Can Voluntary Environmental Program Reduce Greenhouse Gas Emissions? An Analysis of the US DOE's Climate Challenge Program

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Abstract

This paper assesses the impact of the Climate Challenge Program (CCP), a voluntary environmental agreement (VEA) negotiated between the Department of Energy and the U.S. utility industry. The aim of the agreement was to reduce carbon emissions between 1994 and 2000. Our analysis involved a statistical study based on a panel data set composed of investor-owned power plants (n=358) for the 17 years from 1990 to 2006. The panel data analysis used a fixed effects model with a first-order autoregressive disturbance, an approach which handles both self-selection and serial correlation. The analysis shows that the impacts of the CCP varied over different performance measures and different time periods. During the program's operational period, the CCP significantly induced fuel switching but did not reduce CO2 emissions per unit of net generation (CO2 intensity). Afterwards, CCP members were more likely to fuel switch and lower CO2 intensity. However, the total plant emissions of CCP members continuously increased during the program's operational period, and in the period afterwards. This mixed pattern of results has policy and methodology implications. The policy implication is that voluntary programs, which by design do not impose emissions caps, may have some success in achieving some performance objectives, such as reducing emissions intensity, without reducing overall emissions levels (relative to the emissions baseline at the start of the program). The methodology implication is that a precise assessment of voluntary programs has to consider a time horizon that extends beyond the program's operational period, and also consider range of performance measures. This conclusion is especially relevant for VEAs whose participation metrics include capital investments, or whose programmatic design involves information exchange components with possibly longer-lasting effects, and for programs whose participation metrics are flexible enough to have multiple effects which can only be captured by different performance measures.

I. Introduction

Reducing the risks of climate change is one of the most vexing policy challenges facing decision-makers in the 21st century. To date, the United States has relied on voluntary programs for greenhouse gas emissions control. After a proposal in 1992 to tax energy confronted powerful political resistance, an alternative Climate Change Action Plan (CCAP) was developed. The "Climate Challenge Program" (CCP) was one of action programs in the CCAP. The CCP targeted the electric utility industry, which alone contributes over thirty percent of carbon dioxide emissions in the United States. The CCP aimed to encourage voluntary carbon reductions from electric utilities over the period 1994-2000. A total of 124 agreements were initiated during the program's operational period representing more than 650 utilities covering 71% of the generating capacity in the U.S.

This study aims to evaluate the performance of the CCP on CO2 emissions reduction focusing on plant level strategies and management. The research questions are twofold: (1) Did the utilities that participated in the CCP reduce both CO2 intensity (emissions per net generation) and total CO2 emissions per plant more than business-as-usual during the program's operational period? 2) Is there evidence of persistent effects on CO2 intensity and total CO2 emissions after the CCP ended? To our knowledge, no empirical work has assessed the impact of the CCP during the program's complete operational period, or beyond the program's operational period to gauge the possibility of longer lasting effects.

To answer the research questions, this study conducted an empirical study based on a panel data set composed of investor-owned power plants (n=358) for the 17 years from 1990 to 2006 , covering the pre and post-CCP period as well as the operational period (1994-2000). In the first model, factors explaining the plant's participation in the CCP were examined using a logit model. In the second model, performance of the CCP was investigated using a fixed effects model with a first-order autoregressive disturbance, which is a methodology approach which handles both the problems of self selection and serial correlation.

This paper is structured as follows. The next section explains electric utility industry and the Climate Challenge Program. Section 3 surveys some salient parts of the literature used to develop research hypotheses. Section 4 then describes the models used for the evaluation, while section 5 discusses the data sources for the study. Section 6 presents the results of the assessments and Section 7 discusses some research issues and future study direction. The last section of the paper offers conclusions about evaluating the performance of the CCP and the policy implications for voluntary programs to control carbon emissions.

II. Background

A. Voluntary Environmental Agreement & the Climate Challenge Program

By offering tangible or non-tangible incentives, Voluntary Environmental Agreements (VEAs) aims to induce voluntary efforts from firms to improve their environmental performance without use of regulation. Because the participants of the VEA can decide how to comply, the VEA is believed to achieve environmental improvements in a relatively flexible and efficient way. However, whether the VEA has been working effectively is still questionable. "Voluntary" means firms have many choices such that they can choose whether they participate or not, and how much they improve their performance. Most VEAs lack sanctions or penalties for non-participation or non-compliance. As a result, the possibility of the participant's opportunistic behaviors is quite high, thus free-riding is the biggest issue of the VEA. Participants may enjoy the benefits of the VEA without making sufficient efforts to fulfill the program's requirements. Given that most VEAs do not have systematic monitoring methods and heavily depend on self-reporting, it is hard to verify whether participants actually meet their stated commitments. Free-riding among VEA participants would lower overall environmental performance and thus reduce program effectiveness.

