Strategic environmental disclosure: Evidence from the DOE’s voluntary greenhouse gas registry

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ARTICLE INFO

Article history:
Received 27 May 2008
Available online 30 November 2010

Keywords:
Information disclosure
Public voluntary programs
Early reduction credits
Greenhouse gas
Electric utilities
Greenwash
The 1605(b) program

ABSTRACT

Although mandatory disclosure programs have been studied extensively, strategic voluntary environmental disclosures by firms are not well understood. We study the motivations for and impacts of firms’ strategic disclosure of greenhouse gas reductions to the US government. We first model firms’ joint abatement and disclosure decisions, incorporating both economic and political incentives. We then use data from the Department of Energy’s Voluntary Greenhouse Gas Registry to compare reported reductions to actual emissions. We find that participants in the program engage in highly selective reporting: in the aggregate, they increase emissions over time but report reductions. In contrast, non-participants decrease emissions over time. Participants tend to be large firms facing strong regulatory pressure; pressure from environmental groups reduces the likelihood of participation, suggesting such groups viewed the program as a form of greenwash. Participating in the 1605(b) program had no significant effect on a firm’s changes in carbon intensity over time.

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1. Introduction

Environmental information disclosure programs have been hailed as the “Third Wave” of environmental regulation, following initial reliance on “command and control” policies such as Best Available Control Technology standards and a subsequent shift toward market-based policies such as tradable emissions permits [24]. A growing empirical literature suggests that mandatory disclosure programs do indeed lead to improved environmental performance, although the mechanisms by which this occurs remain somewhat unclear [2,4,5].

The effects of voluntary, as opposed to mandatory, environmental disclosures are more controversial. Non-governmental organizations (NGOs) often decry corporate environmental claims as mere greenwash, intended to unfairly bolster a dirty company’s public image.1 Furthermore, there is no academic consensus on whether voluntary environmental disclosures and environmental performance are even positively correlated. Economic models of disclosure imply a positive relationship,
since firms with better performance will have more positive outcomes to disclose [16,22,23,27], and there exists some empirical literature to support this view [1,3]. In contrast, some management scholars argue that firms increase their disclosures after an accident or other negative event in order to bolster their tarnished reputations [18], and there exists empirical support for this view as well [19]. In light of these mixed findings, it is not surprising that many environmental advocates are distrustful of voluntary environmental disclosures and wary of greenwash.2

Most previous work measures voluntary environmental disclosures using content analysis of statements in corporate annual reports, corporate social responsibility reports and 10Ks.3 In this paper, we take an alternative approach, making use of a unique dataset created by section 1605(b) of the Energy Policy Act of 1992, which directed the Department of Energy to create a registry in which companies could report their voluntary reductions of greenhouse gas (GHG) emissions, in terms of tons of CO2. For most industries, it is difficult to compare these disclosures against actual environmental performance, since the US currently has no federal regulation of GHG emissions. However, electric utilities must report detailed fuel use data to the Federal Energy Regulatory Commission (FERC), so we can compare their actual emissions performance against the disclosures they make through the DOE’s Voluntary Greenhouse Gas Registry.4 Thus, we are able to directly examine the link between reports and environmental performance, without having to interpret corporate statements through content analysis.

In order to sharpen our focus on the factors motivating firms to make voluntary environmental disclosures, we create a formal model of firms’ incentives for emissions reductions. We model the economic benefit from disclosure as an increased chance of obtaining “early reduction credits” (ERCs) that would have value if the US were to impose an emissions cap in the future.5 We incorporate both economic and political incentives, and in addition, we analyze firms’ incentives for disclosure of their emissions reduction efforts.

Our empirical analysis finds that participants in the program generally engaged in highly selective reporting of successful emissions reduction projects, without disclosing their overall carbon footprint. Indeed, in the aggregate, participants increased emissions over time but reported reductions, while non-participants actually decreased emissions over time. In terms of who participates, our empirical results indicate that large firms, who may have had lower costs of participation, were more likely to join the program. Political pressures also played a significant role: participation was more likely in states that devote greater resources to enforcement, and in states that had not yet passed a Renewable Portfolio Standard (RPS). In addition, the fear of a backlash from NGOs appears to have been real: firms were less likely to participate in states with more environmental group members per capita. Finally, we use propensity-score matching to test whether participation had a measurable effect on changes over time in a firm’s CO2 emissions intensity (CO2 emissions per unit of generation), and find it to be statistically insignificant.

2 Lyon and Maxwell (2011) present a theoretical model that combines a persuasion game with an NGO watchdog that punishes greenwash, thus combining the economic and management approaches.

3 Most of this work appears in the accounting literature [3,8,19].

4 Converting fuel use to carbon emissions is straightforward, as shown in Table 1.

5 The value of such permits could be large indeed. According to the Carbon Trust, electric utilities in the UK made profits of over $1 billion in 2005 from carbon permits they were allocated under the E.U. Emission Trading Scheme.

6 Most of this work appears in the accounting literature [3,8,19].

7 Direct reductions refer to reductions from sources owned by the reporter. Indirect reductions refer to reductions from sources not owned by the reporter but somehow affected by reporter actions. An example of indirect reductions is a decrease in power plant emissions due to a decrease in end-use electricity consumption, which in turn is at least partly attributable to electric utilities’ demand side management programs. Sequestration refers to the removal and storage of carbon from the atmosphere in carbon sinks such as trees, plants, or underground reservoirs. See [26] for details.

8 To illustrate the kinds of projects actually reported to the program, we provide three short case studies, which are contained in an appendix at JEEM’s online archive of supplementary material; this archive may be accessed at http://aere.org/journals/.

2 Lyon and Maxwell (2011) present a theoretical model that combines a persuasion game with an NGO watchdog that punishes greenwash, thus combining the economic and management approaches.
Why should firms participate? The DOE’s Voluntary Registry website suggests that benefits of participation are primarily in the form of publicity and improved relationships with regulators, though it also hints obliquely at ERCs in its reference to establishing a baseline for measurement. In fact, it is our reading that ERCs provided the most potent incentive for participation in 1605b. Support for this view comes from comments filed by interested parties during the process that led up to the program revisions that went into place in 2006. For example, the Edison Electric Institute (EEI), the trade association of investor-owned electric utilities, argued firms have many motives for participating, including recording transferable credits, obtaining credit for past actions, and improving public relations. However, the bulk of the EEI comments focused on transferable credits, and argued vigorously for project-level reporting. In opposition to EEI, the Natural Resources Defense Council (NRDC), an environmental NGO, condemned project-level reporting, arguing that it allows companies to game the system by “cherry picking” the projects they want to report. NRDC argued that entity-wide reporting obviated the need for project-level reporting.

Our formal model incorporates both of these possibilities, and suggests that neither EEI nor NRDC fully captured the impacts of alternative disclosure strategies. The EEI ignores the fact that without entity-level information, the firm can withhold information on actions that increased emissions, such as marketing efforts to expand sales. The NRDC ignores the fact that firms in high-growth areas may have rising emissions through no fault of their own. Our model incorporates both of these possibilities.

3. An economic model of early emissions reduction and disclosure

The most conspicuous economic benefit from participating in the 1605(b) program was the possibility that participants would receive early reduction credits (ERCs), which might have significant value if the US eventually creates a tradable permits scheme for GHG emissions [11,17]. In particular, participants would benefit if the government adopted an allocation scheme for permits that would award them free permits for reductions in GHG emissions made prior to the beginning of the trading scheme. In fact, just such a proposal was introduced by Senators John Chafee (R-RI) and Joseph Lieberman (D-CT) in the 105th and 106th Congresses. Despite the failure of both bills to pass, these proposals made industry (and investors) keenly aware that ERCs could be awarded at some point in the future.

