ESSAYS ON BUSINESS AND CLIMATE CHANGE

by

Eun-Hee Kim

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Business Administration)
in the University of Michigan
2009

Doctoral Committee:

Professor Thomas P. Lyon, Chair
Professor James D. Westphal
Associate Professor Andrew J. Hoffman
Assistant Professor Jagadeesh M. Sivadasan

ACKNOWLEDGEMENTS

I am deeply indebted to my dissertation chair, Tom Lyon. He deserves a great deal of credit for my growth and development during my doctoral studies. Without his strong support, this dissertation would not have been possible. I am also grateful to my committee members—Jim Westphal, Andy Hoffman, and Jagadeesh Sivadasan—for their time and effort in helping me develop and refine my work. Jim Westphal encouraged me to take a step back and see the big picture. Andy Hoffman challenged the foundations of my arguments and provided important insights. Jagadeesh Sivadasan went through my rough drafts and gave detailed comments and suggestions. Further, all these advisors offered invaluable advice and guidance above and beyond the call of duty.

In addition, I would like to thank the faculty of the Business Economics and Public Policy Group and the Strategy Group in the Ross School of Business for their help during various stages of my academic development. I also greatly appreciate the financial support I received from the Erb Institute for Global Sustainable Enterprise, the Graham Environmental Sustainability Institute, the Center for International Business Education, and the Ross School of Business Doctoral Program over the last five years. Special thanks to the Erb, Graham, and Ross PhD communities for their camaraderie.

Most of all, I would like to thank my parents, my sisters, and my husband for their unconditional love and support. For so many years, they have provided a nurturing environment for me to pursue my doctoral studies. I dedicate this dissertation to them.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This dissertation consists of three distinct essays. Nevertheless, they study a common topic: how business interacts with its environment.[1] The first two essays study how the rising threat of climate change regulations affects motivations to engage in one particular instrument of nonmarket strategy, voluntary information disclosure, and what the consequences of the strategy are in terms of firm-level environmental and financial performance. Climate change provides an interesting context for studying relationships between business and its environment because climate change presents companies with opportunities as well as risks. In the legislative/regulatory arena, for example, those firms able to influence legislation/regulation in their favor will have comparative advantage over other firms in terms of compliance and liability costs. In capital and goods markets, those companies that can appeal to green consumers and investors will erode brown firms' profits. The third essay examines how dramatic changes in a firm's competitive environment brought about by economic deregulation affect capital investment in green technologies.

The first essay examines how firms respond to pressures to voluntarily disclose environmental information when there is a strong regulatory threat. Information

[1] Business environment refers to the nonmarket as opposed to the market environment (Baron, 1995). The nonmarket environment includes those interactions that are intermediated by the public, stakeholders, government, the media, and public institutions.

disclosure programs are often considered to be the "third wave" of environmental regulation, following command-and-control and market-based programs. Indeed, Tietenberg (1998) argues that the accumulated evidence suggests that disclosure strategies can ultimately motivate polluters to reduce emissions even in the absence of more traditional regulatory controls.

Previous studies, however, do not take into account the possibility that firms may take advantage of voluntary information disclosure programs to obtain favorable regulatory outcomes. This possibility is explored by making use of the U.S. Department of Energy (DOE)'s voluntary program to report reductions of greenhouse gases—a registry created in accordance with section 1605b of the Energy Policy Act of 1992. This program provides an ideal setting for this study in two respects. First, for reported reductions, participants might receive early reduction credits that are likely to have significant value once a cap-and-trade policy is in place. Second, for electric utility companies, it is possible to evaluate the reported reductions against actual reductions because these companies must report detailed fuel use data to the Federal Energy Regulatory Commission. The most important finding is that electric utility participants tend to engage in selective disclosure, i.e., reporting good news while concealing bad news. This finding suggests that under strong regulatory pressure companies may use voluntary information disclosure programs for the purpose of obtaining favorable regulatory outcomes.

The second paper studies the circumstances under which a voluntary disclosure program initiated by institutional investor activism affects shareholder value. The empirical context is the Carbon Disclosure Project (CDP), a consortium of over 300 institutional investors with over $57 trillion in assets in 2008. Since 2002, the CDP has asked the world's 500 largest companies every year to disclose their greenhouse gas emissions, risks, opportunities, and management strategies. Some companies participate in the CDP, while others do not. The CDP publicly discloses company responses on its website, presumably in the hope that publicized information will affect investment behavior. The CDP is different from typical activism which interferes with management decisions with the intention of increasing shareholder value. Although disclosure is encouraged by institutional investors who have large stakes in the companies examined, their activism is passive in nature, encouraging and monitoring disclosure of environmental performance.

Using the event study methodology, the essay finds that there was no systematic effect of CDP participation on shareholder value around the dates each year that participation was announced. However, when the likelihood of climate change regulation increased, CDP participants experienced positive abnormal stock returns, suggesting that they were viewed as better prepared for the exogenous regulatory shock. This finding shows that institutional investor activism toward climate change, although passive in nature, increases shareholder value when the external business environment becomes more climate conscious.

The third essay explores how changes in the competitive environment of firms brought about by deregulation affect incentives for green investment. The central idea behind economic deregulation is that increased competition provides firms with incentives for greater efficiency, for example, exerting downward pressure on costs, reducing slack, and even driving innovation forward (Stigler, 1971; Jordan, 1972;

Peltzman, 1976; 1989; Winston, 1998). More recent research suggests that deregulation may also do something good for the natural environment. These studies find that the intensity of competition is positively associated with environmental differentiation, i.e., production of green goods or better management of environmental performance (Arora and Gangopadhyay, 1995; Delmas et al., 2007; Fernandez-Kranz, 2008). In particular, firms that produce final goods engage in environmental differentiation because final customers are more responsive to "being green" (Arora and Cason, 1995 and Khanna and Damon, 1999). The third paper investigates whether the positive relationship between competition and environmental differentiation, holds true for traditionally regulated firms within an industry context following deregulation.

Among recently deregulated industries, the electric utility industry provides the best possible setting for this study because this industry emits the greatest amount of greenhouse gases and has access to a range of electricity generating technologies in terms of production costs and environmental impacts. The essay finds that retail electricity deregulation, which allows customers to choose their own electricity suppliers, is associated with lower probability of entry into renewable generation by companies. Furthermore, I find that once a company makes its initial investment in renewables, it tends to increase the share of renewables in its portfolio. Together, these findings suggest that the negative effect of deregulation on renewable investment could persist over a prolonged period of time.

CHAPTER 2

Greenhouse Gas Reductions or Greenwash?: The DOE's 1605(b) Program

I. 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. (Tietenberg 1998) A growing empirical literature suggests that mandatory disclosure programs do indeed lead to improved environmental performance, at least for firms that were initially weak performers. (Blackman, Afsah and Ratunanda 2004; Dasgupta, Wheeler and Wang 2007; Delmas and Shimshack 2007)

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.[2] 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

---

[2] Webster's New Millenium Dictionary of English defines greenwash as "The practice of promoting environmentally friendly programs to deflect attention from an organization's environmentally unfriendly or less savory activities."

performance will have more positive outcomes to disclose, and there exists some empirical literature to support this view.[3] In contrast, sociological "legitimacy theory" asserts that firms increase their disclosures after an accident or other negative event in order to bolster their tarnished reputations, and there exists empirical support for this view as well.[4] In light of these mixed findings, it is not surprising that many environmental advocates are distrustful of voluntary environmental disclosures and wary of greenwash.[5]

Most previous work on environmental disclosures measures them using content analysis of statements in corporate annual reports and 10Ks.[6] In this paper, we take an alternative approach, and make 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 record their voluntary reductions of greenhouse gas (GHG) emissions, in terms of tons of CO_2. For most industries, it is difficult to compare these disclosures against actual environment performance, since the U.S. 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. Thus, we are able to directly address the question

---

[3] For theoretical models, see Milgrom (1981), Verecchia (1983), Shin (2003), and Sinclair-Desgagne and Gozlan (2003). For empirical support, see Al-Tuwaijri et al. (2004) and Clarkson et al (2008).
[4] For a discussion of the theory see Patten (1991); for empirical evidence see Patten (1992) and Deegan and Rankin (1996).
[5] Lyon and Maxwell (2008) present a theoretical model that combines a persuasion game with an NGO watchdog that punishes greenwash, thus reconciling the economic and sociological approaches.