The Climate Challenge Program is a joint voluntary program of U.S. Department of Energy (DOE) and the electric utility industries. It was launched in 1994 and aimed at voluntary carbon dioxide (CO_2) emission control by electric utilities by 2000. A total of 124 agreements were initiated during the program's operational period. Without nationwide mandatory regulation, the voluntary approach has been the main instrument in U.S. climate policy. Participating utilities signed a Memorandum of Understanding (MOU) with the U.S. Department of Energy pledging to (1) undertake one or more out of six actions to reduce CO_2 emissions[1], (2)

[1] Utilities can select one or more activities among the listed below: (1) Reduce greenhouse gas emissions by a specified amount below the utility's 1990 baseline level by the year 2000; (2) Reduce greenhouse gas emissions

report annually their progress to the Department of Energy, and (3) discuss their progress with the DOE (U.S. Department of Energy, 2000). Joining the CCP is rather easy in terms of the stringency of the requirements for entry into the program. There is no prerequisite for utilities to join the program and utilities could select one or more actions from various options aiming at reducing greenhouse gas emissions by the year 2000 (U.S. Department of Energy, 2000). No direct sanctions or penalties existed even though the participants did not comply for the program requirements. As rewards for voluntary actions, utilities expected public recognition, cost reductions, and the possibility of getting future credits from their CO_2 emission reduction.

B. Deregulation

Traditionally, the electric utility industry was highly regulated and monopolistic. However, deregulation during 1990s caused the electric utility industry to be competitive and less regulated. Wholesale competition was encouraged by Order 888 and 889 of Federal Energy Regulatory Commission (FERC) issued in 1996, which opened transmission access to nonutilities. Legislation for retail competition was passed in Rhode Island and California in 1996 and until December 1999, 24 States allowed consumers to choose electricity suppliers (EIA 2000a). Introduction of those competitions threatened investor-owned utilities (IOUs) which enjoyed producing and selling most of the electricity in the United States. To remain competitive, IOUs took several actions to lower operations and maintenance (O&M) costs. There were almost 50 mergers during 1990s, thus many electric power plants experienced huge changes for their ownership structure (EIA 2000b). To take priority in price competition, using a lot of low cost coal as input fuel was another strategy for IOUs. Considering coal has the highest carbon intensity among fossil fuels, combustion of a lot of low cost coal should have increased of CO_2 emissions from the electric utilities.

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to the utility's 1990 baseline level by the year 2000; (3) Reduce greenhouse gas emissions to a particular level expressed in terms of emissions per kWh generated or sold; (4) Reduce greenhouse gas emissions by or to some other specified level; (5) Undertake or finance specific projects or actions to reduce greenhouse gas emissions, or (6) Make a specified contribution to particular industry initiatives (U.S. Department of Energy, 2000).

On the contrary, to appeal their green customer, electric utilities might have focused on developing green power which is generated from renewable energy resources. This strategy might have decreased CO_2 emissions. Therefore, it is hard to predict what would be the ultimate effects of deregulation on CO_2 emissions from electric utilities. In the long run, increasing the amount of green power may survive the strict environmental regulations and satisfy green customer pressure. The study of Delmas et al. (2007a) supports the possibility of generating more green power as a response to deregulation. However, in the short run, electric utilities might have more interested in reducing O&M cost by using cheaper fuel. Particularly during the operation period of the Climate Challenge Program, which is from 1994 to 2000, deregulation might have worked as a barrier to reduce CO_2 emissions.

C. SO2 & NOx regulation

Electric power plants emit significant quantities of sulfur dioxide (SO2) and nitrogen oxides (NOx) that contribute heavily to local, regional, or national environmental problems. 72 percent and 33 percent of total emissions of SO2, and NOx respectively, came from utility power plants as of 1993 (Carlin 1995). The Title IV of the Clean Air Act Amendment of 1990 (CAAA) reflect a federal effort to resolve common environmental problems that cross State lines.
Title IV of the CAAA authorizes EPA to develop a program to reduce SO2 and NOx emissions by 10 million tons annually and 2 million tons annually, respectively, from 1980 emission levels by 2000. Phase I, effective January 1, 1995, set an SO2 emission limit for 261 generating units at 110 electric utility power plants in 21 States. Also effective 1996, Phase I sets NOx emission limits for the same 239 generating units if they use dry bottom wall-fired boilers or tangentially-fired boilers (US EPA 2001).

Utility power plants developed several methods to comply with SO2 and NOx regulation under Title IV. Those methods and strategies mainly targeted to cut down the emissions of SO2 and NOx emissions (Burtraw & Evans 2004a; Burtraw & Evans 2004b), but also those methods might have impacted CO_2 emissions from utility power plants. Whether SO2 and NOx regulation would lead to CO_2 emission reduction is not clear. But many strategies for SO2 and NOx reductions are related with fuel switching and efficiency improvements (Palmer and Burtraw

2005). Thus some of CO_2 variance from power plant utilities might have been caused as side effects of SO2 and NOx regulation. To discern the net effect of CCP participation, the plausible effects of SO2 and NOx regulations on CO_2 emissions should be controlled.

III. Literature Review and Research Hypothesis

A. Literature on the VEA Participation

The literature on VEA participation and performance can be viewed through various theoretical lenses. One strand of the literature derives from the environmental economics field, which focuses on the incentive effects of policy instruments on the behavior of rational-choice actors. Studies in this tradition indicate that firms participate in VEAs expecting various benefits such as reducing the probability of future regulatory threats (Lyon and Maxwell, 2002; Segerson and Miceli, 1998); obtaining regulatory relief (Alberini and Segerson, 2002); reducing the probability of future liability risks (Hamilton, 1995); achieving cost savings (Lyon and Maxwell, 2002); or appealing to green consumers (Lyon and Maxwell, 2002). These incentives could lead to more participation in the VEA and better environmental performance.

