offers a variety of benefits over maximum likelihood regression, because of the large-n assumptions required of maximum likelihood. Because MLE is only asymptotically unbiased, a sample size of 48, with seven regressors is not likely sufficient. Instead, however, I use bootstrapping, a resampling method that allows for consistent, unbiased parameter estimates for MLE from a small sample (Mooney & Duval, 1993). I estimated the model with both an OLS and a bootstrapped negative binomial specification, generating similar results. In addition two specifications of each estimation technique are presented in table 4 in order to demonstrate the effects of creating a renewables index from the solar density and wind potential variables by adding the z-scores of each of the state's solar densities and wind potentials.

Because the dependent variable is a sum of three different counts, it is necessary to check the robustness of the model for each of the three types of state energy programs or regulations. I ran bootstrapped negative binomial models for each of the three different counts: renewable energy financial incentives, energy efficiency financial incentives, and energy rules and regulations. I dropped wind potential and solar potential as explanatory variables for energy efficiency financial incentives, as these programs are unrelated to generation of electricity from wind energy. As demonstrated in table 2, all three of these models are significant at the $\alpha = .05$ level for the model, and all signs on parameter estimates are the same.[4]

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[4] I attempted to expand the population to include other types of climate change policies, and while the model as a whole was significant, if the population was reduced to these individual segments, the model would not have been robust for the transportation policies segments.

Table 2.2: Two models regressing state characteristics on total number of energy policies. Parameter estimates are shown, with standard errors in parentheses. (48 Observations)

Model	OLS	OLS	Neg-bin bootstrap (500 reps)	Neg-bin bootstrap (500 reps)
F Statistic	7.15***	8.42***		
Wald Chi Squared			37.48***	43.46***
R-Squared	.56	.55		
GSPPC	.2e-04 (.2e-04)	.2e-03 (.2e-03)	.3e-04 (.3e-04)	.2e-04 (.2e-04)
CO_2Intensity	-2.25 (1.90)	-4.60 (2.57)*	-.204 (.359)	-.412 (.316)
Coal & Gas PC	1.06e07 (9.51e-07)	2.8e-07 (8.93e-07)	-3.38e-08 (3.97e-07)	-2.13e-08 (3.31e-07)
Criteria Air Pollutants PC	5.54 (3.10)*	4.34 (2.25)*	.576 (.456)	.508 (.336)
Citizen Ideology	.357 (.075)***	.370 (.07)***	.031 (.007)***	.031 (.007)***
Solar Density	1.82 (1.87)		.166 (.192)	
Wind Potential	-.089 (.155)		-.0058 (.025)	
Renewables Index		1.88 (1.85)		.173 (.196)
Constant	-25.25 (12.92)*	-22.67 (12.00)*	-1.09 (1.62)	-957 (1.34)

* represents significance at the $\alpha = .1$ level
** represents significance at the $\alpha = .05$ level
*** represents significance at the $\alpha = .01$ level

Discussion of Internal Determinants Model

The OLS model produces a surprisingly large amount of explanatory power. The full model is highly significant as a whole, with an F statistic of 7.15 and an R squared values of .56, representing that 56 percent of the variation in the number of state energy efficiency and renewables programs can be explained through these seven explanatory variables. Combining the solar density and wind potential variables into a renewables index does not have much of an effect on results.

Nevertheless, despite the strong significance of the model as a whole, it is necessary to examine the individual parameter estimates. As expected, GSP per capita, and citizen's ideology are positively correlated with an increase of climate change programs. The measurement of citizen ideology is the only significant variable at the .05 or .01 levels, suggesting that citizen preferences drive state policy decisions more than geographic, environmental, or political characteristics.

As citizen ideology increases by approximately three points in the Berry and others index, a state is likely to implement one more climate change mitigation program. This parameter estimate supports our hypothesis earlier that states with more liberal populations are more likely to adopt climate change policies, indicating the high salience of energy issues with the public.

The positive correlation of GSP per capita indicate that, as expected, as government institutions become more liberal, and as wealth increases, states are likely to implement more climate change mitigation programs.

The parameter estimate for carbon dioxide (CO_2) intensity is negative, though is only statistically significant in the reduced-form OLS regression. This supports the hypothesis that states may seek to protect carbon intensive industry, rather than encourage them to reduce carbon dioxide in order to meet expected carbon emissions requirements.

In these two model specifications, coal and natural gas production does not appear to be correlated with energy efficiency programs. This lack of significance for this parameter is likely due to the strong collinearity between coal and natural gas production and carbon dioxide (CO_2) intensity. If either CO_2 intensity or coal and gas per capita are dropped from the model, either variable becomes statistically significant and negative, demonstrating states' desires to protect local industries and a decrease in the likelihood of implementing climate change mitigation programs, all other factors remaining constant.

A path analysis conducted below will illuminate the extent to which coal and gas production may have an indirect effect on state energy program adoption. These findings support the idea that state policy adoption is heavily influenced by political considerations.

These results suggest that states may adopt climate change policies in order to address other environmental concerns; however, results for this parameter are not robust across the two specifications. In the OLS specification, the parameter estimate on criteria air pollutants is large, positive, and significant, with a p value of .08 and a parameter estimate indicating that a 1 ton increase of criteria air pollutants per capita leads to an increase of 5.5 energy policy programs. The negative binomial specification, while positive, is not statistically significant at any reasonable alpha value.

The negative parameter estimate for wind potential is surprising, and these estimates and low t statistics indicate that wind potential may be nearly independent of energy legislation. Wind potential may be unrelated to climate change policies because of the types of states that have wind potential. Frequently, these states are rural, sparsely populated states, putting the wind resources geographically removed from load centers. States such as North and South Dakota are outliers in this group with huge amounts of wind potential that dwarf other states' wind potentials; however, these states have few climate change policies. Even with our controls for the other economic and political factors, these states are likely to drive the results for the wind potential parameter. Nevertheless, these results demonstrate that states with high wind potentials do not seem to be taking advantage of this abundant energy resource.

The positive parameter estimate for solar density, suggests that, in contrast to wind potential, states with high solar potential may be taking advantage of their geographic endowments. However, this result is not significant at a reasonable alpha value.

A renewables index was created in order to aggregate solar density and wind potential, in order to reduce downward bias introduced by using both measurements to predict average effects across states. This measure is positive across both models, though not statistically significant.

The statistical insignificance of many of the parameters, coupled with the highly significant model and high R squared indicates that many of these variables – and in particular – the CO_2 intensity, criteria emissions, and coal and gas production measurements may be capturing similar concepts. Indeed, when constructing this model, other related variables such as environmental groups per capita and energy consumption per capita were dropped in order to reduce this collinearity and improve the statistical significance of the variables that remained included in the model. Even with this reduced form model, other variables could be dropped to further improve the hypothesis tests.

Nevertheless, the high explanatory power of the model and low statistical significance of the explanatory variables seems to indicate that no one of these measurements is particularly responsible for state adoption of climate change policies, but rather that these factors work together as a whole to generate support for state climate change policies. Further, while individual correlation statistics between the number of climate change policies and any one of these explanatory variables is quite high, the model as a whole works much better and is much better theoretically justified.

2.6. Path Analysis of the Internal Determinants Model

Multiple regression may not be the best empirical tool in which to analyze policy outcomes as it only allows us to determine the direct effects of each variable on the dependent variable. As discussed above, many of these variables are highly correlated and are likely causally related. In particular, coal and gas production likely determines carbon dioxide intensity and criteria air pollutants emissions. Carbon dioxide intensity and gross state product likely have an effect on criteria air pollutants. Single-equation regression techniques do not allow us to measure these causal relationships or the indirect effects that these relationships have on the dependent variable. In addition, the use of a single-equation regression technique does not allow the researcher to compare the relative influence of the independent variables when these variables are causally related. For these reasons, the model is also operationalized as a set of path analytic equations.

In the path analysis, wind potential, solar density, citizen liberalism, gross state product, and coal and gas production are treated as exogenous variables. Wind potential, solar density, and fossil fuel production are largely determined geographically. Citizen liberalism and gross state product are exogenous in the sense that no other variables in the model are causally related to these variables. Carbon dioxide intensity is assumed to be partially determined by coal and gas production. Criteria air pollutants are assumed to be partially determined by coal and gas production, carbon dioxide intensity, and gross state product.

Using a path analysis, I can determine the extent to which each of these variables has an indirect effect on the dependent variable and in turn allow me to determine the total effect each variable has on the dependent variable. The path analysis, described in table 3, supports some of our earlier hypotheses. If I consider the total effects of coal and gas production and carbon dioxide intensity on the number of energy policies, the total standardized parameter coefficient estimates are negative. Indeed this path diagram also emphasizes some strong relationships between the variables in the model. For example, a one standard deviation increase in coal and gas production leads to a .738 standard deviation increase in carbon dioxide intensity and a .273 standard deviation increase in criteria air pollutants. The only major shift in total effects from direct effect is a change in gross state product, due to a large, negative indirect effect through criteria air pollution.

Table 2.3: Direct Effects and Total Effects of Variables on Energy Policy Adoption

Variable	Direct Effect	Total Effect
Coal and Gas Production	.02	-.02
Carbon Dioxide Intensity	-.252	-.191
Criteria Air Pollutants	.343	.343
Gross State Product	.19	-.19
Wind Potential	-.096	-.096
Solar Density	.128	.128
Citizen Liberalism	.749	.749

2.7. Event History Analysis Model

Data for the event history analysis model was collected beginning in 1997, which coincides with the first adoption of a RPS by Massachusetts (though it did not go into effect until 2001). This model explains the likelihood that a state will adopt a RPS in a given year. In addition to the explanatory variables representing state characteristics, a variable was coded explaining the percentage of states that share a border with each state that had adopted an RPS in that year or earlier. In its current form, data has not been released past 2005 for many of the explanatory variables of the states.

For this model, the adoption of an RPS standard in each state is coded as a '1' for the year of adoption, and '0' if the RPS standard has not been adopted. Once a state adopts a policy, it drops out of the data set. This coding indicates that a particular policy can only be adopted once for each state (although it can be renewed or strengthened). It is estimated with a probit model as each state has a probability of adopting a RPS, given the characteristics of the state. This process assumes that at any given time after 1997 states are considering the possibility of adopting a RPS, and will adopt it once a certain threshold is exceeded.

This model can be described as:

$$P=(e^{\alpha+\beta_1 X_1+\beta_2 X_2 \dots +\beta_8 X_8+\epsilon})/(1+e^{\alpha+\beta_1 X_1+\beta_2 X_2 \dots +\beta_8 X_8+\epsilon})$$

This model was estimated using a probit maximum likelihood regression, with a time counter in order to help control for time related drift and robust standard errors to control for additional geographic or temporal heteroskedasticity.[5] Two specifications are presented in table 4 in order to demonstrate the effects of creating a renewables index from the solar density and wind potential variables.

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[5] The estimation with regular standard errors did not produce significantly different results. The robust standard errors are used to reduce concerns of heteroskedasticity and autocorrelation from the time-series results.

Table 2.4: Robust Probit parameter estimates, with robust standard errors in parentheses, regressing state characteristics and regional diffusion on renewable portfolio standards adoption (374 observations)

Dependent variable = RPS adoption (374 observations)

Model	Model 1	Model 2
Wald Chi^2	34.96***	33.11***
Pseudo R^2	.28	.27
Neighboring States	-.215 (.57)	-.196 (.57)
CO_2 Intensity	-.290 (.25)	-.436 (.24)*
GSPPC	.3e-4 (.2e-04)	.3e-04 (.2e-04)
Wind Potential	.023 (.16)	
Solar Density	.628 (.33)*	
Renewables Index		.237 (.11)**
Criteria Pollutant Index	1.69 (.82)**	1.81 (.81)**
Gas and Coal Per Capita	2.41e-08 (4.06e-08)	4.36e-08 (4.32e-08)
Citizen Liberalism	.052 (.01)***	.050 (.01)***
Timecounter	.131 (.07)*	.131 (.07)*
Constant	-8.88 (2.39)***	-5.83 (1.27)***

* represents significance at the α = .10 level
** represents significance at the α = .05 level
*** represents significance at the α = .05 level

2.8. Discussion of Event History Analysis Model

The event history analysis model demonstrates strong support for the internal determinants model, but no support for the regional diffusion model. Both models provide similar results, with citizen liberalism, solar density, the criteria pollutant index, and the time counter control statistically significant and in the expected directions. In addition, model 2 demonstrates significance for the carbon dioxide intensity parameter in the expected directions. All other parameters are in the expected directions, with the exception of gas and coal production per capita.

According to model 1, the expectation that a state will adopt a renewable portfolio standard in the year 2001 (the median year in the sample), with all factors held at their means is .1 percent. Varying citizen liberalism by one half of a standard deviation on either side of the mean leads to states with low citizen liberalism adopting a RPS at a rate of <.1 percent and states with high citizen liberalism adopting a RPS at a rate of .4 percent demonstrating that a 1 standard deviation change in citizen liberalism more than quadruples the probability of a state adopting an RPS.

The effect of resources and other motivations for RPS adoption is much more muted. Using the same methodology, and varying solar density, wind potential, or the criteria pollutant index from one-half of a standard deviation below the mean, to one half of a standard deviation above the mean, holding all other factors at their means leads to an increase in the probability that a state adopts an RPS standard from .1 percent to .2 percent, doubling the probability of RPS adoption. Varying GSP per capita by one standard deviation does not have a substantial effect on the predicted probability of RPS adoption. Varying the carbon dioxide intensity leads to a decrease in the expected probability of RPS adoption from .2 percent to .1 percent, halving the probability of RPS adoption. These changes in expected probability from a one standard deviation change in each of the independent variables demonstrates that individually each of these factors only has a moderate effect on RPS policy adoption; however, in concert, these factors can dramatically increase the probability of RPS adoption.

Combining the measures of solar density and wind potential in order to remove downward bias results in a positive and statistically significant relationship between a renewable energy potential index and renewable portfolio standards at the α=.05 level. Similarly to the cross-sectional model discussed earlier, citizen liberalism is perhaps the strongest predictor of state policy adoption, consistently indicating that states with more liberal citizens are more likely to expand the role of government in order to address energy consumption patterns. Indeed, in earlier iterations of this model with data ending in 2003, the liberalism index was the only consistently statistically significant predictor of RPS adoption, indicating that over time, environmental, geographic, and political-economic characteristics have increased in their ability to explain RPS adoptions by states.

The positive and statistically significant coefficient on the criteria pollutant index demonstrates that states with poor air quality are much more likely to consider RPS standards as a method of improving their air quality, indicating that states may pursue climate change policies in order to address other social problems.

The positive coefficients on wind potential and statistically significant coefficient on solar density and the subsequent statistically significant and positive coefficient on the renewables potential index is an encouraging sign that states consider their geographic characteristics when making policy adoption decisions. In contrast to the cross-sectional model presented earlier, this model demonstrates a closer link between state resources and policy tool choice.

Most strikingly, perhaps, is the lack of support for the regional diffusion model. While a glance at a map might and existing policy adoption theory may lead one to believe that states adopt policies in clusters, imitating their neighbors, this model does not provide any support for this hypothesis. Indeed, the sign on neighboring states is negative, though not statistically significant. Earlier iterations with data through 2003 also returned a negative correlation between neighboring states adoption and the state's likelihood of adopting and RPS. The lack of support for the regional diffusion model may be due to two reasons. First, neighboring states are also similar in many geographic, political, and economic factors as well. Thus, while regional diffusion takes place, it takes place due to the similar political, geographic and economic factors of a state, rather than due to the imitation of one's neighbors. Second, it is possible that energy policies, and other types of policies that generate global public goods, rely less upon regional diffusion and more upon internal characteristics of states than policies that involve other types of public programs, suggesting that the regional diffusion explanation for policy innovation is limited to certain types of policies.

2.9. Directions for Future Research

While this study has provided a thorough analysis of the internal determinants model, and tested this model against the regional diffusion model, the time frame studied here is short. The data concludes with 2005 data, which includes the adoption of RPS by 20 states, but excludes the adoption of RPS standards by an additional 5 – 10 states. It would be helpful to extend the time frame to include more RPS adoptions in order to determine if regional diffusion is present at a later point in the policy process. Measurements of concepts such as 'renewable potential' can be improved and refined. Future measurements may be able to use wind density, rather than wind potential, and include the potential of other renewable resources such as geothermal and biomass.

This study also does not account for the different types, or strengths, of renewable portfolio standards or the different types of energy and climate change policies. In the cross-sectional study, energy policies are simply counted, without regard to a policy's scope or strength, in order to give a general picture of policy activity. In the event history analysis, states either adopt or do not adopt a renewable portfolio standard. There is no room in this methodology to consider modifications or strengthening of an RPS standard.

Methodological developments that would allow for tracking the strength of RPS standards over time, by state, would be a major development. Finally, while this study determines why states adopt energy-related climate change policies, and in particular, renewable portfolio standards, there is the need to quantitatively assess whether these have effects on a state's air quality, renewable electricity generation, or carbon dioxide emissions.

2.10. Survey of State Climate Change Policy Effectiveness

While this study does not assess the effectiveness of state climate change policies, a variety of studies have begun to assess the impact of RPS and other state policies, as well as to discuss the significance of these efforts in the context of global climate change. Because many of these policies have been adopted recently, it is often difficult to assess the significance and effectiveness of state climate change efforts.

A noted earlier in this chapter, and by an increasing number of studies, states have adopted a patchwork quilt of policies that are designed to address climate change, putting a large portion of the U.S. population under various climate change and energy policies (Ramseur, 2007). Studies of individual policies demonstrate a mixed record on the effectiveness, while research taking a more holistic view demonstrates the difficulties of a patchwork approach to climate change policy yet demonstrate some evidence for an impact of state and local climate change policies (Lutsey & Sperling, 2008).

Several studies have addressed the effectiveness of RPS standards using qualitative criteria and a small-n approach (Bird, et al., 2003; Langniss & Wiser, 2003; Rader, 2000; Wiser, et al., 2005). These studies have concluded that well-designed renewable portfolio standards are directly responsible for the development of wind and other renewable energy at little to no cost (Bird, et al., 2003; Langniss & Wiser, 2003; Rabe, 2006; Wiser, et al., 2005). In contrast, poorly designed RPS standards have been hypothesized to make little difference (Rader, 2000; Wiser, et al., 2005). Studies on the early experience with RPS conclude that wind energy production may have been increased in states adopting early versions of RPS (Ohler, 2007).

While examinations of RPS standards conclude that there is a correlation between RPS adoption and renewable energy production, it has been difficult to attribute RPS as the driver of renewable energy growth in states (Wiser, Namovicz, Gielecki, & Smith, 2007). RPS are just one of an array of policies that can be adopted by states (often jointly), and it is difficult to control for existing renewable energy trends in these states (Wiser, et al., 2007).

While case and small-n studies have been able to highlight best practices for state renewables policies, other research demonstrates the promises and pitfalls of the bottom-up approach. The patchwork of state programs can lead to regulatory and administrative inefficiency and burdens, with duplicative enforcement, uneven enforcement and performance by jurisdictions, and confusion over jurisdiction (Lutsey & Sperling, 2008). In addition, firms may shuffle pollution across political boundaries to adjust to local regulations, nullifying the impact of any individual state policy (Lutsey & Sperling, 2008).

A holistic approach examining the total of state policies, and forecasting impacts into the future demonstrates that states adoption of stricter fuel standards and state renewable electricity plans could lead to the stabilization of GHG emissions by 2020 at

2010 levels, if only the third of states with GHG reduction goals achieve those goals (Lutsey & Sperling, 2008).

2.11. Conclusion

Literature regarding the state policy adoption has focused on two perspectives. The internal determinants model, which characterizes state policy adoption as a function of its internal characteristics, and regional diffusion, in which states are laboratories for experimentation, and successful policies are mimicked by neighboring states. These two models help determine the veracity of two perspectives regarding state policy adoption. These results demonstrate that state characteristics drive climate change policies, rather than regional diffusion and suggest that the regional diffusion hypothesis ought to be re-examined.

In addition, these models are substantively significant regarding the implications of state climate change policy, which is the major driver of mandatory climate change policy in the United States. States appear to adopt climate change policies for a variety of reasons including the desire to curb harmful criteria air pollutant emissions, supporting the view that carbon dioxide mitigation may be seen as a positive externality of other types of policies. States also tailor their policies to match their particular characteristics. States with high wind potential tend to adopt RPS standards. States with solar potential adopt solar easements. Nevertheless, despite the variation among states in the types of climate change policies they adopt, we can generally predict which states will be more likely to adopt further measures to address climate change. In general, states with more liberal populations, higher per capita emissions of criteria air pollutants, more renewable potential and less carbon dioxide intensive industry make more attempts to curb greenhouse gas emissions.

This paper emphasizes the political nature of energy policy adoptions, but provides an optimistic view towards policy adoption aligned with environmental goals and geographic resources. Across the two models, citizen liberalism, the strength of industry, measured in carbon dioxide intensity, renewable resources, and air quality all served as statistically significant predictors of RPS policy adoption. While the most powerful explanation for the adoption of RPS standards is citizen liberalism – or the willingness of citizens to use government to expand the powers of government - there is support for states adopting policies appropriate for its geographical characteristics, or in order to address public bads such as air pollution. In addition, these results suggest that regional diffusion of policies may vary with the intended effects of a policy. If a policy promotes a global public good, such as reduced carbon emissions, its adoption may be more dependent on internal determinants and political ideology than on regional diffusion mechanisms.

This area of research begins to open a pathway for exploration of how and why different states adopt varying types of climate change policies. While this study attempted to address RPS standards, one of the most prevalent and prominent climate change policies, there are many more policies that deserve attention. In addition, this study only looked at energy efficiency and renewable energy policies. There are many other types of climate change policies that deserve attention including forestry, transportation, agriculture and direct emissions control policies, which can be addressed through a similar theoretical framework. In addition to continued exploration regarding the adoption of these policies, it becomes increasingly important to assess their effectiveness and whether or not state policy adoption will have impact on states' carbon emissions.