[6] The empirical literature in accounting that studies environmental disclosures typically uses content analysis of annual reports or corporate social responsibility reports to gauge the extent of environmental disclosures, rather than direct quantitative measures of environmental improvements. See, for example, Patten (2001, 2002) and Clarkson et al. (2008).

of whether cleaner or dirtier firms tend to make more disclosures, without having to interpret corporate statements through content analysis.

We are also interested in the factors motivating firms to make voluntary environmental disclosures. We formulate and test a series of hypotheses regarding why firms participate in the 1605(b) program, and which types of firms are more likely to participate. There is a plausible economic benefit from participation, namely the hope of obtaining "early reduction credits" (ERCs) that would have value if the U.S. were to impose an emissions cap in the future.[7] We expect that firms with lower costs of emissions reductions were more likely to participate in order to pursue ERCs, so we include a variety of variables to capture this effect. In addition, firms might derive public relations benefits from participation, so we include a set of variables proxying for social and political pressures facing firms. However, firms also face the risk that participation could trigger negative backlash from environmental non-governmental organizations (NGOs) if it is perceived as mere greenwash.

Our empirical results indicate that firms with lower costs of participation were more likely to join the program. Political pressures also appear to have had a significant effect: participation was more likely in states that had not yet passed a Renewable Portfolio Standard (RPS) but that had environmentally conscious Congressional delegations. 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 test whether participation had a measurable effect on a firm's carbon emissions per unit of generation, and find it to be statistically insignificant.

---

[7] The value of such permits could be large indeed. According to the Carbon Trust (2006, p. 8), electric utilities in the U.K. made profits of over $1 billion in 2005 from carbon permits they were allocated under the E.U. Emission Trading Scheme.

The remainder of the paper is organized as follows. Section 2 describes the 1605(b) program, and illustrates the sort of reports firms file with the Department of Energy. Section 3 surveys the relevant literature, and develops a set of testable hypotheses. Section 4 describes our econometric model, section 5 describes our data, and section 6 reports results. Section 7 describes recent modifications to the 1605(b) program, which provide further insight into the political economy of the program and reinforce our econometric results. Section 8 concludes.

II. The 1605(b) program

The voluntary registry program was established by section 1605(b) of the Energy Policy Act of 1992. The general features of the 1605(b) program align well with the proposals laid out in former President Bill Clinton and former Vice President Al Gore's report titled, "Reinventing Environmental Regulation" (Clinton and Gore, 1995). One of the proposals is to take full advantage of the power of information. The 1605(b) program allows public electronic access, so the public as well as government and firms can access the program's database. The 1605(b) program also has a self-certification feature proposed in the report.

Why should firms participate? According to the DOE's Voluntary Registry website:

> "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."[8]

This statement of the benefits of participation suggests that they 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.

A critical aspect of the 1605(b) program is that it was designed with no hard and fast rules about how to report reductions.[9] First of all, voluntary reporters could choose to report reductions at the "entity level" (entire firm) or at the "project level" (individual reduction project). Moreover, reporters could define the boundary of the entity or project.[10] Reporters were even allowed to report entity-level reductions just as the sum of project-level reductions. Second, voluntary reporters also had leeway in choosing baseline emissions against which to measure their reductions: historical or hypothetical. In the case of historical emissions, reporters could select any one year between 1987 and 1990 or use an average of any of those years. In the case of hypothetical emissions, reporters estimated what emissions would have been without entity- or project-level reductions. Third, reporters could report either reductions in absolute emissions or reductions in emissions intensity. Fourth, voluntary reporters could report indirect reductions or sequestration as well as direct reductions.[11]

---

[8] http://www.eia.doe.gov/oiaf/1605/1605(b).html

[9] The unique features described here do not reflect the recently revised guidelines (effective date: June 1, 2006). This is because our analysis is based on the data firms reported to the 1605(b) program during 1995-2003, which is before the revised guidelines were introduced.

[10] This information is based on personal correspondence with EIA's 1605(b) project manager, Mr. Stephen E. Calopedis (October 18, 2005).

[11] 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

In 2003, the latest year covered in this paper, the 1605(b) program received a total of 98 reports from the electric power sector and the reports provided information on 485 GHG emissions projects. The projects covered a wide range from reducing emissions at the electric power generation, transmission and distribution stages to demand-side management and carbon sequestration.

Abatement strategies at the generation stage include fuel switching from high- to low-carbon fuel sources, improving plant availability at low-carbon generators such as nuclear and hydro, plant efficiency improvement, increases in low- or zero-emitting generation capacity, decreases in high-emitting capacity, and retirement of high-emitting plants. Reductions at the transmission and distribution stages involve reduced losses in the delivery of electricity from power plants to end use through the use of high-efficiency transformers, transmission line improvements, etc. Demand side management projects aim to improve end-use energy efficiency of both stationary and mobile sources in the industrial, commercial, residential, agricultural, and transportation sectors. Carbon sequestration projects report carbon fixing through afforestation, reforestation, etc. Projects on other GHGs such as methane are also reported to the 1605(b) program.

Three case studies in the appendix illustrate what kinds of projects are actually reported to the program. American Electric Power and Southern Company represent fossil fuel-oriented companies and Exelon Corporation a nuclear-oriented one. American Electric Power participates at the project level and most of its projects involve carbon sequestration. Southern Company participates both at the entity and the project level but the sum of the project level reduction is the same as the entity level reduction. Exelon

---

such as trees, plants, or underground reservoirs. See *Voluntary reporting of Greenhouse Gases 2003*, EIA (2005).

Corporation participates at the project level and its projects include transportation-related ones. For all three companies generation at non-fossil fuel units such as nuclear or hydro accounts for the majority of their generation-related projects.

III. Literature Review and Testable Hypotheses

As of this writing, the U.S. has not imposed mandatory federal restrictions on GHG emissions. Instead, it has relied on an array of "public voluntary programs" (PVPs) that encourage, but do not require, firms to reduce emissions. As described by Lyon and Maxwell (2007), PVPs--- such as Climate Leaders, Climate Challenge, Motor Challenge, and Sustainable Slopes---typically invite firms to set reduction targets and share information about their efforts with regulators and other firms. In return, they may receive technical assistance and/or favorable publicity from the government; there are no penalties for failing to meet stated targets and no attempts to assess the accuracy of reported information. The DOE's Voluntary Greenhouse Gas Registry is part of the broad array of voluntary climate programs, but it is somewhat unusual in that it does not ask participants to set goals. Instead, it simply invites firms to disclose GHG reductions and emissions, and to describe actions they took to achieve reductions. Thus, the program resembles both a standard PVP and also a straightforward information disclosure program. In developing testable hypotheses, then, we draw upon both the literature on PVPs and the literature on environmental information disclosure.

We structure our hypotheses around the anticipated benefits and costs of participation. On the benefit side, firms may receive tangible benefits in the form of ERCs, and may also receive intangible benefits such as favorable publicity, improved relationships with regulators, and the preemption or delay of mandatory GHG regulations. On the cost side, firms face the marginal costs of resources invested to reduce emissions, the costs associated with reporting to the program, and the risk of being labeled a greenwasher by environmental groups opposed to the program.

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 U.S. eventually creates a tradable permits scheme for GHG emissions. (Michaelowa and Rolfe 2001, Kennedy 2002, Parry and Toman 2002) 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.[12] Despite the failure of both bills to pass, these proposals made industry (and investors) keenly aware that ERCs might be awarded at some point in the future.[13]

Which firms are more likely to register GHG reductions in an attempt to garner ERCs depends upon the benefits and costs of participation. The value of a tradable GHG permit is set by market forces independent of any given firm's identity, while the cost of GHG reductions is firm-specific. Hence, we expect firms with low-cost reduction

[12] In the 105th Congress, Senator Lieberman, along with Senators John Chafee (R-RI) and Connie Mack (R-FL) introduced S. 2617, the "Credit for Early Voluntary Action Act." In the 106th Congress, Senators Chafee, Lieberman, Mack, Warner (R-VA), Moynihan (D-NY), Reid (D-NV), Jeffords (R-VI), Wyden (D-OR), Biden (D-DE), Collins (R-ME), Baucus (D-MT), and Voinovich (R-OH) introduced S. 547, the "Credit for Voluntary Reductions Act."