B. Literature on the VEA Performance

However, there are concerns about the actual outcome of the VEA. Some scholars argue that without explicit penalties and sanctions, voluntary approaches will not be effective (King and Lenox, 2000; Grief, 1997). Due to the opportunistic behaviors of free-riding participants, the VEA can yield a lower level of environmental performance than firms would otherwise achieve in a regime of command and control regulation (Lyon 2003).

On the contrary, more optimistic appraisal about whether VEAs will induce environmental performance improvements comes from the literatures of institutional theory. This literature suggests that VEAs can induce behavior changes through more informal means such as institutional pressures (DiMaggio & Powell, 1991; Scott, 1995; Potoski and Prakash, 2004, 2005). More informal mechanisms, such as public exposure of the lack of progress, encouragement of collectively valued actions, and dissemination of the knowledge and information on best practices could encourage better performance (Gunningham, 1995; Hoffman, 1999; Kraatz, 1998).

These literatures are not necessarily at odds on all points. For example, both would suggest that large firms would be more likely to participate in a VEA either because they are more likely to fear being targeted by future regulatory sanction (a response to an incentive) or alternatively, they could face more pressures for conformity, as would be suggested by institutional theory.

In the CCP, the government originates the agreement and attempts to elicit participation. Such an agreement is regarded as relatively a weak instrument in the environmental economics literature owing to the fact that it is likely to emerge when the background regulatory threat is relatively low (Lyon, 2003). In fact, the CCP was the Clinton administration's response to its failure to pass an energy tax before the U.S. congress in 1993. Although the possibility of a future climate regulation was still viewed as a realistic possibility at that time, the near-term probability of binding CO_2 emissions caps, and certainly emissions taxes, was low. Thus, as with other VEAs, the CCP involved modest, mostly in-kind subsidies in the form of technical assistance and information exchange to induce firms to undertake some level of emissions reductions after the failure of the more stringent tax policy option. Even these relatively modest actions were undermined by Congressional funding constraints, and it made it difficult for the Department of Energy to fulfill its obligations under the MOUs it signed (Cleverdon and Klein, 1999).

This historical context suggests a policy-relevant question which a performance evaluation of the CCP might answer: could pressures for conformance to performance norms, which would be suggested by neo-institutional theorists, overcome the weak incentive system for environmental performance inherent in the political context in which the CCP actually emerged? The question is now explored through the analysis of the CCP in the next sections.

As for the performance of the CCP, two empirical studies investigated whether the CCP was effective in reducing CO_2 emissions from electric utilities. The study of Welch, Mazur, and Bretschneider (2000) found that participation in the CCP did not impact CO_2 reduction level. Firms pledged to reduce higher level of CO_2 emissions rather increased CO_2 emissions more than non-participants. However, Welch et al.'s study is based on small sample of utilities (n=41) located east of Rockies for the partial period of CCP operation, and therefore, the result of the study should be carefully interpreted considering those limitations. Delmas and Montes-Sancho (2007b) examined the performance of the CCP from the dataset of larger sample size and for most of the period of the CCP. They found that utilities which participated in the CCP at its initiation (early joiners) were more likely to reduce CO_2 emission rate while utilities that participated in the CCP in the later time period (late joiners) did not show any additional CO_2 emissions rate reductions during the period of CCP operation. They concluded that the opportunistic behavior of late joiners lowered the overall performance and made the CCP ineffective. Although their study includes a larger number of utilities than the study of Welch, Mazur, and Bretschneider (2,000) only one outcome is assessed by using one evaluation methodology: a two-stage least squares model.

Related to the studies on the CCP, Lyon and Kim (2007) investigated the performance of the 1605(b) Voluntary Reporting of Greenhouse Gases Program, which aims to target GHG emissions reductions from industry-wide facilities. 1605(b) program is U.S. Department of Energy's voluntary program to report facilities' progress toward GHG emissions control. Lyon and Kim could not find significant evidence on the effects of the 1605(b) program on GHG emissions reductions.

C. Research Hypothesis

As we have seen in the previous section, literature on the VEA performance predicts mixed result. Literature based on economic theory of rational –choice actors predicts that the VEA is not going to work effectively due to opportunistic behaviors and free-riding (Lyon 2003; King and Lenox 2000; Grief 1997). Literature based on neo-institutional theory predicts that pressure for conformance to performance norms will overcome the weak incentive system of the VEA and opportunistic behaviors of the participants (DiMaggio & Powell, 1991; Scott, 1995; Potoski and Prakash, 2004, 2005; Gunningham, 1995; Hoffman, 1999; Kraatz, 1998). Based on the literature, we constructed a research hypothesis on the effectiveness of the CCP on CO2 emissions control.

Hypothesis 1*: An electric utility plant that participated in the CCP is more likely to reduce CO_2 emissions than non-participants.*

IV. Econometric Models

Many studies in the literature on Voluntary Environmental Agreements (VEA) view success in voluntary programs to be appropriately measured by participation. This study extends the concept of success to be more consistent with the program evaluation literature. In the first section a model of program participation is developed, and, in addition, in the second section, a model of assessing performance is developed. This study examines the outcomes of the CCP participation measured against the counterfactual of non-participation. This research also assesses the possible mechanisms and behavioral changes that participants could employ in complying with CCP commitments.

D. Dependent Variables and Models

Program Participation

Utilities could participate in the Climate Challenge Program during the operational period (1995 to 2000) of the CCP. In order to examine what motivated plants' decision to participate in the CCP, panel data from year 1995 through 2000 are assessed using a logit model.