In this section, we present a simple model of a firm’s early reduction strategy and disclosure behavior when faced with the possibility of earning ERCs. Building on the model of Kennedy [11], we add a number of important extensions. First, with regard to federal regulation, we allow for uncertainty about both the passage of a carbon cap, and the awarding of ERCs conditional on the passage of a carbon cap. Second, we allow for uncertainty regarding the rules by which ERCs will be allocated, should they in fact be awarded. In particular, we model both the possibility that (a) ERCs will be awarded based on the individual emissions reduction projects that a firm can demonstrate that it has undertaken, and (b) ERCs will be awarded based on reductions in a firm’s total historical emissions over time. As we will see below, this uncertainty regarding the nature of the regulatory rule affects both a firm’s emissions reduction investments and its disclosure behavior. Third, we allow for the possibility of state-level regulations that require emissions reductions. Since the primary policy tool used by states in this regard has been the Renewable Portfolio Standard (RPS), we focus on this policy. We allow for the possibility that early reductions might reduce the probability of RPS legislation being passed [15,21]. Finally, we incorporate the possibility that environmental activists take action to oppose what they view as greenwash; specifically, we allow NGOs to investigate the individual emissions reduction projects that a firm can demonstrate that it has undertaken, and (b) ERCs will be awarded based on reductions in a firm’s total historical emissions over time. As we will see below, this uncertainty regarding the nature of the regulatory rule affects both a firm’s emissions reduction investments and its disclosure behavior. Third, we allow for the possibility of state-level regulations that require emissions reductions. Since the primary policy tool used by states in this regard has been the Renewable Portfolio Standard (RPS), we focus on this policy. We allow for the possibility that early reductions might reduce the probability of RPS legislation being passed [15,21]. Finally, we incorporate the possibility that environmental activists take action to oppose what they view as greenwash; specifically, we allow NGOs to investigate environmental claims they find to be incomplete or misleading, and to punish offending firms through attack campaigns [13].

3.1. The basic model

We consider a three-period model, \( t \in \{0,1,2\} \), in which the firm minimizes its expected costs of complying with emissions regulations. Define

\[
\begin{align*}
B_t & \quad \text{business-as-usual emissions in period } t \\
E_t & \quad \text{actual emissions in period } t \\
\delta & \quad \text{growth in business-as-usual emissions each period} \\
D_t & \quad \text{demand-side reductions in period } t \\
S_t & \quad \text{supply-side reductions in period } t \\
K_t(S_t) & \quad \text{cost of supply-side reductions in period } t \\
L_t(D_t) & \quad \text{cost of demand-side reductions in period } t
\end{align*}
\]

Business-as-usual emissions are governed by the process \( B_t = (1 + \delta)B_{t-1} \). The firm knows its own growth rate, but the regulator does not. The firm’s emissions are simply \( E_0 = B_0 \) in period 0, \( E_1 = B_1 - D_1 - S_1 \) in period 1 and \( E_2 = B_2 - D_2 - S_1 - S_2 \) in

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10 “The voluntary reporting program provides an opportunity for you to gain recognition for the good effects of your actions—recognition from your customers, your shareholders, public officials, and the Federal government. Reporting the results of your actions adds to the public groundswell of efforts to deal with the threat of climate change. Reporting can show that you are part of various initiatives under the President’s Climate Change Action Plan. Your reports can also record a baseline from which to measure your future actions. Finally, your reports, along with others, can contribute to the growing body of information on cost-effective actions for controlling greenhouse gases.” [http://www.eia.doe.gov/oiaf/1605/1605(b).html]
period 2. Note that we assume supply-side investments have a longer-term impact on emissions than demand-side reductions, reflecting the notion that the latter may have a behavioral component whose maintenance requires ongoing investment. We assume that both \( K(S_i) \) and \( L(D_i) \) are increasing and convex for positive \( S_i \) and \( D_i \).

We allow the firm to choose \( D_1 < 0 \). This represents marketing efforts to expand sales, in the form of economic development efforts targeted towards attracting new businesses to the firm's service territory, encouraging customers to purchase additional energy-using appliances, or offering declining block tariffs that encourage increases in energy consumption at the margin. We focus on incremental changes in the firm's marketing efforts that are induced by the pursuit of ERCS and that go beyond the level that would be profit-maximizing in their absence. Hence we assume \( L(D_i) \) is positive, decreasing, and convex for negative \( D_i \). Over the entire range of \( D_i \), \( I(D_i) \) is positive and convex, with a minimum at \( I(0)=0 \).

We assume that in period 1 there is no regulatory constraint on emissions, but in period 2 there might be. If emissions regulation is passed, it sets a maximum allowable level of emissions for the firm and imposes a fee on all emissions beyond that level; such a scheme could be the result of either a carbon tax or a cap-and-trade policy. We assume that the firm makes its investment choices in period 2 before it learns whether an emissions fee is imposed. Thus, ERCS may be earned both for reductions in periods 1 and 2.

During our sample period, 11 states imposed Renewable Portfolio Standards (RPSs), which require utilities to supply a minimum amount of renewable energy in their generation portfolios [14]. The passage of these new rules may have led firms to reduce their carbon emissions. Firms in other states may have anticipated that they might face similar policies in the future. To capture this political context, we assume there is a probability \( \rho \) that the state legislature imposes an RPS that mandates a minimum amount of renewable energy, \( S_{\text{Reg}} \), which must be provided by the firm in period 2. If the firm fails below this level then it must pay a penalty of \( \gamma \) for each unit that it falls short. We assume \( \gamma \) is a decreasing function of \( S_i \), which reflects the idea that firms may be able to preempt regulation by making proactive environmentally friendly investments. Finally, we recognize that NGOs are concerned about the information that firms disclose to customers, investors and regulators. In particular, we assume that NGOs oppose corporate "greenwash," which we interpret as selective disclosure of favorable information while withholding unfavorable information. In the context of our model, the NGO opposes GHG disclosures that "cherry-pick" good projects and fail to report activities such as economic development investments that stand to increase a firm's carbon footprint. In our model, the primary situation for which the firm has an incentive to withhold information is \( D_1 \), and the firm only withholds this information if it has chosen \( D_1 < 0 \). Thus, we operationalize the NGO's attack on greenwash as follows: if the firm fails to fully report, then it expects that the NGO will investigate it with some probability \( \eta \), and impose a punishment of magnitude \( A \) if the NGO concludes the firm made an investment \( D_1 < 0 \) which it has withheld in its 1605b report; thus the firm's expected punishment for selective disclosure is \( \eta A \).

To incorporate the foregoing considerations in the model, define

\[
\begin{align*}
\rho & \quad \text{probability of an emissions price in period 2} \\
P & \quad \text{emissions price in period 2 if one is imposed} \\
x & \quad \text{probability early reduction credits are granted if an emissions price is imposed} \\
\sigma(S_i) & \quad \text{Probability of state-level renewable energy legislation} \\
S_{\text{Reg}} & \quad \text{Supply-side emissions reduction required under state renewable energy legislation} \\
\lambda & \quad \text{Penalty imposed per unit by which the firm’s supply-side reductions fall short of the regulatory requirement} \\
\eta & \quad \text{Probability of NGO audit and penalty if the firm engages in selective disclosure} \\
A & \quad \text{Level of harm imposed on the firm if the NGO successfully audits and attacks the firm for greenwash} \\
R & \quad \text{Early reduction credits granted for reductions prior to imposition of a cap}
\end{align*}
\]

Note that \( R \) could be defined in a variety of ways, project-based \( (R^o = S_1 + D_1 + S_2 + D_2) \), or reductions against historical baseline (either using period 0 or period 1 as the baseline). Under the 1605b program, firms had a choice of which baseline to use. If \( R \) is project-based, then the firm will not report projects for which \( D_1 < 0 \), as the regulator would not grant ERCS for them. If ERCS are granted on a historical basis, the firm can choose which baseline year it prefers. (It will choose period 1 if \( E_1 > E_0 \), or \( D_0 > D_1 + S_1 \), that is, if the growth in emissions from period 0 to period 1 outweighs any reductions undertaken by the firm in period 1.) If \( D_1 < 0 \), this obviously makes the firm more inclined to choose a period 1 baseline. Thus, the use of a historical baseline can create a moral hazard problem for the firm, giving it incentives to artificially inflate its emissions in the base period. Clearly, selective disclosure by the firm can have socially detrimental effects, by enabling it to get away with increasing emissions in period 1. We will explore the firm’s choice of period 1 reductions in more detail below.

The firm faces uncertainty regarding the allocation method that will be used by the regulator. The probability \( x \) that ERCS are granted is the sum of \( \beta \), the probability ERCs are allocated based on projects if there is a permit market, and \( \gamma \), the probability ERCs are allocated based on historical reductions if there is a permit market.