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3. Efficiency, Bounded Rationality and the European Union Emissions Trading Scheme

3.1. Abstract

Recent attention to climate change suggests that the adoption of market-based carbon regulation is likely in the United States. As a consequence, there has been increasing attention to European Union efforts that regulate carbon through a tradable emission permits system. Previous research demonstrates a gap between theoretical optimal behavior and actual cost savings in pollution markets. This paper draws upon existing research to examine levers of inefficiency in the carbon cap-and-trade system in Europe and test these factors using firm interviews. I hypothesize that transaction costs, uncertainty, and boundedly rational behavior by firm managers interact to lead to sub-optimal firm behavior, threatening the overall efficiency of the trading system. Using interviews with firms, industry association representatives, and government officials, I highlight the firm and institutional characteristics that lead to inefficiencies in the EU tradable emission permit system.

3.2. Introduction

Recent comments from the new administration suggest that climate change policy will receive increasing attention in the near future, with a preference towards a cap-and-trade approach to addressing climate change (Clinton, 2009; Obama, 2008). With the increasing probability that the United States will adopt national-level climate change policy, the efficiency of a potential carbon dioxide market is central to successful carbon mitigation.

While tradable emissions permits (TEP) seek to establish property rights for pollution emissions and establish a well-functioning market where these permits can be traded (Tietenberg, 2000, 2006b), empirical evidence of TEP demonstrates that observed efficiency gains are far less than those predicted by theoretical, ex-ante models (Burtraw & Palmer, 2004; R. Stavins, 1998). Firms frequently pass abatement costs on to consumers and fail to take advantage of trading opportunities (D. Bohi, 1994).

Sources of inefficiency include the design characteristics of the TEP institution as well as characteristics of participating firms; however, these theoretical inefficiencies have not been unpacked, or studies closely in practice. Econometric models that calculate observed efficiency relative to a production possibilities frontier note that inefficiency is generated from transaction costs or suboptimal behavior by firm officials (Colby, 1990; Leibenstein, 1966; Leibenstein & Maital, 1992). Additional literature suggests that firm characteristics play a greater role in energy efficiency investments than rational behavioral models suggest (DeCanio & Watkins, 1998). In this paper I discuss the interaction of institutional and firm characteristics that lead to inefficient outcomes in emissions permit trading systems.

This paper draws upon existing surveys and literature in order to explain why firms may not behave according to the expectations of the rational economic model. Using the European case and guidance of the results of existing surveys, I conduct original interviews of government officials, firm managers, and industry association representatives in order to investigate sources of inefficiency in the European Union TEP system. The results of this study provide important lessons for policy-makers, as they design carbon-trading systems in the United States, and for firm managers, as they seek to implement these programs. The paper proceeds as follows. First, I give a brief discussion regarding the theory behind the European Union Emissions Trading Scheme (ETS) and Tradable Emissions Permits, provide an overview of the ETS, and discuss the strategies that firms can use to comply with ETS regulation. Second, I detail the institutional and firm characteristics that lead to inefficiencies and detail a framework that explains the interaction between firm behavior and institutional design. Third, I detail findings from a set of 25 interviews that took place between July 2006 and October 2008, which demonstrate the extent and characteristics of firm behavior under the ETS[1]. These findings are supplemented by results from existing surveys. Finally, I conclude with some general conclusions regarding the relationship between firm and institutional characteristics and provide some recommendations for policy design and firm managers.

3.3. Permit trading and the European Union Emissions Trading Scheme

3.3.1. Efficiency gains by Permit Trading

Neoclassical economic theory posits efficiency gains by Tradable Emissions Permits (TEP) as compared to traditional command and control (CAC) regulation across three dimensions: cost-effectiveness; induced technological change; and environmental effectiveness.

TEP allows firms that have higher abatement costs to abate less, while firms that have lower abatement costs can abate more and sell excess permits on the market. In the cost-effective equilibrium of the permit market, marginal abatement costs of each emitter equal permit price. Even if the cost-effective equilibrium is not reached, costs savings result from emissions trading (Burtraw & Palmer, 2004; Hahn & Gordon, 1989; Koschel, Brockmann, Schmidt, Stronzik, & Bergmann, 1998).

TEP systems induce technological change because these systems allow emitters to generate income if they can abate emissions for lower costs than the permit price. Thus, firms have incentives to research innovative emission control technologies. There is limited evidence of the ability of TEP to induce technological change, perhaps resulting from difficulty of proving causal relationships between TEP and technological change (Ellerman, Schmalensee, Joskow, Montero, & Bailey, 1997). However, some authors report anecdotal evidence of innovations within TEP markets (Harrington & Morgenstern, 2004; Lents, 2000).

While the neoclassical model is useful for theory, real-world situations deviate significantly from theoretical assumptions. Markets are characterized by imperfections such as transaction costs. Individuals are faced with uncertainty about the future and act boundedly rational. Transaction costs, uncertainty, and institutional design can contribute to the boundedly rational behavior of firms. Only some of the potential efficiency gains can be realized and many emissions trading programs perform sub-optimally.

3.3.2. The European Union Emissions Trading Scheme (ETS)

The European Union Emissions Trading Scheme (ETS) began in 2005 as a mandatory trading program targeting approximately 12,000 installations (Official Journal of the European Union, 2003). The ETS functions through trading periods. In the first and second trading periods (2005 – 2007 and 2008 – 2012) National Action Plans (NAPs) were devised to allow each member state to allocate emissions permits covering about 40 percent of carbon dioxide emissions in the EU across covered industries and combustion activities. Covered sectors include power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Emissions allowances for each country corresponds to Kyoto Agreement targets and allocations vary among individual states and installations. In general, large utilities have high reduction factors while small utilities and industrial producers have low or no reduction factors, meaning that without trading, nearly all reductions would be required of the large utilities, while small utilities and industrial producers could continue business as usual. National Allocation Plans (NAP) are approved by the ETS and must demonstrate a variety of criteria, including an aim to meet national Kyoto targets, as well as to create carbon market stability. As a whole, the EU-15 – the fifteen states that share a legally binding agreement for joint compliance – must abate 8 percent of 1990 baseline emissions by 2008-2012. After an initial allocation of credits is set, firms may trade their emissions permits across borders; trading is monitored and registered by the ETS in Brussels, as well as by national country registries.

The first trading period had a variety of difficulties. NAPs and emissions registries were developed late, causing significant confusion in permit trading. Emissions permits were over-allocated, allowing for an increase in the amount of emissions during the first period. Finally, there was significant volatility in the permit market due to overallocation: the price of a ton of carbon reached a high of nearly 30 Euros / ton in 2006, and dropped to 0 by the end of 2007 (European Climate Exchange, 2009).

3.3.3. Firm strategies under the ETS

Firms can undertake six basic strategies to comply with and/or profit from ETS regulation. First, firms can secure electricity from wind, solar, gas, combined cycle, and biomass projects in order to phase out coal power plants. Second, firms can improve energy efficiency, and invest in improved boilers, and combined heat and power (CHP) plants. Third, firms can offset emissions through participation in clean development mechanisms (CDM), or joint implementation (JI), which allows firms to invest in projects that reduce emissions abroad – in developing countries or other non-ETS countries, and earn certified emissions reductions (CER), or emission reduction credits (ERC) which can be used similarly to allocated emissions permits. Fourth, firms with multiple power plants can shift the generation load to plants that are less emissions intensive, and switch fuels to minimize emissions. Fifth, firms can purchase permits from other firms, including CERs and ERCs, in order to cover emissions. Finally, while excess permits can be sold on the market, some firms actively speculate and engage in permit trading in order to hedge against other energy positions, making permit trading a potentially profitable strategy.

3.4. Sources of inefficiencies in the ETS

3.4.1. Institutional Characteristics

Transactions costs

The realization of cost savings in greenhouse gas (GHG) abatement and development of innovative abatement technologies in a permit trading market depends on the fluid functioning of that market. Transaction costs include legal fees, forgone time, staff costs, consultant costs etc. (Crals & Vereeck, 2005; R. Stavins, 1995; R. N. Stavins, 2000) and can prevent the cost savings anticipated by ex-ante analyses (R. Stavins, 1995; Woerdman, 2001). Transaction costs of participating in a TEP market result from the necessity to acquire information, search contract partners, negotiate the trade, decide on alternative options, and monitor and enforce outcomes.

When transaction costs exceed the cost savings of additional trades, trading ceases (R. Stavins, 1995). In addition, transaction costs can inhibit the development of a liquid market, leading to few offers and bids and resulting in high spreads leading to uncertainty regarding the availability of permits in the future and firms' preference for autarkic compliance (Zosel, 2000).

Characteristics of institutional design have a large impact on performance and the ability to reduce transaction costs (Crals & Vereeck, 2005; Woerdman, 2001). Trading systems should be designed simply, avoiding complex rules and extensive bureaucratic trading procedures requiring pre-trade governmental approvals and time consuming emission verifications (Endres & Ohl, 2005; Michaelowa & Stronzik, 2002; R. Stavins, 1995; R. N. Stavins, 2000).

According to a 2006 Ecofys and McKinsey & Co. survey of 517 firms, government officials, industry representatives and NGOs yielding 306 responses, firms expressed great concern with the transaction costs involved in the ETS. Firms complained about monitoring and verification costs, particularly when they do not have a substantial reduction factor (European Commission, McKinsey & Company, & Ecofys, 2006a). Firms also expressed concern regarding the process of data certification and approval of authorities, commenting that the system is "unnecessarily burdensome… It is costly, unwieldy, impractical, and not user-friendly… (European Commission, et al., 2006a)."

According to estimates from the UK, it costs between €2,000 and €15,000 per site, per year for operators, and between €3,000 and €10,000 per site, per year, for government administrators in order to administer the ETS program. If these estimates are consistent across the EU, transaction costs for the entire ETS system may cost firms as much as €108 million and government as much as €162 million. The proposed expansion of the ETS to include an additional 1,500 – 2,000 installations, may add an additional

€7.5 million - €50 million to these costs. (Commission of the European Communities, 2008)

Uncertainty

Uncertainty to firms in emissions trading is the result of several primary factors: unclear rules and changes in institutional design; inherent market uncertainty; and technical uncertainty regarding emissions and their monitoring.

Uncertainty regarding the institutional design of the TEP systems represents a major barrier to the efficient functioning of a permit system. Uncertainty can dissuade firms from making effective investment and technological decisions. Forty-eight percent of firms in a ETS survey suggested that technological decisions have been affected by ETS uncertainty, with 58 percent of firms suggesting that medium to long term policy design uncertainty of the ETS has increased the uncertainty in technological investment decisions. In addition, 30 percent of firms report "true ambiguity" in technological decisions (European Commission, McKinsey & Company, & Ecofys, 2006b).

Uncertainty may lead firms to make decisions with unanticipated results and which leads to volatile permit prices. In an uncertain environment, firms are unable to make optimal decisions that are assumed by neoclassical decision theory. If possible outcomes and attached probabilities are unknown, firms cannot maximize their expectation value, leading to reliance on decision criteria such as heuristics, satisficing, and rules of thumb, which do not support the neoclassical profit maximization paradigm (Baumol & Quandt, 1964; European Federation of Energy Traders Emissions Trading Task Force, 2003; Gody, Mestelman, Muller, & Welland, 1998; Simon, 1955).

Unclear rules and procedures, as well as possible changes in institutional design, generates considerable uncertainty in permit trading. The ETS in particular is characterized by such type of uncertainty due to its international character involving political negotiations (Kruger, 2005).

Uncertainty regarding medium or long-term aggregate abatement targets reduces the ability for firms to anticipate the long-term price of carbon. Without understanding of the long-term price of carbon, it is difficult for firms to make decisions regarding which types of technologies to pursue and formulate a long term carbon strategy (European Federation of Energy Traders Emissions Trading Task Force, 2003; Fischer, Kerr, & Toman, 1998; Kruger, 2005). The length of trading periods and the time between allocation and the beginning of the trading period has provided major disagreement between firms and government bodies. While 86 percent of firms surveyed requested longer trading periods, only 21 percent of government officials felt that the trading period should be lengthened and the time period between allocation decisions and trading should be lengthened (European Commission, et al., 2006b).

Altogether, 72 percent of stakeholders preferred a lengthening of the trading period and the time between allocation and trading. Of those stakeholders who preferred longer trading periods, 93 percent percent of firms, and 90 percent of all stakeholders prefer a trading period of at least 10 years, with the majority of both groups preferring trading periods of greater than 10 years. Those firms also preferred the allocation period to be between 2-3 years prior to the beginning of trading. Interestingly, firms that requested longer trading periods suggest that they would be willing to accept more risk in exchange for more certainty. Seventy-seven percent of firms requesting a longer trading period responded that they would be willing to accept future revisions and changes to the allocations, should an international agreement be concluded (European Commission, et al., 2006b).

Uncertainty regarding future price trends is inherent to any kind of market system. Future permit prices may be influenced by technological innovation, economic growth, input and output prices and political responses to new findings on global warming (Jotzo & Pezzey, 2005). In initial phases of a market, before the market is well-developed, uncertainty to market participants and institutions will lead to high volatility. Tradable permit systems require a learning curve, hindering the effective functioning of a system in its early stages.

Firms use instruments to hedge risks similar to those used in financial markets, such as forward settlements, swaps of allowance vintage years, options and banking (Kruger, 2005; Nill & Heiner, 2008). In past permit trading systems, covering SO_2 in the United States, firms have not relied on the future availability of permits in the market and preferred to bank permits rather than to sell them for a profit (Considine & Larson, 2006).

By surveying 51 German enterprises that are regulated by the ETS, Nill et al. find that firms are still faced with considerable market uncertainty within the ETS. Fifty percent of firms considered the risks resulting from the ETS as “high” or “very high.” Firms fear a lack of permits in the future and uncertain permit price trends. During the first phase of the ETS (2005-2007), firms faced low risks due to considerable over-allocation of permits. The survey reports that a lack of permits and increasing prices in the second phase of the ETS (2008-2012) has firms increasingly concerned (Nill & Heiner, 2008).

Lastly, uncertainty to firms may result from monitoring techniques of production processes and abatement measures. In the U.S. SO_2 TEP program, one reason for banking permits was the uncertainty regarding the effectiveness of their pollution control measures (Considine & Larson, 2006). In the ETS, permits created through CDM projects have been traded for a far lower price in the initial phase of the ETS because of the political and technical uncertainty surrounding CDM projects (Böhringer & Löschel, 2002; Chadwick, 2006).

3.4.2. Firm behavior that contributes to inefficiency

According to the neoclassical economic model of tradable permits, rational firms estimate the long term cost of carbon and gauge their own marginal abatement costs of carbon (D. R. Bohi & Burtraw, 1992; Montgomery, 1972; Tschirhart, 1984). If they can reduce carbon more cheaply than the long term cost, they should seek to reduce carbon emissions, and plan to sell excess permits. If firms cannot reduce carbon more cheaply than the long term cost, firms should plan to purchase emissions permits via the trading market and through CDM projects (Tietenberg, 2006a).

In practice however, firms do not behave fully rationally (DeCanio & Watkins, 1998; Tschirhart, 1984). Several characteristics of boundedly rational firm behavior interact with the above transaction costs and uncertainty imposed by the emissions trading institution, leading firms to satisfice and prefer business-as-usual (BAU) outcomes.

First, a poor understanding of carbon trading and the inability for firms to optimize under uncertainty leads firms to satisfice and use heuristics, preferring BAU operations to alternative strategies (Jones, 2001, 2002; Leibenstein, 1966; Leibenstein & Maital, 1992; Simon, 1955). Firm managers exhibit a general lack of understanding of the trading scheme, and how the scheme will affect their business (Brewer, 2005). In the Commission's survey, stakeholders were asked to weigh the barriers to trading in the system. Out of a possible of 100 points, on average, 14 points were allocated to "parties do not understand how to trade," (European Commission, et al., 2006b). This poor understanding of cap and trade systems may vary by industry. Some industries, such as the electricity industry, have deep knowledge of commodities trading and financial instruments. The energy sector appears to already incorporate carbon pricing as a cost factor, with 70 percent of power generation firms reporting that they incorporate CO_2 into marginal pricing decisions. In contrast, other industries lag behind, with Aluminum and Steel reporting 25 percent and 29 percent of firms pricing in carbon, and most industries reporting between 33-44 percent of firms pricing in carbon (European Commission, et al., 2006b). Some industries, such as electricity producers, are familiar with trading systems, as they already trade electricity production or other pollution permits, while other industries are much less familiar with this type of regulation.

Second, firms do not use information efficiently, and gauge risk and uncertainty poorly, preventing optimization of profits. This inefficiency is due to poor foresight, as well as a human inability to solve complex problems (Alchian, 1950; Simon, 1955; Tinter, 1941). Because individuals satisfice rather than maximize, and firms prefer BAU over making changes in operational decisions, firms may seek to avoid adapting to price signals.

Evidence from the Commission's survey suggests that firms may be having a difficult time with the complexity of the ETS policy tool. A respondent from the chemical industry notes, "The ETS is one of the most complex policy instruments and has been developed under high time pressure… in our country we have nearly no experiences with [this type] of policy instrument", with another respondent adding "the interaction with taxation, accounting, and trading make [the ETS] a multidimensional problem that needs additional coordination internally and clear definitions of responsibility." A government official adds, "Our country has had limited experience with the above policy instruments… local industry often does not have the necessary background, expertise, and resources to fully appreciate the implications and impacts of policy measures set out. Similarly, government entities involved in the implementation of policy instruments may also lack the necessary resources." (European Commission, et al., 2006a)

Third, firms may not be cost minimizers. In regulated industries, constraints on profits are invoked by government commissions. In non-regulated industries, organizational complexity and alternative goals may hinder profit-maximizing behavior (Tschirhart, 1984). When faced with reductions, firms prefer to abate carbon internally rather than participate in permit trading, especially when those costs can be passed on to consumers (D. Bohi, 1994; D. R. Bohi & Burtraw, 1992).

Boundedly rational firms may take a long time to incorporate carbon costs into pricing models and have a hard time processing the uncertainty surrounding climate change legislation and carbon prices. Most firms are characterized as "cautious planners," and do not take concrete efforts to adapt to climate change regulation (Kolk & Pinske, 2004, 2005). (Nill & Heiner, 2008) report that by beginning of 2008, one third of the regulated enterprises in the ETS have not even conducted any action to identify GHG emission reduction measures. More than 30 percent of the surveyed enterprises state that

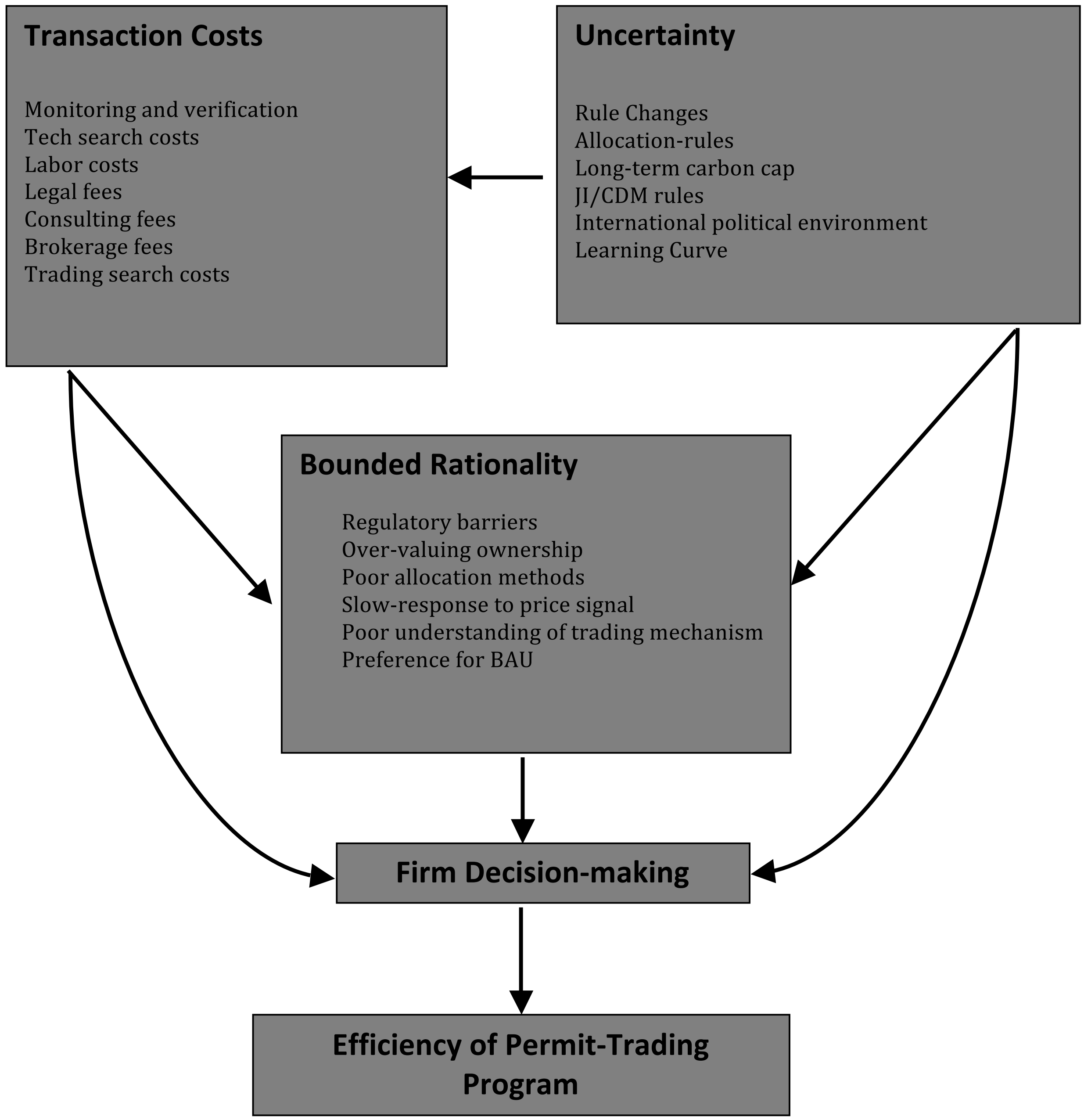
GHG emissions are not important for their investment decisions. Firms do not undertake calculations of their long term permit demand, do not use freely available data on future permit price calculations, and do not evaluate their risks resulting from the ETS.

