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Privatizing Climate Change Policy: Is there a Public Benefit?

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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. 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 the CCX is associated with a decrease in total carbon dioxide emissions for participating plants when non-publicly traded firms are included in the sample. Effects are produced largely by decreases in output. CCX participation is associated with increases in carbon dioxide intensity. The CDP is not associated with a decrease of carbon dioxide emissions or electricity generation, and program participation is associated with an increase in carbon dioxide intensity. I explore these results within the context of voluntary environmental programs to address carbon emissions.

Keywords Voluntary environmental programs · Climate change policy · Chicago climate exchange · Carbon disclosure project · Difference-in-differences model · Propensity score matching · Greenwash

JEL Classification Q50 · Q54 · Q58 · D80 · C23

1 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

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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 approach of different voluntary environmental policy programs (VEP) 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 carbon dioxide emissions against a control group. To test how plants may change behavior, I include interaction terms with fuel use change and measure changes in carbon dioxide intensity and electricity output.

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. Recent research has suggested that benefits from public voluntary programs may accrue to both participating firms, and non-participating firms (Lyon and Maxwell 2007). 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 and Maxwell 2007; Rivera et al. 2006). These spillover effects of voluntary policy may be due to the motivations of government actors to share program benefits across industry in order to reach environmental goals. As a result, current analyses of public voluntary programs may be mis-specified. By examining private voluntary programs, which may be more likely to keep program benefits as a club good, 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. While voluntary programs are typically regarded as non-coercive, voluntary programs can assume the characteristics of many different types of policy tools (Richards 2000). This study seeks to help compare information provision approaches—a relatively low coercive method, where firms do not commit to any explicit emissions reductions, and cap-and-trade approaches—a highly coercive method in voluntary environmental policy, where firms commit to specific changes in environmental behavior and undergo environmental auditing.

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 et al. 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 and Pizer 2007). While some studies examine the impacts of voluntary carbon reduction programs, this area has received much less attention in the literature than toxics (Kim and Lyon 2011a; Morgenstern and Pizer 2007; Welch et al. 2000). 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 detail several approaches to voluntary environmental policy tools, and discuss private approaches to voluntary environmental policy (Sect. 2). 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 (Sects. 3, 4). Third, I present and discuss the impact of participation on carbon dioxide emissions, and test whether participating plants reduce carbon dioxide intensity or whether they reduce output (Sect. 5). I conclude with recommendations for policy design as well as for future study of voluntary environmental policy (Sects. 6, 7).

2 Background and Theory

2.1 Policy Tools and Voluntary Environmental Policy

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 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. While the pressure placed on firms involved in voluntary policy may be different than in mandatory policy, this research seeks to compare two private voluntary programs that employ different policy tools as mechanisms of addressing carbon emissions.

2.2 Private Approaches to Voluntary Environmental Policy

While the literature regarding voluntary environmental programs has examined a multitude of programs, much has focused on public voluntary agreements, and of those—most research has focused 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 (Arimura et al. 2008; Dasgupta et al. 1997; Kim and Lyon 2011b; Potoski and Prakash 2005a,b,c; Prakash and Potoski 2006).

Private voluntary initiatives can take several forms. An NGO or non-profit organization can commit organizations to voluntarily 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 rely on market pressures to induce behavior change and threaten non-participants with financial penalties (Ananathanarayanan 1998; Feldman et al. 1996; Hamilton 1995).

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 or industry association (Lyon et al. 2004). These efforts, such as Responsible Care, 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 (Khanna 2001; Lyon and Maxwell 2004).

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 carbon reduction is in the public interest and may contribute to social welfare, voluntary initiatives may only lead firms to reduce carbon when it is in the private interest of stakeholders, and is likely to be under-provided by the market. 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 and 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 and Prakash 2005c). This characteristic of private initiatives may help solve the specification problems inherent in analyzing public voluntary agreements.

2.3 Addressing Greenhouse Gas Emissions Through VEP

While an enormous body of literature exists regarding the effectiveness of VEP on reducing toxics, greenhouse gases may provide a number of different incentives, and may be handled differently by firms. 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 and 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 and Lenox 2000; Lyon and Maxwell 2007; Morgenstern et al. 2007; Vidovic and Khanna 2007; Welch et al. 2000).

Greenhouse gases depart from toxics along several criteria. While toxics are considered an unpriced byproduct of the production process, greenhouse gases are primarily the result of fossil fuel combustion. Because energy costs are already included in the costs of production, voluntary reductions of greenhouse gases should not be expected. Most research on voluntary greenhouse gas reduction programs have not found substantial reductions as a result of the voluntary programs (Kim and Lyon 2011a; Morgenstern and Pizer 2007; Welch et al. 2000). However, these evaluations are subject to some of the criticisms discussed above.

A contrasting view of voluntary environmental programs suggests that firms are boundedly rational, and may have difficulty incorporating energy costs into production costs (Matisoff 2010). Considerable variation exists regarding the technological and investment decisions by manufacturers and utilities (Kolk and Pinske 2005). Firms—and in particular regulated electricity generators—may be able to vary fuel mixes in order to reach competing production, cost, and environmental goals (Welch and Barnum 2009). Thus, substantial leeway may exist for firms to reduce greenhouse gases. Evidence that investments in capital can improve profitability and environmental outcomes supports this hypothesis (Boyd and McClelland 1999; Shadbegian and Gray 2006). Discussions with managers at utilities suggest that there is substantial leeway regarding how a firm chooses to balance new investments, fuel switching, and balance fuel price risk and generation mix in the medium term.

3 Research Design: Assessing the Effectiveness of VEP

3.1 Sample

The sample for this study consists of electric utility power plants in the United States to evaluate two private voluntary environmental programs. First, the Carbon Disclosure Project (CDP) 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. The CDP began in 2000 with a London-based coordinating secretariat for institutional investors to gain insight to climate related risk of Fortune 500 publicly traded corporations by standardizing reporting procedures for climate change related activities. The results of the first cycle of the project, released February 17th, 2003, were endorsed by approximately 35 investors controlling $4.5 trillion in assets. By the end of 2007, the CDP had grown considerably and was funded and run by over 385 institutional investors including major players such as Goldman Sachs, Merrill Lynch, and state pension funds, controlling over $40 trillion in assets. By 2007, over 2,400 firms were targeted and 1,300 firms responded to the survey (CDP4) reporting on various aspects of carbon management (Kolk et al. 2008). Of the Fortune Global 500 companies, CDP4 resulted in a 91 % response rate and 72 % answered the questionnaire in full. The CDP 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.