[13] To the best of our knowledge, there has been no prior empirical research on firms' pursuit of ERCs.

opportunities to be most active in pursuing ERCs.[14] In particular, *large firms* are more likely to have enough potential ERCs to outweigh the cost of participating in a voluntary registry. Firms with *low-cost opportunities* to reduce emissions are also more likely to participate. This would include firms with inefficient older coal-burning plants that could benefit from a retrofit (proxied for by a high heat rate, or heat input per unit of electricity generated), and firms with nuclear or hydroelectric plants that are currently operating at low capacity factors. This category would also include firms with high-cost oil-burning plants that could be displaced by cheaper, cleaner, gas-fired generating units.[15] (We create a variable called "fuel switch saving" that measures the difference between the cost per kwh of the firm's most expensive fuel source and the cost per kwh of natural gas.) Utilities with *growing demand* can increase their capacity factors, operating more efficiently and reducing their carbon intensity, that is, their emissions per unit of generation. Growing firms can also justify building new plants, which during our sample period tended to be relatively low-emission gas-fired plants; adding new, clean capacity also reduces a firm's overall carbon intensity. To summarize, we have

Hypothesis 1: A firm is more likely to have low costs of participating in the 1605(b) program if it: a) is large, b) has a high heat rate, c) has a low capacity factor, d) has a large potential fuel switch saving, or e) faces growing demand.

[14] Of course, firms with a low cost of participation were also more likely to participate in pursuit of intangible benefits, as well.

[15] During most of our sample period, natural gas was the fuel of choice for new generating units because it was both clean and cheap. As of September 2002, the Energy Information Administration reported that the average wellhead price of natural gas remained below $3.00 per thousand cubic feet (MCF). Since that time, prices have risen sharply, with the price in December 2005 over $10 per MCF. Utilities now face much more difficult choices when they expand capacity than they did during our sample period.

Although the tangible benefits offered by ERCs do not differ across firms, the intangible benefits of participating in the 1605b program might be expected to vary depending upon firm characteristics. These benefits might include favorable publicity, improved relationships with regulators, and information exchange with other participating firms. (All of these benefits are mentioned in the DOE's statement of why firms should participate, as mentioned in section 2 above.) The literature on public voluntary programs has found a number of empirical regularities that we might expect to hold here as well. [16] Research generally finds that firm size, poor environmental performance and greater external pressure have consistently significant and positive effects on voluntary program participation. The effect of firm size suggests that larger firms face greater pressure from environmental or citizens' groups to take action, enjoy economies of scale in compliance, or have better access to capital markets and hence lower costs of new investments.[17] Dirtier firms are more likely to participate, perhaps because they face greater media scrutiny and pressure from environmental or citizens' groups.[18] The effect of greater external pressure suggests that firms are more likely to participate when they face greater external pressure from environmental groups,

---

[16] The program that has received the most attention is the EPA's "33/50" program, which encouraged firms to reduce their emissions of seventeen key toxic chemicals, relative to a 1988 baseline, by 33 percent by 1992 and 50 percent by 1995. Other programs studied include the DOE's Climate Challenge program and EPA's WasteWise program and Green Lights program. See Lyon and Maxwell (2007) for further details.

[17] Large firms were more likely to participate in the EPA's 33/50 program (Arora and Cason, 1995; 1996; Khanna and Damon, 1999; Videras and Alberini, 2000; Sam and Innes, 2005), the EPA's Green Lights program (DeCanio and Watkins, 1998; Videras and Alberini, 2000), the EPA's WasteWi$e program (Videras and Alberini, 2000), the DOE's Climate Challenge program (Karamanos, 1999; Welch, Mazur, and Bretschneider, 2000), and the Sustainable Slopes Program (Rivera and de Leon, 2004).

[18] Dirtier firms were found to be more likely to participate in the 33/50 program (Arora and Cason, 1995; 1996; Khanna and Damon, 1999; Videras and Alberini, 2000; Sam and Innes, 2005), the Green Lights program (Videras and Alberini, 2000), the Climate Challenge Program (Karamanos, 1999), the Sustainable Slopes Program (Rivera and de Leon, 2004) and the WasteWi$e program (Videras and Alberini, 2000).

communities, state politicians, or industry associations.[19] In particular, Sam and Innes (2005) find that the density of state-level Sierra Club membership has a significant and positive effect on joining the 33/50 program, as does being in an industry that experienced a contemporaneous consumer boycott.

Combining these insights from the empirical literature on PVPs, we have:

Hypothesis 2: A firm is more likely to participate in the 1605(b) program to obtain favorable publicity and improve regulatory relationships if it: a) is large, b) emits more greenhouse gases, or c) faces greater external pressure from environmental groups, local communities, state politicians or industry associations.

We turn now to hypotheses from the literature on voluntary disclosures, which can be found in both the economics and accounting literatures (Patten 1991, Patten 1992, Sinclair-Desgagne and Gozlan 2003, Al-Tuwaijri et al 2004, Clarkson et al 2006). As mentioned in the Introduction, however, there is no empirical consensus on the sign of the correlation between environmental performance and disclosures. Nor is there agreement on the theoretical factors that cause that sign to be either positive or negative. Economic theory implies that cleaner firms should have more good news to disclose, and hence be more likely to participate in disclosure programs. Legitimacy theory implies that dirtier firms may face greater pressure from external groups, and make additional disclosures to mollify them.

[19] Firms facing more pressure from environmental groups were more likely to participate in the 33/50 Program (Khanna and Damon, 1999, Sam and Innes, 2005) and the Sustainable Slopes Program (Rivera and de Leon, 2004).

Lyon and Maxwell (2007) develop a model of greenwash as selective disclosure that combines both of these perspectives. In their model, an NGO may attack a firm for promoting its green activities if it finds that the firm also suppressed information about environmentally harmful activities. For a firm with a middling environmental reputation (e.g., most electric utilities), that has both good and bad environmental outcomes to report, selective disclosure may be attractive: disclosing a success can produce a significant improvement in public perception, and withholding information about a failure can prevent a significant negative public perception; thus, as long as external pressure from environmental activists is not too intense, they are willing to risk public backlash by disclosing only partially. However, as activist pressure increases, firms become less likely to take the risk of being attacked as greenwashers, and less likely to engage in selective disclosure.

Hypothesis 3: A firm is more likely to participate in the 1605(b) program if it faces less external pressure from environmental groups opposed to greenwash.

The hypotheses developed so far relate to why firms participate in the 1605(b) program. We now turn to hypotheses regarding the factors influencing firms' environmental performance, which we measure by CO_2 emissions intensity, i.e. CO_2 emissions per net generation (lbs/MWh).[20] First of all, firms with a higher fraction of generation from hydroelectric or nuclear power, which emit zero carbon, should have lower CO_2 emissions intensity than otherwise. Second, firms with growing demand are

[20] We use the intensity measure as our environmental performance indicator since the main product of the electric utilities is electricity, which is more or less a homogeneous good.

likely to have lower CO_2 emissions intensity. During most of our sample period, natural gas was the fuel of choice for new generating units because it was both clean and cheap, so growing firms building gas units could lower their average emissions intensity. Growing firms could also increase their capacity factors, operating more efficiently and thereby reducing their carbon intensity. Third, firms with higher capacity factors, which are able to operate more efficiently, should have lower emissions intensity.

Hypothesis 4: A firm has better environmental performance, i.e., lower CO_2 emissions intensity, *if it: a) has higher fraction of hydro or nuke, b) faces growing demand, or c) has a higher capacity factor.*

Finally, we turn to the expected effects of participation in the voluntary 1605(b) program on environmental performance, which we measure using carbon emissions intensity. As noted by Lyon and Maxwell (2007), the literature that has conducted empirically rigorous assessments of PVPs has generally concluded that they have little or no impact on environmental performance; this includes such well-known programs as the EPA's 33/50 Program, Climate Challenge, Climate Wise, and Sustainable Slopes. Having no reason to expect the 1605(b) program to perform better than other programs in this regard, we have:

Hypothesis 5: Participation in the 1605(b) program has no impact on a firm's carbon intensity.