3.5. A framework and hypotheses for ETS program efficiency

In this section, I briefly describe a framework (see figure 1 below) that helps demonstrate barriers to efficient decision-making in firms with regards to permit trading. The model demonstrates the relationship between uncertainty, transaction costs, bounded rationality, and firm decision-making, and helps explain why firms employ specific tactics or strategies in order to comply with carbon abatement requirements.

Transaction costs, such as the difficulty and costs of participating in trading markets, and the costs of optimizing production lead firms to avoid participation in the trading market and to avoid measures aimed at optimization. High transaction costs contribute to boundedly rational behavior because they put higher costs on optimization and rational participation in the system. These transaction costs are compounded by the uncertain future, which includes likely rule changes, changes in the allocation method, changes in long-term carbon cap, and future technological innovations. Together, uncertainty and transaction costs combine with firm decision-making to exacerbate boundedly rational behavior and produce outcomes that deviate from the rational economic model.

Figure 4.1: A framework for thinking about firm decision-making



Firms that over-value freely allocated carbon credits, make poor allocation decisions, respond slowly to price signals, and have a poor understanding of the trading mechanism tend to prefer BAU outcomes and satisfice rather than optimize. Firms, which may be ill-equipped and lack the capacity to deal with these problems, opt for the easiest solutions that satisfy compliance requirements. Firms that have more capacity will be more likely to attempt to optimize profits, minimize carbon, and resemble the rational model of firm decision-making.

Based on this framework, I expect that firm carbon strategy will vary based on industry and capacity, with large firms possessing considerably greater capacity and ability to take advantage of the variety of opportunities presented through the ETS. Firms that have greater capacity will be more likely to weigh costs and benefits, invest in JI / CDM projects abroad, and take advantage of the permit trading market for profitable purposes. In contrast, I expect smaller firms to rely more on BAU strategy, and seek to meet compliance requirements through the purchasing of permits on the market. In addition, I expect that electric utilities will have a much greater understanding of the permit market, and be able to take advantage of their flexibility in meeting reduction requirements. In contrast, industrial firms are more likely to be bounded by production processes and requirements, have less understanding of carbon permit trading, and be less willing and able to take advantage of diverse strategies for meeting ETS obligations.

3.6. Data collection and research design

In order to explore the role of capacity and industry on firm decision-making, I conducted interviews with several small and large firms representing industry and the electric utilities.[1] Twenty-five interviews took place between July and October, 2008. While the number of interviews is not particularly large, the interviews covered entities responsible for over 50 percent of the emissions in Germany. All interviews took place in Germany, or via phone with firms that operate in Germany.

Interview participants were identified through several mechanisms. Firms were identified through the Deutsche Emissionshandelsstelle (The German Emissions Trading Authority), which maintains the national carbon registry. The largest holders of carbon permits were identified through the registry, and I used personal contacts to gain access to the largest utilities and industrial firms. Second, I gained contact with industry associations representing both large and small firms, who could help relay the aggregated preferences of many of the smaller stakeholders, and helped secure interviews with smaller firms. In Germany, industry associations are used to help aggregate preferences and formulate policy across segments of industries. They are formalized in the policy-making process through organizations such as the AGE, or The Climate Change Working Group, which organizes industries, industry associations, and market intermediaries regarding climate change policy.

3.7. Findings

The interviews revealed a remarkable range of firm behaviors, ranging from firms that behave very similarly to the 'rational' economic model, to firms that deviate very far from this model. I categorize these firms based on the two dimensions: capacity and complexity. The summary of strategies and tactics employed by firms is summarized in table 4.1 below.

Table 4.1: Summary of primary compliance strategies by firm size and type:

	Low Complexity	**High Complexity**
Low Capacity	• Purchase of Permits for Compliance • Investments in Wind and Biomass • Efficiency and Combined Heat and Power Investments	• Purchase of Permits for Compliance
High Capacity	• Joint Implementation / Clean Development Mechanism Investments • Permit Trading for Profit • Fuel Switching • Efficiency and Combined Heat and Power Investments	• Purchase of Permits for Compliance • Efficiency and Combined Heat and Power Investments • Joint Implementation / Clean Development Mechanism Investments

3.7.1. High Capacity, Low Complexity

At one extreme are the large utilities. These firms are responsible for the vast majority of carbon emissions in Germany and in the EU. These firms have hired several traders to deal exclusively with carbon, as well as employees to deal with monitoring, CDMs and JI. Firms may hire between 3 – 15 dedicated carbon traders, a person dedicated to monitoring each plant, and must hire an external verifier for about 10,000 Euros each year, per plant. In order to participate directly with the carbon market in Leipzig, an initial five-digit initial investment, plus an annual fee of 20,000 Euros is required, in addition to staff fees (Interview with trader at large utility, 17 Sept 2008).

These firms break their carbon-related decisions into three major areas. First, large energy utilities base daily energy production decisions on the costs of fuels and carbon permits. Each day models that include carbon costs determine which power plants should be operated (Interview with manager at large utility, 22 Sept 2008). In these firms, traders are responsible for carbon permits and aim to profit from carbon trading.

Second, these firms aggressively pursue Clean Development Mechanism (CDM) and Joint Implementation (JI) projects, in order to strengthen their strategic advantage, and because they view CDM and JI as profitable investments. These projects are operated by a separate department, and are judged based on their prospects for profitability, given the riskiness of CDM project approval (Interview with manager at large utility, 8 September 2008).

Third, investment and energy efficiency decisions are made independently from CDM / JI decisions, and attempt to anticipate a long-term carbon strategy, given a variety of scenarios. Investments in these projects must be robust across both short term and long term models, and do not exclusively focus on climate change, but incorporate fuel costs and carbon risks (valued at about 20 Euros per ton), attempting to follow a no-regrets strategy (Interview with manager at large utility, 8 September 2008). These investments generally are based on short-term projects, as firms find it difficult to anticipate long-term carbon prices, given the political environment surrounding carbon trading. Firms report small improvements such as optimizing the power generation mix, and small efficiency gains with power-plants that become cost-effective at 20 Euros / ton. Medium and long-term uncertainty, however, hampers longer-term investments: investments in high-efficiency lignite coal plants require between 8-9 years from initial planning and licensing until a plant begins generating power (Interview with industry association representative, 30 September 2008; Interview with manager at large utility, 8 September 2008).

One industry representative lists a variety of factors that have contributed to a BAU mentality among power generators. First, medium to long term uncertainty has led to many shifts in the short term production and optimization, mainly leading to shifts in electricity generation, but has not led to the significant change in new investment that was anticipated by models (Interview with industry association representative, 30

September 2008). Second, with nuclear energy scheduled to be phased out, firms expect coal to play an increased role in handling base-loads. Third, due to fears regarding future permitting of coal plants, there has been a rush to replace old coal plants with new coal plants, leading to permitting delays, and the expectation that many projects will not work out. Fourth, increasing fuel prices of alternative fuels, such as natural gas, continue to make coal an affordable alternative.

These firms generally view the ETS as a success and the market as liquid. While they acknowledge that there remains significant uncertainty in the market, these firms believe that they can hedge positions up to 3-4 years into the future, acknowledging that longer-term planning is not currently a political reality. These firms also look to meet as much abatement as possible through CDM sourcing, rather than through efficiency improvements or through building new plants.

3.7.2. Medium and Small Municipal Utilities

The medium (3-4 plants) and small (1-2 plants) utilities are unable to take advantage of the same opportunities as the large utilities. Initially, these firms have felt that they had little understanding of carbon trading. Past experiences with trading have primarily involved energy purchase for plant operation; these firms are not interested in energy trading, but simply in retail electricity generation and sales. While they have built up some of their trading capacity, a medium utility operation of 70 employees is likely to have 25 energy traders, of whom, 2-3 of will be dedicated to carbon. Small utilities are "not there yet". These firms lack understanding of permit markets – and lack the ability to hire permanent workers to follow markets. At first, these firms "didn't have to care, because they were over-allocated." The third trading period includes auctioning for these firms, and it remains unclear if these firms will be able to perform necessary early valuations of carbon. (Interview with industry association representative, 29 September, 2008; Interview with industry association representative 30 September 2008)

The largest difference between the small and medium sized utilities and the large utilities is how they go about attempting to meet reduction factors. Small and medium sized utilities do not have CDM capacity like the larger firms. Instead, they rely on new wind and biomass projects, gas projects over small coal, combined cycle plants, combined heat and power plants, energy efficiency improvements, and combine efforts to jointly build newer and more efficient plants. They also are much more likely to purchase permits in order to meet reduction requirements. (Interview with industry association representative, 29 September, 2008; Interview with industry association representative 30 September 2008).

Despite some subsidies and advantages with small-scale plants, these firms perceive themselves as having a huge disadvantage – "its like sitting down for a game of poker where your opponent starts with 10 times as many chips as you… you don't have much of a chance" (Interview with industry association representative, 29 September, 2008).

3.7.3. Large Industry

A variety of behavior exists within large industry. Some firms have been able to mimic the behavior of the large utilities. They pursue CDM & JI, they allocate permits to the trading desk, and they attempt optimization. However, several important differences between industry and utilities exist. First, because industry is primarily generating electricity for its own use, it does not have the flexibility that the utilities have regarding the operation of their power plants. Further, industrial firms are more likely to point towards energy costs as the primary factor in any change of behavior. One industrial firm reports that 95 percent of any energy efficiency improvements have been completed due to high energy costs in manufacturing. Any savings from carbon permits is just “the cherry on the cake.” (Interview with industrial firm, 20 October, 2008). Thus far, this firm reports “operation as usual” and that they have not altered any existing units. However, the firm reports that there is some consideration of increased reliance on CHP and new investments in boilers (Interview with industrial firm, 20 October, 2008). Due to high long term CO_2 regulatory uncertainty, carbon dioxide is not currently taken into account for long-term decisions. Any energy efficiency investments average a two-year return on investment, with no projects considered that have a return of longer than five years (Interview with large industrial firm, 20 October, 2008). Another firm reports that they consider carbon prices into any investments up until 2012; however, after 2012, there is too much uncertainty and carbon implications are not considered (Interview with large industrial firm, 1 October, 2008).

In industrial firms, in contrast to major utilities, energy efficiency improvements are suggested from the bottom-up, from the plant managers, rather than decisions made by traders or firm strategists. Each month, for example, the traders will inform the plant managers of the price for carbon, and the managers make suggestions or decisions based on this information (Interview with industrial firm, 20 October, 2008; Interview with large industrial firm, 1 October, 2008).

Another large industrial firm noted barriers in optimization in their production process. While this firm has a trading department to manage carbon permits, the firm representative notes that energy efficiency improvements are a continual and iterative process. Due to the nature of the manufacturing process, the generation of one output in one plant leads to an input in another plant. The representative notes that the complexity of this task makes perfect optimization impossible (Interview with large industrial firm, 1 October, 2008).

This firm also notes a change in their strategy that has led to a more efficient management of carbon. Initially, carbon permits were managed by the Corporate Sustainability Department and the Global Resources Group. Under this management system, trades were conducted internally, but the firm took a 'wait and see' approach towards external trades. In addition, the focus of the firm was much more geared towards compliance, "we didn't really care whether we made money from carbon permits. Our goal was to continue operating as we always had. We really just didn't want to have to be burdened by buying permits" (Interview with large industrial firm 1, October, 2008). The manager notes that the shift to managing carbon through the traders has been more efficient; however, the manager notes some continuing clashes between the environmental specialists and the traders. While the traders are interested in the profitability of trading, the environmental specialists are highly concerned with emissions reductions, compliance, and corporate sustainability. In addition, the manager notes that permit trading is of secondary interest. About nine months into a year, energy consumption is forecasted for the last three months, and permit trading decisions are made.

Not all firms have embraced the rational model. A market intermediary notes that many industrial firms he works with – even large ones – have no desire to change behavior, regardless of possible profits from selling carbon permits. Further, he argues that the idea that firms – both large and small - are aware of their marginal abatement costs "only exists in theory," pointing to one large industrial producer who said, "I don't really care about making money from carbon permits, I'm a brick-producer, I want to produce bricks." (Interview with market intermediary, 16 October, 2008). Results from the interviews demonstrate that the preference for BAU is quite common, especially when firms do not operate a trading office, and carbon permits are allocated to a compliance officer – usually an engineer, who has little experience in trading. This approach is exemplified by many of the smaller industrial producers.

3.7.4. Small Industrial Producers

Small industrial producers occupy opposite end of the spectrum as large utilities. These players are characterized by little capacity to deal with trading and little understanding of the trading system. Participation in carbon trading is simply a huge burden – even if they do not have to purchase any permits for compliance. These firms generally have a compliance officer or general manager who is also responsible for ETS compliance.

These firms do not behave in any manner similar to the rational economic model. They do not optimize their energy efficiency. They do not perform cost-benefit analyses regarding additional investments in energy efficiency. One firm, which installs and operates small boilers for industrial consumers, notes that it is extremely difficult to get firms to see the benefits of energy efficiency. Even in energy intensive firms, there appears to be a general ambivalence towards energy savings, and a mindset towards continuing operation as usual, at whatever necessary cost (Interview with small industrial firm, 13 October 2008).

One firm noted a variety of barriers in their participation with the ETS. First, they described difficulty connecting with the national registry system. They required new computer systems, and it required several weeks worth of time to get the system set up. They described a "book" of monitoring and verification requirements that were geared towards large utilities, not towards a small industrial producer with one boiler. In addition, the complexity of interlocking rules from the EU Directive and from the Germany government was considered highly burdensome, confusing, and challenging, taking several days to become familiar with regulations. With regulations changing every few years, the firm feels that it still does not fully comprehend the regulations, and fears the future changes in the system. This firm is really only interested in compliance, "we see this completely as a compliance issue. We are not interested in speculating in energy or with carbon. We simply want to continue our business operations as we did before (Interview with small industrial firm, 8 October 2008)." When this firm sought to purchase additional permits, representatives noted that they were unable to find a market intermediary willing to deal with them. The amount they wanted to purchase (3,000 tons) was so small, that no banks would work with them. They described frantic calls until finally they were able to draw a favor from an energy supplier, who sold them the needed credits.

3.8. Discussion

This study points towards lessons regarding the relationship between firm behavior and institutional characteristics as well as lessons for policy design and for policy implementation and management.

Firm size reflects a firm's capacity and ability to deal with burdensome regulatory requirements, as well as adapt to a complex TEP system. Firms with more capacity seem to be able to deal more effectively with uncertainty and transaction costs. In addition, electric utilities have business models that align closely with the ETS design and allow them to take advantage of a wide array of possible carbon strategies. In contrast, industrial producers are more hindered by institutional barriers such as uncertainty, and are more bounded by their internal organizational structure, leading them to satisfice and prefer BAU outcomes.

First, long-term uncertainty plagues the ability of firms to make investment decisions. While large electric utilities describe a no-regrets policy where they attempt to anticipate the long-term reduction of the carbon cap, other firms – especially those in the industrial sector, describe a very short-term outlook when making investment decisions. Large industrial firms also have a very short time-horizon for investments, which they largely attribute to legislative uncertainty.

Second, organizational barriers prevent firms from optimization. Many industrial firms do not have an organizational structure in place that allows them to adequately manage carbon. Firms that have trading offices have much more capacity to manage carbon than firms that rely on environmental compliance officers, who do not necessarily understand the nature of carbon trading, do not know their marginal abatement costs, nor have an interest in achieving equimarginal abatement costs. Large industrial firms do not have as much flexibility regarding their production decisions. Large industrial firms – even those most pro-active at managing carbon – must continue production and cannot eliminate power generation, or use strategies such as fuel-switching. In addition, they face operational complexity, where optimization is not entirely possible.

Third, small firms and small utilities, simply do not have the capacity to deal with carbon trading or the flexibility to take advantage of CDM and JI. While larger firms are able to build their capacities and draw on CDM opportunities, smaller firms do not have the economies of scale to make these investments worthwhile. For small firms, the transaction costs of building capacity to deal with carbon trading or CDM are too high, and these firms prefer to purchase permits to comply with the ETS. Small firms do not have the resources to optimize carbon efficiency, to hire a carbon trader, to invest globally, or participate in the carbon markets.

Finally, many large industrial firms still do not take carbon prices into account and do not forecast a long-term carbon price into decision-making. While this behavior may be partially attributable to the uncertainty in the system, this behavior also results from preferences that deviate from the profit maximization model. Firms may view their purpose and business as creating a certain industrial product, rather than by generating revenue through carbon reductions. Many firm managers prefer BAU, and appear to satisfice, rather than optimize.

3.9. Conclusions

The results of this study point provide several lessons for policy design, as well as for implementation and management of policy. Small firms and utilities may require capacity assistance. While larger firms want to minimize government interference, smaller firms feel highly burdened by the monitoring and reporting requirements, as well as their position regarding the trading system. When EU and German government officials are consulted, they note that this is not their responsibility, and that industry associations, consultants, and banks should take this role. It is unclear where this responsibility should lie; however, the U.S. has a rich history of small business compliance assistance with environmental and labor regulations. The costliness and burden of carbon regulations on the smallest players should be considered (especially considering that many of these firms may not have a reduction factor). From a social efficiency perspective, few carbon reductions are achieved from these firms, and the costs of their compliance are passed on to society. It may make sense to write guidelines specific for small industry, while providing assistance for meeting those regulations and participating in trading. Indeed, it is in society's best interest that firms behave rationally in this system, which is unlikely if they do not understand the system. If firms hoard permits, refuse to trade, and dump their permits at the end of the trading period, it creates uncertainty as well as a market failure for the rest of the system. A major obstacle in the effectiveness and efficiency of carbon trading is a lack of understanding and a preference towards BAU. It is possible that by educating firms regarding the economics of the system and encouraging firms to allocate permits to finance officers, firms will be able to behave more rationally.

This research also highlights the best practices for the implementation and management of carbon emissions at the firm level. Firms that report the least amount of difficulties with the ETS manage their permits through trading offices, rather than through compliance officers, and treat carbon as they would any other commodity. These firms balance their carbon trading strategy with carbon reduction strategies, treating each business unit separately. Smaller firms ought to consider balancing cost-effective efficiency investments along with other compliance driven strategies. The long-run expected costs of carbon permits ought to be considered when making energy efficiency investment decisions.

Lastly, uncertainty in the system provides an obstacle towards efficient management. Government needs to work hard to send a long-term price signal. While this is politically difficult, it is unlikely that firms will make adequate long-term investment decisions until government can set rules. Few firms reported any long-term strategy regarding carbon, with most firms making decisions for the time period in which rules are set. This behavior emphasizes the need for government to set long term rules and long-term price signals, which should allow for firms to make more efficient long-term decisions.

3.10. Notes

1. Due to institutional review board requirements and the need for confidentiality, interviewees, firms, and organizations cannot be identified in this publication. Interviewees are referred to as a representative of a large or small firm from industry or from a utility. Research notes are available upon request.

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4. Privatizing Climate Change Policy: Is there a public benefit?

4.1. Abstract

The Chicago Climate Exchange (CCX) and the Carbon Disclosure Project (CDP) are two private voluntary initiatives aimed at reducing carbon emissions and improving carbon management by firms. In this study, I sample power plants from firms participating in each of these programs, and match these to plants belonging to non-participating firms, to control for differences between participating and non-participating plants. Using a difference-in-differences model to control for unobservable differences between participants and non-participants, and to control for the trajectory of emissions prior to program participation, I find that CCX participation is associated with a statistically significant decrease in carbon dioxide emissions for participating plants. The CDP also appears to lead to a decrease in carbon emissions, though these findings are not statistically significant. Findings also suggest a positive weak relationship between program participation and an increase in non-fuel expenditures. I conclude that program participation likely reflects behavioral changes by firms and a shift of management strategies that occur with the decision to participate in these voluntary programs.

4.2. Introduction

Voluntary environmental agreements between industry and government have received significant attention in the academic literature over the past decade. While researchers have begun to understand when these types of programs can be effective at improving environmental quality, private initiatives on the part of non-governmental institutions and for profit corporations have received less attention, and it is unclear what the tradeoffs are for these types of initiatives and whether voluntary initiatives by private industry can lead to improvements in environmental quality and enhance the efficiency of environmental policy.

More specifically, this research seeks to determine the relationship between the level of coercion involved in voluntary environmental policy and the effectiveness and efficiency of these approaches. To assess this research question, I examine an information provision approach – the Carbon Disclosure Project - and a cap-and-trade approach – the Chicago Climate Exchange - to greenhouse gas reduction in power plants in the United States. Using a unique dataset where I calculate greenhouse gas emissions from the heat content of fuels, I use a difference in differences model to measure program effectiveness and efficiency by employing a two-stage model that controls for selection bias, and then measure the change in greenhouse gas emissions, greenhouse gas intensity, and the cost-effectiveness of greenhouse gas investments against a control group.