Dependent Variable. Once a plant participated in the CCP in the year t, the plant is coded as 1 for the observations of year t and later years. Before the plant participated, it is coded as 0. If a plant did not participated at all, then all the observations are coded as 0. Since the decision to participate is made at the utility level, a plant level participation is determined according to whether the owning utility of the plant participated in the CCP.

Estimated Model. A logit model is used to investigate what determines a plant's decision to participate in the CCP. For a logit model, the probability of a plant's participation is specified as a function of the set of exogenous variables **x**. Accordingly,

$$Pr\ (y = CCP\ Participation \mid \boldsymbol{x}) = F(\boldsymbol{x\beta})$$

where F is the logistic cumulative density function, which is defined as following.

$$\Pr(y = 1|x) = \frac{\exp\,(\boldsymbol{x\beta})}{1 + \exp\,(\boldsymbol{x\beta})}$$

Program Performance

Utilities began to participate in 1995 and pledged to reduce GHG emissions by year 2000. The focus of this study is to examine whether the CCP was effective in reducing CO_2 emissions by the target timeline. In addition, by assessing the performance of the CCP over longer-term period, the study enables to investigate whether there are any lagged or lasting effects of the CCP even after the program ended. Data are collected from year 1990 through 2006, which covers the pre (1990 to 1994), and post-CCP period (2001 to 2006) as well as the operational period (1995 to 2000).

Dependent Variables and Decomposition. This study develops four dependent variables which measure the performance of the CCP and plant's strategic behaviors with regards to GHG emissions.

1) CO_2 Emissions = CO_2 emissions / Plant
2) CO_2 Intensity = CO_2 emissions / Net Generation
3) Fuel Switching = CO_2 emissions / Heat Input
4) Efficiency Improvement = Heat Input / Net Generation

We measure the performance of the CCP using two dependent variables: CO_2 Emissions and CO_2 Intensity. The CO_2 emissions produced by each plant over a year is obviously the key target variable of the CCP. Considering there are various sizes of power plants, we developed a standardized performance measure, the CO_2 Intensity, which is comparable across different sizes of plants. The CO_2 Intensity is defined as the amount of CO_2 emissions generated per unit of electricity generated over a year. The strategic behaviors that a plant can reduce CO_2 emissions are measured using another two dependent variables: Fuel Switching and Efficiency Improvement. A plant can reduce CO_2 emissions by switching fuels from high-CO_2-generation-fuels to low-CO_2-generating-fules or by improving efficiency of electricity generation. Fuel Switching is measured as the amount of CO_2 emissions generated per unit of heat input from fossil fuel. Efficiency Improvements is measured as the ratio of heat input from fossil fuel to net electricity generation.

Those four dependent variables are related to each other by those two decompositions, as follows, which clearly show the mechanisms by which a plant can reduce CO_2 emissions and CO_2 Intensity.

[Decomposition (1)]

$$\frac{CO_2\ Emissions}{Plant} = \frac{CO_2\ Emissions}{Net\ Generation} \times \frac{Net\ Generation}{Plant}$$

(CO2 Emissions) **(CO2 Intensity)** **(Net Generation)**

[Decomposition (2)]

$$\frac{CO_2\ Emissions}{Plant} = \frac{CO_2\ Emissions}{Net\ Generation} \times \frac{Net\ Generation}{Plant}$$

(CO2 Intensity) **(Fuel Switching)** **(Efficiency Improvement)**

As shown in the decomposition 1 above, a plant can reduce CO_2 emissions in two fundamental ways: (1) by reducing the production of electricity generated (Net Generation); or (2) by reducing CO_2 Intensity. Decomposition (2) shows that CO_2 Intensity can be reduced at plant level in two ways: (1) by switching from high-CO_2-generating fuels (e.g., coal) to low-CO_2-generating fuels (e.g., natural gas), which will cause the variable CO2 Intensity decline; or (2) by improving the efficiency of electricity generation (by better plant operation and maintenance or technology change), which will cause the variable Efficiency Improvement decline.

Estimated Model. In order to test the hypothesis concerning the effects of the CCP on plants' performance, this study estimated a fixed effects model with a first-order autoregressive disturbance, a methodology approach which handles both the problems of self-selection and serial correlation.

Self-selection bias is the main evaluation issue when assessing the performance of voluntary programs. Power plants that participated in the CCP may be systematically different in their characteristics such as the CEO's environmental concern, the size of the plants, the available resources, and etc. Participants' decision to participate may be correlated with traits that also affect the performance of the program, making the participants a non-representative sample. To control for self-selection issue, we estimated a fixed-effects model with the following specification:

$$Performance_{it} = \alpha \boldsymbol{d}_i + \beta \boldsymbol{x}_{it} + \delta CCP_{it} + \varepsilon_{it},$$

where the vector ***d*** is a set of dummy variables corresponding to each unit i (plant) under observation, the vector ***x*** is a set of independent variables and a constant for the unit i at time t, and *CCP* is the bivariate variable for CCP participation. Differencing dependent variable and independent variables over time eliminates time-invariant plant characteristics $\boldsymbol{d}_i$, which is the source of self-selection bias.

Another issue in the panel dataset is serial correlation, which is a correlation of the error terms within panels across time periods. Diagnostic test indicated that there is serial correlation in our dataset. Ignoring serial correlation results in consistent but inefficient estimates of the regression coefficients and biased standard error (Baltagi 2008). We used a Prais-Winsten transformation to correct for serial correlation within plants over time.