Section 5 discusses the precise variables we use to test these hypotheses. Before we turn to that discussion, however, we present the econometric models we use for estimation.

IV. Econometric Models

We use a random utility model to analyze the factors that lead electric utilities to participate in the 1605(b) program (Domencich and McFadden, 1975). In the model, a firm, the decision maker, has complete information and makes a rational choice based on the information it possesses, i.e., the firm chooses the alternative with the highest utility. Unlike the firm, we, the analysts, have incomplete information and thus need to take uncertainty into account. The sources of uncertainty include unobserved alternatives, unobserved individual attributes, and measurement errors. To reflect this uncertainty, we model the firm's utility as a random variable, which has a deterministic part and a stochastic part. Different assumptions about the stochastic part lead to different models. We assume a normal distribution, and use a probit model. (Wooldridge 2002) In this model, let *i* denote the firm and *j* denote the choice to participate in the program (*j*=1) or not (*j*=0). Let

D_{it} = 1 if firm *i* makes choice 1 in period *t*

D_{it} = 0 if firm *i* makes choice 0 in period *t*

The firm's utility is

$$V_{ijt} = \mathbf{X_{ijt}\beta} + \varepsilon_{ijt} \qquad (1)$$

We observe

$y_{it} = 1 \; iff \; V_{i1t} > V_{iot}$

This is equivalent to

$$\mathbf{X_{i1t}\beta} + \varepsilon_{i1t} > \mathbf{X_{i0t}\beta} + \varepsilon_{i0t}$$

or

$$\varepsilon_{i0t} - \varepsilon_{i1t} < (\mathbf{X_{i1t}} - \mathbf{X_{i0t}})\boldsymbol{\beta}$$

Then the probability of participation is

$$\begin{aligned} \mathrm{P}_{it} &= Prob\,(y_{it}=1 \mid \mathbf{X_{it}}) \\ &= Prob\,(\varepsilon_{i0t} - \varepsilon_{i1t} < (\mathbf{X_{i1t}} - \mathbf{X_{i0t}})\boldsymbol{\beta}) \\ &= F[(\mathbf{X_{i1t}} - \mathbf{X_{i0t}})\boldsymbol{\beta}] \end{aligned}$$

where F is cumulative distribution of $\varepsilon_{i0t} - \varepsilon_{i1t}$. If ε_{i0t} and ε_{i1t} are normally distributed with mean 0 such that $\varepsilon_{i0t} - \varepsilon_{i1t} \sim N(0, \sigma^2)$, then

$$\mathrm{P}_{it} = \Phi(\mathbf{Z_{it}}\boldsymbol{\gamma}) \qquad (2)$$

where Φ is the standard normal cumulative distribution and $\mathbf{Z_{it}}\boldsymbol{\gamma} = (\mathbf{X_{i1t}} - \mathbf{X_{i0t}})\boldsymbol{\beta}$

We assume that firms participate in the 1605(b) program if the net benefit with participation is greater than the net benefit without participation. Thus, we include the variables that affect the benefit and cost of 1605(b) participation as regressors in our probit models.

To estimate the impact of a firm's 1605(b) participation on our outcome variable of interest, CO_2 emissions intensity (CO_2 emissions per net generation (lbs/MWh)), we make use of a treatment effects model that takes into account selection on unobservables.[21] The analysis has two stages, participation and outcome. Equation (3)

[21] We follow Cameron and Trivedi (2005). Both in the first and the second stages, the coefficients of the independent variables are assumed to be the same for the participants and non-participants. They are also exposed to a common unobservable shock. The approach is fully parametric and the model is estimated by maximum likelihood.

and equation (4) are the second-stage outcome equations for the participants and non-participants, respectively. Equation (5) is the first stage probit model. [22]

$$y_{1it} = \alpha_1 + \mathbf{X_{it}\beta} + \mu_{it} \quad (3)$$

$$y_{0it} = \alpha_0 + \mathbf{X_{it}\beta} + \mu_{it} \quad (4)$$

$$D_{it}^{*} = \mathbf{Z_{it}\gamma} + \varepsilon_{it} \quad (5)$$

$D_{it} = 1$ if $D_{it}^{*} > 0$ and $D_{it} = 0$ otherwise,

In these specifications, y_{1it} and y_{0it} are CO_2 emissions intensity in the second stage for the 1605(b) participants and non-participants, respectively. $\mathbf{X_{it}}$ is independent variables that affect CO_2 emissions intensity. D_{it} is a participation dummy and D_{it}^{*} is a latent variable for participation. $\mathbf{Z_{it}}$ is independent variables that affect firms' participation decision.

We allow for the possibility of correlation between the error terms in the first and the second stage. The nonzero correlation coefficient, ρ, reflects the endogeneity of the participation variable. We assume $\mu_{it} \sim N(0, \sigma)$, $\varepsilon_{it} \sim N(0, 1)$ and $corr(\mu_{it}, \varepsilon_{it}) = \rho$.

Using the participation dummy, the two outcome equations, equation (3) and equation (4), can be written in one equation.

$$\begin{aligned} y_{it} &= D_{it}y_{1it} + (1-D_{it})y_{0it} \\ &= D_{it}(\alpha_1 + \mathbf{X_{it}\beta} + \mu_{it}) + (1-D_{it})(\alpha_0 + \mathbf{X_{it}\beta} + \mu_{it}) \\ &= \alpha_0 + \mathbf{X_{it}\beta} + \eta D_{it} + \mu_{it} \quad (6) \end{aligned}$$

where $\eta = \alpha_1 - \alpha_0$.

[22] The variables in **X** may overlap with those in **Z**, but it is assumed that there exist at least one component of **Z** that is a nontrivial determinant of the participation dummy and not a part of **X**, that is, significantly correlated with the endogenous participation variable, but uncorrelated with the outcome variable, except through the participation dummy.

The coefficient of the participation dummy variable in equation (6), η, represents the effect of participation on outcomes upon random selection.

The expected difference in outcome conditional on participation, that is, the expected difference in CO_2 emissions intensity between the 1605(b) participants and non-participants, needs to take into account the selection effect. This requires estimating the expected value of μ_{it} conditional on participation, i.e., $E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma})$ and $E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma})$. To estimate this, we assume that μ_{it} and ε_{it} have a joint normal distribution. Under this assumption, the expected values of μ_{it} for the participants and non-participants are represented by:

$$E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma}) = f(\mathbf{Z_{it}}\hat{\boldsymbol{\gamma}})/F(\mathbf{Z_{it}}\hat{\boldsymbol{\gamma}}) \qquad \text{if } D_i=1 \qquad (7)$$

$$E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma}) = -f(\mathbf{Z_{it}}\hat{\boldsymbol{\gamma}})/[1-F(\mathbf{Z_{it}}\hat{\boldsymbol{\gamma}})] \qquad \text{if } D_i=0 \qquad (8)$$

where f is the standard normal density function and F is the standard normal cumulative distribution. The expected difference in outcome conditional on participation can then be calculated as follows.

$$\begin{aligned} & E(y_{it} \mid D_{it}=1) - E(y_{it} \mid D_{it}=0) \\ &= \{\alpha_1 + \mathbf{X_{it}\beta} + E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma})\} - \{\alpha_0 + \mathbf{X_{it}\beta} + E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma})\} \\ &= \eta + E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma}) - E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma}) \qquad (9) \end{aligned}$$

Thus, the unconditional and conditional expected differences in CO_2 emissions intensity between the 1605(b) participants and non-participants can be estimated using equations (6) and (9), respectively. If ρ, the correlation coefficient between μ_{it} and ε_{it}, is significantly different from zero, then estimating the conditional expected difference between the 1605(b) participants and non-participants can provide additional insight into the impact of the 1605(b) program.