This research offers several unique contributions to the understanding of firm behavior, regulation, and environmental policy. First, while significant research has been conducted on the efficacy of public voluntary programs, very little research has addressed the effectiveness of private approaches to voluntary programs. Because of possible spillover effects of public voluntary programs, current analyses of public voluntary programs may be mis-specified (Lyon & Maxwell, 2007). By examining private voluntary programs, it is more likely that the effects of these programs can be isolated.

Second, voluntary programs can take advantage of a variety of policy tools that result in tradeoffs regarding program effectiveness and efficiency. While many studies have examined the impacts of individual programs, less is known about the comparative effectiveness and efficiency of varying levels of coercion in environmental regulation. This study seeks to help compare information provision approaches – a relatively low coercive method, and cap-and-trade approaches – a highly coercive method in voluntary environmental policy.

Finally, as legislators consider policy responses to climate change, it is increasingly apparent that a variety of policy tools and approaches will be necessary to tackle climate change (Victor, House, & Joy, 2005). Much research exists regarding voluntary approaches for addressing toxics, however, it is unclear whether lessons regarding voluntary agreements in toxics will be applicable to greenhouse gases, due to financial incentives to reduce energy costs (Morgenstern & Pizer, 2007). This research will give policy-makers and researchers a better understanding of the potential and role for voluntary programs to help address climate change and greenhouse gas reduction.

This paper proceeds as follows. First, I briefly present a brief framework for understanding why voluntary environmental programs might be effective, detail several approaches to voluntary environmental policy tools, and discuss private approaches to voluntary environmental policy. Second, I discuss my research design, including the construction of my sample and dataset, as well as the methodology for evaluating the effectiveness of voluntary environmental policy. Third, I present and discuss the quantitative results of the study. I conclude with recommendations for policy design as well as for future study of voluntary environmental policy.

4.3. The Effectiveness and Efficiency of Voluntary Environmental Programs

4.3.1. Two Models for VEP Effectiveness

Rational Model

Two models exist for the effectiveness of voluntary environmental policy. In the rational model of voluntary environmental policy, firms undertake voluntary environmental action to deflect the implementation or enforcement of more stringent mandatory regulation in the future (Lyon & Maxwell, 2004). Firms may also participate as part of a rational cost-benefit calculus where firms gain reputational or marketing advantages, experience with new regulations or new mechanisms such as carbon trading. There is mixed evidence for the effectiveness of voluntary policy under this model. While initial analyses concluded that these programs could be effective and in particular could reduce toxic releases, recent research has suggested that participants in these programs reduced toxics or greenhouse gases no more than non-participants in the programs (King & Lenox, 2000; Lyon & Maxwell, 2007; Morgenstern, Pizer, & Shih, 2007; Vidovic & Khanna, 2007; Welch, Mazur, & Bretschneider, 2000).

Several hypotheses exist regarding the lack of success of these programs. First, evidence for greenwashing suggests that some firms agree to improve environmental performance for the marketing benefits, and do not actually improve environmental behavior (Lyon & Kim, 2007). Second, while firms may improve environmental behavior, non-participants also improve environmental behavior suggesting that the program is ineffective, or that contagion exists between participants and non-participants (Lyon & Maxwell, 2007; Rivera, De Leon, & Koerber, 2006). Third, firms may be implementing behavior that was already planned (Khanna & Damon, 1999).

Another strand of literature suggests that firms may pursue voluntary environmental policy in response to demand from consumers, investors, and employees. Information disclosure programs, which reduce information asymmetry between investors and consumers and a firm's production process, may affect the demand for firm's goods, affect the demand for a firm's stock, affect the firm's ability to hire and retain employees, convince private citizens to take tort action against polluters, build support for new pollution control regulation, motivate citizen suits and complaint actions to force firms to undertake abatement, and give rise to judicial actions in countries where the constitution guarantees citizens the right to a healthy environment (Tietenberg, 2006).

Existing studies support the idea that some information disclosure programs can be effective at reducing emissions and improving environmental performance. Stakeholders may pressure firms to improve environmental management, which in turn leads to improved environmental performance (Dasgupta, Hettige, & Wheeler, 1997). Government based labeling programs encourage consumers to make choices that encourage improved environmental performance. Energy Star, for example, allows firms to disclose energy usage costs on consumer goods, and rewards top performers with an energy star label. This program is credited with improving the market value of environmentally sensitive products, reducing energy consumption, and reducing carbon emissions (Webber, Brown, & Koomey, 2000). Indonesia's PROPER program requires that firms disclose environmental performance. Firms receive a rating for their environmental performance, and display this rating on product labels. Afsah et al. (2000) conclude that PROPER has been an important driver in the improvement of environmental performance by operating in concert with pressures relating to public disclosure (Afsah, Blackman, & Ratunanda, 2000).

Capital markets may also respond to environmental performance and provide motivations for firms to improve environmental behavior. Within this literature, there is some division as to whether environmental performance directly drives stock performance, or whether environmental performance acts as an indicator of risk, which in turn drives stock performance (Feldman, 1996). Many empirical studies have used Toxic Release Inventory data as an indicator of environmental performance, indicating that the release of poor environmental performance information can have short term negative impacts on stock price (Ananathanarayanan, 1998; Hamilton, 1995).

Others have examined corporate environmental standards and have demonstrated that more stringent environmental standards and performance lead to higher market value (Dowell, Hart, & Yeung, 2000; Feldman, 1996; Hart & Ahuja, 1996; Kiernan, 2001; Russo & Fouts, 1997; White, 1996). While some research indicates that capital markets are influenced by environmental management, other research demonstrates that investment professionals do not react as strongly to measures of environmental performance (Fayers, Cocklin, & Holmes, 2000) and that financial benefits to firms may only be relevant for product driven environmental initiatives, rather than for process driven initiatives (Gilley, Worrell, Davidson, & El-Jelly, 2000). It has also been difficult to distinguish the advantage gained by environmental performance from the advantage gained from environmental marketing, which has been demonstrated to lead to a reputational, financial, and competitive advantage for firms (Miles & Covin, 2000; Prakash, 2002).

Boundedly Rational Model

While the rational model assumes that businesses make decisions using neoclassical decision theory, another model – or a boundedly rational model of voluntary environmental policy suggests that firms are not always maximizers, and that there may be opportunities for low- and no-cost environmental improvements (Altman, 2001; Porter & van der Linde, 1995). This inefficiency can be measured using input output models of production and has been termed x-inefficiency (Leibenstein, 1966; Leibenstein & Maital, 1992). Evidence that investments in capital can improve profitability and environmental outcomes supports this theory (Boyd & McClelland, 1999; Shadbegian & Gray, 2006), however, critics of this hypothesis argue that it is not plausible that corporate managers systematically overlook profitable opportunities (Palmer, Oates, & Portney, 1995) and that what appears profitable ex-post may not have been identified due to high search costs (Jaffe, Peterson, Portney, & Stavins, 1995). In addition, firm managers may not be aware of environmental management practices. Studies demonstrate that voluntary adoption of environmental management systems can improve environmental outcomes (Potoski & Prakash, 2005a). On a macro-economic scale, studies suggest that as much as 30 percent of Germany's Kyoto target can be reached through negative-cost environmental improvements, especially in energy efficiency (McKinsey & Company, 2007).

4.4. Contributions of this research

4.4.1. Private approaches to voluntary environmental policy

While the literature regarding voluntary environmental programs has examined a multitude of programs, most have focused on public voluntary agreements, and of those – mostly on programs where government negotiates a pollution reduction target with an industry association. Much less is known about private voluntary initiatives to improve environmental quality. These initiatives can take several forms. First, an NGO or non-profit organization can commit organizations to voluntary improving environmental behavior. Examples of this type of arrangement include International Standard for Organization (ISO) certification, which includes the implementation of environmental management practices, the Forest Stewardship Council Certification (FSC), which promotes the responsible management of forests, and the Carbon Disclosure Project (CDP) which asks firms to disclose carbon management practices as well as carbon related risks and opportunities. While public voluntary agreements are driven by government initiative, these programs are driven by consumers, investors, and supply chain managers. Investor led programs depart from government-led voluntary programs or unilateral firm-based programs because they rely on market pressures to induce behavior change and threaten non-participants with financial penalties.

A second type of private voluntary initiative includes firm-led initiatives, which include unilateral measures on the parts of individual firms, or collaborative efforts by a group of firms. These efforts, like public voluntary environmental programs, may be initiated in order to help firms gain experience with new types of regulation, improve public relations, or reduce the prospect or enforcement of more costly mandatory policy.

Several reasons exist for studying private approaches to environmental policy. First, while researchers and policymakers are beginning to get a better understanding of public voluntary initiatives, less is known about the effectiveness of private initiatives. Second, because there is less government oversight of these programs, it is unclear what their impacts may be. These programs may not be responsive to public interests – rather, they fulfill the needs of their stakeholders. While part of the promise of voluntary environmental policy was a movement towards self-regulation, it is important to understand the extent to which these programs can have positive impacts on environmental governance. Third, public voluntary programs have been difficult to study due to possible spillover effects – as government institutions have the incentive to disseminate best practices to non-participating firms (Lyon & Maxwell, 2007). Because government agency goals include improving environmental quality as much as possible, government officials may disseminate best practices for energy efficiency to non-participating firms, late joiners to a voluntary agreement, and other stakeholders. Private initiatives are often able to limit benefits of participation to participants – making participation akin to a club good (Potoski & Prakash, 2005b). This characteristic of private initiatives may help solve the specification problems inherent in analyzing public voluntary agreements.

4.4.2. Policy tools and voluntary environmental policy

In addition to helping researchers and policymakers understand the effects of voluntary environmental programs, and private initiatives in particular, this research hopes to demonstrate the comparative effectiveness and efficiency of different approaches to environmental policy. Policy tools in environmental policy can encompass a wide array of models that vary based on the amount of coercion employed by government. Traditional command-and-control regulation often specifies specific limits for pollutants and can even specify methods and technology for pollution control. Market-based regulation removes either the limits to pollution – by incentivizing emissions reduction through taxes or subsidies, or removes the regulations on how pollution was to be reduced, by establishing tradable property rights through a cap-and-trade system. Even less intrusive are labeling or information disclosure requirements, which seek to reduce information asymmetry between the producer and the consumer.

Voluntary environmental policy is not a unique policy instrument, but rather, can take the form of any of an array of types of policy instruments (Richards, 2000). While studies have examined individual voluntary environmental programs, few studies have sought to quantitatively compare the effectiveness and efficiency of different approaches to voluntary policy. Understanding the tradeoffs in effectiveness and efficiency of voluntary environmental policies is essential for improving the design and implementation of these policies.

4.5. Research Design: Assessing the Effectiveness and Efficiency of VEP

4.5.1. Sample

The sample for this study consists of electric utility power plants in the United States to evaluate two private voluntary environmental programs. The London-based non-profit Carbon Disclosure Project (CDP) represents a voluntary information provision program, with no requirements regarding enforcement or compliance. However, firms are rated on the quality of their responses and are rewarded with recognition for transparency in the Carbon Disclosure Leadership Index (CDLI). The CDP relies on the pressure of institutional investors to encourage firms to disclose carbon emissions and climate change related risks and opportunities. The project, which started in 2002, now boasts the support of institutional investors controlling $57 trillion in assets (PricewaterhouseCoopers, 2008). Approximately 65 percent of targeted companies respond to the survey, and about 75 percent of those responding make their responses public (the others are only accessible by project members). The logic for the project is simple: “addressing the climate change challenge depends on a dialogue, between shareholders and corporations, supported by high quality information. Companies need to articulate their position in a coherent way to an increasingly sophisticated set of stakeholders" (PricewaterhouseCoopers, 2008). Further, the project notes that a business can only manage what it measures – the first step in good management is good measurement. While the program seeks to have independently verifiable emissions data, about 35 to 50 percent of participants have independent verification and about 65 percent of responding firms make their direct emissions publicly available.

The second program represents a more coercive approach towards private voluntary climate change policy. The Chicago Climate Exchange is a private, for-profit venture where firms agree to reduce carbon emissions by one percent per year. Members represent a variety of industries and organizations, and also include offset providers and aggregators. Members make a voluntary but legally binding commitment to meet annual greenhouse gas reduction targets. Those who reduce below the targets can bank or sell excess allowances; those who emit above the targets comply with their contractual obligations by purchasing permits on the market. The exchange also provides independent, third party verification through the Financial Industry Regulatory Authority (FINRA, formerly NASD). While the program seeks to improve facilitate greenhouse gas allowance trading through price transparency and environmental integrity, the program does not make any emissions information available to the public or to investors. Trading began in 2003; the program now boasts over 300 members, including offset providers.

4.5.2. Data

Several types of data had to be collected to analyze the effectiveness of these programs. First, firm level revenue, and whether the firm was publicly traded were required to control for selection bias and match firms in each program against each other, as well as against a control group that did not participate. Second, the regulatory climate of each state was collected and coded to control for varying levels of regulations and incentives that might impact regionally situated electricity producers. Third, plant data was collected to determine the impact of the Chicago Climate Exchange and the Carbon Disclosure Project on plant-level generation decisions.

Firms were coded as public or private using Compustat, Google Finance, and other search engine methods. Firm level revenue data for rural electric coops were collected from the Velocity data suite; public firm revenue data were collected from the Compustat database. Following Berry and Fording (1997) I imputed missing data for firms missing a year’s to several years’ worth of data using Stata’s linear trending missing data function (Berry & Fording, 1997). For firms missing revenue data entirely, I estimated revenue using a tobit regression function where predicted revenue was a function of whether the firm was publicly traded, the year, whether the firm participated in the Chicago Climate Exchange, and whether the firm participated in the Carbon Disclosure Project (Berry & Fording, 1997). Imputed and missing data were limited to less than 12 percent of total observations on firm revenue.

State regulatory data and information regarding renewable energy and energy efficiency programs were compiled from the Database for State Incentives for Renewable Energy (DSIRE) and individual state energy offices (DSIRE, 2009). I count the total number of renewable energy and energy efficiency programs active in a particular state, for each year, which generates an indicator of regulatory activity in each state (Matisoff, 2008). The EPA website and state energy offices were used to determine whether or not states had active restructuring.

Plant level data were collected from 1994 – 2007 for approximately 1,000 power plants (about 5,000 prime movers) in the United States, totaling 14,393 plant-year observations. Plant level data were compiled with the assistance of Indianapolis Power and Light from the Velocity data suite, which relies primarily on data collected from EIA form 861, EIA form 412, and FERC form 1. Because fuel use data were not connected to data regarding plant characteristics, and firm level and state level data were also separate, data were combined into one large dataset using plant ID numbers, and operator ID numbers. Variables contain information on basic plant information including the operator, location, type of prime mover, fuel use for each type of fuel, heat rate of each fuel, plant capacity, plant age, and plant electricity generation. Plant age and capacity information were missing for several years of observations. Where these observations were missing, missing data were imputed using the previous years' data.

There were a variety of obstacles in generating this dataset. Fuel information was only available at the prime mover level, while other information was available at the plant level. Plants with multiple prime movers were combined to form one observation per plant-year. Plant information was linked with holding company information so that each plant would be associated with financials for a corporate parent, and was linked to state regulatory characteristics compiled from DSIRE.

While carbon dioxide emissions data are not publicly available for many power plants, I was able to calculate carbon dioxide data by multiplying the amount of each type of fuel used in each power plant by the heat rate, and I used the DOE regulations for the 1605b voluntary program in order to determine carbon dioxide emissions for each plant.

Because the 1605b regulations only have carbon dioxide emissions information for major types of fuel, I used the closest match for rare types of fuel.

Due to the nature of this work, a variety of tradeoffs had to be made to secure such a complete and detailed dataset. First, plant data is only available for power plants that have greater than 25 megawatt capacity. Second, unregulated electricity generators did not have to report plant characteristics and other plant-level data beginning in 2003. I was able to determine which plants had closed after 2002, and which had ceased to report data based on whether the plant continued to report fuel use, which was still required after 2002. Third, plants that do not have reported fuel use do not appear in the dataset, eliminating many renewable energy plants. Fourth, deregulated plants that began operation in 2003 or later may not have appeared in the dataset, due to changes in reporting requirements. Finally, nuclear plants and plants operated by universities were also eliminated from the dataset to achieve greater unit homogeneity. Altogether, the dataset totals 13,552 plant-year observations, or 968 power plants over 14 years.

4.5.3. Methodology

Because plants participating in a voluntary program may be systematically different than plants not participating in a voluntary program, it is necessary to establish a control group of plants for each of the treatment groups. Creating a matched control group can serve as a method to form a quasi-experimental contrast between a treatment and control, by sampling from a larger pool of cases, or it can serve to adjust for treatment assignment patterns when it is feared that regression parameter estimates cannot be trusted (Morgan & Winship, 2007). Because of the large size of the dataset, and multiple time period nature of the dataset, I chose to use a nearest-neighbor propensity score matching method. Using this method, I match plants based on the probability that plants are participants in each voluntary program, given plant, firm, and state characteristics. Participating plants are matched, without replacement, to the non-participating plant that has the closest likelihood of joining the voluntary program (Morgan & Winship, 2007).

$$Pr[joining = 1 / \sum x] = \frac{exp(a + b_1 x_1 + b_2 x_2 + b_n x_n)}{1 + exp(a + b_1 x_1 + b_2 x_2 + b_n x_n)}$$

Plants from each program were matched with a sample of non-participating plants, based on participation status in 2007. A one to one nearest neighbor match was conducted using the Stata user generated program psmatch2, using a logit regression (Leuven & Sianesi, 2003). For each program, plants were matched by psmatch2 using the likelihood of participation in each voluntary program, based on whether or not the firm is publicly traded (1 = yes), the year of plant construction, the capacity of the plant (in megawatts), the number of state energy programs active, the parent company size (measured as the natural log of millions of dollars in revenue), and whether or not utility restructuring was active in a state (1=yes).

Participation decisions in voluntary environmental agreements are made by corporate parents, rather than individual plants, and larger firms have consistently participated in voluntary environmental agreements more regularly than smaller firms (Khanna, 2001). Revenues for the holding company in 2007 measured firm size. Investor owned utilities are much more likely to participate in voluntary environmental agreements because the CDP specifically targets large, publicly traded firms, while the CCX is comprised primarily of publicly traded firms. Finally, because of varied state regulatory activity, plants that operate in states with more regulatory activity related to energy may be more likely to participate in voluntary initiatives.

Unmatched participating or non-participating plants were discarded from the sample, leaving 5,180 plant-year observations for the Carbon Disclosure Project, and 2,744 plant-year observations for the Chicago Climate Exchange. While matched samples allow me to assume that there is no difference between the treatment group and the control group, it is still possible that unobserved differences within the treatment group and control group exist (Moffit, 1991; Morgan & Winship, 2007).

Once matching has occurred, the expected outcomes for each the control group, and the treatment group are the same, given the observable differences in the treatment group and control group. I test this assumption using a Hotellings T-squared test statistic on the joint equivalence of the covariates between the treatment and control groups. However, this method does not control for unobserved heterogeneity within each plant, nor does it control for changes in conditions over time. To control for unobserved heterogeneity or omitted variables in matching process as well as changes in conditions at each plant over the study period, I take the first difference of my outcome variable *y* (carbon emissions, then total non-fuel expenditures) and each of my control variables λ over time period *s* (1994-2007), where *x* (program participation) is not differenced and is a dummy variable that denotes program participation in year *t* (Allison, 1990; Moffit, 1991; Morgenstern, et al., 2007). Thus, I estimate the change in the dependent variable as a function of program participation and changes in conditions.

$$\Delta_s y_{it} = \alpha + \sum \beta_{it} X_{it} + \sum \theta_{it} \Delta_s \lambda_{it} + e_{it}$$

where: $\Delta y_{it} = y_{it} - y_{i(t-1)}$ and $\Delta \lambda_{it} = \lambda_{it} - \lambda_{i(t-1)}$

This equation is estimated using ordinary least squares, with robust standard errors clustered on the panel variable *i*.

The matching method is used for both the Chicago Climate Exchange and Carbon Disclosure Project. The difference in difference method is repeated for each program for plant level CO_2 emissions (in metric tons), and plant level total non-fuel costs (in dollars). Each model is estimated with and without a control for the quantity of electricity generation.

4.6. Results

Table 4.1: Generating a Matched Sample for the Chicago Climate Exchange: predicting participation in the Chicago Climate Exchange and the Carbon Disclosure Project in 2007

Logistic Model	CCX	CDP
Number of Observations	966	700†
LR Chi^2	66.60***	101.83***
Pseudo R^2	.1050	.1259
Publicly Traded Firm (1=yes)	1.823 (.479)***	†
Firm Level Revenue (ln$000,000)	-.305 (.102)***	.821 (.099)***
Plant Capacity (MW)	.00021 (.00016)	.00002 (.00013)
Year of Construction	-.00587 (.00525)	-.0135 (.0045)***
Active State Restructuring (1=yes)	1.011 (.264)***	-.240 (.2197)
Total State Energy Programs (#)	.0379 (.0134)***	.03387 (.0133)***
Constant	9.058 (10.356)	19.88 (8.81)**

* represents significance at the α = .10 level
** represents significance at the α = .05 level
*** represents significance at the α = .05 level

† because only publicly traded companies participated in the CDP, the matching software excludes non-publicly traded companies from the sample

As demonstrated by Table 4.1 above, I predict 10 to 13 percent of the variation of a plant's probability of joining each voluntary program. While parameter estimates seem to support existing theory regarding participation in voluntary environmental policy, the standard errors are incorrect, due to different levels of measurement of the independent variables, and correlation across observations. Thus, it is not possible to directly interpret parameter estimates as hypothesis tests on the independent variables.[6]

Because the Chicago Climate Exchange is a small program, and the CDP is such a large program, many unmatched observations were eliminated from the sample (see table 2 below). For the CCX, 98 plants in the sample participated in the program, allowing these to be paired with the 98 plants that most closely resembled those that participated in the program. In contrast, only 185 plants belonging to publicly traded firms *did not* participate in the CDP, leading to the exclusion of participating plants. While other methods of matching such as kernal matching, matching with replacement, and weighted matching would have allowed for more data to be used in a difference of means test, these methods would not have been easily compatible with a longitudinal difference in differences model.