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11 We focus on \( D_1, D_2 < 0 \) is possible, but we ignore it for simplicity. Adding \( D_2 < 0 \) will add some technical completeness but also add more complexity without much new insight.
12 Although we would expect the passage of RPS legislation to require greater investments in \( S_2 \), this result might not be observed immediately in the data, since states typically give firms a number of years lead time before requirements begin to bind.
13 See [13] for further discussion of the appropriate definition of greenwash, and a theoretical model of NGO attempts to discourage it.
The firm’s objective is to minimize expected costs, which depend upon disclosure strategy as well as investments in abatement. In our setting, full disclosure can be implemented either by a firm listing all of its projects (including those for which \( D_1 < 0 \)) or by disclosing both entity-level emissions \( E_1 \) and \( E_2 \) along with projects \( S_1 \) and \( S_2 \). Note that simply reporting at the entity level alone is not enough to constitute full disclosure, since without project-level reporting as well, the regulator cannot distinguish “bad luck” (in the form of growth in BAU emissions) from “bad management” (in the form of a failure to invest in emissions reductions). We do not consider project-level reporting to be equivalent to full disclosure, since as we show below the firm has incentives not to disclose fully at the project level and there is no way to verify that the firm listed all of its projects.

3.2. Incentives under full disclosure

If the firm opts for full disclosure then there is no risk of a greenwash penalty. If historical reductions are measured as \( E_0 - E_2 \), then ERCs are determined by \( E_0 - E_2 = B_0 - [(1 + \delta)^2 B_0 - D_2 - S_1 - S_2] = -\delta(2 + \delta)B_0 + D_2 + S_1 + S_2 \). Thus, when the firm discloses fully, its expected costs are

\[
C = K_1(S_1) + K_2(S_2) + L(D_1) + L(D_2) + \rho P \left\{ [(1 + \delta)^2 B_0 - D_2 - S_1 - S_2] - \beta(S_1 + D_1 + S_2 + D_2) - \gamma(-\delta(2 + \delta)B_0 + D_2 + S_1 + S_2) \right\}
\]

\[+ \lambda \sigma(S_1) \max\{S_{\text{Reg}} - S_2, 0\}.
\]

If historical reductions are measured as \( E_1 - E_2 \), then ERCs are determined by

\[
E_1 - E_2 = [(1 + \delta)B_0 - D_1 - S_1] - [(1 + \delta)^2 B_0 - D_2 - S_1 - S_2] = -\delta(1 + \delta)B_0 - D_1 + D_2 + S_2,
\]

so

\[
C = K_1(S_1) + K_2(S_2) + L(D_1) + L(D_2) + \rho P \left\{ [(1 + \delta)^2 B_0 - D_2 - S_1 - S_2] - \beta(S_1 + D_1 + S_2 + D_2) - \gamma(-\delta(1 + \delta)B_0 - D_1 + D_2 + S_2) \right\}
\]

\[+ \lambda \sigma(S_1) \max\{S_{\text{Reg}} - S_2, 0\}.
\]

First-order conditions for \( S_1 \) and \( D_1 \) depend on the baseline year. For year 0, the FOCs are

\[
\frac{\partial C}{\partial S_1} = \frac{\partial K_1}{\partial S_1} - \rho P(1 + \beta + \gamma) + \lambda \sigma(S_1) \max\{S_{\text{Reg}} - S_2, 0\} = 0 \quad \text{and} \quad \frac{\partial C}{\partial D_1} = \frac{\partial L_1}{\partial D_1} - \rho P \beta = 0.
\]

For baseline year 1, the FOCs are

\[
\frac{\partial C}{\partial S_1} = \frac{\partial K_1}{\partial S_1} - \rho P(1 + \beta + \gamma) + \lambda \sigma(S_1) \max\{S_{\text{Reg}} - S_2, 0\} = 0 \quad \text{and} \quad \frac{\partial C}{\partial D_1} = \frac{\partial L_1}{\partial D_1} - \rho P(\beta - \gamma) = 0.
\]

For \( S_1 \), the firm equates the marginal cost of the supply-side abatement activity to the sum of (a) the expected value of marginal avoided purchases of carbon permits, which consists of both the direct impact of reducing emissions (and hence avoiding the need to buy more permits) plus the expected value of ERCs received in the event ERCs are awarded \(^{14}\) and (b) the expected value of a marginal reduction in the risk of a legislatively-imposed RPS.

For \( D_1 \), the firm must choose between setting \( D_1 < 0 \), which inflates the historical emissions in period 1, or setting \( D_1 > 0 \) in the hopes of obtaining ERCs on a project basis. For a period 0 baseline, the firm obtains ERCs for \( D_1 > 0 \) if they end up being allocated on a project basis, but not if ERCs are based on historical reductions, since \( D_1 \) affects neither period 0 nor period 2 emissions. For a period 1 baseline, the incentive to increase \( D_1 \), and pursue ERCs based on project-level allocations, is countered by the incentive to reduce \( D_1 \) and avoid losing ERCs by reducing emissions in the historical baseline year. If \( \beta > \gamma \), then the firm equates the marginal cost of the demand-side abatement activity to the expected value of ERCs received, taking into account the difference in probabilities of ERCs being allocated based on projects vs. historical reductions. If \( \beta < \gamma \), then the only solution involves \( D_1 < 0 \), and the possibility of ERCs distorts the firm’s choice to a more negative level of \( D_1 \) than would be selected in the absence of ERCs.

First-order conditions for \( S_2 \) and \( D_2 \) do not depend upon the baseline year, and are

\[
\frac{\partial C}{\partial S_2} = \frac{\partial K_2}{\partial S_2} - \rho P(1 + \beta + \gamma) - \lambda \sigma(S_1) I\{S_{\text{Reg}} > S_2\} = 0 \quad \text{and} \quad \frac{\partial C}{\partial D_2} = \frac{\partial L_2}{\partial D_2} - \rho P(1 + \beta + \gamma) = 0.
\]

For \( S_2 \), the firm equates the marginal cost of the supply-side abatement activity to the sum of (a) the expected value of marginal avoided purchases of carbon permits, which consists of both the direct impact of reducing emissions (and hence avoiding the need to buy more permits) plus the expected value of ERCs received in the event ERCs are awarded on either a project basis or on the basis of historical reductions, and (b) the marginal reduction in the expected penalty for failing to comply with an RPS, should one be imposed.

For \( D_2 \), the firm equates the marginal cost of the demand-side reduction to the expected value of marginal avoided purchases of carbon permits, which consists of both the direct impact of reducing emissions (and hence avoiding the need to buy more permits) plus the expected value of ERCs received in the event ERCs are awarded on either a project basis or on the basis of historical reductions, and (b) the marginal reduction in the expected penalty for failing to comply with an RPS, should one be imposed.

\(^{14}\) If the historical baseline year is 0, then the firm receives ERCs for \( S_1 \) regardless of whether ERCs are allocated on a project or a historical basis. If the baseline year is 1, then the firm receives ERCs for \( S_1 \) only in the event that ERCs are allocated on a project basis. This is because \( S_1 \) affects emissions in both periods, and so does not affect the difference in emissions between the two periods.
buy more permits) plus the expected value of ERCs received in the event ERCs are awarded on either a project basis or on the basis of historical reductions. Note that compared to demand-side reductions, supply-side reductions create the added benefit of reducing regulatory risk.

3.3. Incentives for selective disclosure

If the firm does not disclose fully, then it may be able to obtain more ERCs, but it also faces the risk of a greenwash penalty. If a baseline year of 0 is used for historical emissions, then expected costs are

$$C = K_1(S_1) + K_2(S_2) + L(D_1) + L(D_2) + \rho P \left[ (1 + \delta)^2 B_0 - D_2 - S_1 - S_2 - \beta (S_1 + \max[D_1, 0] + S_2 + D_2) \right] - \gamma (-\delta (2 + \delta) B_0 + D_2 + S_1 + S_2) + \sigma(S_1) \max(S_{\text{reg}} - S_2, 0) + \eta A.$$

Alternatively, if historical reductions are measured as $E_1 - E_2$, then expected costs are

$$C = K_1(S_1) + K_2(S_2) + I_1(D_1) + I_2(D_2) + \rho P \left[ (-D_2 - S_1 - S_2) - \beta (S_1 + \max[D_1, 0] + S_2 + D_2) - \gamma (-\delta (1 + \delta) B_0 - D_1 + D_2 + S_2) \right] + \sigma(S_1) \max(S_{\text{reg}} - S_2, 0) + \eta A.$$