V. Data

The models are estimated using a pooled database of 83 investor-owned electric utilities (IOUs) over the period 1996-2003.[23] The total number of observations in the sample is 596, and thus a firm is in the sample on average for 7 years. The 1605(b) participation data were collected from the DOE's Voluntary Registry website.[24] Financial, operational and environmental performance-related data were obtained from Platts, a company specializing in energy industry data.[25] Table I provides a list of explanatory variables used in this paper and their definitions. Some of the variables are lagged by one year to avoid endogeneity concerns.

Hypothesis 1 in section 3 proposes that firms are more likely to participate in the 1605(b) program if they have low costs of participation. 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); heatrate (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 lagged 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 over the

---

[23] The reason for pooling is discussed later in the section.
[24] http://www.eia.doe.gov/oiaf/1605/frntvrgg.html
[25] Collecting financial and operational data for electric operating companies has become more difficult since the mid-1990s when the Energy Information Administration (EIA), the statistical agency of DOE, stopped organizing in a convenient format the raw data that electric operating companies report to FERC. More recently EPA has made publicly available an integrated database, eGRID, which provides emissions and generation data, but it has a number of drawbacks. First, there is a considerable time lag involved; for example, the database now available only covers the period from 1996 to 2000. Second, eGRID provides no financial information.

previous three years, on the view that generation growth allows firms to add new generating units with the latest and cleanest technologies.

Hypothesis 2 proposes that firms are more likely to participate in the 1605(b) program in pursuit of regulatory influence if they are larger, have higher greenhouse gas emissions, or face greater external pressure. 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 percent.[26] 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.[27] We also conducted estimations using CO_2 emissions intensity as our measure of greenhouse gas emissions, which we compute by taking CO_2 emissions divided by net generation in megawatt-hours (MWh).

We include a number of variables to proxy for external pressures faced by firms in our sample. These include the density of subscribers to *Sierra* magazine in a given state. This variable proxies for the strength of environmental groups in the state, and has

---

[26] www.nrdc.org/air/energy/rbr/append.asp.

[27] 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.

been found to be significant in previous empirical work by Maxwell, Lyon and Hackett (2000), Sam and Innes (2005), and others. If the coefficient on this variable is positive and significant, this supports the hypothesis that environmental groups pressed firms to participate in 1605(b). We also include an interaction term between Sierra subscriptions and lagged CO_2 emissions, since NGOs may target their pressure toward the dirtiest firms. In addition, we include League of Conservation Voters ratings for the U.S. House and Senate delegations in each state, as a measure of overall environmental preferences in the state. We further include a measure of the stringency of Renewable Portfolio Standards (RPS) in each state that has passed one, expecting that an RPS will induce firms to shift toward less GHG-intensive generation. We also include a measure of how many other firms in the industry participated in the 1605(b) program in the previous year, to allow for the possibility that external pressure to participate grew as participation became more common.

Hypothesis 3 posits 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 number of subscribers to *Sierra* magazine per thousand state residents. If the coefficient on this variable is negative and significant, this supports the hypothesis that environmental activists viewed 1605(b) participation as a form of greenwash.

Finally, in assessing whether 1605(b) participation affected carbon intensity, we include a measure of the fraction of a firm's power that is derived from carbon-free hydroelectric and nuclear sources, a variable we expect to have strong explanatory power.

To investigate firms' participation decisions in the 1605(b) program and their effect on CO_2 emissions intensity, we pool our dataset across years. There are two reasons for this. First, the 1605(b) program does not require that the IOUs make any short- or long- term commitment. This implies that every year they can opt out or opt in, providing theoretical support for pooling. Second, Hausman test results demonstrate that we cannot reject the null hypothesis that the firm-specific effects are uncorrelated with the independent variables. In other words, we do not find evidence that fixed effects are present.[28] This finding further supports pooled analyses (Cameron and Trivedi, 2005). We use panel-corrected standard errors and t-statistics for statistical inference.[29]

Table II provides summary statistics for the explanatory variables used in our analysis, both in the aggregate and by participation category. Out of 596 firm-year observations, 52% have a participation dummy which equals 1. Thus, approximately 44 out of 83 firms participated in the program. On average, 1605(b) participation is associated with larger and dirtier firms, as represented by higher revenue and higher lagged CO_2 and SO_2 emissions, respectively. Participants also have higher CO_2 emissions intensity. In addition, 1605(b) participation is associated with greater external pressure, as measured by larger numbers of Sierra magazine subscriptions and higher LCV scores for the House and Senate. The interaction term between lagged SO_2 emissions and Sierra magazine subscription, and the RPS index, however, are higher for the non-participants.

---

[28] We note two qualifications in this statement. First, only three firms in our sample show variation in participation status during 1996-2003. Accordingly, fixed effect estimates are based only on these three firms, whereas random effect estimates are based on our full sample. Second, due to convergence problems, we could conduct the Hausman test using a model with at most three independent variables deemed most important in making participation decisions (lagged CO_2 emissions, electric operating revenue, and Sierra magazine subscription). We obtain $\chi^2(2)$=2.12 and p-value of 0.346.

[29] We assume observations are independent across firms but not necessarily independent within firms, so use clustered standard errors. For details see Wooldridge (2002).

The 1605(b) participants appear to have more low-cost abatement opportunities, as proxied by lower capacity factor (higher excess capacity), and higher savings possibilities from switching to natural gas. Participation in 1605(b) is also associated with a higher fraction of hydroelectric and nuclear power in overall firm generation, perhaps reflecting opportunities to reduce emissions by improving nuclear available rates. Three-year lagged growth rates are higher for participants, although one-year and two-year growth rates are lower.

Table III presents the correlations between each of the variables. Most correlations are relatively low. However, not surprisingly, there are significant correlations between operating revenues, CO_2 emissions and SO_2 emissions; between House and Senate LCV scores; and, negatively, between heatrate and fraction hydroelectric and nuclear capacity.

VI. Results

In this section, we report our empirical 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, which test our Hypotheses 1 - 3, and then to treatment effects estimates of the effect of participation on carbon emissions intensity, which test our Hypotheses 4 and 5. Following that, we explore whether our basic estimates are robust to the inclusion of measures of indirect emissions reduction and sequestration.

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 Figure 1.[30] In fact, participants in the 1605(b) program reported significant reductions in tons of greenhouse gases emitted while increasing their emissions.[31] Ironically, firms that did *not* participate in the program actually reduced their emissions, as is shown in Figure II.

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.[32] 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."[33] This complaint is consistent with Lyon and Maxwell's (2008, p. 8) definition of greenwash as "selective disclosure of positive information about a company's environmental or social performance, without full disclosure of negative information on these dimensions, so as to create an overly positive corporate image."

We examine the extent of selective disclosure in Table IV, which shows the number of firms opting for particular disclosure formats over time. We distinguish three groups of firms. First are firms that provide only project-level information. This

---

[30] The reported reductions data are collected from the DOE's Voluntary Registry website. The actual reductions are calculated against the base year 1995 using data obtained from Platts, as described in section 5.

[31] When we compare reported and actual reductions at the firm level, we find that 68% of the reports to the 1605(b) program showed positive reductions while the firm's actual emissions rose.

[32] Firms might have reduced emissions compared to the 1605(b) benchmark years (1987-1990) but not compared to our benchmark year, 1995. For instance, this may be the case if firms increased renewable energy generation as a substitute for coal-based generation between the 1605(b) benchmark years and 1995.

[33] The quotes are taken from pages 3-4 of the comments on the 1605(b) program filed by a group of seven environmental groups led by the Natural Resources Defense Council on June 5, 2002, and available on the web at http://www.pi.energy.gov/enhancingGHGregistry/comments/documents/doniger.doc.

includes firms that report only at the project level, and also firms that report at both the project and the entity level, but whose entity-level report is simply the sum of their project-level reductions and hence provides no new information about entity-level behavior. Second are firms that report only at the entity level. 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 IV that the vast bulk of companies that participate in the 1605b program opt to report only at the project level. Furthermore, the percentage who do so rose from 82% in 1995 to 87% in 2003. Selective disclosure is clearly the dominant mode of participating in the 1605(b) program. The aggregate statistics on the program strongly suggest that it has been used by participants as a tool for greenwashing. We turn now to examining the drivers of participation.