Independent Variables in Participation Model

Based on previous literature, independent variables are developed to see what their effects are on CCP participation. Two independent variables--Net Generation and Plant Age—measure the characteristics of the plant and internal pressures. Five independent variables—Ownership Change, SO2 Regulation, NOx regulation, Sierra Club Membership, and LCV Score—measure external pressures that a plant was confronting. Table 1 presents the descriptive statistics of all the independent variables used in the participation model.

Net Generation. Firm size is a commonly-used explanatory variable in the literature on VEAs. It is thought that larger firms are more visible to pressure groups and regulators. Additionally, they may be more adaptable and able to realize cost-savings from making process changes or using new technology. To proxy for firm size, a logged form of the plant’s net electricity generation in megawatt hours is measured.

Plant Age. Older plants are inefficient and emit more pollutants. Plant Age is computed by calculating capacity weighted average from the information on the year when generators began to operate. Then, we calculated Plant Age by subtracting the capacity weighted average from the data year. Plant Age reflects how long the capital stock of the plant been in operation.

To control for the effects of deregulation and other environmental regulation, three independent variables are used.

Ownership Change. Electric utility industry has experienced huge deregulation and structural change during this study period. One of direct effects of deregulation on power plants is ownership change. Ownership Change is coded as 1 if a plant had any change it its ownership structure in the previous year and 0 if there was no ownership change.

SO_2 Regulation. SO_2 Regulation proxies the regulatory pressure for air pollution that a power plant is confronting. SO_2 Regulation is coded as 1 if a plant is regulated in the year under Title IV of Clean Air Act Amendment of 1990 for SO_2 emissions. If the plant is not regulated, then it is coded as 0.

NO_x Regulation. Like SO_2 Regulation, NO_x Regulation proxies the regulatory pressure to a power plant for air pollution. NO_x Regulation is coded as 1 if a plant is regulated in the year under Title IV of Clean Air Act Amendment of 1990 for NO_x emissions. If the plant is not regulated, then it is coded as 0.

We measured stakeholder pressure using two independent variables—Sierra Club Membership and LCV Scores, which represents external pressures from environmental group and political pressure at the state level.

Sierra Club Membership. Sierra Club is the largest environmental group in the U. S. and the data on the membership of Sierra Club were used frequently in the previous studies (Helland, 1998; Kassinis & Vafeas, 2002; Lyon and Kim, 2007; and Delmas and Montes, 2007). The number of Sierra Club member per 1000 state residents was measured to represent environmental group pressure in the State where the power plant is located.

LCV Score. To proxy political pressure, we calculated the average of LCV Scores of the U.S. Senate and the U.S. House of Representatives where a plant was operating. The nonprofit organization, League of Conservation voters (LCV) has published a National Environmental Scorecard every year since 1970. The Scorecard records how member of Congress voted on key energy and environmental issues at the State level. The Score ranges from 0 to 100 scales, which 0 means for no vote at all and 100 means all votes for energy and environmental issues.

Independent Variables in Performance Model

In the performance model, in addition to the independent variables in the participation model, we included more variables that could explain the performance of CO_2 emissions reductions during 1990-2006 time periods.

CCP (1995-2000). To examine the effects of the CCP over the different time periods, we separated the participation variable into two independent variables: CCP (1995-2000) and Post CCP (1996-2000). The CCP (1995-2000) variable measures the status of participation during the operational period of CCP (1995-2000). During the time period of the CCP operation, once the owner of a plant participated in the CCP, then the plant is coded as 1 in the year through year 2000. If the plant didn't participated in the year, then it is coded as 0. During the pre-operation period (1990-1994) and post-operation period (2001-2006), the CCP variable is coded as 0 for both the participating plants and non-participating plants.

Post CCP (2001-2006). This variable aims to measure whether the participation in the CCP has lagged or lasting effects after the CCP ended. If a plant ever participated in the CCP, then the plant is coded as 1 in the years from 2001 through 2006. Otherwise, the plant is coded as 0. During the pre-operation period (1990-1994) and the operation period (1995-2000), the variable is coded as 0 for both the participating plants and non-participating plants.

% Fossil Fuel Generation. We measure the fraction of the electricity generated from the combustion of fossil fuels to the total electricity generated.

V. Data

This study built a pooled dataset of 5,728 observations from 358 power plants of electric utilities for 17 years from 1990 through 2006. This study period covers the pre (1990 to 1994) and post-CCP period (2001 to 2006) as well as the operational period (1995 to 2000). This study limited the dataset to the power plants whose net electricity generated and CO_2 emissions generated from the combustion of fossil fuel is greater than zero and whose owning utility is investor-owned utility (IOU). The remaining 358 power plants in the dataset represent 35% of net electricity generation and 55% of CO2 emissions from electric utility industry as of year 2000.

Information on the utilities participated in the CCP was obtained directly from the U.S. Department of Energy (United States. Department of Energy. 1998). Their unpublished data spreadsheet includes information on the names of participating utilities, program options they selected, the amount of CO_2 emissions they pledged to reduce, and the date of the agreement's signing. In the dataset, 225 out of the 358 plants, or 62.8%, had ever participated in the CCP.