Expected costs are increased by the risk of a greenwash penalty, but this could be outweighed by the benefits of hiding information about negative $D_1$ and thus obtaining more ERCs. Compared to the full disclosure case, first-order conditions for $S_1$, $S_2$, and $D_2$ are unchanged. The first-order condition for $D_1$ is different from the full disclosure case. For baseline year 0, the FOC is

$$\frac{\partial C}{\partial D_1} = \frac{\partial L_1}{\partial D_1} - \rho P(\beta|D_1 > 0) = 0.$$

For baseline year 1, the FOC is

$$\frac{\partial C}{\partial D_1} = \frac{\partial L_1}{\partial D_1} - \rho P(\beta|D_1 > 0) - \gamma = 0.$$

If $D_1$ is positive, the first-order conditions are the same as the full disclosure case. For negative $D_1$, the indicator function means that the firm no longer faces a marginal cost in lost ERCs for $D_1 < 0$. Thus, for a period 0 baseline, negative $D_1$ is more attractive at the margin than under full disclosure, so if the firm does choose a negative $D_1$, it will be at a larger absolute value than in the full disclosure case. However, although the greenwash penalty does not enter the first-order condition, it is a real fixed cost faced by the firm if it engages in selective disclosure; hence, it may deter the firm from choosing a negative $D_1$. For a period 1 baseline, once again a negative $D_1$ is the only possible solution, and selective disclosure leads to a value of $D_1$ that is larger in absolute value than under full disclosure.

There is a subtle difference between incentives under full and incentives under selective disclosure. Under full disclosure, if ERCs are based on projects then choosing $D_1 < 0$ will cause the firm to lose some ERCs. Under selective disclosure, however, the firm hides information about $D_1 < 0$, which gives it incentives to choose a more negative value of $D_1$, since it further artificially inflates the historical baseline emissions in period 1. Of course, the firm must balance the economic benefits of selective disclosure against the risk of punishment for greenwash, and may opt not to pursue the benefits of selectivity if the expected penalty is too high.

We summarize the foregoing analysis in the following proposition.

Proposition 1. Growing firms are more likely to disclose selectively. The firm has incentives to engage in selective disclosure when it chooses $D_1 < 0$, which is more likely when $\delta B_0 > D_1 + S_1$. The incentive to disclose selectively is increasing in $\gamma$ and decreasing in $\beta$.

3.4. Comparative statics of abatement incentives

In this section, we develop a series of propositions regarding the firm’s incentives to pursue different types of emissions abatement, how they are affected by changes in the parameters of the model, and what they imply for participation in 1605b. We begin our comparative statics analysis by exploring how the possibility of ERCs (and the method of allocating them) changes a firm’s incentives to invest in supply-side and demand-side emissions reductions. The following proposition follows immediately from the first order conditions.

Proposition 2. The possibility of earning ERCs induces a firm to increase $S_1$, $S_2$, and $D_2$. If the firm chooses a historical baseline of period 0, or if $\beta - \gamma > 0$ then the firm increases its investment in $D_1$, but if the firm chooses a historical baseline of period 1 and $\beta - \gamma < 0$ then the firm decreases its investment in $D_1$.

Proposition 2 shows that the chance to earn ERCs does indeed motivate a firm to increase its investments $S_1$, $S_2$, and $D_2$ in emissions reductions. Whether the firm invests more in period 1 demand-side reductions is unclear. The reason is that granting emissions based on historical reductions may give the firm incentives to inflate its initial level of emissions by choosing $D_1 < 0$.

To the best of our knowledge, there is no indication that Congress or the Department of Energy ever indicated that ERCs were more likely to be allocated based on verifiable abatement projects or on reductions against a historical baseline. Indeed,
the great latitude granted to reporters under the 1605b program suggests substantial uncertainty regarding the ultimate nature of the allocation process. Given this uncertainty, it is important to understand whether we can confidently expect that the prospect of obtaining ERCS would lead firms to increase abatement, or whether instead it is possible that the perverse incentives created by historical ERC allocation might outweigh the positive incentives. This is the subject of Proposition 3.

**Proposition 3.** If $L(D_t)$ is symmetric about 0, then the prospect of earning ERCS unambiguously increases the firm’s incentives for abatement, regardless of uncertainty on the allocation rule. Hence, all other things equal, firms that participate in the 1605b program are expected to reduce their carbon emissions more than those that do not participate.

**Proof.** Proposition 2 shows that ERCS induce increases in $S_t$, $S_{2}$, and $D_2$. We will show that symmetry of $L(D_t)$ about 0 is sufficient to ensure that $D_2 > |D_1|$, and hence total abatement is increased by ERCS. This inequality follows from the first-order conditions for $D_1$ and $D_2$. The first-order condition for $D_2$ is $eL_2/cD_2 = \rho\gamma + \beta$. The greatest incentive for a negative value of $D_1$ occurs when the firm engages in selective disclosure and the baseline year is 1. Then the first-order condition for $D_1$ is $eL_1/cD_1 = -\rho\gamma$. Obviously $-\rho\gamma$ is strictly smaller in absolute value than $\rho\gamma$. Hence, if $L(D_t)$ is symmetric about 0, then $D_2 > |D_1|$ regardless of the values of $\beta$ and $\gamma$, and the prospect of ERCS leads the firm to increase its abatement.

Thus, we have identified conditions under which the prospect of ERCS induces the firm to increase its abatement, even when there is a chance that the ERCS will be allocated based upon historical reductions.15 This implies that firms that participate in the 1605b program ought to have lower emissions, *ceteris paribus.*16

We turn now to identifying some empirical implications of the model for firms’ incentives for participation in the 1605b program.

**Proposition 4.** Firms with lower marginal costs of abatement have greater incentive to participate in the 1605b program.

**Proof.** Marginal costs of abatement are reflected in $\partial K_t/\partial S_t$ and $\partial L_t/\partial D_t$. Any parameter change that lowers $\partial K_t/\partial S_t$ or $\partial L_t/\partial D_t$ but leaves the rest of the marginal conditions unchanged, will increase the benefits obtained by the firm from joining the 1605b program and hence increase participation. □

There are a number of firm characteristics that would be expected to lower abatement costs, which we discuss in more detail in Section 5. Next, we turn to a pair of propositions concerning the impact of political pressure on disclosure behavior.

**Proposition 5.** A firm has greater incentive to participate in the 1605b program when it faces a greater threat of state regulation.

**Proof.** The first-order condition with respect to $S_1$ shows that investment in $S_t$ increases as $\sigma(S_1)$ increases. In addition, the first-order condition with respect to $S_2$ shows that investment in $S_2$ increases as $\sigma(S_1)$ increases. When the firm has greater emissions reductions to report, it has a greater incentive to participate in the 1605b program. □

The strength of regulatory threats is difficult to observe directly, but can be detected with a number of proxies. For example, states whose Congressional delegations are rated more favorably by the League of Conservation Voters are more likely to pass new environmental legislation. Likewise, states that allocate significant effort to regulatory enforcement are more likely to support new legislation. In addition, states that have not yet passed RPS legislation pose a regulatory threat that firms may be motivated to preempt.

Finally, we address the firm’s incentive to avoid 1605b participation in order to avoid being attacked as a greenwasher.

**Proposition 6.** A firm has less incentive to disclose selectively as $\eta A$ increases.

**Proof.** Evident by comparing the firm’s expected costs with full and selective disclosure. As $\eta A$ increases, selective disclosure becomes less profitable, and the firm has less incentive to engage in the practice of selective disclosure. □

The expected penalty for greenwashing is difficult to measure directly, but is likely to increase when a firm faces a larger number of environmental group members in its service territory. We discuss the specific variables we use to test Propositions 4–6 in more detail in Section 5.

4. Econometric models

The propositions presented in Section 3 can be grouped into two categories, depending upon whether they address: (1) participation in the 1605(b) program, or (2) the impact of the 1605(b) program. Here, we describe the econometric strategies we use to study each category.

---

15 Kennedy [11] finds that ERCS do not implement the first-best levels of investment in abatement, because they induce the firm to divert investment away from long-term R&D on abatement, and toward early-term reductions. Nevertheless, his model still implies that the prospect of ERCS increases abatement compared to no prospect of ERCS.