Recent literature suggests that because poorly matched samples may create bias in estimated program effects, the matched samples should be tested for balancing to reduce bias and ensure that the matching process sufficiently controls for observable differences between the treatment and control group (Smith & Todd, 2005a, 2005b; Smith & Zhang, 2009). A variety of tests exist to check for balancing, and these methods have received criticism due to the inconsistency of results (Lee, 2006; Smith & Zhang, 2009), and whether or not balancing tests are necessary (Dehejia, 2005).

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[6] While the standard errors are not correct – the parameter estimates are unbiased and consistent. This allows for substantive interpretation of the parameter estimates, but not for causal relationships.

While a balancing test is not essential for this sample, as the difference in differences model will control additional heterogeneity by examining only the within unit changes over time, following Smith and Petra, 2005b, I conduct a Hotelling T-Square balancing test to demonstrate the similarity of treatment group and control group after matching. The Hotelling T-Square test is essentially an F-test on the joint equivalence of the covariate means of the treatment group and control group and can be conducted in Stata. As Table 4.2 below demonstrates, the treatment group and control group have extremely similar means and standard deviations, and the F test fails to reject the null hypothesis that the means of the two samples are jointly equivalent. Both the CCX sample and the CDP sample appear balanced by both measures, even before within differencing.

Table 4.2: Means and Standard Deviations of Matched Samples, with Hotelling T-Square Balancing Test

Chicago Climate Exchange Matched Sample (98 pairs)

Variable	Control Mean	Treatment Mean	Control Standard Deviation	Treatment Standard Deviation
Publicly Traded Firm (1=yes)	.83	.88	.380	.329
Firm Level Revenue (ln$000,000)	8.17	8.28	1.61	.98
Plant Capacity (MW)	700	691	739.46	697.28
Year of Construction	1968	1963	19.57	21.04
Active State Restructuring (1=yes)	.76	.70	.432	.458
Total State Energy Programs (#)	20.77	19.85	10.46	8.49

Two Group Hotelling T-Square = 5.38

F Statistic = .8737; p-value = .5153

Carbon Disclosure Project Matched Sample (185 pairs)

Variable	Control Mean	Treatment Mean	Control Standard Deviation	Treatment Standard Deviation
Firm Level Revenue (ln$000,000)	8.33	8.51	1.38	.89
Plant Capacity (MW)	693	741	639.78	677.82
Year of Construction	1971	1976	20.89	20.70
Active State Restructuring (1=yes)	.41	.36	.492	.481
Total State Energy Programs (#)	14.42	13.37	8.45	6.30

Two Group Hotelling T-Square = 8.50

F Statistic = 1.683; p-value = .1378

Table 4.3: Observations in Dataset and for each program

Program	CCX	CDP
Number of initial plants	966	966
Initial plant-year observations	13,558	13,558
Matched pairs	98	185
Total plant-year observations after first differencing	2,548	4,810

Table 4.4: Chicago Climate Exchange versus the Carbon Disclosure Project: Difference-in-differences model, Effect of Participation on ΔCO_2 emissions (metric tons), OLS parameter estimates shown, clustered standard errors in parentheses

Model	CCX1	CCX2	CDP1	CDP2
Observations	2548	2548	4810	4810
F Statistic	3.83***	14.62***	1.35	33.63***
R-Squared	.0027	.0162	.0007	.1846
Program Participation	-228,416 (126,926)*	-216,802 (126,446)*	-11,260 (21,425)	-21,560 (13,782)
ΔState Restructuring	191,576 (112,076)*	96,009 (108,807)	71,312 (87,058)	28,773 (77,923)
ΔFirm Revenue (ln $000,000)	118,535 (81,973)	70,392 (80,848)	38,765 (51,722)	-599 (49,823)
ΔState Programs	73,913 (108,902)	77,278 (108,580)	-12,775 (7,726)*	978 (6,796)
ΔMWh		.745 (.1098)***		.8008 (.0653)***
Constant	-25.25 (12.92)*	-92,242 (151,024)	22,243 (13,158)*	-6,851 (12,553)

* represents significance at the $\alpha = .1$ level
** represents significance at the $\alpha = .05$ level
*** represents significance at the $\alpha = .01$ level

Table 4.4 above demonstrates the impact of program participation in either the Chicago Climate Exchange or the Carbon Disclosure Project on changes in plant level emissions, compared to what would have occurred had program participation not occurred. Specification 1 for each program does not control for changes in electricity output for each plant, while specification 2 controls for electricity output, which is similar to measuring the changes in carbon intensity of greenhouse gas emissions.

Participation in the Chicago Climate Exchange is associated with, on average, approximately a cumulative 220,000 metric ton decrease in carbon emissions, compared to the matched control group and the emissions trajectory prior to participation. The standard errors demonstrate a significant amount of variability in the CCX program participation estimates; however, it is important to recognize that the nature of the CCX program allows firms to trade emissions permits. Thus, a high variability of CO_2 reductions amongst participants should be expected. Control variables, such as the change in state restructuring, firm growth rate, and the change in state programs, are added to capture observable changes over time, which the matching exercise does not capture. It is not surprising that these variables are not statistically significant, given the matching technique that should already control for static differences in these factors.

Participation in the Carbon Disclosure Project, in contrast, is associated with a decrease of approximately 10,000 – 20,000 metric tons of carbon, depending on the model specification, though neither of these values is statistically significantly different from 0 at any reasonable value of α.

The CCX program has been in effect for 4 years, meaning that on average participating power-plants have each reduced emissions by 220,000 metric tons, or 55 thousand tons per year, per plant. While the CDP program is as old as the CCX program, many firms joined the CDP much later, and have only been members for a year or two. The average length or participation in the CDP in this sample is 2.69 years. CDP plant participants have each reduced their carbon emissions by 4,000 to 8,000 tons per year, per plant, compared to the matched control group and the trajectory prior to participation.

Table 4.5: Chicago Climate Exchange versus the Carbon Disclosure Project: difference-in-differences model, effect of participation on the change in non-fuel operating expenses, OLS parameter estimates shown, clustered standard errors in parentheses

Model	CCX1	CCX2	CDP1	CDP2
Observations	2548	2548	4810	4810
F Statistic	1.20	1.75	0.77	2.26**
R-Squared	.001	.0194	.0007	.003
Program Participation	279,952.2 (173,924.4)	297,643.2* (168,025.1)	160,817 (119,731)	156,021.9 (118,956.6)
ΔState Restructuring	112,209 (159,792.7)	-33,359.71 (190,199.5)	-58,462.4 (130,520.6)	-78,267.53 (132,869.3)
ΔFirm Revenue (ln $000,000)	-39,867.47 (111,375.4)	-113,199.5 (118,176.1)	-29,443.25 (98,636.96)	-47,769.98 (96,980.41)
ΔState Programs	-55,787.08 47,820.51	-50,661.04 (46,835.18)	-23,129.52 38,457.52	-16,726.53 (38,798.99)
ΔMWh		1.135121** (.5395278)		.3728116 (.1434044)***
Constant	228,550.3 69,029.82	240,515.5*** 66,198.4	292,651.4 (46,492.18)***	279,105.9 (46,144.55)***

* represents significance at the $\alpha = .1$ level
** represents significance at the $\alpha = .05$ level
*** represents significance at the $\alpha = .01$ level

Table 4.5 above represents increases in total non-fuel spending by participants in the Chicago Climate Exchange and Carbon Disclosure Project, in contrast with what would have occurred without program participation. Both programs appear to have a mild impact on plant non-fuel investments. Participating firms have increased total plant-level non-fuel expenditures. Due to the accounting nature of the data, where firms depreciate the costs of investments quickly over time, leading to negative fixed cost data, standard errors for this data may be inflated due to high variability of individual plant costs over time.

Control variables are not statistically significant in these models, but simply serve to control for changes in conditions over time, given that plants were already matched based on their propensity to participate in the CCX or CDP.

According to these results, CCX participants spend, on average between $280,000 and $300,000 each over four years of participation (or about $70,000-$75,000 per year) more than matched non-participants. CDP participants spend, on average, about $120,000 more than matched non-participants or their trajectory prior to participation, or approximately $45,000 per year more than their trajectory prior to participation or control group participants.

4.7. Discussion

When interpreting parameter estimates it is important to remember the purpose of this study and the limitations of these methods. Program participation is measured by a dummy variable, which measures the decision to participate in a voluntary environmental program, but also captures any unobservable changes in firm behavior that directly coincide with the decision to participate. The measurement of program participation can capture a broader array of behavioral changes by a firm than simply the decision to participate. It seems likely that any decision to participate in a voluntary environmental program was accompanied by changes in how firms decide to manage carbon; however, these changes are not observable, and are captured by the program participation measurement. Nevertheless, firms that participate in these voluntary programs improve their environmental behavior while firms that do not participate do not. These results support the hypothesis that a contractually binding voluntary environmental program has a greater relationship with plant level reductions of carbon dioxide emissions and on the increase in plant level non-fuel expenditures, as well as on expenditures by program participants.

Due to high variability of CO_2 emissions estimates, perhaps as a result of emissions trading, and high variability of cost estimates, perhaps as a result of capital depreciation accounting practices, results are not strongly statistically significant. Nevertheless, parameter estimates in these models are unbiased and consistent and are substantively interpretable.

With CCX emissions permits trading with a value between $0 and $2, it seems unlikely that drastic changes in firm behavior occurred due to a price on carbon permits. It seems much more likely that firm management recognized carbon emissions as a growing liability, chose to participate in the voluntary trading program, and chose to shift management practices towards increased efficiency and fuel switching when these changes were not particularly costly. Participation in the CCX is associated with firms identifying and taking advantage of low cost emissions abatement opportunities. Evidence from other studies suggests that low and no cost efficiency improvements may be widely available, and it is possible that participation in voluntary programs can help firms identify these opportunities. Results of these models suggest that firms traded decreases in fuel use for increases in capital, maintenance, and other non-fuel expenditures. Because regulated power plants can pass along the costs of efficiency investments to consumers, these firms may not be cost minimizers, but instead may have been able to build in modest carbon emissions reduction goals into medium term investment decisions.

Conversations with firm managers support these conclusions. According to one manager, “joining the Chicago Climate Exchange was part of an effort to start to become more attuned to our carbon impact, gain experience with carbon trading and prepare for changing regulatory conditions. We have made a lot of subtle changes in the way carbon is managed – from experimenting with hybrid cars and trucks to efficiency upgrades at power plants, where we try take a long-term view…”[7]

CDP results seem to reinforce these findings. While the CDP has no emissions reduction requirements and firms simply report their carbon management strategies, CDP participants decrease their emissions and emissions intensity associated with electricity production, and increase their non-fuel expenditures. Conversations I have had with program participants and CDP officials suggest that the decision to participate in the CDP reflects behavioral changes made by firm managers aimed at improving the management of carbon.

4.8. Conclusion

The important results of this study indicate that participation in voluntary initiatives by firms may be associated with a small improvement in comparison to what would have occurred without program intervention. While the measurement of program participation captures any behavioral changes made by firms at the time of the decision to participate, participation in the CCX or CDP demonstrates a firm’s commitment towards

[7] Conversation with Electric Utility Firm Manager July, 27, 2009.

improved management practices, or may serve as a justification for firm managers to pursue strategies that reduce carbon emissions and intensity.

Firms are faced with a variety of strategic options when attempting to address carbon management. Firms can invest in efficiency and technology improvements, engage in fuel switching, purchase or create offsets from developing countries, or do nothing. Previous research suggests that many firms prefer to pursue business-as-usual outcomes, and that many firms severely discount the benefits of efficiency investments (Matisoff, 2010). Firms that participate in the CCX or CDP appear to depart from the business-as-usual trajectory, and have chosen to invest in cost-effective carbon reduction strategies. In particular, it appears that these firms have chosen to reduce fuel use in exchange for non-fuel expenditures, such as technological and efficiency improvements.

These results may understate changes due to the CCX or CDP. This sample only measures changes in fossil fuel consumption, and does not measure changes in the increase of renewable electricity, or other changes that might occur outside of the sample. In addition, electric utilities are potentially the most rational of industries, with simple production processes that make it easy to consider carbon dioxide emissions in electricity production. In contrast, manufacturers face more complex production processes and decision-making, and are more likely to pursue business-as-usual under uncertain conditions (Matisoff, 2010). Most importantly, these results contribute to the growing body of literature that suggests that voluntary programs may have a modest impact on pollution decisions by firms.

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5. Which type of sunlight is the best disinfectant? The comparative effectiveness of mandatory and voluntary information disclosure programs

5.1. Abstract

In this study, I compare the effectiveness of state mandatory carbon reporting programs with the voluntary Carbon Disclosure Project, which uses investor pressure to push firms to disclose carbon emissions and carbon management strategies. I match firms in each program to control groups of firms that have not participated in each program. I then use a difference-in-differences model in order to measure the impact of each program on plant-level carbon emissions, plant-level carbon intensity, and non-fuel cost expenditures. I find that the Carbon Disclosure Project is associated with reductions in plant level carbon intensity in comparison to state reporting programs. State reporting programs do not have any impact on carbon emissions or plant-level non-fuel expenditures. While the Carbon Disclosure Project seems to reduce greenhouse gas emissions and lead to increases in non-fuel expenditures, parameter estimates are not sufficiently statistically significant to make strong claims about the effectiveness of this program. I conclude that participation in the CDP reflects changes made by firm managers that lead to improved carbon management.

5.2. Introduction

As industrialized nations prepare to deal with climate change policy, it has become increasingly important that quality greenhouse gas emissions data are collected from firms. The aggregation of this information is the first step towards improved management of greenhouse gases. In addition, the transparency of firm operations and the reduction of information asymmetry between firms and their investors and consumers may provide a vehicle for free-market environmental policy and the impetus for improved management and increased efficiency of greenhouse gas operations.

Experiences with the Toxic Release Inventory program have increased hopes that improved transparency can lead to pressure on firms to reduce pollution voluntarily; however, carbon dioxide may prove to be a more difficult pollutant to address than toxics. Carbon dioxide is the product of fossil fuel combustion. Because fuel is costly, firms already face an incentive to reduce costs to maximize profits (Morgenstern & Pizer, 2007).

Nevertheless, a variety of information disclosure programs have arisen on the national, state, and international levels. Since 1993, Wisconsin has mandated greenhouse gas emissions disclosure from large emitters of carbon dioxide (EPA, 2009). Over time, the number of states requiring this disclosure has increased to 18 states, and a proposed rule currently exists to require national greenhouse gas reporting from large emitters. Voluntary initiatives have proliferated as well. The Department of Energy's 1605b program encourages firms to voluntarily report carbon emissions to the federal government. The Carbon Disclosure Project is a non-profit voluntary initiative designed to improve transparency between firms and investors, and encourage improved management of greenhouse gases by firms.

Despite the proliferation of information disclosure programs, little understanding exists regarding the effectiveness of individual programs and more importantly, the comparative effectiveness of different approaches to information disclosure programs. As industrialized countries seek to address greenhouse gases, they are faced with an increasingly broad array of policy tools and approaches to policy that can be used to improve the governance of greenhouse gases. In addition, while a vibrant research program has evolved evaluating the effectiveness of voluntary environmental programs, little is known about the comparative effectiveness of voluntary and mandatory initiatives.

Using a panel of plant-level data, this research seeks to evaluate a voluntary and a mandatory approach to information disclosure programs and determine the comparative effectiveness of these two approaches. This research will help contribute to the debate regarding the effectiveness of voluntary programs, while specifically comparing the effects of state mandatory programs to the impact of a non-profit voluntary initiative. Through this research, researchers and policy-makers will gain a better understanding of the tradeoffs of voluntary and mandatory environmental policy, and an understanding of the extent to which information disclosure programs can play a role in the mix of policy tools used to address climate change. With the U.S. considering mandatory greenhouse gas reporting and other greenhouse gas regulation, it is important to understand the expected impacts and tradeoffs of these policy approaches.

This research proceeds as follows. First, I detail research regarding the comparative effectiveness of mandatory and voluntary environmental programs. Second, I discuss information disclosure programs as a mechanism for addressing environmental problems. Third, I discuss my sample and methodology. I then present results and conclude with a discussion and conclusion, highlighting the implications of this research for climate change policy and environmental policy-making.

5.3. The comparative effectiveness of mandatory and voluntary programs

5.3.1. Why study the comparative effectiveness and efficiency of information disclosure programs?

The impact of voluntary environmental programs has received significant attention in the policy literature over the past decade. Voluntary environmental programs were developed by government with the aim to reduce confrontation between firms and government in environmental policy, reducing the cost of the implementation of environmental policy while increasing satisfaction by stakeholders (Khanna, 2001). To date, most research on voluntary environmental programs has sought to analyze whether these programs could replace mandatory policy by examining the effectiveness of these programs. Increasingly, policy researchers have concluded that voluntary policy cannot replace mandatory policy. While firms that participate in voluntary policy have modestly improved their environmental performance, firms that have not participated have improved their behavior as well, leading researchers to conclude that voluntary programs likely formalize environmental improvements that would have occurred without program intervention. These results have led to a pessimistic outlook on voluntary environmental programs as a mechanism to improve environmental performance (Lyon & Maxwell, 2007).

While analyzing the impact of voluntary programs is certainly an important exercise, there are a variety of flaws with the approach taken thus far. First, if voluntary policies are designed to exist as an alternative to mandatory programs, voluntary initiatives ought to be compared to mandatory alternatives. Few studies have attempted to compare the effectiveness of voluntary and mandatory programs. Because policy-makers are faced with a variety of policy instruments and each instrument involves trade-offs, it is essential to improve the understanding of the comparative impact of voluntary and mandatory approaches.

Second, many voluntary environmental policies that have been studied are public voluntary agreements, which involve agreements between industry and government, and specifically set environmental goals for firms. Even when these goals are reached, policy-researchers have concluded that these programs may be ineffective, due to behavioral change by non-participants as well. It is possible that mis-specification has masked the improvement of environmental performance by firms participating in voluntary public programs (Lyon & Maxwell, 2007). Studying a private voluntary program makes it more likely to isolate club good benefits that result from these initiatives, and makes it possible to better isolate the impacts of voluntary environmental policy (Prakash & Potoski, 2006).

Third, studying information provision approaches to voluntary policy allows for an evaluation of a less coercive approach to environmental policy. While game theoretic models suggest that negotiated voluntary agreements will provide less environmental behavioral change than mandatory policy due to the firm's ability to deflect the enactment and enforcement of more costly mandatory policy, information provision approaches to voluntary policy work by facilitating improved management of pollutants, taking advantage of low and no cost improvements, and allowing firms to respond more effectively to consumer and investor preferences. Information provision approaches to environmental policy may provide different lessons regarding the comparative impacts of voluntary and mandatory policy.

5.3.2. Hypotheses regarding the comparative effectiveness of mandatory and voluntary information disclosure programs

Information disclosure programs do not have specific emissions targets. Information disclosure programs are based on the idea that through transparency, firms will be encouraged via market and public pressures to reduce emissions (Ananathanarayanan, 1998; Hamilton, 1995). It is increasingly recognized that firms are boundedly rational actors, and that opportunities for low or no cost environmental improvements may exist (Matisoff, 2010; Porter & van der Linde, 1995; Shadbegian & Gray, 2003, 2006). Research in Germany demonstrates that as much as one third of Germany's targets under Kyoto can be reached through negative or no cost environmental improvements (McKinsey & Company, 2007). Individuals and businesses are prone to business as usual behavior – or adherence to the default heuristic, where individuals and firms accept the status quo as a mechanism to make quick and frugal decisions (Bennis, Berg, Katsikopoulos, Goldstein, & Dieckmann, 2009; Girgerenzer & Todd, 1999; Matisoff, 2010)

The process of information disclosure forces a firm to analyze its activities, seek out means for improvements in efficiency, and improve management techniques. The effectiveness of the information disclosure programs is likely a function of the extent to which firms are engaging suboptimal behavior, and the extent to which a program may provide incentives that would encourage a firm to act on improved information, such as more provisions for collaboration. A private program, linked closely with investors who link emissions to financial risk may have a greater impact than a public registry of firm emissions. While public programs and private programs may be able to be designed similarly, in practice, private programs may be able to keep informational and reputational benefits as a club good, create closer linkages with market forces that would encourage beyond compliance behavior, and encourage participants to use information collection as a mechanism to improve efficiency.

> ***Hypothesis:*** *In information provision programs, voluntary environmental agreements produce greater reductions in firm emissions of greenhouse gases than similar mandatory arrangements.*

5.4. Research design

5.4.1. Sample and dataset

Two types of programs were selected for this research. First, the Carbon Disclosure Project is a private voluntary initiative designed to promote improved management of carbon by pressuring firms to report their carbon emissions, and describe their carbon strategies and carbon related risks and opportunities. It is funded and run by institutional investors, which currently control over $33 trillion in assets. The Carbon Disclosure Project began in 2003, and targets the largest publicly traded firms. It ranks firms based on the quality of their responses and rewards transparent firms with acknowledgement in their Carbon Disclosure Leadership Index. Firms are allowed to make their responses public, or can keep responses limited to the institutional investors that fund the program.

Second, state reporting programs are mandatory state efforts designed to help states manage and prepare for mandatory carbon regulation. Emissions reporting of greenhouse gases is currently required in eighteen states. For example, Wisconsin has required emissions reporting since 1993 for firms that emit more than 100,000 tons of carbon per year. The state's strong community right-to-know ethic makes the information readily available to the public via the Internet. As more states strengthen their carbon reporting requirements, it is increasingly important to include measurements regarding state level regulatory environments.