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 35–50 % of participants have independent verification and about 65 % of responding firms make their direct emissions publicly available. While firms may be coerced into joining the CDP due to pressure from external stakeholders, there are no explicit contractual obligations involved in the CDP. Firms can choose whether or not to respond, how much information to provide, and whether or not they make their responses public. Firms do not have to have their responses audited, and responses can be extremely detailed or extremely vague and not disclose anything at all. Thus, for the purposes of generating a change in environmental emissions output, the CDP represents a less-coercive approach to VEP.

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 1 % 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 boasted over 400 members, including offset providers. In this paper, I assess the performance of electric utilities that participated between 2003 and 2007.

3.2 Data

Three types of data had to be collected to analyze the effectiveness of these programs. First, plant level data, including CO_2 emissions, electricity output, and emissions intensity (emissions/output) were collected as dependent variables. Electricity generation, type of fuel use, and plant construction year were also collected at the plant level. Second, because participation in voluntary programs is determined at the firm level, firm level data were collected, including firm size (measured as revenue), firm growth rate, and whether or not a firm is publicly traded. Finally, 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. In addition, environmental interest group membership was collected in order to proxy for environmental attitudes of each state (Ringquist 1993).

3.2.1 Plant Level Data

Fuel use data was used to estimate carbon emissions. To calculate carbon dioxide emissions, the amount of each type of fuel used in each power plant was multiplied by the heat rate, and the DOE regulations were used for the 1605b voluntary program in order to determine carbon dioxide emissions for each power plant reporting fuel use to the Energy Information Administration.[1] Data also included electricity generation by power plant. Plant level data were collected from 1994 to 2007 for approximately 5,000 prime movers[2] (engines or turbines), which was then compiled, based on locational attributes, to generate fuel use data for 960 fossil fuel power plants in the United States. After dropping nuclear plants and non-publicly traded firms, the dataset totaled 691 power plants over 14 years for an unbalanced panel of 8,537 observations. Plant level data were compiled with the assistance of Indianapolis Power

[1] 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.

[2] Prime movers are the engines or turbines in a power plant. Each power plant may be composed of multiple prime movers. Fuel use is reported to the EIA at the prime mover level.

and Light from the Velocity data suite, which relies primarily on data collected from EIA forms 861, 412, 906, 920, 923, and FERC form 1.[3] In addition, variables were collected to control for plant characteristics. These variables include plant capacity, electricity generation, year of construction, and the percentage of electricity generated from coal.[4]

3.2.2 Firm Level Data

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.[5] Firm growth rate was calculated as the growth in revenue between 1994 and 2003.

3.2.3 State Level Data

Several state-level variables were collected in order to control for regulatory differences across states. The average penalty assessed to Clean Air Act violators was derived from the EPA ECHO state data in order to proxy for state regulatory pressure (Kim and Lyon 2011a). Membership in environmental interest groups, represents citizen pressure to enact greenhouse gas regulation (Ringquist 1993), and annual Sierra Club membership data were obtained directly from the Sierra Club office.

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, as well as the Environmental Protection Agency website (DSIRE 2009). The changing regulatory environment in each state may have a relationship with the electricity generation decisions made by individual power plants. Previous research has demonstrated the number of energy programs active in a state to be the product of political ideology, geographic resources, economic resources, and carbon-intensive industry present in a state (Matisoff 2008). Similarly to Hall and Kerr (1991) and Gray and Shadbegian (2003), who employ a count of laws regulating toxic waste in the states in order to construct a TOXIC index, measuring the regulatory stringency of each state, I count the total number of renewable energy and energy efficiency programs active in a particular state, for each year, as an indicator of regulatory activity in each state (Gray and Shadbegian 2003; Hall et al. 1991). This was compiled through the DSIRE website, as well as via e-mails and phone calls to individual state energy offices. While this measurement is an imperfect measurement of the regulatory stringency of each state, it is a good time-variant indicator available of the changing energy regulatory environment at the state level.[6] The EPA website and state energy offices were used to determine whether or not states had active restructuring in each year. State level energy demand per capita was collected from the EIA.

[3] Because fuel use data, data containing plant characteristics, and firm level and state level data were contained in separate datasets, data were merged into one large dataset using plant ID. numbers, and operator ID numbers.

[4] Missing plant construction year data and capacity data were periodically encountered. In these cases data were carried down from previous years.

[5] Following Berry and Fording (1997), I imputed missing data for firms missing a year to several years of revenue data using Stata's linear trending missing data function (Berry and Fording 1997). These observations were less than 2 % of the total observations.

[6] For more information about the types of energy policies included in this measure, see the DSIRE database and Matisoff (2008). For more information about the reliability of this measurement, see Matisoff (2008).

3.2.4 Obstacles and Challenges

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 MW 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 2002, and which had ceased to report data based on whether the plant had reported fuel use, which was still required after 2002. If plants had no reported fuel use, plants were assumed to have closed, and fuel use (and thereby emissions) were inputted as 0s. If firms had reported fuel use, then emissions could still be calculated and plant characteristics were carried down from pre-2003 years. 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 held by universities were also eliminated from the dataset to achieve greater unit homogeneity.[7] For the CDP, plants owned by non-publicly traded firms were eliminated from the dataset, since the CDP only targets publicly traded firms. For the CCX, one sample was created that includes plants owned by all firms, including cooperatives and municipal utilities, and another sample which drops plants owned by non-publicly traded firms serves as a better comparison to the CDP sample.

4 Methodology

This study employs propensity score matching, to control for static observable differences between the treatment group and control group, and a difference-in-differences model to control for unobservable static differences between the treatment group and the control group. I check for robustness by estimating effects with a fixed effects model as well. These results are included in the appendix. Below, I review the methodology in further detail.

Non-experimental methods of assessing program effectiveness are susceptible to a variety of biases (LaLonde 1986). These include selection biases based on the propensity to join a program, the distributions of propensity to join a program, and "pure" self-selection, when individuals' self selection behavior is based on information that researchers cannot observe, or is caused by inter-temporal dependence of an outcome variable (Heckman et al. 1997, 1999; Jung and Pirog 2011). Selection bias based on the observable propensity to join a program can be controlled for using propensity score matching (Dehejia and Wahba 2002; Heckman et al. 1997; Jung and Pirog 2011).

Following Heckman et al. (1997), and similarly to Pizer et al. (2011), this study employs propensity score matching and a difference in differences approach, which has been demonstrated effective at eliminating bias, especially when it is due to temporally invariant omitted variables—that is, static differences between the treatment group and control group (Heckman et al. 1997). It is an extremely effective way of measuring average program effects under much weaker assumptions than matching alone (Heckman et al. 1997). The effects of the treatment on the treated can be identified under the relatively weak mean independence assumption, formulated in terms of $P(X)$, where X represents the observable conditions that lead to program participation and D represents whether or not plants participate in a specific program.