16 From an econometric perspective, of course, all other things are not necessarily held equal. We therefore implement our test of this hypothesis by normalizing by initial emissions level; that is, we examine firms’ emissions intensity rather than their total emissions.
4.1. Participation in the 1605(b) program

We begin by modeling the decision to participate in the 1605(b) program as a binary choice. Because most firms did not change their participation status over time, we model participation cross-sectionally, asking whether a firm ever participated. We let firm i’s propensity to participate be denoted by

\[ D_i^* = X_i \beta + \epsilon_i \]

where \( X_i \) is an array of independent variables, \( \beta \) is a vector of coefficients, and \( \epsilon_i \) is a random variable distributed according to the normal distribution. Since participation is a discrete decision, we then denote it by

\[ D_i = 1 \text{ if } D_i^* > 0 \text{ and } D_i = 0 \text{ otherwise}. \]

Then the probability of participation is

\[ P_i = \text{Prob}(D_i = 1 | X_i) = \text{Prob}(\epsilon_i < X_i \beta) = F(X_i \beta) \]

where \( F \) is the cumulative distribution of \( \epsilon_i \). If \( \epsilon_i \) is normally distributed with \( \epsilon_i \sim N(0, \sigma^2) \), then

\[ P_i = \Phi(X_i \beta) \]

where \( \Phi \) is the standard normal cumulative distribution. Thus, to study the binary choice of participation or non-participation in the 1605(b) program, we use probit analysis. We expect that firms participate in the 1605(b) program if their net benefits with participation are greater than their net benefits without participation. Accordingly, in our probit models, we include various factors that affect the benefits and costs of 1605(b) participation as regressors. We describe these regressors in detail in Section 5.

In addition to understanding which firms choose to participate in the 1605(b) program, we would like to understand what drives them to report fully or selectively. In our setting, the most complete form of reporting is to disclose at both at the project and the entity levels. Clearly project-level reporting alone is not complete because firms may fail to report activities that increase emissions. Even entity-level reporting is not a complete account of the firm’s abatement activities unless accompanied by project-level reporting, because companies whose demand is shrinking can achieve entity-wide emissions reductions without incurring any costs to reduce emissions. Thus, among the 1605(b) participants, the variable that represents the extent of disclosure is clearly ordered: no reporting, reporting at one level only, and reporting (informatively) at two levels. Therefore, ideally, we would model the extent of disclosure using ordered multinomial models.

As we discuss further below, the challenge is that our cross-sectional sample is extremely skewed: 53 firms do not participate at all, 42 firms participate at one level, and only 3 firms report informatively at two levels. We tested the proportional odds assumption, implicit in ordered probit models, that the relationship between each pair of outcome groups is the same, and found it to be violated. Specifically, the \( p \)-values from the likelihood-ratio tests of the equality of coefficients across response categories range from 0.01 to 0.005 in alternative model specifications. Thus, in our context, it is impossible to make use of the ordered nature of the extent of disclosure in the 1605(b) program; the vast majority of firms either does not disclose at all, or disclose at one level only, so we focus on the participation decision.

4.2. Impact of the 1605(b) program

In addition to understanding motives for participation, we are interested in whether participation in the 1605(b) program led firms to improve their environmental performance over time. We measure environmental performance improvement as the change in CO\(_2\) emissions intensity (CO\(_2\) emissions per megawatt-hour of net generation), a measure that is not directly driven by project and the entity levels. Clearly project-level reporting alone is not complete because companies whose demand is shrinking can achieve entity-wide emissions reductions without incurring any costs to reduce emissions. Thus, among the 1605(b) participants, the variable that represents the extent of disclosure is clearly ordered: no reporting, reporting at one level only, and reporting (informatively) at two levels. Therefore, ideally, we would model the extent of disclosure using ordered multinomial models.

As we discuss further below, the challenge is that our cross-sectional sample is extremely skewed: 53 firms do not participate at all, 42 firms participate at one level, and only 3 firms report informatively at two levels. We tested the proportional odds assumption, implicit in ordered probit models, that the relationship between each pair of outcome groups is the same, and found it to be violated. Specifically, the \( p \)-values from the likelihood-ratio tests of the equality of coefficients across response categories range from 0.01 to 0.005 in alternative model specifications. Thus, in our context, it is impossible to make use of the ordered nature of the extent of disclosure in the 1605(b) program; the vast majority of firms either does not disclose at all, or disclose at one level only, so we focus on the participation decision.

\[ Y_{1i}, Y_{0i} \perp D_i \mid P(X_i) \]

where \( Y_1 \) and \( Y_0 \) indicate the outcome with and without treatment \( D \), respectively. The array \( X \) represents covariates that affect the likelihood of treatment, i.e., participation in the 1605(b) program. The conditional independence assumption allows

\[ Y_{1i}, Y_{0i} \perp D_i \mid P(X_i) \]

where \( Y_1 \) and \( Y_0 \) indicate the outcome with and without treatment \( D \), respectively. The array \( X \) represents covariates that affect the likelihood of treatment, i.e., participation in the 1605(b) program. The conditional independence assumption allows
treatment to be considered as a randomized experiment, so we have

\[ E[Y_0 | D = 1, P(X)] = E[Y_0 | D = 0, P(X)] \]

The average effect of treatment on the treated can be calculated as follows:

\[ E[Y_1 - Y_0 | D = 1] = E[Y_1 | D = 1, P(X)] - E[Y_0 | D = 0, P(X)] \]

Typically, the conditional probability of treatment, \( P(X) \), is estimated using standard logit or probit models. Following the estimation strategy for the participation probability, we use probit models. Assuming \( X \) includes all the relevant variables that affect the decision to participate in the program; the average treatment effect on the treated is unbiased. In other words, unobservable variables play no role in the treatment assignment and outcome determination. In the case of 1605b, we might speculate that firms would be more likely to participate if their management held stronger personal convictions about preventing climate change, or if they had particularly good personal relationships with the DOE. Since these same factors also make it more likely that the firm would actually reduce its carbon intensity over time, we are biased towards finding a significant impact of the 1605b program using propensity score matching.

The evaluation results can be sensitive to the chosen matching method and the set of regressors used to estimate propensity scores [10]. Thus, we use a variety of covariates and propensity score matching algorithms; we describe these in more detail below. We impose the common support condition, so that matching is performed over the propensity scores region that is common to the treated and untreated groups. Upon calculating propensity scores, we conduct the balance test to ensure that the means of the propensity scores and the means of the covariates are not significantly different in the treated and the corresponding untreated groups.

5. Data

Our sample consists of 98 investor-owned electric utilities (IOUs) over the period 1995–2003. The total number of observations in the sample is 837, and thus a firm is in the sample for about 8 years. The 1605(b) participation data were collected from the DOE’s Voluntary Registry website.18 Financial, operational and environmental performance-related data for IOUs were obtained from Platts, a company specializing in energy industry data. State-level variables were compiled from appropriate websites, including the Environmental Protection Agency (EPA), the League of Conservation Voters, and the Database of State Incentives for Renewable Energy. Table 1 provides a list of explanatory variables used in this paper and their definitions.

Greenhouse gas emissions are calculated based on fuel consumption. We take this approach rather than using direct observations from the continuous emissions monitoring system (CEMS) for several reasons. First, the Natural Resources Defense Council (NRDC) reported that turbulent flow in the emissions stack could bias the CEMS estimates upward by 10–30%.19 Second, NRDC also found cases where the CEMS data deviate from the EIA and FERC estimates when the latter two agreed for the most part. In these cases of discrepancies, NRDC used the FERC-based estimates. Third, we were able to obtain a more complete dataset using the fuel consumption data than would have been possible using the CEMS data alone. In cases where fuel consumption data were not available, we supplemented our fuel consumption-based estimates with adjusted CEMS estimates to increase the number of observations.20 We also conducted estimations using CO2 emissions intensity as our measure of greenhouse gas emissions, which we compute by taking CO2 emissions divided by net generation in megawatt-hours (MWh). The rest of the variables in Table 1 proxy for various economic and political incentives that could affect participation in the 1605(b) program.

To test Proposition 4, we include several variables designed to capture the presence of low-cost opportunities for emissions reductions. These include size (as captured by electric operating revenues); heat rate (the ratio of heat input to electricity generated), which is a direct measure of combustion inefficiency; capacity factor (ratio of energy generated to capacity), a measure of how well capacity is used; and fuel switch saving (a measure of how much money a firm could save by switching from oil to natural gas). In addition, we include growth in generation, since generation growth allows firms to add new generating units with the latest and cleanest technologies. We also include a measure of the fraction of a firm’s power that is derived from carbon-free hydroelectric and nuclear sources.