Participation

We estimate four alternative probit specifications to analyze what factors motivate firms to participate in the 1605(b) program. These specifications utilize different measures of greenhouse gas emissions, and also explore the role of the interaction between Sierra membership and emissions of CO_2. The results are presented in Table V.

Hypothesis 1 garners moderate support in our estimations, suggesting that opportunities for low-cost abatement indeed played a role in participation decisions. Large firms are significantly more likely to participate, which may reflect the role of scale economies in making participation cost-effective. In addition, firms with growth in net generation three periods earlier were significantly more likely to participate in

1605(b) in all of our models. Firms with high heatrates, and firms with low capacity factors, are more likely to participate, although the effects are not statistically significant. Nor were greater opportunities for savings from fuel switching a significant determinant of participation.

We find strong support for Hypotheses 2a and 2b, namely that larger firms and firms with greater CO_2 emissions are more likely to participate. The coefficient on electric operating revenue is consistently positive and significant in all four specifications. Higher CO_2 emissions, whether measured as total tons of lagged emissions or lagged carbon intensity, are also consistently associated with a significantly greater likelihood of participation. In Models 3 and 4, which include both lagged emissions and lagged intensity, only CO_2 intensity is statistically significant.

Hypothesis 2c, which predicts that firms facing greater external pressure are more likely to participate, receives mixed support. Sierra subscriptions per thousand residents is consistently negative and significant, contrary to the notion that 1605(b) participation was encouraged by activists. (Model 4 shows that the interaction term between Sierra subscriptions and CO_2 emissions, is not statistically significant.) However, League of Conservation Voters scores consistently have positive coefficients, though they are only significant for the House of Representatives. In addition, 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.

Hypothesis 3 receives strong support, suggesting that environmental activists associated with the Sierra Club perceived 1605(b) participation as greenwash and attempted to penalize firms that participated. This result helps to explain why non-participants, who typically have declining emissions over time, elect not to join the program. Data on their total emissions readily show they are improving over time, so they have less need to use the 1605(b) program to prove their environmental credentials. At the same time, staying out of the program avoids the risk of being labeled a greenwasher.

Overall, we find strong evidence that large firms with growing generation were more likely to participate in the DOE's Voluntary Greenhouse Gas Registry; both of these results support the notion that firms with low-cost abatement opportunities were more likely to participate. In addition, we find strong evidence that firms with high carbon emissions intensity were more likely to participate, consistent with prior work on public voluntary programs. Participation was more likely in states with higher LCV scores and states that had not passed RPS legislation, consistent with the notion that external 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.

Treatment Effects

Table VI presents the estimation results of three alternative treatment effect models. The exclusion restriction is satisfied via the electric operating revenue variable.

It has a significant effect on the participation decision, but not on CO_2 emissions intensity, which is already adjusted for the amount of net generation.[34] The three models differ in terms of which other variables are excluded from the second stage estimation, with Model 2 excluding growth in net generation and Model 3 also excluding lagged fuel switch savings. The first stage specifications of the treatment effect models do not include lagged CO_2 emissions. This is because CO_2 emissions intensity, our dependent variable in the second stage, is calculated by dividing the current CO_2 emissions level by net generation and the current and lagged CO_2 emissions are highly correlated with each other, and hence including the CO_2 emissions variable is likely to create an endogeneity problem.

Consistent with our results from the stand-alone probit model, Table VI provides support for Hypotheses 1a (and 2a), 1e, 2b and 2c; that is, firms are more likely to participate in the 1605(b) program if they have high revenues, growth in lagged net generation, high carbon intensity, and greater external pressure. Now we also find support for Hypothesis 1c, that firms with low capacity factors were more likely to participate. In addition, we again find strong support for Hypothesis 3, that activists pressured firms not to participate in 1605(b).

The second-stage estimations of all three Models in Table VI support Hypotheses 4a and 4c: firms with a higher fraction of power from hydroelectric or nuclear sources and higher capacity factors have lower CO_2 emissions intensities. It would be surprising indeed if low-carbon fuel sources such as hydroelectric and nuclear did not reduce

[34] We tested that the electric operating revenue variable does not affect the 2nd stage outcome variable, CO_2 emissions intensity.

emissions intensity; we find the effect is highly significant. Growing demand has a negative effect on carbon intensity, but it is not statistically significant.

Finally, we also find support for Hypothesis 5: although 1605(b) participation has a negative effect on CO_2 emissions intensity, it is insignificant.[35]

Regressions after adjusting for indirect reductions and sequestration

We next explore the role of indirect emissions reductions and sequestration. The CO_2 emissions and emissions intensity variables as used in the participation probit and the treatment effect models are based on fuel consumption data and hence do not reflect the indirect reductions and sequestration reported to the 1605(b) program. Thus, it is potentially important to investigate the role of indirect reductions and sequestration, which would reduce emissions relative to what would be expected from fuel consumption alone.

We are particularly interested in whether the opportunity to report indirect reductions and sequestration provides firms with added or possibly different incentives to participate in the 1605(b) program than does reporting direct reductions alone. This question arises because, as described in the Introduction, firms are required to file their operational and financial performance to FERC including their fossil fuel consumption. This fossil fuel consumption data, which is publicly available, implicitly reveals firms' CO_2 emissions.[36] Thus, even if a utility does not participate in 1605(b), its overall carbon

[35] The correlation coefficient between the first and second stage equations, ρ, is consistently positive across alternative model specifications. This indicates that we would overestimate the impact of the 1605(b) program, if we do not control for selection on unobservables. Yet, the chi-square test statistic shows that we cannot reject the hypothesis that ρ is not significantly different from zero. This in turn tells us that the degree of overestimation due to selection on unobservables, if any, is insignificant.

[36] Fossil fuel consumption broken down by fuel types reveals CO_2 emissions level because there is no commercialized end-of-pipe CO_2 removal technology yet.

footprint can still be verified. When indirect reductions and sequestration are taken into account, however, firms have an additional incentive to participate in the program, so as to report indirect reductions and sequestration that would not be obvious from FERC data. Examining the role of indirect reductions and sequestration also allows us to examine whether 1605(b) participation does indeed make a difference in CO_2 emissions intensity if all types of reductions reported to the program, including direct and indirect reductions and sequestration, are taken into account.

We examine the impact of indirect reductions and sequestration by re-running the same participation probit and treatment effect models as before, but with two new variables: adjusted CO_2 emissions and adjusted CO_2 emissions intensity. The adjusted CO_2 emissions variable is created by subtracting the sum of indirect reductions and sequestration as reported to the 1605(b) program from the fuel consumption-based CO_2 emissions estimates.[37] The adjusted CO_2 emissions intensity variable is obtained by dividing the adjusted CO_2 emissions by net generation.

Tables VII and VIII show the regression results for the probit and treatment effect models, respectively. They are virtually identical to those reported in Table V and Table VI in terms of the significance of the coefficients and their signs. This suggests that the opportunity to report indirect and sequestration projects did not provide much in the way of added or different incentives to participate in the program. However, we do find that with the adjusted CO_2 emissions and intensity variables, 1605(b) participation now has a

[37] Reductions reported to the 1605(b) program include greenhouse gases other than CO_2. The DOE's Voluntary Registry website reports total reductions in terms of CO_2 equivalents.

more negative effect on CO_2 emissions intensity; nevertheless, its effect is still not statistically significant.[38]

VII. Recent Revisions to the 1605(b) Program

The 1605(b) program has recently been substantially revised. In this section, we offer further insight into the motives of firms participating in the 1605(b) program, drawing upon the comments filed by various interested parties in the revision process. On April 15, 2002, the Department of Energy (DOE) issued a Notice of Inquiry requesting public comments on the 1605(b) program, with a goal to "enhance measurement accuracy, reliability and verifiability, working with and taking into account emerging domestic and international approaches."[39] Over one hundred sets of written comments were filed,[40] and six public workshops were held to discuss the program. After soliciting public comments, the DOE on April 21, 2006, published in the Federal Register the final revised General Guidelines governing the Voluntary Reporting of Greenhouse Gases (1605(b)).[41]

Perhaps the most significant change in the 1605(b) program is that the revised guidelines place greater emphasis on entity-wide reporting. Large emitters interested in not just "reporting" reductions, but also formally "registering" them must submit entity-wide emission inventories.[42] To the extent that "registered" reductions are more likely to

---

[38] In a separate regression, we also examined whether 1605(b) participation had any measurable effect on reductions in CO_2 emissions intensity over the period 1995-2003. We did not find any significant effect of 1605(b) participation.