7 Eliminating nuclear plants is essential to get good matches in the matching process. The elimination of non-publicly traded firms from the CCX sample makes certain specifications for total CO_2 emissions statistically insignificant, but makes results between the CDP and the CCX more comparable.

$$E(Y_o \,|P(X)\,,D=1)=E(Y_o\,|P(X)\,,D=0) \tag{1}$$

In order to fulfill this assumption and identify the causal effects in the difference-in-differences approach, at least one of the matching variables (X) must be uncorrelated with the outcome variable Y (in this case, the annual change in plant-level carbon dioxide emissions, carbon dioxide intensity, and electricity output) (Caliendo and Kopeinig 2008). For more information on this identification strategy, or alternative identification strategies, see Heckman et al. (1997), or Heckman and Robb (1986). A more thorough discussion of the consequences of this approach follows below.

4.1 Matching

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 (Morgan and Winship 2007), and can serve as a form of nonparametric preprocessing that can improve the reliability of parametric estimates (Ho et al. 2007). I matched samples using 1–1 nearest neighbor approach, with replacement, which has been demonstrated to reduce selection bias (Heckman et al. 1996).[8]

Plants are matched based on the probability that plants are participants in each voluntary program, given plant, firm, and state characteristics. The nearest neighbor method matches plants, with replacement, to the non-participating plant that has the closest probability of joining the voluntary program.

$$Pr\left[joining=1\left|\sum x\right.\right]=\frac{e^{a+b_1x_1+b_2x_2+b_nx_n}}{1+e^{a+b_1x_1+b_2x_2+b_nx_n}} \tag{2}$$

Plants from each program were matched with a sample of non-participating plants, based on participation status in 2007, which represents the widest net for program participation.[9] A one to one nearest neighbor match, with replacement, was conducted using the Stata user generated program psmatch2, using a probit regression (Leuven and Sianesi 2012). For each program, plants were matched by psmatch2 using the likelihood of participation in each voluntary program, based on the year of plant construction, the capacity of the plant (in megawatts), the percentage of electricity at the plant generated from coal in 2003, the average amount of penalties assessed to polluting firms in each state for Clean Air Act violations between 2004 and 2007, the average growth rate in the holding company from 1994 to 2003, the per-capita membership in environmental organizations in 1990, the parent company size (measured as the natural log of millions of dollars in revenue), the number of active state energy programs in 2003, and whether or not utility restructuring was active in a state in 2003 (1 = yes).

To fully identify the causal effects in the difference-in-differences approach below, it is important to have at least one predictor in the propensity score matching equation that is correlated with the decision to participate, but is uncorrelated with plant level carbon dioxide

[8] Alternative matching specifications, including a Gaussian Kernel approach did not result in different results. 1–1 matching without replacement was unable to generate sufficiently good matches for the CDP project, and for CCX, resulted in slightly more efficient estimates, but not substantive or statistically significantly different estimates.

[9] Once firms chose to join the CDP, they rarely, if ever, left. Matching based on 2007 data ought to reduce selection bias, as it accounts for firm future expectations regarding the regulatory environment, firm growth, and expected plant openings and closings when deciding to join the CDP during program years 2004–2006.

emissions or plant output. Several variables in the matching model ought to be uncorrelated with plant-level carbon dioxide emissions or output. First, state-level green group membership from 1990 is temporally antecedent to plant output and is unlikely directly correlated with annual changes in plant-level emissions between 1994 and 2007. Second, the regulatory threat provided by the Clean Air Act may be correlated to the decision to join an environmental program, but should not be correlated to carbon dioxide emissions, because the Clean Air Act does not regulate carbon dioxide emissions. Third, the long-term *parent* company growth rate and holding company size ought to be uncorrelated with *plant* level annual change of carbon dioxide emissions. Because each holding company owns multiple plants—and in many cases operates in multiple industries—there is little reason to believe that the size of the corporate parent is directly correlated with plant-year observations of changes in carbon dioxide emissions. However, the size of the corporate parent, the growth rate of the firm, the membership in green groups, and the average penalties assessed to firms violating the Clean Air Act are strong predictors of whether or not a firm joins a voluntary environmental program, making them good instrumental variables for this purpose.

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). Logged revenues for the holding company in 2003 measure firm size. 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. This method does not control for unobserved heterogeneity within each plant, nor does it control for changes in conditions over time. These issues are addressed in the difference-in-differences approach discussed next.

4.2 Difference in Differences Approach

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, megawatt hours of electricity production, and carbon intensity) 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.

$$\Delta_s y_{it} = \alpha + \sum \beta_{it} X_{it} + \sum \theta_{it} \Delta_s \lambda_{it} + \varepsilon_{it} \quad (3)$$

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 *representing each power plant.*

The difference in differences approach controls for static heterogeneity between the treatment group and the control group, assuming that participants and controls have the same distributions of unobserved attributes; that they have the same distributions of the observed attributes; and that they are in a common economic environment (Heckman et al. 1997). The time-variant control variables control for observable conditions that change over time including changes in the state regulatory environment (measured as the number of energy programs in a state each year, and whether or not a state has active electricity restructuring) and firm growth rate. Thus, the difference in differences approach does not control for any time-variant unobserved heterogeneity, such as a change in firm philosophy over time, or a change in firm management over time, and assumes constant program effects over time (or alternatively calculates an average program effect over time). Because the panel consists of 14 years of data, for time-variant unobserved heterogeneity to impact the measurement of program effects, it must occur simultaneously with the program participation. That is, the difference-in-differences approach only fails to control for unobserved heterogeneity when it is time-variant and occurs simultaneously to the decision to participate in the voluntary program.

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), electricity output (in megawatt hours), and carbon intensity (in metric tons/megawatt hours). A fixed effects specification for each model is included in the "Appendix".

5 Results

5.1 Matching

In this section, I present the results from the propensity score matching methodology discussed above.

As demonstrated by Table 1, I predict 13 (CCX—All), 9 (CCX—Public) and 5 (CDP) 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, due to different levels of measurement of the independent variables, and correlation across observations it is not possible to directly interpret parameter estimates as hypothesis tests on the independent variables.[10] For the CCX, 171 total plants, and 123 publicly traded plants in the sample participated in the program. For the CDP, 516 plants participated in the CDP, leading to a much larger matched sample size.