Proposition 5 addresses political pressures affecting 1605b participation, and we include several variables to capture these effects. These include League of Conservation Voters ratings for the US House and Senate delegations in each state, as a measure of overall environmental preferences in the state. We also include a measure of the stringency of Renewable Portfolio Standards (RPS) in each state. As shown in Proposition 5, early reductions might help preempt the introduction of RPS in states without RPS. In addition, we include a variable that captures state-level enforcement and inspection activities associated with environmental issues in general.

Finally, Proposition 6 predicts that firms will be less likely to participate in 1605(b) when they face greater scrutiny from environmental activists opposed to greenwash. We proxy for activist pressure using the density of subscribers to Sierra

19 www.nrdc.org/air/energy/rbr/append.asp.
20 Although we ultimately chose not to use the CEMS data as our primary data source, we did run our estimations using this data as a robustness check. Results were qualitatively similar to what we obtained from the fuel consumption data.
Table 1
Explanatory variables and their definitions.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition (unit of measurement)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO₂ emissions</strong></td>
<td>Total carbon dioxide (CO₂) emissions (10⁸ lbs)</td>
</tr>
<tr>
<td></td>
<td>This is calculated based on fuel consumption data. First, total carbon input is calculated using carbon coefficients: 25.97 for Coal, 14.47 for Natural Gas, 17.51 for Refinery Gas, 19.95 for Distillate fuel (Oil-L), 21.49 for Residual fuel (Oil-H) and 27.85 for Petroleum Coke (The units for carbon coefficients are Million Metric Tons per Quadrillion Btu). These estimates are then converted to CO₂ emissions by multiplying by 3.7, the molecular weight of CO₂ relative to carbon. When carbon input data is missing, but Continuous Emissions Monitoring System (CEMS) data are available, CEMS data are used instead.</td>
</tr>
<tr>
<td><strong>CO₂ emissions intensity</strong></td>
<td>CO₂ emissions per net generation (lbs/MWh)</td>
</tr>
<tr>
<td></td>
<td>Net generation (MWh) is defined as the amount of gross generation less the electrical energy consumed at generating stations.</td>
</tr>
<tr>
<td><strong>Sierra subscription per thousand population</strong></td>
<td>Number of subscriptions to Sierra magazine per thousand population at the state level in 2000</td>
</tr>
<tr>
<td><strong>Electric operating revenue</strong></td>
<td>Revenue from sales of electricity (10⁹$).</td>
</tr>
<tr>
<td><strong>Capacity factor</strong></td>
<td>The ratio of heat input to net energy generated (Btu/kWh).</td>
</tr>
<tr>
<td><strong>Fraction of hydro and nuclear</strong></td>
<td>The ratio of energy generated from hydro and nuclear units to total energy generated.</td>
</tr>
<tr>
<td><strong>LCV scores</strong></td>
<td>The League of Conservation Voters (LCV)'s scorecards for US Senate and House</td>
</tr>
<tr>
<td><strong>Renewable Portfolio Standards</strong></td>
<td>State Renewable Portfolio Standard index. It is calculated by dividing % goal by the difference between the goal year and the enacted or effective year, whichever comes first.</td>
</tr>
<tr>
<td><strong>Growth in generation</strong></td>
<td>Percentage growth in firm-level net generation over the longest time period in the sample</td>
</tr>
<tr>
<td><strong>Fuel switch saving</strong></td>
<td>Low cost and low carbon fuel switching opportunity (10⁶$)</td>
</tr>
<tr>
<td></td>
<td>Estimated for the month with the highest generation for the year, this is calculated by ordering generators from the lowest to highest cost, and multiplying the amount of oil-based generation times the difference in fuel costs between oil and natural gas if oil-based and natural gas-based generation are adjacent in the dispatch order and the cost of natural gas is lower.</td>
</tr>
<tr>
<td><strong>Enforcement</strong></td>
<td>State-level enforcement and inspection activities obtained from the EPA ECHO database</td>
</tr>
</tbody>
</table>


** An adjustment factor is calculated to convert Platts’ CO₂ emissions data to fuel-based CO₂ estimates. The fuel-based estimates are regressed on Platts’ reported emissions data and the inverse of the coefficient, 0.7527, is used as an adjustment factor. This aligns well with NRDC’s report that continuous emissions monitoring data could be biased upward by 10–30% relative to fuel-based estimates. [www.nrdc.org/air/energy/rbr/append.asp].

* State Renewable Portfolio Standards data are obtained from [www.dsireusa.org].

Table 2 provides summary statistics for the explanatory variables used in our analysis, both in the aggregate and by participation category for 1995 and 2003.

6. Results

We begin with summary measures that provide a broad overview of participation in the program. We then turn to estimates of the factors driving participation in the 1605(b) program. Finally, we discuss the impact of the 1605(b) program.

6.1. Overview

In the aggregate, there is a large gap between actual and reported emissions reductions over the period 1996–2003, as can be seen in Fig. 1. The reported reductions data are collected from the DOE’s Voluntary Registry website. The actual entity-level reductions are calculated against the base year 1995 using fuel input and emissions data obtained from Platts, as shown in Table 1. Participants in the 1605(b) program reported significant reductions in tons of greenhouse gases emitted while increasing their emissions. Upon comparing reported and actual reductions at the firm level, we find that for 68% of firms, the 1605(b) program reported positive reductions while the firm’s actual emissions rose. Ironically, firms that did not participate in the program actually reduced their emissions, as shown in Fig. 2.