Three types of data had to be collected to analyze the effectiveness of these programs. Because participation decisions for the CDP are made at the firm level, firm level characteristics, such as whether or not a company is publicly traded, and firm size were measured. Second, state characteristics relating to the regulatory climate of each state were coded and collected to control for varying levels of regulations and incentives that might impact regionally situated electricity producers. Third, plant characteristics were collected to match similar plants and control for plant changes over time.

Firms were coded as public or private using Compustat, Google Finance, and other search engine methods. Firm revenue data were collected from the Compustat database. Following Berry and Fording (1997) I imputed missing data for firms missing a year to several years of data using Stata's linear trending missing data function (Berry & Fording, 1997). For firms missing revenue data entirely, I estimated revenue using a tobit regression function where predicted revenue was a function of whether the firm was publicly traded, the year, whether the firm participated in the Chicago Climate Exchange, and whether the firm participated in the Carbon Disclosure Project (Berry & Fording, 1997). Imputed and missing data was limited to less than 12% of total observations on firm revenue.

State regulatory data and information regarding renewable energy and energy efficiency programs were compiled from the Database for State Incentives for Renewable Energy (DSIRE) and individual state energy offices (DSIRE, 2009). I count the total number of renewable energy and energy efficiency programs active in a particular state, for each year (Matisoff, 2008). The EPA website and state energy offices were used to determine whether or not states had active restructuring in each year.

Plant level data were collected from 1994 – 2007 for approximately 1,000 power plants (about 5,000 prime movers) in the United States, totaling 14,393 plant-year observations. Plant level were compiled with the assistance of Indianapolis Power and Light from the Velocity data suite, which relies primarily on data collected from EIA form 861, EIA form 412, and FERC form 1. Because fuel use data, data containing plant characteristics, and firm level and state level data were contained in separate datasets, data were combined into one large dataset using plant ID numbers, and operator ID numbers. Variables in the dataset contained basic plant information including the operator, location, type of prime mover, fuel use for each type of fuel, heat rate of each fuel, plant capacity, plant age, and plant electricity generation. Plant age and capacity information were missing for several years of observations. Where these observations were missing, missing data were imputed using the previous years' data.

There were a variety of obstacles in generating this dataset. Fuel information was only available at the prime mover level, while other information was available at the plant level. Plants with multiple prime movers were combined to form one observation per plant-year. Plant information was linked with holding company information so that each plant would be associated with financials for a corporate parent, and was linked to state regulatory characteristics compiled from DSIRE.

While carbon dioxide are not publicly available for many power plants, I was able to calculate carbon dioxide data by multiplying the amount of each type of fuel used in each power plant by the heat rate, and I used the DOE regulations for the 1605b voluntary program in order to determine carbon dioxide emissions for each plant. Because the 1605b regulations only have carbon dioxide emissions information for major types of fuel, I used the closest match for rare types of fuel.

Due to the nature of this work, a variety of tradeoffs had to be made to secure such a complete and detailed dataset. First, plant data is only available for power plants that have greater than 25 megawatt capacity. Second, unregulated electricity generators did not have to report plant data beginning in 2003. I was able to determine which plants had closed after 2003, and which had ceased to report data based on whether the plant had reported fuel use, which was still required after 2002. Third, plants that do not have reported fuel use do not appear in the dataset, eliminating many renewable energy plants. Fourth, deregulated plants that began operation in 2003 or later may not have appeared in the dataset, due to changes in reporting requirements. Finally, nuclear plants and plants operated by universities were also eliminated from the dataset to achieve greater unit homogeneity. Altogether, the dataset totals 13,552 plant-year observations, or 968 power plants over 14 years.

5.4.2. Methodology

Because plants participating in a voluntary program may be systematically different than plants not participating in a voluntary program, it is necessary to establish a control group of plants for each of the treatment groups. Creating a matched control group can serve as a method to form a quasi-experimental contrast between a treatment and control, by sampling from a larger pool of cases, or it can serve to adjust for treatment assignment patterns when it is feared that regression parameter estimates cannot be trusted (Morgan & Winship, 2007). Because of the large size of the dataset, and multiple time period nature of the dataset, I chose to use a nearest-neighbor propensity score matching method. Using this method, I match plants based on the probability that plants are participants in each voluntary program, given plant, firm, and state characteristics. Participating plants are then matched, without replacement, to the non-participating plant that has the closest probability of joining the voluntary program (Morgan & Winship, 2007).

$$Pr[joining = 1 / \sum x] = \frac{exp(a + b_1 x_1 + b_2 x_2 + b_n x_n)}{1 + exp(a + b_1 x_1 + b_2 x_2 + b_n x_n)}$$

Plants from the CDP were matched with a sample of non-participating plants, and plants participating in mandatory state reporting programs were matched based on participation status in 2007. A one to one nearest neighbor match was conducted using the Stata user generated program psmatch2, using a logit regression (Leuven & Sianesi, 2003). For each program, plants were matched by psmatch2 using the likelihood of participation in each voluntary program, based on whether or not the firm is publicly traded (1 = yes), the year of plant construction, the capacity of the plant (in megawatts), the number of state energy programs active, the parent company size (measured as the natural log of millions of dollars in revenue), and whether or not utility restructuring was active in a state (1=yes).

For the CDP, participation decisions in voluntary environmental agreements are made by corporate parents, rather than individual plants, and larger firms have consistently participated in voluntary environmental agreements more regularly than smaller firms (Khanna, 2001). For the state reporting programs, participation depends solely upon location, but the matching method helps find plants that are a good comparison. Revenues for the holding company in 2007 measured firm size. Investor owned utilities are much more likely to participate in voluntary environmental agreements because the CDP specifically targets large, publicly traded firms. Finally, because of varied state regulatory activity, plants that operate in states with more regulatory activity related to energy may be more likely to participate in voluntary initiatives.

Unmatched participating or non-participating plants were discarded from the sample, leaving 5,180 plant-year observations for the CDP and 2,352 plant-year observations for the state reporting requirements. While matched samples allow me to assume that there is no difference between the treatment group and the control group, it is still possible that unobserved differences within the treatment group and control group exist (Moffit, 1991; Morgan & Winship, 2007).

Once matching has been completed, the expected outcomes for each the control group, and the treatment group are the same, given the observable differences in the treatment group and control group. I test this assumption using a Hotellings T-squared test statistic on the joint equivalence of the covariates between the treatment and control groups. However, this method does not control for unobserved heterogeneity within each plant, nor does it control for changes in conditions over time. In order to control for the unobserved heterogeneity or omitted variables in matching process as well as changes in conditions at each plant, I take the first difference of the outcome variable y and each of my control variables λ over time period s, where x is not differenced and is a dummy variable that denotes program participation in year t (Allison, 1990; Moffit, 1991;

Morgenstern, Pizer, & Shih, 2007). Thus, I estimate the change in the dependent variable as a function of program participation and changes in conditions.

$$\Delta_s y_{it} = \alpha + \sum \beta_{it} X_{it} + \sum \theta_{it} \Delta_s \lambda_{it} + e_{it}$$

where: $\Delta y_{it} = y_{it} - y_{i(t-1)}$ and $\Delta \lambda_{it} = \lambda_{it} - \lambda_{i(t-1)}$

This equation is estimated using ordinary least squares, with robust standard errors clustered on the panel variable *i*.

The matching method is used separately for the Carbon Disclosure Project and the state reporting requirements. Each matched sample is used to evaluate each program. I also evaluate both programs jointly using the CDP matched sample. The difference in difference method is repeated for each program for plant level CO_2 emissions (in metric tons), and plant level total non-fuel costs (in dollars). Each model is estimated with and without a control for the quantity of electricity generation.

In order to compare the effectiveness of the two programs, I perform a Wald F-test to determine whether the parameter estimates are statistically significantly different across programs, using the testparm postestimation technique in Stata (Gujarati, 2003).

5.5. Results

Table 5.1: Generating a Matched Sample for the Carbon Disclosure Project: predicting participation in the Carbon Disclosure Project, or State Reporting Requirements in 2007

Logistic Model	State Reporting Requirements	CDP
Number of Observations	966	700†
LR Chi^2	59.37***	101.83***
Pseudo R^2	.104	.1259
Publicly Traded Firm (1=yes)	2.11 (.492)***	†
Firm Level Revenue (ln$000,000)	-.364 (.105)***	.821 (.099)***
Plant Capacity (MW)	-.00008 (.0002)	.00002 (.00013)
Year of Construction	-.004 (.005)	-.0135 (.0045)***
Active State Restructuring (1=yes)	-.264 (.277)	-.240 (.2197)
Total State Energy Programs (#)	.073 (.014)***	.03387 (.0133)***
Constant	6.52 (10.24)	19.88 (8.81)**

* represents significance at the $\alpha = .10$ level
** represents significance at the $\alpha = .05$ level
*** represents significance at the $\alpha = .05$ level

† because only publicly traded companies participated in the CDP, the matching software excludes non-publicly traded companies from the sample

As demonstrated above in table 5.1, firm, state, and plant characteristics provide me with a modest amount of explanatory power to help predict which plants participate in state reporting requirements or the Carbon Disclosure Project, allowing a matched sample to be created for each program. While parameter estimates are unbiased and consistent, the standard errors are incorrect due to correlation across observations on the independent variables. This heteroskedasticity means that the parameter estimates cannot be used for hypothesis testing on the independent variables. However, these results seem to demonstrate previous findings demonstrating that larger, publicly traded firms, and plants located in areas with stronger regulatory regimes are more likely to participate in voluntary policy. Plants participating in state reporting requirements seem to belong to smaller publicly traded firms in areas with stronger regulatory regimes. After eliminating unmatched observations, and calculating the first difference of observations, two matched samples are left totaling 2,184 plant-year observations for the state reporting programs, and 4,810 plant-year observations for the Carbon Disclosure Project (see Table 6.3 below).

Recent literature suggests that because poorly matched samples may create bias in estimated program effects, the matched samples should be tested for balancing to reduce bias and ensure that the matching process sufficiently controls for observable differences between the treatment and control group (Smith & Todd, 2005a, 2005b; Smith & Zhang, 2009). A variety of tests exist to check for balancing, and these methods have received criticism due to the inconsistency of results (Lee, 2006; Smith & Zhang, 2009), and whether or not balancing tests are necessary (Dehejia, 2005).

While a balancing test may not be essential for this sample, as the difference in differences model will control additional heterogeneity by examining only the within unit changes over time, following Smith and Petra, (2005b), I conduct a Hotelling T-Square balancing test to demonstrate the similarity of treatment group and control group after matching. The Hotelling T-Square test is an F-test on the joint equivalence of the covariate means of the treatment group and control group and can be conducted in Stata. As Table 5.2 below demonstrates, the treatment group and control group have extremely similar means and standard deviations, and the F test fails to reject the null hypothesis that the means of the two samples are jointly equivalent. Both the CCX sample and the CDP sample appear balanced by both measures, even before within differencing.

Table 5.2: Means and Standard Deviations of Matched Samples, with Hotelling T-Square Balancing Test

State Reporting Requirements Matched Sample (84 pairs)

Variable	Control Mean	Treatment Mean	Control Standard Deviation	Treatment Standard Deviation
Publicly Traded Firm (1=yes)	.90	.87	.295	.339
Firm Level Revenue (ln$000,000)	7.93	8.06	1.64	1.65
Plant Capacity (MW)	686	562	720.31	608.15
Year of Construction	1961	1964	22.85	20.64
Active State Restructuring (1=yes)	.44	.51	.499	.502
Total State Energy Programs (#)	18.83	20.64	9.17	8.27

Two Group Hotelling T-Square = 7.77

F Statistic = 1.26; p-value = .281

Carbon Disclosure Project Matched Sample (185 pairs)

Variable	Control Mean	Treatment Mean	Control Standard Deviation	Treatment Standard Deviation
Firm Level Revenue (ln$000,000)	8.33	8.51	1.38	.89
Plant Capacity (MW)	693	741	639.78	677.82
Year of Construction	1971	1976	20.89	20.70
Active State Restructuring (1=yes)	.41	.36	.492	.481
Total State Energy Programs (#)	14.42	13.37	8.45	6.30

Two Group Hotelling T-Square = 8.50

F Statistic = 1.683; p-value = .1378

Table 5.3: Observations in Dataset and for CDP and state reporting programs

Program	State Reporting Programs	CDP
Number of initial plants	966	966
Initial plant-year observations	13,558	13,558
Matched pairs	84	185
Total plant-year observations after first differencing	2,184	4,810

Results from the differences-in-differences model (see table 5.4 below) demonstrate some evidence of emissions intensity and carbon emissions reductions due to participation in the Carbon Disclosure Project. When controlling for electricity generation, participation in the Carbon Disclosure Project is associated with a reduction of plant-level emissions by 21,560 metric tons, per plant, during the period of participation, in contrast to what would have occurred without CDP participation. Because plants average 2.69 years of participation, average emissions reduction per plant is about 8 thousand metric tons, per year, when controlling for electricity generation, and about a 4 thousand metric ton, per year, absolute greenhouse gas emission reduction, regardless of electricity generation. While results are not statistically significantly different from 0 at typical values of α, when controlling for electricity production, the reduction of greenhouse gasses is statistically significant with p value of .12, indicating that I am 88% certain that the CDP is associated with a decrease in CO_2 emissions, in comparison with what would have occurred, without program intervention. When electricity production is not controlled for, statistical significance is much weaker, producing a p value of .6. Thus, it appears that program participation in the CDP causes firms to pay more close attention to carbon intensity rather than absolute carbon emissions.

State reporting requirements, in contrast, do not seem to impact greenhouse gas emissions or intensity, regardless of model specification. Participating plants in the sample have averaged 6.5 years of program participation. With parameter estimates suggesting that total program effect is 6.7 thousand metric tons over the course of program participation, state reporting requirements seem to be associated with an increase of just 1 thousand metric tons, per plant per year, than they would have without program intervention. When the program is measured in comparison to the CDP, with a sample matched for CDP participation, these estimates are even closer to demonstrating no impact from the state reporting requirements.

Table 5.4: State Reporting Mandates versus the Carbon Disclosure Project: Difference-in-differences model, Effect of Participation on ΔCO_2 emissions (metric tons), OLS parameter estimates shown, clustered standard errors in parentheses, on matched samples

Model	State Reporting Mandates1	State Reporting Mandates2	CDP1	CDP2	Combined1	Combined2
Observations	2,184	2,184	4810	4,810	4,810	4,810
F Statistic	.33	3.35***	1.35	33.63***	1.12	28.13
R-Squared	.002	.012	.0007	.1846	.0007	.1846
Program Participation – State Reporting Mandates	6,683 (27,552)	6,861 (22,741)			1,001 (15,752)	475 (11,288)
Program Participation – CDP			-11,260 (21,425)	-21,560 (13,782)	-11,291 (21,352)	-21,573 (13,622)
ΔState Restructuring	104,463 (156,238)	48,097 (147,538)	71,312 (87,058)	28,773 (77,923)	71,362 (87,337)	28,797 (78,197)
ΔFirm Revenue (ln $000,000)	144,436 (165,168)	162,414 (160,922)	38,765 (51,722)	-599 (49,823)	38,803 (51,932)	-580.51 (50,052)
ΔState Programs	67,575 (100,423)	71,046 (100,334)	-12,775* (7,726)	978 (6,796)	-12,788* (7,737)	971.54 (6,787)
ΔMWh		.538*** (.134)		.8008 (.0653)***		.8008 (.0653)***
Constant	-99,986 (151,585)	-115,700 (151,988)	22,243* (13,158)	-6,851 (12,553)	22,188 (13,513)	-6,877 (12,895)

* represents significance at the $\alpha = .1$ level
** represents significance at the $\alpha = .05$ level
*** represents significance at the $\alpha = .01$ level

The difference in differences model examining changes in the total non-fuel operating costs of firms suggests that program participation is associated with an increase in non-fuel operating expenses of all plants (see Table 5.5 below). On average, plants participating in the Carbon Disclosure Project increased spending by about $150,000 over the course of program participation, or by about $56,000 per year. Plants participating in the state disclosure programs increased non-fuel expenditures by $37,000 per year, or by about $250,000 total, over the course of carbon reporting programs.

However, none of these results are statistically significant at any reasonable value from alpha. The p-value for state reporting requirements is .28, while the p-value for the Carbon Disclosure Project is .19 with two-tailed hypothesis tests, indicating that I am 72% and 81% certain that each of these programs has increased investment in non-fuel expenditures. The standard errors in this model are particularly large, perhaps due to the accounting of capital expenditures and the depreciation of capital goods, leading to large year-to-year swings in reported non-fuel operating expenses.

Table 5.5: State Reporting Requirements versus the Carbon Disclosure Project: Difference-in-differences model, Effect of Participation on Δ$Total Non-Fuel Operating Expenses, OLS parameter estimates shown, clustered standard errors in parentheses

Model	State Reporting Mandates1	State Reporting Mandates2	CDP1	CDP2	Combined1	Combined2
Observations	2,184	2,184	4,810	4,810	4,810	4,810
F Statistic	1.05	1.95	0.77	2.26**	.78	2.06*
R-Squared	.0035	.0089	.0007	.003	.0005	.0038
Program Participation – State Reporting Mandates	246,335 (230,722)	246,514 (229,464)			236,724 (272,054)	236,479 (270,433)
Program Participation – CDP			160,817 (119,731)	156,022 (118,957)	153,600 (121,256)	148,813 (120,511)
ΔState Restructuring	-171,297 (215,114)	-227,774 (228,179)	-58,462 (130,520)	-78,267 (132,869)	-46,816 (129,246)	-66,632 (131,727)
ΔFirm Revenue (ln $000,000)	-50,625 (137,005)	-32,613 (126,844)	-29,443 (98,637)	-47,770 (96,980)	-20,258 (99,693)	-38,594 (98,144)
ΔState Programs	-99,389 (66,104)	-95,910 (65,705)	-23,130 38,458	-16,727 (38,799)	-26,211 (39,648)	-19,806 (39,979)
ΔMWh		.539** (.215)		.373*** (.143)		.373** (.143)
Constant	374,516*** (81,676)	358,771*** (75,537)	292,651*** (46,492)	279,106*** (46,145)	279,928*** (41,034)	266,396*** (40,515)

* represents significance at the α = .1 level
** represents significance at the α = .05 level
*** represents significance at the α = .01 level

Table 5.6: Wald tests comparing parameter estimates between public mandatory and private voluntary information disclosure programs, using the Matched CDP sample:

Specification	Dependent Variable	F statistic
Total CO2 emissions	CO2 emissions (metric Tons)	.25
CO2 emissions, controlling for electricity generation	CO2 emissions (metric tons)	2.85*
Total Non-fuel costs	Total Non-fuel costs	.07
Total Non-fuel costs, controlling for electricity generation	Total Non-fuel costs	.07

* represents significance at the α = .1 level
** represents significance at the α = .05 level
*** represents significance at the α = .01 level

A Wald test designed to test the equality of parameter estimates suggests that the CDP is more effective than state reporting programs at decreasing carbon dioxide emissions when controlling for electricity production. These results are not statistically significant for gross carbon dioxide emissions or for non-fuel expenditures, due to large standard errors and variation – especially amongst participants in the state reporting programs. If similar t tests are used to test the difference between parameter estimates across samples, similar results are found.

5.6. Discussion

This model assumes that electric utilities can improve the efficiency of existing plants through upgrades and improved maintenance or that utilities can replace older fossil fuel plants with newer more efficient power plants. Several limitations of the data exist. Renewable energy production such as wind, solar, geothermal, and hydro-electric production are not captured by this dataset. In addition, improvements in nuclear efficiency are ignored by this data. These limitations suggest that improvements by participating firms may understate the total program impact of the CDP. In addition, the non-fuel expenditures data allows for capital depreciation expenditures, leading to large variation from year to year costs, and inflating standard errors. This variation may cause the statistically insignificant results on cost data.

These results demonstrate that the decision to participate in the Carbon Disclosure Project appears to be closely correlated with shifts in carbon dioxide intensity (carbon dioxide emissions when controlling for electricity generation), and smaller shifts in total carbon dioxide emissions, in contrast with what would have occurred without program intervention.

Program participation in the CDP is measured as a dummy variable, which captures the observable change in behavior caused by program participation, but also any unobservable changes in firm behavior that directly coincide with the decision to participate. It seems likely that the decision to participate in the CDP is closely related to a firm's decision to take steps to improve carbon management.

In contrast, mandatory state reporting programs do not seem to have any impact on carbon dioxide emissions or intensity. The parameter estimates, which indicate a slightly positive impact of reporting requirements on carbon dioxide emissions and intensity, are statistically and substantively indistinguishable from zero.

These results emphasize the unobserved management decision and process involved in collecting carbon dioxide information that leads to improved performance amongst CDP participants. If firms simply have to report carbon dioxide emissions to authorities – which is as simple as plugging fuel data into an equation – there is little impact on firm carbon management. In contrast, if a firm makes the decision to increase focus on carbon management and improve environmental management strategy, and reports on this strategy to its shareholders – a firm is much more likely to improve carbon performance.

While non-fuel costs seem to rise with CDP participation, there is not enough evidence to conclude that firms participating in the CDP increases non-fuel expenditures. Surprisingly, plants participating in state reporting requirements also appear to increase non-fuel expenditures, though these are also not statistically significant. These results may be influenced by large standard errors due to accounting practices. In addition, state reporting requirements often coincide with the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI) agreements, which require state reporting in 2007, but do not have carbon reduction requirements until 2008 or later. Thus, the positive parameter estimate for plants with state reporting requirements may reflect investments made in anticipation of RGGI or WCI mandates.