Recent literature suggests that because poorly matched samples may create bias in estimated program effects, the matched samples should be examined to ensure that the matching process sufficiently controls for observable differences between the treatment and control group (Smith and Todd 2005a,b; Smith and Zhang 2009). Following the recommendations of Ho et al. (2007), I provide the pre and post-matched samples as well as the propensity scores of those samples (see Table 2).

The matching exercise had dramatic effects on the sample characteristics (see Table 2). For the CCX, participants were from slightly larger holding companies, with slightly older plants, more likely to be owned by publicly traded firms, and in states much more likely to have active electricity restructuring. They were also much more likely to use coal (suggesting a greater potential for emissions reductions), and were in states with more stringent environmental enforcement. Surprisingly, there was little difference in the presence of environmental organizations, but this measure is likely correlated with environmental programs and the stringency of environmental enforcement. As demonstrated in Table 2, the matched sample has much more similar observable characteristics and provided a much closer propensity score match. Prior to matching, non-participants were 8–11 % less likely to have participated in the CCX. After matching there is no difference between the samples' likelihood of participation.

[10] 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.

Table 1 Generating a matched sample for the Chicago Climate Exchange: Predicting Participation in the Chicago Climate Exchange and the Carbon Disclosure Project in 2007

	CCX—All plants	CCX—Publicly traded	CDP
Publicly traded (1 = yes)	1.266***		
	(0.235)		
Firm level revenue (ln$000,000)	−0.154***	−0.204***	0.243***
	(0.0558)	(0.0652)	(0.0613)
Plant capacity (MW)	0.000175**	0.000183**	6.99e−05
	(8.37e−05)	(8.67e−05)	(9.43e−05)
Year of construction	−0.00465*	−0.00990***	−0.00321
	(0.00260)	(0.00299)	(0.00304)
Firm growth rate	0.194***	0.199***	−0.106
	(0.0601)	(0.0632)	(0.0669)
Active state restructuring (1 = yes)	0.344***	0.410***	0.0243
	(0.124)	(0.137)	(0.148)
Avg regulatory penalties	0.00274	0.0174	−0.0590***
	(0.0186)	(0.0198)	(0.0215)
Coal % of electricity generation	0.0477	0.0364	0.0861
	(0.120)	(0.131)	(0.138)
Green group membership (1990)	0.0566***	0.0621***	0.0791***
	(0.0197)	(0.0221)	(0.0239)
Total state energy programs	−0.00737	−0.0127	0.0150
	(0.0103)	(0.0114)	(0.0128)
Constant	7.620	19.53***	4.555
	(5.155)	(5.959)	(6.049)
Observations	904	638	638
Pseudo R^2	0.125	0.0876	0.0547
LR Chi^2	109.9***	62.79***	34.04***

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

For the CDP, prior to matching, participants were slightly larger, grew faster, had a greater presence of environmental organizations, less stringent environmental enforcement, more energy programs, and have a greater percentage of coal generation. Prior to matching non-participants were 5 % less likely to have participated in the CDP. After matching, both the treatment and control were equally likely to have participated in the CDP. Table 2 provides pre- and post-matching sample characteristics.

5.2 Carbon Emissions

Table 3 demonstrates the impact of program participation in either the Chicago Climate Exchange or the Carbon Disclosure Project on changes in plant level carbon emissions, compared to what would have occurred had program participation not occurred. In the first

Table 2 Means and Standard Deviations of Matched Samples

	All Plants	Publicly Traded	CCX—All—Pre		CCX—All—Post		CCX- Public—Pre		CCX—Public—Post		CDP—Pre		CDP—Post	
	Full Sample	Full Sample	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
Number of plants	935	660	762	173	171	171	495	161	159	159	123	533	516	516
Publicly traded	0.70	1	0.65	0.93	0.92	0.93	1	1	1	1	1	1	1	1
	(0.46)	(0.00)	(0.48)	(0.25)	(0.27)	(0.26)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Firm level revenue (ln$000,000)	7.80	8.77	7.66	8.43	8.49	8.43	8.81	8.65	8.55	8.64	8.44	8.85	8.69	8.85
	(1.85)	(0.98)	(1.95)	(1.09)	(1.25)	(1.10)	(1.03)	(0.78)	(0.99)	(0.78)	(1.37)	(0.85)	(1.29)	(0.85)
Plant capacity (MW)	624	740	593	760	654	766	726	781	743	788	685	755	755	773
	(651)	(703)	(629)	(723)	(612)	(725)	(692)	(737)	(730)	(739)	(666)	(713)	(606)	(716)
Year of construction	1967	1965	1968	1962	1967	1962	1966	1960	1961	1960	1968	1964	1963	1964
	(21.2)	(20.4)	(21.2)	(20.4)	(21.9)	(20.5)	(20.5)	(19.4)	(22.4)	(19.5)	(19.2)	(20.6)	(18.9)	(20.6)
Avg growth rate	0.80	0.93	0.73	1.11	1.32	1.11	0.87	1.15	1.31	1.15	0.88	0.95	0.54	0.48
	(0.85)	(0.96)	(0.63)	(1.43)	(1.76)	(1.43)	(0.72)	(1.47)	(1.60)	(1.48)	(0.84)	(0.99)	(0.50)	(0.50)
Green group membership	7.79	7.85	7.57	8.74	8.40	8.77	7.51	8.88	7.84	8.92	7.32	7.95	7.17	7.98
	(3.01)	(2.96)	(3.00)	(2.88)	(2.92)	(2.88)	(2.89)	(2.93)	(2.64)	(2.93)	(3.00)	(2.94)	(2.71)	(2.92)
Average penalties $000	3.56	3.65	3.42	4.17	4.16	4.17	3.42	4.39	3.70	4.40	4.04	3.55	3.68	3.55
	(3.37)	(3.56)	(3.38)	(3.22)	(3.94)	(3.24)	(3.64)	(3.23)	(3.81)	(3.24)	(4.31)	(3.36)	(2.55)	(3.38)
Active state restructuring (1=yes)	0.44	0.47	0.41	0.58	0.67	0.58	0.43	0.61	0.54	0.61	0.45	0.47	0.87	0.95
	(0.50)	(0.50)	(0.49)	(0.49)	(0.47)	(0.49)	(0.50)	(0.49)	(0.50)	(0.49)	(0.50)	(0.50)	(0.95)	(1.00)
Number of state Energy Program	9.19	9.14	8.98	10.12	10.95	10.13	8.78	10.28	9.96	10.30	8.94	9.19	10.44	9.17
	(6.71)	(6.51)	(6.84)	(6.02)	(7.39)	(6.04)	(6.61)	(6.07)	(7.15)	(6.10)	(6.16)	(6.62)	(6.07)	(6.54)
% of Coal	0.43	0.46	0.42	0.49	0.46	0.49	0.45	0.50	0.50	0.50	0.40	0.48	0.53	0.48
	(0.48)	(0.49)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)	(0.48)	(0.49)	(0.49)	(0.49)	(0.50)	(0.49)
Propensity scores	0.19	0.25	0.17	0.28	0.29	0.28	0.23	0.31	0.31	0.31	0.77	0.82	0.82	0.82
	(0.13)	(0.13)	(0.11)	(0.15)	(0.16)	(0.15)	(0.11)	(0.16)	(0.15)	(0.16)	(0.10)	(0.06)	(0.06)	(0.06)