CO_2 emissions are calculated using power plant's fossil fuel consumption data. This study employed the methodology developed by U.S. Department of Energy and U.S. Environmental Protection Agency in their study "Carbon Dioxide Emissions from the Generation of Electric Power in the United States (2000)." Using their procedure, CO_2 emissions for each fuel is computed as the product of fuel consumption and emission factors. Then, CO_2 emissions for each fuel are aggregated at the plant level. Fossil fuel consumption data at the plant level are available through the Energy Information Administration (EIA)'s Power Plant Report - EIA-759 (now EIA-906) data file (EIA, 1990-2006a). Information on emission factors are obtained from the EIA's website (EIA, 2001).

Total heat inputs are calculated by multiplying the power plants' fuel consumption and heat contents. U.S. Environmental Protection Agency (2004) provides heat content for each fuel type. Information on net electricity generated, ownership, plant age, capacity, and net electricity generated from fossil fuel is obtained from the Energy Information Administration (EIA)'s annual survey Annual Electric Generator Report (EIA-860) data file (EIA, 1990-2006b).

The performance model includes two variables representing stakeholder pressure: Sierra Club membership and LCV scores. Information on Sierra Club membership was obtained directly from the Sierra Club and National Environmental Scorecard of the League of Conservation Voters (LCV) are available through the website of the League of the Conservation Voters (LCV, 1990-2006).

Data on the electric utility plants which are regulated for SO_2 & NO_x emissions under the Acid Rain Program are obtained from U.S. Environmental Protection Agency (EPA)'s Clean Air Markets database, which is available through EPA's website (EPA, 2008).

VI. Results

A. Descriptive Statistics

Table 1 provides summary statistics for the explanatory variables used in the participation model.

Table 1. Summary Statistics of Variables

Variables	Description	All (N=6,086)	CCP (N=3,825)	Non-CCP (N=2,261)
CCP (1995-2000)	CCP participation between 1995 and 2000 (1=Yes, 0=No)	0.21	0.33	0.00
		(0.41)	(0.47)	(0.00)
Post CCP (2001-2006)	Ever participated in CCP is coded for the post CCP period between 2001 and 2006 (1=Yes, 0=No)	0.22	0.35	0.00
		(0.42)	(0.48)	(0.00)
Net Generation	Logged net generation (MWh)	13.31	13.76	12.55
		(2.81)	(2.63)	(2.93)
Plant Age	Capacity weighted average of the plant age	29.07	29.37	28.57
		(11.04)	(10.71)	(11.55)
Ownership Change	Ownership change (1=Yes, 0=No)	0.04	0.04	0.04
		(0.20)	(0.19)	(0.21)
SO2 Regulation	Regulated for SO_2 emissions under EPA's Acid Rain Program (1=Yes, 0=No)	0.38	0.42	0.32
		(0.49)	(0.49)	(0.47)
NOx Regulation	Regulated for NOx emissions under EPA's Acid Rain Program (1=Yes, 0=No)	0.29	0.31	0.26
		(0.46)	(0.46)	(0.44)
Sierra Club Membership	Sierra Club Membership (rate per thousand people)	1.83	1.74	2.00
		(1.40)	(1.56)	(1.08)
LCV Score	Sum of the League of Conservation Voters scores of Senate and House	41.92	42.14	41.55
		(22.30)	(22.09)	(22.66)
Interaction between CCP (1995-2000) and net generation	Product of CCP (1995-2000) and Net generation (MWh)	2.90	4.61	0.00
		(5.77)	(6.71)	(0.00)
Interaction between Post CCP (2001-2006) and net generation	Product of Post CCP (2001-2006) and Net generations (MWh)	3.06	4.87	0.00

		(5.87)	(6.79)	(0.00)
% Fossil Fuel Generation	A ratio of net generation from the combustion of fossil fuels to the total net generation	96.77	96.61	97.04
		(16.63)	(16.90)	(16.16)
CO_2 Emissions	Logged CO_2 Emissions (lbs)	20.82	21.25	20.10
		(2.94)	(2.80)	(3.02)
CO_2 Intensity	CO_2 Emissions per net generations (lbs/MWh)	2106.45	2077.83	2154.86
		(733.26)	(720.26)	(752.43)
Fuel Switching	CO_2 Emissions per total heat input (lbs/109 BTU)	186.86	189.32	182.70
		(45.27)	(45.43)	(44.69)
Energy Efficiency	A ratio of total heat input to net generation (10^9 BTU/MWh)	11.56	11.22	12.11
		(4.22)	(4.11)	(4.35)

On average, the plants that participated in the CCP are larger and older than the plants that didn't participate. As for the stakeholder pressure, the summary statistics show mixed directions. Plants that participated in the CCP are located in the States with lower Sierra Club Membership but higher LCV scores. As for the government regulation, plants that participated in the CCP are more affected by both SO_2 and NOx regulations.

B. Participation Model

Logit estimates of Participation model in the Table 2 confirm that most of previous studies on the motivations of CCP participation are still valid. As for plant characteristics, larger and older plants are more likely to participate in the CCP. Ownership Change is significant in deciding to participate in the CCP. Plants that experienced ownership change are less likely to participate in the CCP, which is consistent with our expectation. Once a plant is affected by deregulation and industry restructuring, the investments and strategic actions are more directed toward being competitive. Participating in voluntary programs is not likely to stand in its priority action lists. Our model also demonstrated that NO_x regulation is more likely to promote a plant's participation in the CCP while SO_2 regulation does not have any significant effects on the CCP participation. This result implies that environmental regulation for power plants have impacts on plants' decision to participate in voluntary CO_2 reduction program.