5.7. Conclusion

The effectiveness of the Carbon Disclosure Project in comparison to state mandatory reporting requirements suggests that program participation is associated with improvements in a firm's carbon management. However, participation in the Carbon Disclosure project cannot guarantee that environmental performance will be improved. The high variation of the standard errors and statistical insignificance of the parameter estimates suggests that on average – participants in the Carbon Disclosure Project improve their environmental performance, but that not all participants behave similarly.

The measurement of the impact of CDP participation in this study was limited by a short time horizon, and was hampered by imperfect measurement techniques, which simply measured whether or not a firm responded to the CDP survey. While the CDP produces a climate leaders index, which rates firms on the quality and transparency of their responses, this data has not existed for a long enough time to allow me to incorporate this information into my analysis. In addition, the average participation time of 2.69 years by CDP participants is not likely long enough to see dramatic shifts in carbon intensity or carbon emissions.

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6. Re-evaluating the Effectiveness of Voluntary Environmental Programs

6.1. Summary

Voluntary environmental policy has often been criticized as picking the low-hanging fruit, producing benefits that are relegated to a self-selected sample, and improvements observed in voluntary environmental policy are indistinguishable from business as usual. I argue that these criticisms are the result of the methods used to evaluate voluntary environmental programs, and that voluntary environmental policy may play a valuable role in achieving effective, efficient, and meaningful change in corporate behavior. While voluntary environmental policy may not be a sole driver in the change of corporate behavior – voluntary environmental policy can help firm managers learn improved management techniques, improve understanding of environmental management and regulation, and provide a justification and transparency to shareholders. This dissertation demonstrates that management decisions can strongly influence environmental performance and that participation in voluntary environmental programs is associated with improved environmental management. By rewarding industry leaders through voluntary environmental programs, policy-makers may be able to help shift social norms and change industry behavior as a whole. Further, the consequences of adopting ineffective voluntary programs may be less severe than failing to adopt effective voluntary programs. Voluntary programs may help society achieve low-cost environmental improvements by helping firms take advantage of low and no-cost environmental improvements, rewarding environmental leaders, and improving environmental management.

6.2. Introduction

The promises of voluntary environmental policy (VEP) include increased cooperation between government and business, reduced implementation, monitoring, and enforcement costs, and increased satisfaction by parties while attaining environmental goals. After over a decade of research on the effectiveness of Voluntary Environmental Policy (VEP), the findings of VEP effectiveness have been somewhat mixed, with most quantitative evidence suggesting that VEP are ineffective (Lyon & Maxwell, 2007). While this finding may due to specification error in the way that these programs are evaluated, formal models of VEP conclude that "An environmental tax is inherently a more effective instrument than a PVP (public voluntary program) (Lyon & Maxwell, 2007)."

In this paper, I argue that conclusions regarding the superiority of environmental taxes or market-based instrument to voluntary programs may be premature, and that the comparative effectiveness and efficiency of these programs depends on the trade-offs of consequences of adopting alternative policy instruments, and in comparison to inaction – or not adopting a voluntary or mandatory program. While numerous studies have assessed the effectiveness and efficiency of specific mandatory or voluntary environmental programs, few studies have compared the effectiveness and efficiency of voluntary and mandatory programs. Most studies of voluntary programs have found that the environmental behavior of targeted facilities improves under voluntary environmental regulation; however, recent studies have found evidence that once non-participating firms' behavior is controlled for, or once firm behavior preceding voluntary program adoption is controlled for, these programs appear ineffective (Darnall & Sides, 2008). These results point to the need to consider the consequences of adopting an ineffective

VEP versus the consequences of failing to adopt an effective VEP. The comparative effectiveness of voluntary and mandatory environmental policy should be evaluated by comparing environmental outcomes to a baseline of inaction. Important advantages and disadvantages of voluntary programs have been overlooked by recent formal modeling and empirical efforts, due to the methodology employed to evaluate voluntary programs. Voluntary environmental policy promises a host of benefits over mandatory initiatives, yet empirical research has focused narrowly on environmental impacts in comparison to non-participating firms.

Formal modeling efforts and recent empirical research have ignored the long-term value of shifting the social norms of business behavior, the potential social costs of monetizing environmental improvements, and have potentially underestimated the environmental and policy learning benefits associated with achieving low-cost environmental improvements with low-cost voluntary initiatives. Evidence from the behavioral economics literature suggests that using economic incentives to change behavior can be much costlier than using moral suasion and that placing monetary values on social norms can reduce or eliminate any moral imperative to act, and prevent firms from distinguishing themselves in the marketplace by taking advantage of socially responsible behavior. In a business environment that is defined by leaders and laggards and where laggards seek to emulate the successes of industry leaders, achieving substantial long-run change in business behavior may be dependent on encouraging business leaders to adopt improved environmental management practices so that this shift in behavior eventually disseminates to all market participants. In real-world situations, where neither economic incentives nor voluntary programs meet theoretically optimal conditions, it is possible that the efficiency and effectiveness of a voluntary program could exceed that of mandatory government-driven regulations.

Conversely, the empirical literature on voluntary programs has ignored the impact of displacing more effective mandatory programs through voluntary or international NGO based initiatives (Lyon & Maxwell, 2007). It is possible that implementing voluntary environmental programs may dry up any existing political will to mandate policies or standards that can be more effective. Further, if voluntary programs are implemented and goals of these programs are met by industry, implementing strict mandatory programs may generate significant hostility from industry if these programs are seen as violating the voluntary agreement.

This chapter is organized as follows. First, I briefly discuss two schools of thought regarding the motivations for voluntary program participation and the comparative implications for voluntary program effectiveness and efficiency. Second, I summarize findings that suggest that voluntary programs may be more effective and offer more potential than most literature suggests, emphasizing several limitations in existing research regarding the consequences of adopting voluntary environmental programs. Third, I discuss the trade-offs of adopting ineffective VEP in comparison to the consequences of failing to adopt effective voluntary environmental policy. Finally, I generate a series of recommendations regarding future research of VEP.

6.3. The rational model of voluntary environmental policy

Most formal modeling and empirical research has been firmly rooted in a rational model of voluntary program participation and effectiveness. According to this model, firms participate in voluntary programs due to tangible benefits, such as improving their public image, small program subsidies, such as technical assistance, and the potential to deflect or weaken future mandatory regulations (Khanna, 2001; Khanna & Damon, 1999; King & Lenox, 2000; Lyon & Maxwell, 2004).

This literature has been unable to establish major changes in environmental behavior from participating firms in comparison to non-participants, generally concluding that environmental benefits may accrue to participants and non-participants alike (Darnall & Sides, 2008; Lyon & Maxwell, 2007; Morgenstern, Pizer, & Shih, 2007). Econometric analyses have also demonstrated that public voluntary programs' effect on firm behavior is significant only in the first years of a program (Sam & Innes, 2007), which may be due to emissions reductions that were already planned or already had occurred (Vidovic & Khanna, 2007). Similarly, firms that join a voluntary agreement early may reduce more emissions than late joiners, who free-ride on the efforts of early joiners (Delmas & Montes-Sancho, 2007). This literature suggests that government incentives to disseminate information amongst participants and non-participants may reduce the observed difference between these two groups, and that currently employed econometric techniques may not be able to properly identify the effects of public voluntary programs (Lyon & Maxwell, 2007).

Most studies regarding the environmental effectiveness of VEP focus on the behavior of participating firms or facilities in comparison to a control group of firms that do not participate in the voluntary program (Darnall & Sides, 2008). While initial studies of the 33/50 program led Khanna and Damon (1999) to the conclusion that participation in the program led to a statistically significant decrease in toxic releases (Khanna & Damon, 1999), later research suggests that this benefit only accrued during the first two years of program participation (Sam & Innes, 2007). When emissions reductions prior to the start of the program are considered, the program is found to be ineffective (Vidovic & Khanna, 2007).

Studies of voluntary policies addressing climate change have concluded similarly that voluntary programs are ineffective. In the Department of Energy (DOE)'s Climate Challenge program for electric utilities, program participation had, at best, no impact on greenhouse gas (GHG) emissions and some results suggest that program participation negatively impacted environmental performance, particularly among late-joiners (Welch, Mazur, & Bretschneider, 2000). In the 33/50 program, early joiners reduced their emissions more than non-participants, but this effect is neutralized when late-joiners are considered (Delmas & Montes-Sancho, 2007). Similarly, the Climate-Wise voluntary agreement had only a modest and temporary impact on reducing carbon emissions from program participants. Most environmental improvements were matched by non-participants, and that the poor environmental performance late joiners undermined efforts of early joiners to improve environmental performance, reducing the overall effectiveness of the program (Morgenstern, et al., 2007).

Recent empirical results suggests that voluntary programs can even have a negative impact on environmental performance, and that non-participating firms improve their environmental behavior more than participating firms (Darnall & Sides, 2008). Some have suggested that these programs are a form of greenwashing, where firms seek to influence public and 3rd party opinion by advertising selective environmental initiatives that make them appear more environmentally responsible (Lyon & Kim, 2007)

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Two examples support the greenwashing hypothesis. While the chemical industry appeared to improve as a whole due to its Responsible Care program, participating firms improved behavior more slowly than non-participating firms (King & Lenox, 2000). Participants in the Sustainable Slopes initiative received even lower environmental ratings from third party NGOs as non-participating firms (Rivera & de Leon, 2004).

6.4. The Boundedly Rational Model of Voluntary Environmental Policy

A second approach to the study of environmental behavior is derived from a boundedly rational view of firm behavior. According to this model, firm managers fail to maximize firm profitability (Simon, 1955). This inefficiency is due to poor foresight, as well as a human inability to solve complex problems (Alchian, 1950; Simon, 1955; Tinter, 1941). Evidence suggests that firms routinely fail to take advantage of profitable investments in energy efficiency (DeCanio & Watkins, 1998). Contrary to economic theory, firm characteristics play an important role in how firms make decisions regarding energy and environmental decisions (DeCanio & Watkins, 1998). Input – output models of productivity can measure the inefficiency of firms by comparing actual productivity to theoretical productivity, demonstrating that firms fail to maximize production (Leibenstein, 1966; Leibenstein & Maital, 1992). These findings have led some economists to believe that managers may fail to recognize optimal behavior, providing opportunities for win-win situations (Porter & van der Linde, 1995).

Increasing evidence of low and negative cost environmental improvements exists in certain situations. Manufacturing production data demonstrates that investments in capital provide both increases in productivity and improvements in environmental outcomes, suggesting that firms can improve both profitability and environmental performance simultaneously (Shadbegian & Gray, 2003, 2006). Evidence from the paper industry also suggests that more stringent environmental regulation can lead to improved profitability (Boyd & McClelland, 1999). A recent McKinsey study commissioned by the German business association concluded that as much as one third of the Kyoto Protocol target could be reached with negative cost investments in energy efficiency (McKinsey & Company, 2007).

A variety of reasons may exist that prevent firm managers from optimization or can explain firms' failure to employ cost-effective environmental management strategies. Complex processes may make optimization impossible. Firm managers have expertise and interest in maximizing the core business of their company, and do not give much attention to energy efficiency issues (The Economist, 2006). Search costs and other transaction costs exist for firms hoping to implement optimal technologies and efficiency improvements (Crals & Vereeck, 2005; R. Stavins, 1995; R. N. Stavins, 2000). Recent research has demonstrated a wide variety of strategies that firms may have towards energy efficiency and climate change (Kolk & Pinske, 2004, 2005). While some firms may even have a good understanding of how environmental issues impact their firm, this understanding may not translate to changes in long term investment decisions (Hoffman, 2007). In addition, firms operate under considerable technological and regulatory uncertainty, which can limit the ability of firms to accurately calculate costs and benefits from environmental improvements (Considine & Larson, 2006). Due to these barriers, firms and individuals are often likely to employ a default heuristic and continue operations as usual until they are faced with overwhelming need to adjust behavior (Gigerenzer & Todd, 1999; Matisoff, 2010).

Under the boundedly rational model of VEP, information disclosure programs and environmental management programs can be implemented in order to improve firm environmental performance (Börkley, Glachant, & Lévêque, 1998). Studies of the voluntary ISO environmental management program have demonstrated that firms voluntarily adopting this program are more likely to be in compliance with environmental regulations (Potoski & Prakash, 2005b) and are more likely to improve environmental performance (Potoski & Prakash, 2005a). According to this model, more effort should be spent eliminating barriers to attaining these low and no cost environmental improvements and helping improve firm environmental management.

Examples from this dissertation suggest that substantial benefits can be obtained through improved environmental management, and that this improved environmental management is associated with the decision to participate in voluntary environmental policy. Both the Chicago Climate Exchange and the Carbon Disclosure Project are associated with participating firms decreasing carbon emissions, decreasing the carbon intensity of power production, and increasing spending on non-fuel costs in comparison with what would have occurred without participation in a voluntary program. While it seems unlikely that environmental performance improvements were caused by participation in the voluntary programs, participation seems to be clearly associated with a movement towards improved management and focus on carbon emissions. Firms participate in the Chicago Climate Exchange as a mechanism to improve their understanding of carbon trading and carbon management; firms participate in the Carbon Disclosure Project in order to increase transparency to shareholders. The decision to participate in these programs demonstrates a commitment by firm management to improve environmental management of carbon.

6.5. The advantages and disadvantages of voluntary environmental policy and weaknesses in existing research

Voluntary environmental policy may hold several advantages that have been overlooked by empirical research attempting to measure the specific impacts of voluntary environmental programs. These advantages include environmental benefits that have not been measured due to specification error, shifting norms of firm behavior to improve environmental performance, and the comparative effectiveness, cost-effectiveness, and overall efficiency of voluntary environmental programs in comparison to mandatory efforts. Likewise, much of this research has downplayed the possibility for voluntary programs to crowd-out or undermine support for more effective mandatory programs.

6.5.1. Specification error in evaluations of VEP

Recent research suggests that empirical models have failed to find effective voluntary environmental programs due to specification error (Lyon & Maxwell, 2007). Most rigorous quantitative evaluations of voluntary policies use a 2-stage approach to evaluate voluntary program effectiveness. The first stage controls for the self-selection of firm participation in a voluntary program, while the second stage compares the environmental performance of participating firms against non-participating firms.

Most findings suggest that the environmental performance of participating firms improves, and that the environmental performance of the entire industry improves as well

(Koehler, 2007).[8] In EPA's 33/50 program, targeted chemical releases declined by 50% from 1988-1994, meeting the 50% reduction target a year ahead of schedule (Environmental Protection Agency, 1999). In the DOE's Climate Challenge program, electric utilities reduced or sequestered 237 million metric tons of carbon (Edison Electric Institute, 2003). EPA's Climate Wise program claimed to have "started or completed more than 1,000 energy efficiency and emission reduction projects eliminating almost 3.3 million tons of carbon from the atmosphere" in 1997 alone (U.S. Environmental Protection Agency, 1998). Altogether, the program claims to reduce emissions significantly while saving firms hundreds of millions of dollars (Morgenstern, et al., 2007).

Researchers are often skeptical of these claims, however, due to the difficulty of comparing claims to a baseline of what would have occurred without the voluntary program (Alberini & Segerson, 2002). In addition, because environmental goals are usually determined by industry rather than by an environmental agency, it is particularly difficult to ascribe environmental improvements to specific voluntary initiatives (Alberini & Segerson, 2002).

Frequently, the environmental performance of participating firms does not improve more than non-participating firms, causing researchers to conclude that voluntary programs are ineffective. Some research suggests that voluntary programs have a negative impact on environmental behavior, and that non-participating firms improve their environmental outcomes more than participating firms (Darnall & Sides, 2008).

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[8] Koehler, 2007 provides a thorough review of motivations for participation in and the effectiveness of voluntary environmental programs.

This conclusion of ineffectiveness may be premature. It is possible that voluntary environmental improvements disseminate across an entire industry and accrue to participating firms and non-participating firms (Lyon & Maxwell, 2007). In a public voluntary program, the regulatory agency – usually the EPA - has incentive to share best practices and technologies with both participants and non-participants alike. Under this model, the regulatory agency explicitly disseminates information to participants and non-participants in order to maximize environmental benefits.

Evidence that early joiners seem to improve environmental behavior prior to late joiners supports this hypothesis (Delmas & Montes-Sancho, 2007). If voluntary programs target industry leaders that have already taken advantage of the lowest marginal cost environmental improvements, it is likely that non-participating firms will have more opportunities for low-cost improvements, and that these firms should experience a greater improvement in environmental behavior. Evidence from the Climate Challenge program demonstrates that firms with more potential to reduce emissions are more likely to pledge, and later accomplish emissions reductions (Welch, et al., 2000). In addition, evidence that environmental behavior disseminates across geographical regions and industrial sectors supports the conclusion that the dissemination of voluntary environmental behavior might be responsible for environmental improvements in participating and non-participating firms (DeCanio & Watkins, 1998).

A comparison between private voluntary programs, such as ISO 14001, which provides a club good where benefits accrue only to participating firms - and public voluntary programs – where benefits accrue to all firms, demonstrates the potential for public voluntary programs to appear ineffective even if they are truly effective. A metaanalysis comparing the effectiveness of ISO 14001 versus public voluntary programs suggests that ISO 14001 is comparatively more effective than public voluntary environmental programs (Darnall & Sides, 2008). In this dissertation, results of the Chicago Climate Exchange and the Carbon Disclosure Project – both private voluntary programs, demonstrate that private voluntary programs may be able to provide environmental benefits compared with non-participants. While these results can be used to condemn public voluntary programs, they may simply reflect the club good nature of ISO 14001, CCX, and CDP, as opposed to a public voluntary program, where agency incentives encourage the dissemination of information across participants and non-participants alike. Altogether, it appears that conclusions that voluntary environmental programs are ineffective, or at worse – have a negative impact on environmental performance might be due to the methods of analysis and the difficulties of evaluating a voluntary environmental program, rather than due to flawed policy design.

6.5.2. Shaping social norms

While the hypothesis above suggests that explicit agency behavior might be responsible for findings of ineffectiveness in voluntary environmental programs, the impact of voluntary environmental programs need not require explicit actions of the regulatory agency to improve environmental behavior. Because industry routinely implements best practices, industry laggards attempt to mimic the successful strategies and practices of industry leaders. Evidence from the Green Lights program demonstrates that best practices for energy efficiency can disseminate across industries and geographical regions (DeCanio & Watkins, 1998). If VEP can help shift behavior of the industry leaders, or if VEP simply rewards industry leaders for early changes in environmental management, then industry laggards will improve their environmental behavior as well, simply to keep pace with the leaders. Further, if changes in environmental behavior disseminate to non-participating firms, who might have lower marginal costs of pollution abatement, then statistical analysis that shows non-participating firms' substantial improvement of environmental behavior may have been misinterpreted.

In this instance, the more important effect of VEP can be to change the social norms of firm behavior, to one that is much more responsive to environmental concerns. Non-participants, by attempting to keep pace with industry leaders, may improve environmental behavior as much or even more than participating firms, due to lower marginal costs of pollution abatement. Results from this dissertation support this conjecture. The CCX and CDP participants joined these voluntary programs in conjunction with an overall shift in management strategy that included carbon management in managerial decision-making. In contrast to firms that simply were mandated to report carbon emissions, voluntary participants serve as entrepreneurs in improved management techniques. While CCX and CDP participation may not be required in order to achieve these benefits, CCX and CDP participation help signal stakeholders of the changes in environmental management decisions. If these firms are viewed as successful by their competitors, best environmental practices should spread to non-participants.

Initial motivations for VEP did not focus as much on the environmental benefits of voluntary environmental policy, but rather focused on changing the nature of industry – government interaction from a combative relationship towards a more productive and collaborative nature (Anton, Deltas, & Khanna, 2004). The rising enforcement costs of existing regulation, combined with cutbacks in agency funds for the enforcement of regulation, and an increasing number of citizen enforcement actions against firms for violating existing laws and against the agency for lax enforcement, led to a desire to find a collaborative approach between government and industry to address environmental problems (Khanna, 2001; Maxwell, Lyon, & Hackett, 2000; Morgenstern & Pizer, 2007). Voluntary approaches enhance the prospects for improved satisfaction with government and generate more positive and productive relationships between government and industry (Durant, Fiorino, & O'Leary, 2004).

This impact leads to a possible advantage that VEP has over market-based or traditional command and control environmental policy. The success of VEP, under this model, is based on shifting the norms of behavior, and relies on moral pressure on firms, as firms attempt to distinguish themselves as environmental leaders. Market-based instruments to improve environmental outcomes, such as taxes or a cap-and-trade system, put a monetary value on environmental damages or emissions as a mechanism to change corporate behavior. When an explicit financial value is placed on behavior, it frequently overshadows any moral imperative to improve environmental behavior and go beyond compliance. Existing research regarding the environmental effectiveness of VEP based in the rational model ignores the long-term implications of putting an economic value on pollution, the potential to shift norms of behavior, and the benefits that can arise from a more cooperative relationship between firms and government.

Behavioral economics holds important lessons regarding placing incentives on moral behavior using studies of morality and individual behavior (Gneezy & Rustichini, 2000; Heyman & Ariely, 2004; Vohs, Mead, & Goode, 2006). It has been demonstrated that moral imperatives can be undermined with financial incentives, and that this destruction of a moral imperative may be irreversible (Gneezy & Rustichini, 2000). Thus, if market based incentives are implemented in environmental policy, a firm may no longer be able to distinguish itself based on its voluntary initiatives, and environmentally sensitive behavior will not spill over to laggard firms.

6.5.3. Cost advantages of VEP

Recent findings criticize VEP because it may select the low-cost abaters of emissions through voluntary participation and reward firms who may have improved their environmental performance without the existence of the program in a process known as green-washing (Lyon & Kim, 2007). Because firms will not undertake costly environmental improvements voluntarily, all environmental improvements obtained from a VEP are expected to be low or no cost (Börkley, et al., 1998). This study highlights two problems with this assumption. First, because the electric utility industry remains highly regulated, participating firms need not be cost minimizers, but may pass along modest costs of improved environmental management to consumers. Second, if a goal of regulation is to achieve low-cost emissions reductions, then using VEP in order to achieve easy and low-cost emissions reductions might be an easy way to pick the low-hanging fruit.