Table 3 Chicago Climate Exchange versus the Carbon Disclosure Project: difference-in-differences model, matched sample, effect of participation on ΔCO_2 emissions (metric tons), OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—All	CCX—All	CCX—Pub	CCX—Pub	CDP	CDP
Program participation	−33,605**	−32,562**	−26,347	−25,308	−310.4	−44.57
	(16,259)	(16,358)	(19,941)	(20,143)	(15,035)	(15,289)
Prog*Δcoal		667,480		666,800		−1.816e+06**
		(614,047)		(613,826)		(880,707)
Prog*Δng		−183,128		−186,398		−144,463**
		(151,652)		(151,413)		(62,044)
Publicly traded	11,488	12,209				
	(17,206)	(17,832)				
Active electricity restructuring	26,319	25,780	12,114	12,112	−4,300	−1,699
	(18,840)	(19,329)	(23,600)	(24,288)	(23,357)	(23,936)
Δrevenue (ln)	−22,068	−22,215	−22,654	−22,968	74,279**	76,824**
	(17,280)	(17,683)	(17,456)	(17,944)	(35,563)	(36,528)
Δ state energy programs	−22,019***	−22,023***	−19,005***	−18,952***	−25,023***	−25,333***
	(5,728)	(5,795)	(5,215)	(5,288)	(6,368)	(6,470)
Δ Sierra club membership	381.9	399.7	47.01	36.94	154.9	162.5
	(855.8)	(879.6)	(697.3)	(709.1)	(1,174)	(1,199)
Δ energy consumption per capita	4,488*	4,617*	1,910	2,016	4,888*	5,220*
	(2,634)	(2,697)	(2,239)	(2,325)	(2,734)	(2,837)
Constant	30,518*	30,282*	36,328***	36,458***	47,844***	47,524***
	(17,416)	(18,078)	(12,808)	(12,952)	(12,776)	(13,024)
Observations	4,027	3,939	3,874	3,804	12,467	12,204
R-squared	0.006	0.008	0.004	0.005	0.006	0.007

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

specification for each program, the program participation variable is not differenced, and represents a simple dichotomous measurement of continuous annual program effect. A second specification is included for each program includes interaction terms for the change in fuel mix percentage. These terms help discern the types of behavioral change occurring at the plant level. Results for a fixed effects approach are found in the appendix (see Table 6).

Participation in the Chicago Climate Exchange is associated with, on average, an annual 33,000 metric ton decrease in carbon emissions for the full sample and a 26,000 metric ton decrease in carbon emissions for plants owned by publicly traded firms, compared to the matched control group and the emissions trajectory prior to program participation.[11]

[11] Due to the trading nature of CCX program requirements, standard errors are likely to be inflated, because individual power plants do not have specific emissions reductions requirements. Some power plants ought

Because the average participating plant in the sample emits about 3.2 million tons of carbon dioxide per year and has participated in the CCX for 5 years, this is equivalent to approximately a 153,000 ton decrease of carbon dioxide emissions, or a 1 % decrease in carbon emissions, per year, over 5 years for the full sample, and a 130,000 ton decrease of carbon dioxide emissions, or 0.8 % decrease in carbon emissions, per year, over 5 years, for the publicly traded sample. These results are statistically significant at $\alpha = .05$ for the full sample, though are not statistically significant for the publicly traded sample. Interestingly, the parameter estimate is quite comparable to the requirements of the program (a 1 % decrease in emissions per year, from a 1998 to 2001 baseline). While the parameter estimates suggest that plants reduced emissions, the results are only statistically significant for the full sample, and are not statistically significant for the sample restricted to plants owned by publicly traded firms. Some inconsistency in the statistical significance of the parameter estimates is likely due a large amount of variation in the performance of individual plants, which ought to be expected in a trading system, where plants with low marginal costs of emissions reduction decrease emissions, and plants with high marginal costs of reduction increase emissions.

Results from the interaction terms suggest that plants that increased the natural gas in their fuel mix decreased overall emissions, while plants that increased coal increased emissions, though these results are not statistically significant.

Participation in the CDP, also has a negative parameter estimate, though this is also not statistically significant, and it is extremely close to 0. Parameter estimates suggest that participating firms reduce emissions by just 300 tons per year, for an average of 2.7 years. Results from the second specification suggest that both plants that increased usage of coal or natural gas and participated in the CDP decreased their emissions more.

5.3 Emissions Intensity

Both the CCX and the CDP lead to increases in carbon intensity (Table 4). Among all plants, CCX participation is statistically significant at $\alpha = .10$. Among publicly traded plants, both the CCX and CDP show statistically significant increases of CO_2 intensity at the $\alpha = .05$ level. Of participating plants, not surprisingly, plants that increase the percentage of coal in their fuel mix have large increases in carbon intensity. Results for a fixed effects approach are found in the appendix (see Table 6).

5.4 Electricity Generation

CCX participants had statistically significant decreases in electricity output in comparison to matched non-participants and the trajectory prior to program participation by an average of about 34,000 MWh per year during the 2003–2007 time period for both the publicly traded ($\alpha = .10$) and full samples ($\alpha = .05$). CDP participants, in contrast, appear to have a slight increase in electricity generation of 900 MWh per year, though this is not statistically significant. Participating plants in the CDP that increase the percentage of generation from coal also reduce total electricity generation (Table 5).

Footnote 11 continued
to increase electricity production and carbon emissions, while others ought to decrease carbon emissions. Nevertheless, the program parameter estimates ought to be unbiased.