[39] U.S. Department of Energy, "Voluntary Reporting of Greenhouse Gas Emissions, Reductions, and Carbon Sequestration," Federal Register: May 6, 2002 (Volume 67, Number 87), pp. 30370-30373.

[40] The comments can be found at http://www.pi.energy.gov/enhancingGHGregistry/commentsspring2002.html.

[41] The revised General Guidelines referenced Technical Guidelines dated March 2006 that were made available on the internet.

[42] DOE, Guidelines for Voluntary Greenhouse Gas Reporting, General Guidelines Finalized 04/21/06.

be granted early reduction credits (ERCs),[43] this change in reporting rules discourages companies from the selective reporting of good news.

Electric utility companies fought hard against requiring entity-wide inventories for registering reductions. The Edison Electric Institute (EEI), the trade association of investor-owned electric utility companies, argued that firms have many motives for participating, including (p. 7) "the recordation of transferable credit, baseline protection and credit for past actions" and "public relations material and releases and annual reports." The bulk of the EEI comments are oriented towards transferable credits, though, and EEI reluctantly admits that (p. 7) "If the purpose is to obtain transferable credits…the reporting under the revised guidelines may need to be more rigorous in the criteria to be applied…" Even then, however, it maintains that (p. 7) "these criteria should not, and need not, be dependent on entity-wide reporting."

The EEI gives a hypothetical example (pp. 4-5) that crystallizes its views. It posits a predominantly nuclear-fueled utility whose sales grow over a decade from 32.6 terawatthours (TWH) to 35.7 TWH, and whose carbon emissions increase from 12.3 to 13.6 million tons. The utility meets the new demand with natural gas, and undertakes two other "projects": an increase in the heat rate of a coal plant, and a demand-side management program to reduce peak demand; its overall carbon intensity is unchanged. The firm's aggregate GHG emissions have risen by about 10%, however. The EEI complains that "Under an approach where transferable credits could only be earned for

[43] Free market advocates such as Competitive Enterprise Institute (CEI) oppose the idea of ERCs, arguing that the introduction of ERCs effectively facilitates the adoption of a mandatory Kyoto-style cap-and-trade program. Companies with ERCs will lobby for such a program, since ERCs are valuable only under such circumstances. CEI further states that early action crediting was the centerpiece of a Clinton-Gore strategy to divide and conquer business opponents of the Kyoto Protocol. CEI, Public comments on DOE's notice of inquiry on ways to enhance the existing greenhouse gas registry, spring 2002. http://www.pi.energy.gov/enhancingGHGregistry/commentsspring2002.html

absolute reductions in entity-wide emissions, this utility would receive no credits…However, in examining this utility's actions more closely, one sees that it provided real emissions reductions. As a result, it would need to be able to report at a project level in order to receive credit for the two actions that do make such contributions."

The EEI example perfectly mirrors our empirical results. The firm faces increasing demand, and increases its aggregate carbon emissions over time. Nevertheless, it wants to obtain early reduction credits, so it participates in 1605(b) in order to highlight two individual projects, while electing not to report on the 1.3 million ton increase in its overall GHG emissions.

In opposition to EEI, the Natural Resources Defense Council (NRDC), an environmental NGO, condemned project-level reporting, arguing that it allows companies to "cherry pick" the projects they want to report:

> "Without full and transparent entity-wide emissions accounting, project-based reporting weakens the system and undermines the value of real reductions by providing opportunities for gaming the system and claiming hypothetical reductions while emissions are actually increasing. While companies report their entity-wide emissions, there is no reason to continue providing for a separate registry on a project basis, since any legitimate project-based activity is automatically incorporated in company-wide totals and will show up as part of the firm's changes in total emissions from year to year." (NRDC, p.4)[3]

After considering both points of view, DOE voiced a similar rationale for why it finally decided to require entity-wide registration under the revised guidelines:

> "…Because most large companies and institutions regularly take actions that have as one of their effects the reduction of greenhouse gas emissions, there are always many candidates for project-based emission reductions. But the net effect of such project-based reductions on an entity's total emissions is often questioned, because large entities may be taking actions that reduce emissions, while simultaneously taking other actions that increase emissions. Furthermore, it is

impossible to evaluate the significance of a particular entity's actions to reduce emissions unless the total emissions of that entity are known." (DOE, p.19)[44]

In the end, the utilities lost in 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. It also reinforces the argument that the 1605(b) program, as originally created, served as a vehicle for corporate greenwash.

VIII. Conclusion

We have presented what is to our knowledge the first empirical analysis of the factors that lead electric utilities to participate in the Department of Energy's Voluntary Greenhouse Gas Registry, and the impact of participation on their actual emissions performance. 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 find that in the aggregate, participants in the Voluntary Registry increased emissions over time but reported reductions, while non-participants decreased emissions over time. At the firm level, participants tended to have high carbon dioxide emissions, and high carbon intensity. Thus, our results demonstrate a negative relationship between environmental performance and environmental disclosures. Furthermore, we find that participating in the program had no significant effect on a firm's carbon intensity.

---

[44] DOE, Guidelines for Voluntary Greenhouse Gas Reporting, General Guidelines Finalized 04/21/06.

Our results clearly demonstrate that participants in the 1605(b) program engaged in selective disclosure of positive environmental results. Further, we find evidence that political or public relations factors played important but subtle roles in firms' disclosure behavior; "greener" House attitudes on environmental issues increased participation, as did the possibility that a state would impose an RPS in the future. However, 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.

Why did non-participants decline to register for a chance at early reductions credits? The answer is presumably that the benefits of participation did not justify the costs of joining the program. Non-participants tended to be smaller firms serving areas with stagnant demand, and they tended to have relatively low carbon emissions intensity to start with, making further reductions more difficult. They also faced relatively little political pressure to participate, since their emissions were declining over time, and on average their Congressional representatives had weaker records of environmental support. For these firms, the gains of participation may have been outweighed by the risk they would be branded as greenwashers, especially since there was no certainty that a future Congress would allow early reduction credits.

The DOE's Voluntary Greenhouse Gas Registry affords an unusual opportunity for quantitative analysis of corporate disclosure behavior. Our results confirm that firms are highly selective in what they report, typically disclosing positive information but withholding information that is not favorable to them. In this case, however, disclosures appear to have been targeted not at investors or consumers, but at government regulators. Furthermore, an interesting wrinkle is that the form of disclosure itself (e.g., project-based or entity-wide) constituted a form of advocacy regarding the terms on which future regulators should allocate early reduction credits. Finally, our finding that dirtier firms engage in more disclosure of specific emissions reduction projects highlights the fact that firms make joint decisions regarding projects and disclosure strategies. Although a seemingly obvious point, this observation has not yet made it into the theoretical literature on disclosure, which has focused on disclosure decisions taking project choices as exogenously given. Allowing for endogenous project choice would open the door to a new generation of models that yield new insights into corporate environmental behavior.

APPENDIX

In this appendix we present three case studies (American Electric Power, Southern Company, and Exelon Corporation) on projects reported to the 1605(b) program.

American Electric Power

American Electric Power (AEP) participates at the project level and reported a total of 100 projects in 2003. 15 of them are about electricity generation, transmission, and distribution, 4 about energy end use, and 77 about carbon sequestration. AEP also reported 1 halogenated substance and 4 other emission reduction projects.

More than half of the electricity generation, transmission and distribution projects relate to non-fossil fuel units, such as increases in solar and wind power capacity and availability, and efficiency improvement at nuclear and hydro units. For example, the nuclear projects improve availability by decreasing the length of refueling outages and reducing forced outage rates by enabling certain maintenance activities, which used to be performed only during outages, to be performed with the unit online. The hydro projects improve efficiency and extend the life of aging equipment through facility improvement. A few projects report activities related to coal-fired units: improving heatrate via non-routine activities such as operational changes, equipment replacement and load optimization, and adding gas capability to previously coal-fired units.