Table 2. Factors Affecting Participation in the Climate Challenge Program

(358 Power Plants from Year 1995 to Year 2000)

Dependent Variable	*CCP Participation (1 for Yes, 0 for No)*
Independent Variables	*Coefficients (Standard Error)*
Net Generation	0.80*** (0.12)
Plant Age	0.35*** (0.05)
Ownership Change	-1.47* (0.87)
SO2 Regulation	-0.23 (0.65)
NOx Regulation	2.29*** (0.68)
Sierra Club Membership	-1.15*** (0.08)
LCV Score	-0.05** (0.02)
Constant	-10.82*** (2.12)
Observations	2,148
Log Likelihood	-465.30
χ^2	423.37

Notes: *** Significant at .01; ** Significant at .05; * Significant at .10
[a]Standard errors are in parentheses.

On the contrary to our expectation, stakeholder pressure doesn't seem to have positive effects on plants' motivation to participate in the CCP. Both Sierra Club Membership and LCV Score have significant negative impacts on the CCP participation. Plants which are located in the State where stakeholder pressure is high, they might have used most of their resources to comply for mandatory government regulation, which is more urgent. As a result, they might not have enough resources for voluntary environmental agreements.

C. Performance Model

To see whether participation in the CCP made any impact on the performance of electric utilities, a fixed effects model with a first-order autoregressive disturbance is estimated. As seen in the Table 3 below, participation in the CCP has impacts on three out of four dependent variables.

Table 3. Factors Affecting Performance Measures of Plants

	Model 1	Model 2	Model 3	Model 4
Dependent Variable	CO_2 Emissions	CO_2 Intensity	Fuel Switching	Efficiency Improvement
Independent Variable				
CCP (1995-2000)	0.166***	-43.836	-2.035**	-0.130
	(0.061)	(28.213)	(0.847)	(0.154)
Post CCP (2001-2006)	0.410***	-66.574**	-3.195**	-0.176
	(0.067)	(33.533)	(1.266)	(0.174)
Ownership Change	-0.020***	0.322	-0.369	-0.100
	(0.012)	(23.099)	(0.542)	(0.140)
SO_2 Regulation	0.015	-9.611	0.764	-0.066
	(0.014)	(23.892)	(0.724)	(0.131)
NO_x Regulation	-0.016	-79.645***	-1.665**	-0.027
	(0.014)	(23.729)	(0.741)	(0.129)
Plant Age	0.004**	7.605***	0.392***	0.023
	(0.002)	(2.616)	(0.084)	(0.014)
Sierra Club Membership	0.000	-1.692	0.091	-0.003
	(0.002)	(4.400)	(0.102)	(0.027)
Net Generation	0.903***			
	(0.005)			
LCV Score	0.000	-0.397	-0.053***	0.001
	(0.000)	(0.579)	(0.015)	(0.003)
Interaction between CCP (1995-2000) and net generation	-0.013***			
	(0.004)			
Interaction between Post CCP (2001-2006) and net generation	-0.030***			
	(0.005)			
% Fossil Fuel Generation		20.907***	0.051	0.150***
		(2.829)	(0.075)	(0.016)
Constant	8.650***	-91.442	161.808***	-2.917**
	(0.041)	(170.947)	(1.811)	(1.157)
Observations	5728	5728	5728	5728
F	1425.96	7.66	32.03	7.05
R^2				
Within	0.874	0.033	0.126	0.031
Between	0.917	0.280	0.003	0.263
Overall	0.915	0.230	0.016	0.217

Notes: *** Significant at .01; ** Significant at .05; * Significant at .10
[a]Standard errors are in parentheses.

As for absolute CO_2 emissions, when relevant factors are controlled, power plants that participated in the CCP rather increased CO_2 emissions during and post the operational period. The analysis on CO_2 intensity show somewhat different results. Participating in the CCP did not make any significant effects on CO_2 intensity reductions during the CCP operational period. However, during the post operational period (2001 through 2006), plants that participated in the CCP are more likely to reduce CO_2 intensity. As for third dependent variable, Fuel Switching, the results show that participation in the CCP is more likely to increase switching from high-CO_2-generating fuel to low-CO_2-generating fuel through operational and post operational period. The result indicates that the CCP doesn't have significant impacts on Efficiency Improvements.

This result implies that plants that participated in the CCP initiated behavioral changes since they participated in the program. Based on the results below, that changes more likely focus on switching fuel mix from high-CO_2-generating fuels to low-CO_2-generating fuels rather than improving fuel efficiency. These behavioral changes did not lead to visible outcome during the operational period of the CCP but those changes caused visible for reductions of CO_2 intensity after the program ended. Therefore, the effects of the CCP on reduction of CO_2 intensity existed but it took time to see the visible outcome. If we evaluated the effects of the CCP on the CO_2 intensity just during the program operational period, we would have concluded that the CCP is not effective on CO_2 emissions control.

However, the amount of absolute CO2 emissions was greater for the plants that participated in the CCP. Considering that the amount of CO2 emissions are proportional to the amount of net generation, which is decided by electricity demand, the reductions of CO2 intensity was overwhelmed by continuous increase of the electricity demand. Our results show that the reduction of CO2 intensity could not guarantee the reduction of CO2 emissions. In summary, the CCP made some effects on CO2 emissions control but our results shows that the effects were rather slow and weak.