Table 4 Chicago Climate Exchange versus the Carbon Disclosure Project: difference-in-differences model, matched sample, effect of participation on $\Delta(CO_2/MWh)$, OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—All	CCX—All	CCX—Pub	CCX—Pub	CDP	CDP
Program participation	0.0145*	0.0145*	0.0117**	0.0119**	0.0245**	0.0262***
	(0.00872)	(0.00859)	(0.00545)	(0.00521)	(0.0100)	(0.00978)
Prog*Δ coal		0.328***		0.339***		0.272
		(0.0865)		(0.0909)		(0.243)
Prog*Δ ng		−0.397***		−0.394***		−0.330
		(0.0762)		(0.0762)		(0.461)
Publicly traded	0.000561	0.000592				
	(0.0137)	(0.0137)				
Active electricity restructuring	0.0211	0.0202	0.00655	0.00551	0.0278***	0.0272**
	(0.0136)	(0.0136)	(0.00604)	(0.00603)	(0.0107)	(0.0107)
Δrevenue (ln)	−0.0175	−0.0169	−0.0237	−0.0232	0.0877	0.0877
	(0.0243)	(0.0243)	(0.0247)	(0.0247)	(0.0954)	(0.0955)
Δ state energy programs	−0.00530	−0.00516	−0.00661	−0.00645	0.000248	0.000280
	(0.00419)	(0.00419)	(0.00402)	(0.00402)	(0.00638)	(0.00638)
Δ Sierra club membership	−0.000713	−0.000735	−0.000506	−0.000528	−0.000995	−0.000991
	(0.000542)	(0.000542)	(0.000542)	(0.000542)	(0.000895)	(0.000895)
Δ energy consumption per capita	0.00220	0.00227	0.00201	0.00208	0.00184	0.00184
	(0.00322)	(0.00322)	(0.00323)	(0.00323)	(0.00176)	(0.00176)
Constant	−0.0117	−0.0117	0.00205	0.00211	−0.0230	−0.0229
	(0.00948)	(0.00946)	(0.00724)	(0.00725)	(0.0174)	(0.0174)
Observations	3,865	3,865	3,750	3,750	11,958	11,958
R-squared	0.001	0.002	0.002	0.003	0.001	0.001

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

6 Discussion

The matching process highlights some possible differences in the drivers of participation in an investor driven initiative such as the CDP versus a management driven initiative such as the CCX. CDP participants were more likely to be located in states with a greater presence of environmental interest groups, but not stronger enforcement of environmental regulations; CCX participants were more likely to be located in states with greater enforcement of environmental regulations, but not a greater presence of environmental organizations. These results suggests that participation in the CDP may be more influenced by stakeholder groups, consistent with findings from Reid and Toffel (2009). In contrast, CCX participation may be driven more by strategic considerations, such as the ability to reduce criteria emissions while also addressing carbon emissions.

Table 5 Chicago Climate Exchange versus the Carbon Disclosure Project: difference-in-differences model, matched sample, effect of participation on ΔMWh (electricity output), OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—All	CCX—All	CCX—Pub	CCX—Pub	CDP	CDP
Program participation	−34,037**	−34,557**	−34,825*	−35,970*	904.1	1,453
	(16,843)	(17,025)	(19,543)	(19,798)	(18,642)	(18,870)
Prog*Δcoal		−280,991		−285,461		−2.851e+06**
		(559,729)		(556,501)		(1.259e+06)
Prog*Δng		95,674		98,651		−24,494
		(119,502)		(119,375)		(106,895)
Publicly traded	−18,357	−18,996				
	(20,132)	(20,740)				
Active electricity restructuring	31,581	31,529	24,601	26,067	−41,812**	−39,518**
	(24,221)	(24,871)	(26,440)	(27,160)	(17,673)	(18,176)
Δrevenue (ln)	−29,332	−30,080	−30,762	−31,499	63,696*	65,788*
	(20,291)	(20,768)	(20,546)	(21,150)	(37,786)	(38,700)
Δ state energy programs	−17,725***	−17,839***	−18,665***	−18,875***	−14,434***	−14,541***
	(6,212)	(6,297)	(6,115)	(6,217)	(4,683)	(4,755)
Δ Sierra club membership	819.6	910.1	869.7	926.6	315.2	331.8
	(790.5)	(813.1)	(757.8)	(771.1)	(1,010)	(1,031)
Δ energy consumption per capita	7,192**	7,278**	5,292**	5,436**	5,991**	6,393***
	(2,793)	(2,854)	(2,640)	(2,735)	(2,325)	(2,416)
Constant	57,784***	58,208***	44,214***	43,952***	52,399***	51,757***
	(19,514)	(20,098)	(16,109)	(16,275)	(10,164)	(10,383)
Observations	4,027	3,939	3,875	3,805	12,470	12,207
R-squared	0.006	0.007	0.005	0.006	0.005	0.007

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

Overall, results for the CCX and CDP suggest that these programs may be slightly different than other voluntary programs aimed at addressing carbon emissions. While Pizer et al. (2011) find modest decreases in fuel costs due to 1605(b) and Climate Wise participation, Kim and Lyon (2011a) find no difference in carbon emissions intensity due to program participation. In contrast, the magnitude of emissions reductions is much larger in the CCX than in other programs evaluated. A 5 % decrease in emissions, compared with the prior trajectory and non-participants is quite large. Even when the sample is restricted to plants owned by publicly traded firms, carbon emissions were reduced by 4 %, compared with the trajectory prior to participation and non-participating plants. While the results for plants owned by non-publicly traded firms are not statistically significant, the parameter estimates are unbiased and consistent, and statistical insignificance is due to large standard errors. The CDP performs less well and demonstrates virtually no change in CO_2 emissions.

It is concerning that CO_2 intensity increased for both programs. Both CCX and CDP participation seems to be associated with slight increases in carbon intensity, undermining two of the presumably easier ways of reducing emissions—improving the efficiency of power plants or shifting to natural gas from coal. Instead, CCX participants reduced emissions from reducing electricity output, which may be due to demand management, but may have many other complex explanations that have little to do with behavioral shifts by program participants.

Comparing a simple average of plant-level emissions from 1999 to 2001 versus 2004–2007 suggests a more optimistic snapshot of the CCX. CCX plants (including non-publicly traded plants) decreased average emissions from 6.39 to 5.75 MMT, versus a reduction from 4.86 to 4.59 MMT tons for non-participating plants. Electricity production decreased from an average of 3.3 to 2.9 million MWh, for participating plants versus a decrease of 2.4–2.3 million MWh for non-participating plants. CO_2 intensity decreased slightly for participating plants (.91–.88 tons/MWh) while increasing slightly for non-participating plants (.91–.95 tons/MWh).