Because increasing evidence from the boundedly rational model suggests that firms do not automatically take advantage of negative cost environmental improvements, VEP may provide for the ability of firms to develop and disseminate incremental improvements.

The boundedly rational model suggests that low or no cost improvements exist; however, firms fail to take advantages of these opportunities due to a variety of systematic and cognitive barriers. In the area of climate change and energy efficiency, firms appear to have a particularly difficult time incorporating the costs of energy into decision-making (Matisoff, 2010). EU firm managers report that they may not consider the costs of carbon permits in production decisions, and only invest in energy efficiency projects that return their investment in two years or less (Matisoff, 2010). Increasing evidence demonstrates that energy and environmental decisions and investments are highly influenced by firm capacity – and that many firms do not have the technical capacity to maximize energy efficiency. Larger firms may simply fail to maximize cost-effective energy efficiency due to adherence to a default heuristic (Matisoff, 2010). Implementing tradable permits or environmental taxes may generate revenue from firms, but it may not change environmental behavior if the underlying problem is a lack of technical capacity and understanding of energy efficiency issues. In concentrated or regulated markets, firms may face little pressure to minimize costs when cost increases can be passed on to consumers. Voluntary environmental programs that disseminate best practices or that encourage firms to implement improved environmental management have the capacity to improve environmental performance at a low cost (Börkley, et al., 1998).

In addition to cost advantages from achieving low cost reductions of emissions, the success of VEP rests heavily on promises of decreased enforcement costs and decreased litigation expenses (Alberini & Segerson, 2002; Börkley, et al., 1998; Segerson & Miceli, 1998). Little empirical research has explored these benefits of VEP; however, interviews with firm managers suggest that VEP, generally designed by industry groups, has comparatively fewer implementation and other transaction costs than similar mandatory policies (Matisoff, 2010).

6.6. Disadvantages of VEP

While VEP may have several advantages that have not been examined through the empirical literature and rational economic models, it may also have some disadvantages. Primarily, the implementation of voluntary environmental policy can undermine support for more stringent mandatory regulations. According to formal models, where a VEP is an explicit attempt to attain less stringent and less costly regulations in comparison to mandatory efforts, the adoption of a less-stringent voluntary program can erode any political will to implement strict mandatory regulation (Lyon & Maxwell, 2004). Further, while one of the main benefits of voluntary environmental policy is cooperation between government and business and a reduction of conflict, including lawsuits, etc., firms may be unhappy with attempts by government to implement mandatory environmental regulation after fulfilling obligations of a VEP. While there is little empirical evidence of VEP that suggests it has prevented more stringent mandatory regulation, or that it has upset relations between firms and government, a conversation with firm officials in the EU suggested that the firm was extremely upset after reaching its voluntary targets for carbon emissions reduction and mandatory regulation was subsequently implemented.[9]

[9] Interview with large industrial participant – July, 2007.

6.7. Weighing the advantages and disadvantages of VEP adoption

In order to best understand the appropriate uses for voluntary environmental policy, the consequences of applying ineffective voluntary programs and the consequences of failing to adopt effective voluntary environmental programs must be understood.

Research evaluating VEP using statistical analyses has focused on avoiding the adoption of ineffective VEP. Statistical analyses hinge on trade-offs of type I versus type II errors. By setting statistical significance α at .1, .05, or .01, as is typical in statistical analyses, we favor making a type II error – or wrongly concluding that VEP is ineffective, when VEP is actually effective, over a type I error – concluding that VEP effective, when it is not. In this study, many more impacts of VEP would have been found statistically significant if alpha was set at .20 or .25.

6.7.1. The consequences of adopting ineffective VEP

The consequences of adopting an ineffective VEP are equivalent to the consequences of making a type I error (α) in statistical analyses of voluntary environmental programs. These consequences may include government expenditures for ineffective voluntary programs, forgone opportunities for stricter mandatory regulation, and the possibility of awarding recognition to firms that are not improving environmental behavior. In addition, firm or government resources might be wasted on an ineffective program.

Evidence concerning greenwashing suggests that ineffective voluntary programs may reward firms that do not actually improve voluntary behavior, in comparison to non-participating firms. However, this research has not demonstrated that firms participating in VEP produce environmental behavior that is worse than they would have without regulation. Empirical research has also been unable to determine whether VEP adoption prevents or hinders the adoption of stricter mandatory environmental policies, as predicted by game-theoretic models.

6.7.2. The consequences of failing to adopt effective VEP

Even though some statistical analyses conclude that VEP is ineffective, or has only minimal gains, these results have been generated by comparing participating firms to a control group of non-participating firms that have also improved their environmental behavior. With evidence demonstrating that public voluntary programs have benefits that accrue to participating and non-participating firms alike, statistical analyses are unable to distinguish whether observed environmental improvements are due to VEP, or whether environmental improvements would have occurred without the VEP. When concluding that VEP is ineffective, it is possible that researchers are committing a type II error – wrongly concluding that VEP is ineffective. In the studies of the Carbon Disclosure Project and the Chicago Climate Exchange, large standard errors on parameter estimates made it difficult to conclude that the programs were statistically significantly effective. However, the average participant seemed to improve environmental performance and invest in non-fuel expenditures in order to increase efficiency. Results across samples were consistent, robust, and demonstrated substantial gains by participating firms. The statistical insignificance of parameter estimates is due to the variation of activity across firms and across years, suggesting that environmental performance and non-fuel expenditures may vary greatly from year to year, across firms, and may be affected by accounting procedures.

The consequences of failing to adopt VEP that is responsible for both improvements to participating firms and non-participants would result in lower levels of environmental performance and higher levels of emissions in participants and non-participants.

Under the boundedly rational model of VEP, many environmental improvements are low or negative cost, and the role of VEP is to help firms overcome cognitive barriers that prevent them from recognizing these opportunities. If the dissemination of best practices and the recognition of firms who make strides to improve energy efficiency helps industry achieve low and no-cost environmental improvements, then the failure to adopt effective VEP may result in a much higher cost of environmental policy implementation.

In addition to environmental benefits that may accrue due to VEP, motivations for VEP include changing the combative nature of environmental policy in the United States. Empirical research has not tackled this important goal of VEP.

VEP provides an opportunity to allow firms to shift social norms towards environmental stewardship and sustainability and claim recognition for their efforts. Without voluntary policy tools, government may have to resort to the more traditional, and more combative nature of traditional regulation, and firms may be less willing to voluntarily change their behavior, especially when firms can pass along additional costs to consumers.

6.8. A role for voluntary environmental programs under findings of ineffectiveness

These results point towards a slightly different direction for voluntary environmental programs. Voluntary environmental programs ought to be designed in order to minimize possible consequences of implementing ineffective voluntary agreements, while maximizing the possible benefits of implementing effective VEP.

In order to maximize the potential gains of voluntary environmental programs, environmental goals must be carefully considered. Voluntary programs appear to be most successful when programs involve the dissemination of incremental improvements, improve the capacity of firms, and allow them to take advantage of low to no cost environmental improvements (Lyon & Maxwell, 2007). Results from ISO 14000 studies, and results within the boundedly rational paradigm of VEP suggest that substantial gains can be made from VEP, and that many environmental improvements can be achieved at negative or low cost. This study contributes to the findings that VEP that encourages improved environmental management practices is most likely to be effective.

New research suggests that firms do not minimize costs associated with energy and tradable emissions permit costs due to a lack of capacity regarding carbon trading and a considerable amount institutional uncertainty, leading firms to pursue business as usual strategies, rather than attempt to optimize. Environmental regulations are viewed with an eye towards compliance, rather than profit maximizing behavior, which violates the assumptions of many of the new, highly complex, market-based initiatives. A government or non-governmental facilitator that helps disseminate best practices towards carbon and energy management and encourages firms to improve environmental management practices might help firms achieve optimal behavior.

Certain firms may be more appropriate targets for these policy tools. In the past, voluntary environmental policy has targeted larger firms in more concentrated industries; however, results of this analysis suggest that VEP may be more appropriate in less concentrated industries, among smaller firms, who may have more potential to benefit from the dissemination of best practices and incremental improvements. Smaller firms are less likely to wield political capacity to use VEP to deflect stricter mandatory approaches to environmental policy, one of the strongest negative consequences of adopting ineffective VEP.

In addition, many small firms are excluded from mandatory climate change regulation, such as cap-and-trade regulation. In the EU and in the U.S., firms under 25,000 metric tons of carbon per year will likely be excluded from the mandatory trading regime, and various sectors or pollutants may be excluded as well. With cap-and-trade programs' incomplete coverage of greenhouse gas emissions, voluntary programs may be a way to target small polluters, industries, or pollutants that have been excluded from mandatory regulation.

When VEP focuses on specific environmental targets, success ought to be measured by setting environmentally appropriate targets and achieving those environmental goals. If environmental goals are set at appropriate levels, policy-makers should be happy with the achievement of these goals, and should focus on other benefits of VEP, such as the reduction of transaction and enforcement costs, building a collaborative relationship between government and industry, and the possible improvements in the cost-effectiveness of achieving these environmental targets.

6.9. Implications for further research

This research points towards a need for studies that evaluate some of the benefits that may result from VEP, and a shift in the manner in which researchers evaluate environmental benefits of VEP. Models that account for shifts in behavior of an entire industry may be necessary in order to capture the benefits of VEP. Studies that seek to evaluate the benefits of cooperative and collaborative decision-making between firms and government, as well as shifts of norms that result from VEP can help evaluate the promises of VEP. In addition, focus on the comparative cost-effectiveness of mandatory and voluntary approaches to environmental policy can highlight the financial promises of VEP.

The wave of research regarding VEP has demonstrated that VEP alone will not likely achieve stringent environmental goals in place of mandatory regulation. Future research must determine when VEP can be implemented without producing negative consequences, and what types of benefits society can reap from the implementation of VEP.

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7. Stitching together state climate change programs, cap-and-trade, and voluntary environmental programs and directions for future research

In this dissertation, cap-and-trade, state environmental programs, and voluntary programs have been presented as if these programs were substitutes in addressing climate change. In reality, these policy tools and approaches are complementary – and each policy tool has different strengths and weaknesses, and involves different tradeoffs. For climate change policy to be truly successful, policy-makers must take advantage of the strengths of each type of policy and refrain from misapplying each policy where they will be less successful.

Cap and trade policy, for example, is most applicable for targeting large sources of emissions; however, problems with cap-and-trade are correlated with the number of facilities, and are more heavily associated with smaller firms with high complexity and low capacity. Cap-and-trade may be the best available policy tool offering the most flexibility for large firms, able to take advantage of economies of scale, offset provisions, and trading, but may not be appropriate for smaller and more diffuse emitters of carbon. While cap-and-trade has been seamlessly implemented in the largest utilities, the small utilities and manufacturers lag behind. These firms may benefit from voluntary initiatives, improvements in management processes, and dissemination of best-practices. Alternative regulations that are simpler and provide easier compliance may be more appropriate for smaller emitters of carbon. Paradoxically, the firms that may stand to gain the most from management improvements and capacity building are the least likely to participate in voluntary environmental programs. It is unclear why smaller firms are less likely to participate in voluntary initiatives – these firms may not be targeted by voluntary programs for participation as voluntary programs seek to target the largest producers, or smaller firms may have less to gain from voluntary initiatives.

Voluntary programs seem to have promise as a means of shifting corporate behavior towards valuing longer term goals, achieving low-cost environmental improvements, and helping firms gain experience with new policy tools. One of the most problematic issues reported by EU firms, was the complexity of the cap-and-trade tool. Because cap-and-trade programs often require a substantial amount of time between the formulation of the policy and implementation of the policy, future research should investigate how voluntary programs may help smooth the transition from an unregulated carbon economy to a constrained carbon economy.

In this paradigm, voluntary programs would not be a means to deflect the enforcement of mandatory policy, but would work to help improve the functioning of complex policy tools, and improve firm decision-making with regards to carbon. By encouraging firms to disclose carbon management strategies and techniques, and encouraging firms to voluntarily participate in a weak cap-and-trade model, the transition to a regulated carbon economy may be less volatile. In addition, the largest firms participating in the EU ETS appear to favor offset provisions over efficiency improvements and technological investments. These strategic preferences may be due to regulatory uncertainty or a short time horizon by firm managers. Participation in voluntary programs may encourage firms to shift carbon management strategy.

Both voluntary environmental programs and cap-and-trade programs seek to address the major point sources of pollution that are most easily targeted through regulation. In contrast, state climate change policies have the ability to target the other

50% of emissions that are not covered under certain cap-and-trade policy designs. In addition, state policies can be designed to encourage electricity generators to seek solutions that include the adoption of technological and efficiency improvements. In the regulated electricity market, a variety of barriers prevent firms from investing in long-term technological solutions that target carbon emissions. The patchwork of state policies has the potential to reduce some of the uncertainty and provide for a laboratory of experimentation where successful policy experiments by states can be adopted by other states, or expanded to national level policy.

While this research demonstrates some of the tradeoffs involved and the best uses for different types of policy used to address climate change, it also highlights areas for increased research, new research questions, and areas where improved understanding would be helpful.

First, improved understanding of what combinations of state policies work and how well they work would be useful for evaluating state climate change and energy programs. Individual policies also have a large amount of diversity across states, and the "optimal" designs of these policies are not well understood. Initial efforts to address climate change policies have focused on individual state efforts or individual policies. In practice, policies interact and overlap, and states demonstrate a diversity of combinations of different types of energy policies.

Second, the role that voluntary programs can play in bolstering mandatory efforts, is not well understood. While significant effort has examined individual policies, and this dissertation has attempted to compare different approaches to voluntary policy, detailed understanding of how voluntary policies interact and how they can be best used would be helpful for the successful implementation of voluntary environmental policy.

Third, the interactive effects of cap-and-trade, voluntary policy, regional efforts, and state climate change policy are not well understood. While multi-level governance has received significant attention in the literature, this attention has not translated well to improved understanding of the relationships between different levels of policy. Increased research regarding spillover effects of policy, and the interaction between policy-makers at different levels would be helpful for gaining an improved understanding of multi-level governance to address a global problem.

Finally, while some of the research in this dissertation examined decision-making processes amongst regulated targets (firms), this area remains understudied. It is clear that regulated firms do not always behave as anticipated by rational models. Improved understanding of firm decision-making processes and how firms interact with complex policy tools can help improve policy design and the implementation of policy tools.

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Education

Indiana University, School of Public and Environmental Affairs, Bloomington, IN — Sept 2004 – Present
Ph.D. Candidate in Public Policy, concentration in Environmental Policy and International Relations
GPA: 3.9/4.0 (20 courses) (Currently ABD status)
Coursework includes heavy concentration in statistics and quantitative techniques, as well as research design.
Dissertation title: "The Patchwork Quilt of Climate Change Policies: An Assessment of Voluntary and Mandatory Greenhouse Gas Reduction Programs"

Inter-University Consortium for Political and Social Research (ICPSR), Ann Arbor, MI — Summer, 2006
Quantitative methods seminar for Ph.D. students and faculty.

University of Pennsylvania, Philadelphia, PA — May 2002
Bachelor of Arts in Economics and International Relations with a minor in Hispanic Studies
Senior Thesis: "Cooperation and the Kyoto Protocol: Domestic Politics Affect an International Game."

ICADE, Madrid, Spain — Spring 2001
Attained fluency in Spanish and completed all coursework in Spanish including courses in Management, Economics, and Spanish Literature.

Academic Work and Research Experience

School of Public and Environmental Affairs, *Research Assistant,* Bloomington, IN — Sept 2004 – Summer 2006
Worked for Dr. Evan Ringquist on the projects "Do international environmental agreements matter?" and "Do congressmen keep campaign promises?" Coding of international environmental agreements and survey design. Extensive data collection, entry, and analysis.

Houston Advanced Research Center (HARC), *Research Associate,* The Woodlands, TX — Nov 2002 – Jun 2004
Worked for Dr. Mitchell Mathis conducting environmental economic research on the project "Valuing Nature in Texas." Wrote journal articles, grant applications and proposals, and supervised both technical and non-technical elements of the projects. Responsibilities included supervision and creation of economic methodology, use of GIS, hedonic pricing analysis, CV survey development, non-technical report writing and supervision, and other project responsibilities. Worked on U.S.-Mexico scrap tire cooperation project, providing an institutional analysis of border scrap tire disposal.

Wharton Management Department, *Research Assistant,* Philadelphia, PA — Jun 2001 – Apr 2002
Worked for Dr. Witold Henisz conducting economic and regulatory research of the power industry and mobile services industry in South America and East Asia; use of Lexis/Nexis, ISI, and Dow Jones Interactive databases. Work has resulted in numerous books and World Bank publications.

World Game Institute, *Research and Production Assistant,* Philadelphia, PA — Jan 2000 – Jan 2001
Conducted economic research of multinational enterprise for the Mapping the Global Corporations Project funded by the Ford Foundation; assisting in the writing and production of the book "Global, Inc." published in summer 2003 by the Free Press; use of ArcView GIS mapping software, use of Microsoft Excel and Adobe Illustrator for the production of graphs.

Cleveland Council on World Affairs, *Intern,* Cleveland, OH May 1998

Duties included the preparation of press releases; representation of the council at regional conferences, including the banquet for Kofi Annan, and supervision of a host family database for study abroad.

Publications in Refereed Journals

Matisoff, Daniel. (2008) "The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Internal Determinants or Regional Diffusion?" *Review of Policy Research*, v25, n6 Dec 2008.

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Under Review at Refereed Journals

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Reports and Working Papers

Mathis, Mitchell and Daniel Matisoff. 2004. "The Value of Water to Sustain and Preserve the Ecosystem in the Lower Rio Grande Valley: Characterization of Ecotourism in the Lower Rio Grande Valley." Houston Advanced Research Center. Working Paper. VNT 04-01.

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Cook, Valerie, Matisoff, Daniel, and Lisa Gonzalez. 2004. "Scrap Tire Disposal and Recycling Options." Report to the Border Environmental Cooperation Commission.

Barker, William, Hitchcock, David, and Daniel Matisoff. 2003. "Baseline Class 4 Truck Inventory for the Houston-Galveston Region." Deliverable from Task 3: Regional Vehicle Estimates and Survey: Emissions Testing of Prototype Diesel/Electric Hybrid Commercial Pickup/Delivery Vehicles (PUDS) and Assessment of Potential Emission Reductions in the Houston-Galveston Non-Attainment Area from Widespread Use in Delivery Fleets. Prepared for Texas Council on Environmental Technology, University of Texas, Austin.

Conference Proceedings, Conference Presentations, and Invited Presentations

"Understanding the trade-offs of climate change policy design: incorporating lessons from the European Union to policy formulation in the United States." The Search for Wise Energy Policy Conference: June 11, 2009. Published online: http://www.indiana.edu/~cree/documents/Climate%20Policy.pdf

"What we know about voluntary environmental policy." Invited presentation for Ken Richards' capstone class in environmental policy. April 1, 2009.

"Firm Decision-making and cap-and-trade policy." Invited presentation for SPEA Dean's Council. May 5, 2009.

"Bounded Rationality and the European Union Emissions Trading Scheme." Association of Public Policy Analysis and Management (APPAM) Conference, Los Angeles, CA: November 6-8, 2008.

"The Efficiency and Effectiveness of Institutions to Address Climate Change." Invited Presentation. ETH Zurich: September, 15 2008.

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"The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Internal Determinants or Regional Diffusion?" Association of SPEA Ph.D. Students (ASPS) Conference, Bloomington, Indiana: February 22, 2008.

"Domestic Political Structures, Coalition Realignments and the Adoption of the Kyoto Protocol." Association of SPEA Ph.D. Students (ASPS) Conference, Bloomington, Indiana: April 23, 2007.

"Are International Environmental Agreements Enforceable? Implications for Institutional Design." Workshop on Political Theory and Policy Analysis Mini-Conference. Bloomington, Indiana: December 13, 2005.

"Designing Effective International Environmental Agreements: Theory and Evidence from Europe." Association of Public Policy Analysis and Management (APPAM) Conference, Washington D.C.: November 3–5, 2005. (With Evan Ringquist & Tatiana Kostadinova)

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Teaching Experience

Associate Instructor, Indiana University, Bloomington, IN — Fall 2006 – Present

Statistical Techniques – Fall 2006, Spring 2007, Spring 2008 (accelerated), Spring, 2009; Introduction to National and International Policy Fall, 2007; Environment and People Fall, 2008 (accelerated)

Kaplan Test Preparation, Bloomington, IN — Spring 2005 – Fall 2005

SAT and GRE tutoring.

Club Z Tutoring, Houston, Texas — Spring 2003

Tutored mathematics to middle school and high school students.

Kefiada, Beit She'an, Israel — Summer 1999

Taught English to children aged 10-13. Planned school programs, activities, and curriculum.

Grants, Awards, Honors, and Fellowships

Graduate Fellowship, Indiana University ($93,000)	2004 – 2007
NSF Dissertation Improvement Fellowship ($12,000)	2008-2009
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European Union Center for Excellence: Pre-dissertation Travel Fellowship ($2,800)	2006
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Service, Leadership Experience, and Other Interests

- Association for SPEA Ph.D. Students, Chair, 2007
- SPEA Dean's Student Committee 2007-2008
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- Bloomington Faculty Council (BFC)'s Student Academic Affairs committee 2008-2009
- Avid runner, including Boston Marathon (2004)
- Indiana University Ultimate Frisbee Club Team 2004-2007 (Collegiate Nationals, 2007)
- University of Pennsylvania Crew Team, Coxswain, 1998
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Professional Association Memberships

Association for Public Policy Analysis and Management
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