To discern the net effects of CCP participation, several control variables added to the performance model. And those control variables also provide more insights on power plants' behaviors. Plant Age is significant in predicting CO2 Emissions, CO2 Intensity, and Fuel Switching. Older plants are more likely to increase fuel switching from low-CO2-generating fuel to high-CO2-generating fuel and to increase CO2 intensity and CO2 emissions. Given that the older plants are more likely to participate in the CCP, this result demonstrates that older plants are more likely to free-ride and use the voluntary environmental program as greenwash. NO_x regulation is significant in predicting the level of CO_2 intensity and Fuel Switching. Plants that are regulated under NO_x emissions are more likely to switch fuel from high-CO_2-generating fuel to low-CO_2-generating fuel and to decrease CO_2 Intensity. Considering that a power plant prioritizes complying mandatory regulation, this result implies that a plant's strategy of complying for NO_x regulation might be also helpful in reducing CO_2 Intensity, and the strategy could be fuel switching from high-NOx-generating and high-CO_2-generating fuel (e.g., coal and oil) to low-NO_x-generating and low-CO_2-generating fuel (e.g., natural gas). However, in order to understand the relationship between NO_x regulation and CO_2 controls, more analysis should be done.

VII. Issues & Discussions

There are some limitations and issues in this study and they will be explored further in the future study. First, this study focuses only on the efforts to reduce CO_2 emissions during electricity generations. However, CO_2 reductions can also be achieved during the process of distribution and transmissions. Demand side management and sequestration are other options that electric utility can take for CO_2 emissions reductions. Thus evaluating the CO_2 reductions in the process of electricity generations from the combustion of fossil fuel might have underestimated the efforts of CCP participants. Thus the results of this study should be understood considering those limitations.

Second, it should be noted that there are other voluntary programs for CO_2 emissions control which affects electric utility industry. Controlling effects from other voluntary programs should be considered in the future study.

There are other plausible explanations for lagged effects of the CCP on CO2 intensity. It may be because it took time for the investment made during the operational period to produce visible effects. Scientific evidences on global warming have accumulated since the 1990s and public awareness has increased. Those changes might have worked as outside pressure to the electric utility industry. This outside pressure might be able to explain the significant effects of the CCP on CO_2 intensity reduction during the post-operation period of the CCP.

Political environment has changed a lot recently with regards to climate policy as Obama administration began. As a result, mandatory CO_2 emissions controls are supposed to be implemented very soon. However, given that there exist many voluntary programs in the area of CO_2 emissions control[2], we should consider the role of the voluntary programs as a supplement approach and how to balance mandatory programs and voluntary programs.

VIII. Conclusion

The basic evaluation issue surrounding the CCP is whether the program actually influenced utility decision makers to change behaviors to reduce CO_2 emissions that otherwise would not have changed in the absence of the program. There are possibilities that plants participated in the voluntary program only for enjoying public recognitions and other benefits while largely ignoring their commitments as binding obligations.

This study provides empirical evidence on the impacts of the CCP on the firm's behavior to reduce CO_2 emissions. By developing various dependent variables on program outcomes and behavior changes of an electric utility plant, this study provides in depth insights on how firms react to meet the CCP requirements. By focusing on the plant level analysis, the study shed the light on what is actually happening at the place of electricity generation and CO_2 emissions.

The overall conclusion of the analysis is that there are some effects of the CCP on CO_2 emissions control but the effects are rather weak and slow. Behavioral changes have made early and it is connected to the reduction of CO_2 Intensity in the period of post-operational period. Nonetheless, the behavioral changes and reductions of CO_2 intensity could not lead to reductions of CO_2 emissions, which is the ultimate goal of climate change control. Continuing increase of electricity demand offsets the achievements of the CCP and lead to the increase of CO_2 emissions.

These results suggest several policy implications when designing and employing the VEAs. First, when mandatory regulation is not available, voluntary programs can be adopted as an alternative way or the second-best way to handle the issues. However, it should be kept in

[2] As of 2009, 185 Voluntary Programs at Federal and State government are listed in the EPA web page.

mind that the effects of the voluntary program could be weaker and slower than mandatory programs.

Second, particularly in short-term period, the voluntary program may not produce visible effects. Particularly, opportunistic behaviors of participants would lower the overall effectiveness of the voluntary program. If we want more compliance and more outcomes in short-term period, preventing opportunistic behaviors by employing stringent monitoring and penalty could accelerate the effective implementation of the voluntary program.

Third, it should be recognized that voluntary programs have virtues. Because of its expected low cost at initiation and implementation, a voluntary program can be adopted easily with less political resistance. Information sharing and technical assistance of a voluntary program can facilitate organizational learning for the participants. It also helps to build cooperative relationship between the regulator and the regulated. Those virtues of voluntary programs can lead to society-wide cultural change and enhance awareness of the environmental issue. Those changes could enhance CO_2 emissions control in longer-term period. The lagged effects of the CCP on CO_2 Intensity--reduction of CO_2 Intensity during the post-operational period-- could be the results of those indirect effects of the CCP.

Fourth, cultural changes and social awareness due to the voluntary program could pave the way for adopting more stringent mandatory programs for CO_2 emissions control. The voluntary program may serve to reduce the political resistance to future pollution taxes or Cap-and-Trade systems.

The results of this study do suggest the importance of decomposing performance measures to fully gauge program effects. Based on the analysis of various dependent variables, this study shed lights on how the CCP affected plants' strategies and outcomes in detail. By expending the study period beyond the program operation period, this study could investigate the longer-term effects of the CCP, which were ignored in the previous studies.

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