When considering just plants owned by publicly traded firms, participating plants decreased emissions from 6.35 million tons to 5.84 million tons, electricity output from 3.3 to 3 million MWh, and intensity from .92 to .89 tons/MWh. Non-participants decreased emissions from 5.91 to 5.62 million tons, electricity generation from 3.0 to 2.8 million MWh, and intensity from .90 to .89 million tons/MWh.

These simple averages, compared with the more complex econometric analysis, demonstrates the role of the matching and differencing. Once matching and differencing occurred, the CCX appears much less effective, suggesting that CCX participants have unique opportunities to decrease emissions that non-participants may not have had. Among plants owned by publicly traded firms carbon intensity from 2004 to 2007 is virtually identical, suggesting that firms participating in the CCX may have caught up to practices already in place by non-participating firms.

By any metric, CDP does not reduce either carbon emissions or electricity generation, and evidence suggests that participants increased carbon intensity, compared to non-participants and firm trajectory prior to program participation. These results suggest that the CDP ought to be examined with greater scrutiny, and that existing evidence suggests that this initiative is little more than greenwash.

From a practical perspective, there are issues related to the integrity of the CCX. Firms chose to participate in 2003 or thereafter. However, emissions reductions requirements are based on 1999–2001 average emissions, essentially allowing firms that already reduced emissions to retroactively join the program, with total emissions reductions requirements of 6 % by 2010 from baseline levels. While the econometric methods employed in this paper control for these issues, these issues deserve further consideration.

Interestingly, the CCX was recently purchased and closed down, which suggests that there might be larger difficulties in generating profitability from private environmental improvements. At the end of the program, carbon permits were valued at around $3 per ton (possibly reflecting transaction costs involved with trading), suggesting that caps were not stringent enough, that emissions reductions or offsets were achievable too cheaply, or that firms did not feel they were gaining additional value from participation. Firms that joined to gain experience in carbon trading may have felt they had achieved their goals. Firms joining to gain early credit for carbon emissions reductions may have seen major changes in the political environment in 2010 that made participation less valuable. In addition, the recession of 2007 and decreases in economic output and carbon emissions made emissions reduction goals easily achievable, and contributed to the drop of the carbon price. All of these explanations are possible and are not mutually exclusive.

Caution is needed when interpreting these parameter estimates as program effectiveness. 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 temporally coincide with the decision to participate. Changes made by a firm prior to participation should not impact estimated program effect, and controls for growth rate prior to participation were included to help control for this problem. However, 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. In particular, CDP participation does not reflect any particular action by a firm, other than filling out a survey. It is possible that early-joiners to the CDP may be more pro-active than late joiners, or that the contents of the survey responses may allow for better understanding of the extent to which firms are proactively addressing carbon.

Because CCX emissions permits traded at a value between $0 and $4 (though briefly reached highs of $7–$8 per ton), 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 to reduce electricity demand and promote fuel switching when these changes were not particularly costly. Evidence from other studies suggests that low and no cost efficiency improvements may be widely available, and it is possible that participation in certain voluntary programs can help firms identify these opportunities. 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.[12]

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…"[13] Another manager indicated that changes in power plant operations allowed the firm to easily achieve the required emissions reductions.

CDP results seem to reinforce these findings. Because the CDP has no emissions reduction requirements and firms simply report their carbon management strategies, CDP participants do not decrease their emissions or emissions intensity associated with electricity production. Conversations I have had with program participants and CDP officials suggest that the decision to participate in the CDP reflects public and shareholder relations more than it reflects behavioral changes made by firm managers aimed at improving the management of carbon, though many firms maintained that participating reflects a broader commitment to improved environmental behavior.

7 Conclusion

These results highlight several tradeoffs for the design of voluntary environmental programs and their effectiveness. First, this research hypothesized that private voluntary environmen-

[12] Results, not reported here, showed increases in non-fuel expenditures for both the CCX and the CDP compared with control groups. These results were not statistically significant, likely due to capital depreciation practices leading to large swings in reported capital investments.

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

tal agreements may demonstrate more effectiveness than public voluntary programs, due to their ability to limit gains to participants. This hypothesis produced mixed results. The CCX appears to have achieved modest reductions in carbon dioxide amongst a small number of firms, while the Carbon Disclosure Project may have had little impact. Examining a comparison of means, pre and post program participation suggests that both participants and non-participants shifted behavior, though for the CCX, program participants seem to achieve more emissions reductions and output reductions non-participants. This finding continues to suggest that contagion is not fully eliminated by private voluntary programs.

Second, this research highlights the tradeoffs of privately run voluntary environmental programs. In particular, this research highlights the tradeoffs between high participation in a program and the types of emissions reductions that can be achieved voluntarily. The CCX, viewed from an institutionalist perspective, is highly coercive. It requires emissions reductions, and commits firms via contract law to those reductions. And it requires verification of emissions data. It does not ask firms how they achieve those reductions, and allows them to trade emissions permits in order to meet reduction requirements. While firms are audited, they disclose very little information to the public.

In contrast, the CDP may be coercive in the sense that investor pressure may force many firms to participate in the CDP, but it does not require behavioral change or specific emissions reductions. Rather, firms are rewarded by investors for transparency and their overall strategy related to carbon, even if this amounts to greenwashing. The CDP may simply reward firms that can appear pro-active in carbon management, rather than firms that take concrete action. Because CCX program commitments are more coercive in nature, it is to be expected that CCX participation will be narrower, yet produce deeper reductions per firm, while the CDP, with voluntary disclosure rules, might produce broader participation, but shallower (or no) reductions.

While it is not clear that the program participation drives these behavioral changes, voluntary environmental programs may provide a reward or recognition for firms that are already planning to improve (or recently instituted changes to improve) environmental behavior, and a way for firms to signal to the market that they take environmental management seriously. This reward to firms—especially when provided by the private sector, and not by the government, seems like an exceptionally low price to pay for improvements in environmental behavior.

Nevertheless, the extent to which there is a danger of greenwash—and allowing firms to represent themselves as more "green" than they actually are, there is similarly a danger of discouraging firms from participating in environmentally beneficial activities. These tradeoffs must be carefully balanced. The CCX, achieved gross reductions by participants, and achieved reductions by participants in comparison to non-participants. It seems that the CCX was not simply greenwash though the ease in which emissions reductions were achieved may have more to do with macro-economic conditions. In contrast, the CDP has produced no evidence of decreases in emissions and may even mask increases in carbon intensity. Participation in the CCX or CDP may simply demonstrate a firm's commitment towards improved management practices, or may serve as a justification for firm managers to pursue strategies that reduce carbon emissions and intensity. Alternatively, in the case of the CDP, participation may be simply a matter of filling out paperwork, attempting to greenwash, and not achieving any environmental benefits.