The sharp disconnect between actual emissions and reported reductions suggests that 1605(b) participants took advantage of the program’s loose reporting requirements, selectively reporting on successful projects while remaining silent about any actions that increased emissions. Indeed, environmental groups have decried the 1605(b) program because it
encourages firms to make filings not on their entire corporate emissions profile, but on cherry-picked emission reduction projects.

```
Table 2
Descriptive statistics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Entire sample (N=98)</th>
<th>1605(b) participants (N=45)</th>
<th>1605(b) non-participants (N=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. dev.</td>
<td>Mean</td>
</tr>
<tr>
<td>Year 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>16.88471</td>
<td>18.07051</td>
<td>26.38348</td>
</tr>
<tr>
<td>CO₂ emissions intensity</td>
<td>947.2028</td>
<td>480.0793</td>
<td>1016.555</td>
</tr>
<tr>
<td>Sierra subscription per thousand</td>
<td>0.780096</td>
<td>0.531047</td>
<td>0.668315</td>
</tr>
<tr>
<td>Electric operating revenue</td>
<td>1.27218</td>
<td>1.617858</td>
<td>2.132534</td>
</tr>
<tr>
<td>Heatrate</td>
<td>8490.768</td>
<td>3770.109</td>
<td>9174.969</td>
</tr>
<tr>
<td>Capacity factor</td>
<td>0.485825</td>
<td>0.178964</td>
<td>0.499636</td>
</tr>
<tr>
<td>Fraction of hydro and nuke</td>
<td>0.245194</td>
<td>0.391585</td>
<td>0.238294</td>
</tr>
<tr>
<td>LCV score: senate</td>
<td>38.23469</td>
<td>33.09991</td>
<td>36.46667</td>
</tr>
<tr>
<td>LCV score: house</td>
<td>39.29592</td>
<td>20.38911</td>
<td>40.22222</td>
</tr>
<tr>
<td>Renewable Portfolio Standard</td>
<td>0.175706</td>
<td>0.391249</td>
<td>0.174713</td>
</tr>
<tr>
<td>Growth in net generation</td>
<td>0.148871</td>
<td>0.477347</td>
<td>0.141705</td>
</tr>
<tr>
<td>Fuel switch saving</td>
<td>0.020704</td>
<td>0.122259</td>
<td>0.015363</td>
</tr>
<tr>
<td>Enforcement</td>
<td>0.078058</td>
<td>0.072319</td>
<td>0.096209</td>
</tr>
<tr>
<td>Year 1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>15.84954</td>
<td>15.69642</td>
<td>22.83077</td>
</tr>
<tr>
<td>CO₂ emissions intensity</td>
<td>954.2005</td>
<td>449.3003</td>
<td>959.2578</td>
</tr>
<tr>
<td>Sierra subscription per thousand</td>
<td>0.780096</td>
<td>0.531047</td>
<td>0.668315</td>
</tr>
<tr>
<td>Electric operating revenue</td>
<td>1.00954</td>
<td>1.363063</td>
<td>1.709461</td>
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<td>Heatrate</td>
<td>8741.166</td>
<td>3593.887</td>
<td>2890.789</td>
</tr>
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<td>Capacity factor</td>
<td>0.484159</td>
<td>0.165836</td>
<td>0.476524</td>
</tr>
<tr>
<td>Fraction of hydro and nuke</td>
<td>0.211247</td>
<td>0.362694</td>
<td>0.245505</td>
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<tr>
<td>LCV score: senate</td>
<td>41.81633</td>
<td>28.88775</td>
<td>43.33333</td>
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<tr>
<td>LCV score: house</td>
<td>40.62040</td>
<td>18.19977</td>
<td>40.93333</td>
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<tr>
<td>Renewable Portfolio Standard*</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Growth in net generation</td>
<td>0.148871</td>
<td>0.477374</td>
<td>0.141705</td>
</tr>
<tr>
<td>Fuel switch saving</td>
<td>0.010181</td>
<td>0.029844</td>
<td>0.012554</td>
</tr>
<tr>
<td>Enforcement</td>
<td>0.078058</td>
<td>0.072319</td>
<td>0.096209</td>
</tr>
</tbody>
</table>

* State adoption of Renewable Portfolio Standards did not begin until 1998.

Fig. 1. 1605(b) Reported reductions (IOUs) vs. actual reductions (IOUs).

"encourages firms to make filings not on their entire corporate emissions profile, but on cherry-picked emission reduction projects." 21
We examine the extent of selective disclosure in Table 3, which shows the number of firms opting for particular disclosure formats over time. We distinguish three groups of firms. First are firms that do not provide any information. Second are those which provide information either at the project level or at the entity level. (Those firms that report at both the project and the entity levels, but whose entity-level report is simply the sum of their project-level reductions are included in this category because entity-level reports do not provide any additional information.) Third are firms that report at both the project and the entity level, and whose entity-level report is not simply the sum of its projects.

It is evident from Table 3 that the vast bulk of companies that participate in the 1605(b) program opt to report only at the project level. Furthermore, the percentage that does so rose from 82% in 1995 to 87% in 2003. Selective disclosure is clearly the dominant mode of participating in the 1605(b) program.

Fig. 3 shows changes in carbon intensity over time across different subgroups of firms: those that never participated, those that participated at least once, and those that participated at both entity and project levels but with entity-level reductions simply the sum of project-level reductions. While 1605(b) participants that reported at both the entity and project levels performed a little better than the other two groups, their performance worsened over time.

### Table 3
Number of firms reporting at the entity and project levels.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>One category only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Project only</td>
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<td>58</td>
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<td>57</td>
<td>57</td>
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<td>60</td>
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<td>Entity only</td>
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<td>6</td>
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<td>5</td>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Sub-total</td>
<td></td>
<td>64</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>63</td>
<td>65</td>
<td>64</td>
<td>64</td>
<td>86</td>
</tr>
<tr>
<td>Two categories</td>
<td></td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

- includes 1605b participants categorized as Electric Providers, which includes non-IOUs such as municipal, city, and federal utilities [26].
- Number of firms reporting either at the project level only, or at both project and entity levels but with entity-level reductions simply the sum of project-level reductions.
- Number of firms whose reported entity-level reductions are not equal to the sum of project-level reductions.

We examine the extent of selective disclosure in Table 3, which shows the number of firms opting for particular disclosure formats over time. We distinguish three groups of firms. First are firms that do not provide any information. Second are those which provide information either at the project level or at the entity level. (Those firms that report at both the project and the entity levels, but whose entity-level report is simply the sum of their project-level reductions are included in this category because entity-level reports do not provide any additional information.) Third are firms that report at both the project and the entity level, and whose entity-level report is not simply the sum of its projects.

It is evident from Table 3 that the vast bulk of companies that participate in the 1605(b) program opt to report only at the project level. Furthermore, the percentage that does so rose from 82% in 1995 to 87% in 2003. Selective disclosure is clearly the dominant mode of participating in the 1605(b) program.

Fig. 3 shows changes in carbon intensity over time across different subgroups of firms: those that never participated, those that participated at least once, and those that participated at both entity and project levels with entity-level reductions not equal to the sum of project-level reductions. 1605(b) participants and non-participants are similar in terms of their environmental performance, as measured by CO₂ emissions intensity. While 1605(b) participants that reported at both the entity and project levels performed a little better than the other two groups, their performance worsened over time.

### 6.2. Participation

We analyze factors that motivate firms to participate in the 1605(b) program using probit models. There is relatively little within-group variation in 1605b participation. Thus, in our empirical analysis, we make use of cross-sectional variations in the participation status among 98 investor-owned electric utilities. Since the number of participants is largest in 2003, we use data for 2003. We use contemporaneous values of independent variables in order to capture changes that motivated firms...
to join even after the initial year of the program. The results are shown in Table 4 and reported in terms of the associated marginal effects (calculated at the means of the independent variables).

We consistently find that dirtier firms, as represented by higher CO\textsubscript{2} emissions or emissions intensity, are more likely to participate, although the effect is not statistically significant. Proposition 4 garners moderate support, as shown by the fact

![Graph](image-url)

Fig. 3. CO\textsubscript{2} emissions intensity over time.

Table 4

<table>
<thead>
<tr>
<th>Variables</th>
<th>Probit marginal effects (dependent variable: binary dummy that indicates participation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>CO\textsubscript{2} emissions</td>
<td>0.00437</td>
</tr>
<tr>
<td></td>
<td>(0.00755)</td>
</tr>
<tr>
<td>CO\textsubscript{2} emissions intensity</td>
<td>0.000161 *</td>
</tr>
<tr>
<td></td>
<td>(0.000108)</td>
</tr>
<tr>
<td>Sierra subscription per thousand population</td>
<td>–0.525 *</td>
</tr>
<tr>
<td></td>
<td>(0.292)</td>
</tr>
<tr>
<td>Electric operating revenue</td>
<td>0.397 ***</td>
</tr>
<tr>
<td></td>
<td>(0.130)</td>
</tr>
<tr>
<td>Heatrate</td>
<td>9.92E–06</td>
</tr>
<tr>
<td></td>
<td>(4.25e–05)</td>
</tr>
<tr>
<td>Capacity factor</td>
<td>–0.183</td>
</tr>
<tr>
<td></td>
<td>(0.429)</td>
</tr>
<tr>
<td>Fraction of hydro and nuke</td>
<td>0.152</td>
</tr>
<tr>
<td></td>
<td>(0.423)</td>
</tr>
<tr>
<td>LCV score: senate</td>
<td>0.00123</td>
</tr>
<tr>
<td></td>
<td>(0.00364)</td>
</tr>
<tr>
<td>LCV score: house</td>
<td>0.000754</td>
</tr>
<tr>
<td></td>
<td>(0.00596)</td>
</tr>
<tr>
<td>Renewable Portfolio Standard</td>
<td>–0.464 *</td>
</tr>
<tr>
<td></td>
<td>(0.236)</td>
</tr>
<tr>
<td>Growth in net generation</td>
<td>–0.0876</td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
</tr>
<tr>
<td>Fuel switch saving</td>
<td>–0.537</td>
</tr>
<tr>
<td></td>
<td>(2.745)</td>
</tr>
<tr>
<td>Enforcement</td>
<td>3.140 **</td>
</tr>
<tr>
<td></td>
<td>(1.148)</td>
</tr>
</tbody>
</table>

Marginal effects are calculated at the means of the independent variables. Standard errors in parenthesis.

*** \( p < 0.01 \).

** \( p < 0.05 \).

* \( p < 0.1 \).