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. The difference-in-differences model only measures within plant changes of behavior, when there is likely to also be across-plant changes in behavior. 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.

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Appendix

See Tables 6, 7, 8.

Table 6 Chicago Climate Exchange versus the Carbon Disclosure Project: fixed-effects model, matched sample, effect of participation on CO_2 emissions (metric tons), OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—all plans	CCX—all plants	CCX—publicly traded	CCX—publicly traded	CDP	CDP
Program participation	−155,752***	−289,512***	−116,366***	−274,414***	36,762	−313,375***
	(33,734)	−89,736	(36,891)	−93,174	(24,774)	−68,847
Program participation* coal		362,261***		437,882***		651,320***
		−96,698		−100,362		−75,236
Program participation * NG		−172,701*		−228,124**		54,215
		−104,077		−108,742		−79,973
Total state energy programs	−831.8	672.4	−72.91	2,328	13,804***	15,220***
	(2,859)	−2,894	(3,174)	−3,204	(2,087)	−2,112
Publicly traded	694,912***	693,095***				
	(165,155)	−165,234				
State electricity restructuring	177,424***	148,096***	136,401***	99,360***	−155,015***	−163,794***
	(32,657)	−33,523	(35,354)	−35,959	(20,189)	−20,464
Sierra club membership per 10,000 capita	623.0	530	−416.8	−524	1,531***	1,558***
	(864.3)	−875.5	(909.5)	−912.5	(496.9)	−502.2
Energy consumption per capita	339.2	796.8	−1,252	−565.2	7,516***	8,368***
	(4,551)	−4,592	(4,753)	−4,795	(2,433)	−2,476
Firm revenue	31,687*	35,802**	32,272*	36,667**	166,775***	165,149***
	(16,350)	−16,514	(16,608)	−16,712	(11,567)	−11,693
Constant	1.723e+06***	1.738e+06***	2.573e+06***	2.573e+06***	1.485e+06***	1.544e+06***
	(199,289)	−200,295	(132,265)	−133,026	(93,852)	−94,874

Table 6 continued

	CCX—all plans	CCX—all plants	CCX—publicly traded	CCX—publicly traded	CDP	CDP
Observations	4,369	4,294	4,191	4,132	13,487	13,246
R-squared	0.020	0.035	0.009	0.031	0.036	0.049

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

Table 7 Chicago Climate Exchange versus the Carbon Disclosure Project: fixed-effects model, matched sample, effect of participation on CO_2/MWh (intensity), OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—all plants	CCX—all plants	CCX—publicly traded	CCX—publicly traded	CDP	CDP
Program participation	0.0446*	0.0914	0.00643	0.019	0.0732**	0.275***
	−0.0266	−0.0703	−0.0221	−0.0556	−0.0302	−0.0849
Program participation* coal		−0.0327		0.011		−0.216**
		−0.0757		−0.0598		−0.0922
Program participation * NG		−0.084		−0.0543		−0.245**
		−0.0817		−0.0651		−0.0985
Total state energy programs	−0.00770***	−0.00770***	−0.000811	−0.000646	−0.00538**	−0.00579**
	−0.00225	−0.00226	−0.0019	−0.00191	−0.00253	−0.00253
Publicly traded	−0.0589	−0.0586				
	−0.128	−0.128				
State electricity restructuring	0.027	0.0233	0.0297	0.0252	0.0558**	0.0551**
	−0.026	−0.0262	−0.0211	−0.0214	−0.0246	−0.0246
Sierra club membership per 10,000 capita	−0.000329	−0.000317	−0.000807	−0.000811	−0.000299	−0.000278
	−0.000682	−0.000683	−0.00054	−0.00054	−0.000603	−0.000603
Energy consumption per capita	0.00225	0.00231	0.00221	0.00226	−0.000757	−0.000676
	−0.00359	−0.0036	−0.00286	−0.00286	−0.00298	−0.00298
Firm revenue	−0.006	−0.00563	−0.0104	−0.00997	−0.0547***	−0.0546***
	−0.0129	−0.0129	−0.00988	−0.00989	−0.0142	−0.0142
Constant	1.061***	1.058***	1.013***	1.009***	1.412***	1.414***
	−0.156	−0.156	−0.0787	−0.0788	−0.115	−0.115
Observations	4,233	4,233	4,090	4,090	13,055	13,055
R-squared	0.004	0.004	0.002	0.002	0.003	0.003

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

Table 8 Chicago Climate Exchange versus the Carbon Disclosure Project: fixed-effects model, matched sample, effect of participation on MWh (electricity output), OLS parameter estimates shown, clustered standard errors in parentheses

	CCX—all plants	CCX—all plants	CCX—publicly traded	CCX—publicly traded	CDP	CDP
Program participation	−202,060***	−402,981***	−229,659***	−423,833***	107,241***	−330,014***
	−37,285	−98,189	−43,695	−109,845	−26,167	−72,597
Program participation* coal		557,310***		570,485***		748,866***
		−105,806		−118,321		−79,334
Program participation * NG		−275,175**		−336,324***		156,177*
		−113,880		−128,200		−84,330
Total state energy programs	4,921	7,451**	6,700*	9,942***	11,863***	13,488***
	−3,160	−3,167	−3,760	−3,777	−2,204	−2,226
Publicly traded	840,186***	837,614***				
	−182,539	−180,799				
State electricity restructuring	157,876***	104,357***	150,782***	99,038**	-247,752***	-260,268***
	−36,095	−36,681	−41,872	−42,390	−21,325	−21,577
Sierra club membership per 10,000 capita	1,258	1,055	424.4	287.1	121.2	105
	−955.2	−957.9	−1,077	−1,076	−524.9	−529.6
Energy consumption per capita	−710.9	119.9	−4,484	−3,510	8,610***	9,465***
	−5,030	−5,024	−5,630	−5,653	−2,570	−2,611
Firm revenue	−4,591	2,121	3,892	9,192	133,912***	130,822***
	−18,071	−18,070	−19,668	−19,700	−12,216	−12,328
Constant	2.145e+06***	2.148e+06***	3.088e+06***	3.085e+06***	2.096e+06***	2.172e+06***
	−220,266	−219,162	−156,629	−156,798	−99,111	−100,019
Observations	4,369	4,294	4,192	4,133	13,490	13,249
R-squared	0.019	0.049	0.011	0.04	0.027	0.04

* Significance at the $\alpha = .10$ level
** Significance at the $\alpha = .05$ level
*** Significance at the $\alpha = .01$ level

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