that opportunities for low-cost abatement played a role in participation decisions.\footnote{Recall that Propositions 1–3 generate insights about the program but are not directly testable.} Large firms, as measured by electric operating revenue, were significantly more likely to participate, which may reflect the role of scale economies in making participation cost-effective. The marginal effect, i.e., the slope of the probability function relating independent variables to probability, is about 0.4. This means that the change in the probability of participation for an incremental change in revenue at the mean is 0.4. The effects of other factors such as heatrates, capacity factors, fraction of hydro and nuclear, and opportunities for savings from fuel switching are not statistically significant.

Proposition 5, which predicts that firms facing greater political pressure are more likely to participate, also receives support. Enforcement has a strong positive effect on 1605(b) participation; at the mean, the change in the probability of participation for an incremental change in enforcement is roughly 3.\footnote{The marginal effect of an independent variable is the derivative (that is, the slope) of the predicted probability. Thus, the marginal effect can be greater than one.} We find that firms are less likely to participate in states with an RPS, and that participation is less likely the stronger is the RPS. This is consistent with the notion that firms may participate in 1605(b) in an attempt to preempt a state RPS. Once the RPS is passed, however, preemption is no longer possible, and participation in 1605(b) flags. League of Conservation Voters scores, however, do not have significant effects on participation.

Proposition 6 receives support, suggesting that environmental activists associated with the Sierra Club perceived 1605(b) participation as greenwash and attempted to penalize firms that participated. The marginal effect is around $-0.5$, meaning that an incremental increase in Sierra club membership per thousand population at the mean decreases the probability of participation by 0.5. This result helps to explain why non-participants elected not to join the program. Staying out of the program avoids the risk of being labeled a greenwasher.

Overall, we find strong evidence that large firms were more likely to participate in the DOE’s Voluntary Greenhouse Gas Registry; this result is consistent with the notion that firms with low-cost abatement opportunities were more likely to participate. Also, participation was more likely in states with higher enforcement activities and states that had not passed RPS legislation, consistent with the notion that political pressure played a role in influencing participation. Finally, there is strong evidence that participation was less likely in states with strong Sierra Club membership, suggesting that environmental groups considered 1605(b) participation to be greenwash rather than meaningful action.

6.3. The impact of the 1605(b) program

Did 1605(b) participants improve their environmental performance over time compared to non-participants? To answer this question, we make use of the propensity score matching method using changes in CO$_2$ emissions intensity from 1995 to 2003 as the outcome variable.\footnote{When the observation has no data for 1995 or 2003, we use the first or the last year available in the sample.} We calculate changes in CO$_2$ emissions intensity as follows:

\[ \text{Outcome variable} = \frac{\text{CO}_2 \text{ emissions intensity in 1995} - \text{CO}_2 \text{ emissions intensity in 2003}}{\text{CO}_2 \text{ emissions intensity in 1995}}. \]

Since larger CO$_2$ emissions intensity indicates poorer environmental performance, changes in CO$_2$ emissions intensity calculated as above are positive if environmental performance improved over time, that is, if CO$_2$ emissions intensity in 2003 is lower than CO$_2$ emissions intensity in 1995. Negative values indicate that environmental performance deteriorated over time. Independent variables used to estimate propensity scores are in terms of their 1995 values, in order to avoid endogeneity concerns.\footnote{If 1995 data is missing for an observation, we use the first year in the sample.}

The estimation results for the effect of treatment on the treated are shown in Table 5. We do not find substantial support for Proposition 3’s prediction that 1605(b) participants improve more over time. Although the estimated treatment effects are positive in most of our estimations, often ranging from 10% to 35% over the 8 year period, they are not statistically significant. Thus, we conclude that the 1605(b) program did not have a significant impact on CO$_2$ emissions intensity. The sum of the numbers of treatment and controls is less than the sample size because we use the common support condition. Those treated observations whose predicted probability is larger than the largest predicted probability for non-participation are dropped from matching.

We use alternative matching algorithms to estimate treatment effects on the treated. Since our cross-sectional sample size is not large, Kernel matching is helpful in keeping the size of matched observations as large as possible. Kernel matching, however, can exacerbate potential problems of inexact matching because all non-treated observations are used, although weights are used to take into account closeness to the treated observations. Thus, we use other matching algorithms such as caliper, stratification, and nearest neighbor matching to test the robustness of the insufficiency of the treatment effect on the treated. For every treated observation, the nearest neighbor matching chooses the untreated observation whose propensity score is closest as a control. Stratification/interval matching divides the range of variation in propensity scores into equal intervals between treated and untreated groups such that within each interval the treated and untreated observations have, on average, the same propensity score. Treatment effect on the treated is then calculated as the weighted average, with weights representing the distribution of the treated units across the blocks. Caliper/radius matching uses all the untreated
observations within the pre-assigned caliper as controls. Throughout we allow matching with replacement so that the same untreated observations could be used more than once as control. Regardless of the matching algorithm used, the treatment effect on the treated is not significant. We do not find any evidence that participants in the 1605(b) program improved their environmental performance over time significantly more than non-participants.

The results of treatment effects can also be sensitive to different specifications used to estimate propensity scores. Thus, we use alternative specifications to calculate propensity scores ((1)–(8)). As shown in Table 5, our finding of insignificance of the treatment effect is robust to different model specifications. Thus, we conclude that the 1605(b) program did not have any significant effect on the CO2 emissions intensity of program participants.

7. Conclusions

In this paper, we have provided a theoretical and empirical exploration of the use of strategic environmental disclosures of greenhouse gas emissions. We developed a formal model that emphasizes firms’ pursuit of early reduction credits (ERCs), but also takes into account a variety of political pressures. We tested the model’s predictions using a unique government data registry to explore the causes and consequences of electric utilities’ participation in the Department of Energy’s Voluntary Greenhouse Gas Registry. With this data, we are able to provide an unusually sharp comparison of firms’ environmental disclosures with their actual environmental performance, because utilities are regulated and must file detailed fuel-use data with the Federal Energy Regulatory Commission.

We show that in the aggregate, participants in the Voluntary Registry increased emissions over time but reported reductions, while non-participants decreased emissions over time. Our results clearly demonstrate that participants made selective disclosures of positive environmental results, while withholding information on negative results. Participants tended to be large firms, as measured by revenues. Political factors played important but subtle roles in firms’ disclosure behavior. The threat that a state would impose an RPS in the future increased participation, as did stronger state enforcement of environmental laws. In contrast, a greater presence of environmental group members in a given state significantly decreased the likelihood of participation. Nevertheless, although political factors played a significant role, the public comments of the utility trade association strongly suggest that the primary driver for participation in the program was the possibility of obtaining early reduction credits.

Table 5
Impact of the 1605(b) program.

<table>
<thead>
<tr>
<th>Matching</th>
<th>Average treatment effect on the treated (participation in 1605(b) program)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kernel</td>
</tr>
<tr>
<td>(1)*</td>
<td>0.121 (0.180)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>23</td>
</tr>
<tr>
<td>(2)*</td>
<td>0.311 (0.355)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>23</td>
</tr>
<tr>
<td>(3)*</td>
<td>0.158 (0.215)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>27</td>
</tr>
<tr>
<td>(4)*</td>
<td>0.182 (0.341)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>24</td>
</tr>
<tr>
<td>(5)*</td>
<td>0.127 (0.172)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>24</td>
</tr>
<tr>
<td>(6)*</td>
<td>0.186 (0.321)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>21</td>
</tr>
<tr>
<td>(7)*</td>
<td>0.184 (0.187)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>27</td>
</tr>
<tr>
<td>(8)*</td>
<td>0.300 (0.388)</td>
</tr>
<tr>
<td>Number of treatment</td>
<td>39</td>
</tr>
<tr>
<td>Number of controls</td>
<td>24</td>
</tr>
</tbody>
</table>

Standard errors in parenthesis. When there are two standard errors, the second one is a bootstrapped standard error. When there is only one, it is bootstrapped (the raw standard errors are not available) except for caliper/radius matching, where it is a raw standard error.

* (1)–(8) refer to models displayed in the probit table (Table 5).

b Caliper: 0.15.
c Caliper: 0.2.
d Caliper: 0.25.
e Caliper: 0.35.
Our results indicate that the 1605b program’s reporting flexibility undermined the credibility and effectiveness of the program. This aligns with previous theoretical findings that disclosure programs can be made more informative by limiting reporting discretion [7]. The Carbon Disclosure Project, for example, asks firms a highly structured and detailed set of questions, rather than allowing them to report as they so desire.27 Fortunately, it appears the Department of Energy (DOE) has learned some valuable lessons from the 1605b program. In its 2006 revisions to the program, DOE required entity-wide registration of reductions by firms that hoped to earn ERCs. Thus, utilities lost their bid to retain the extraordinary flexibility of the original reporting system. The resolution to this heated debate—entity-wide reporting for registering reductions—makes it much more difficult for 1605(b) participants to obtain early reduction credits while increasing their overall GHG emissions. Future reporting programs would do well to take the 1605b experience to heart.

References