The energy end use projects encourage efficient energy use by providing incentives for homeowners, commercial and industrial customers to adopt more efficient equipment and to use lighting more efficiently. Of AEP's projects, 77% involve carbon sequestration, most of which is accomplished by afforestation and reforestation through tree planting. The halogenated substance project involves sulfur hexafluoride (SF_6) gas reduction. SF_6 is a GHG that has about 22,000 times higher global warming potential per unit than carbon dioxide (CO_2), the most abundant GHG (EIA, 2004). AEP achieved SF_6 reduction by replacing high-volume leaky circuit breakers with low-volume ones. Other emission reduction projects are fly ash utilization and Enviro Tech Investment funds. The fly ash program recycles fly ash (a coal combustion byproduct) as a substitute for Portland cement in concrete production. This eliminates the need to dispose of the fly ash and at the same time reduces CO_2 emissions from manufacturing Portland cement. Enviro Tech Investment funds refer to funds that are exclusively used for investment in companies, both US and foreign, that perform R&D on products that reduce energy consumption.

Southern Company

Southern Company (SO) participates both at the entity and the project level, although the sum of the project level reductions is the same as the entity level reduction. In 2003 SO reported a total of 35 projects. Fifteen involve electricity generation, transmission, and distribution, 3 involve cogeneration and waste heat recovery, 1 affects energy end use, 2 are about transportation and off-road vehicles, and 12 about sequestration. SO also reported halogenated substance and "other" emissions reduction projects.

About half of the electricity generation, transmission and distribution projects are similar to those reported by AEP, but SO also reported seven "other" projects. They include nuclear capacity uprating, natural gas-based combustion turbine and combined cycle units, biomass and switchgrass projects. Nuclear capacity uprating refers to increasing the maximum power level at which nuclear power units operate, which requires NRC approval. Nuclear capacity uprating is equivalent to increasing low carbon emitting capacity. The increases in natural gas fired units (new combustion turbine and combined cycle units) represent CO_2 reductions compared to coal-fired generation. SO was also investigating the feasibility and profitability of co-firing biomass and switchgrass with coal. Two of its subsidiaries, Georgia Power and Mississippi Power, have co-fired biomass with coal. Cofiring with switchgrass is still at an experimental stage.

The cogeneration and waste heat recovery projects report the use of natural gas at cogeneration plants, that is, plants that produce both electricity and steam. CO_2 reduction is achieved in two ways. One is by using a low emitting fuel source, natural gas, instead of coal. The other is by utilizing heat that would otherwise have been discarded. Had the same amount of heat been generated separately, CO_2 emissions would have been greater no matter what fuel sources were used. The energy end-use project promotes energy efficiency in residential, commercial and industrial sectors. The transportation and off-road vehicles projects report how SO supports the operation of alternative fuel vehicles, and promotes carpooling and mass transit use for its employees. The projects on carbon sequestration, halogenated substances and other emissions reduction are similar to those reported by AEP.

Exelon Corporation

Exelon Corporation (EXC) participates at the project level and reported a total of 42 projects in 2003. Twenty six involve electricity generation, transmission, and distribution, 1 involve cogeneration and waste heat recovery, 4 affects energy end use, 2 are about transportation and off-road vehicles, 3 about waste treatment and disposal, 1 about oil and natural gas systems and coal mining, and 4 about carbon sequestration. EXC also reported one “other” emission reduction project.

All of the electricity generation, transmission and distribution projects are about non-fossil fuel units. Eleven projects reported nuclear uprating, 9 reported wind and solar energy-related efforts, 5 reported hydro facility overhauls, and 1 reported improvement in distribution efficiency. Wind and solar energy related projects cover a wide range of applications from installing new facilities to raising public awareness of alternative energy resources and renewable energy markets. EXC overhauled seven hydro units to improve unit efficiency and overall plant capacity.

The cogeneration and waste heat recovery project reported fuel switching from coal to natural gas and installing heat exchange equipment. In addition to typical efficiency improvement projects, the energy end-use projects include a load control program which provides incentives for large commercial and industrial customers to cut electric loads upon request during peak periods. Transportation and off-road vehicle projects report how widely EXC invests in alternative fuel vehicles and uses them in its facilities. The waste treatment and disposal projects are about using landfill gas to generate energy; this reduces emissions of methane, which has 23 times higher global warming potential than CO_2 (EIA, 2004). The project on oil and natural gas systems and coal mining reports improvement of the natural gas distribution system. Carbon sequestration was mostly done by tree planting but also by recycling some wood utility poles. Each pole reused represents a tree that was not cut down to manufacture a new utility pole. The "other" emission reduction project reported recycling of materials including paper and metals, which can reduce GHG emissions by displacing the production of these products from alternative sources, which may require more energy intensive production processes.

Table 2-1 Explanatory variables and their definitions

Variables (proxy for)	Definition (unit of measurement)
Lagged CO_2 emissions	Lagged (t-1) total carbon dioxide (CO_2) emissions (10^9 lbs) 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 CO_2 emissions by multiplying by 3.7, the molecular weight of CO_2 relative to carbon,,. When carbon input data is missing but Platts' emission data are non-missing, Platts' emission data are used instead.**
CO_2 emissions intensity	CO_2 emissions per net generation (lbs/MWh). Net generation (MWh) is defined as the amount of gross generation less the electrical energy consumed at generating stations.
Sierra magazine subscription per thousand population	Number of subscriptions to Sierra magazine per thousand population at the state level in 2000.
Electric operating revenue	Revenue from sales of electricity (10^9 \$).
Heatrate	The ratio of heat input to net energy generated (Btu/kWh).
Capacity factor	The ratio of energy generated to the maximum that could have been generated. It is calculated by dividing net generation (MWh) by (nameplate capacity (MW)×8760(hours)).
Fraction of hydro and nuclear	The ratio of energy generated from hydro and nuclear units to total energy generated.
LCV scores	The League of Conservation Voters (LCV)'s scorecards for U.S. Senate and House.
RPS index	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.***
Lagged fuel switch saving	Lagged (t-1) low cost and low carbon fuel switching opportunity (10^6 \$). Estimated for the month with the highest generation for the year, this is calculated by ordering generators from 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.
Lagged SO_2 emissions	Lagged (t-1) sulfur dioxide (SO_2) emissions (10^9 lbs).
Lagged 1605(b) participation trend	Lagged (t-1) total number of 1605(b) participants in the electric power sector****
Growth in generation (t-1, t-2, and t-3)	Percentage growth relative to years t-1, t-2, and t-3.
Interaction between lagged CO_2 emissions and Sierra Subscription	This is obtained by multiplying the values for lagged CO_2 emissions (10^9 lbs) and the number of Sierra subscriptions per thousand population.

* *Documentation for Emissions of Greenhouse Gases in the U.S. 2003*, EIA (2005), p. 189.

** An adjustment factor is calculated to convert Platts' CO_2 emissions data to fuel-based CO_2 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 percent relative to fuel-based estimates. www.nrdc.org/air/energy/rbr/append.asp.

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

**** *Voluntary reporting of Greenhouse Gases 2003*, EIA (2005), p. 4.

Table 2-2 Descriptive statistics for explanatory variables

Variable (unit)	Entire sample N=596	1605(b) Participants N=309	1605(b) Non-Participants N=287
Lagged CO_2 emissions (10^9 lbs)			
Mean	17.751	24.966	9.984
Standard Deviation	16.817	19.096	8.883
Min	0.006	0.130	0.006
Max	109.224	109.224	30.203
CO_2 emissions intensity (lbs/MWh)			
Mean	1172.405	1246.034	1093.133
Standard Deviation	690.168	740.465	623.171
Min	0.351	7.201	0.351
Max	4659.061	4659.061	3590.840
Sierra magazine subscription per thousand population			
Mean	0.721	0.671	0.775
Standard Deviation	0.420	0.288	0.522
Min	0.237	0.287	0.237
Max	3.760	1.572	3.760
Electric operating revenue (10^9 \$)			
Mean	1.431	2.158	0.649
Standard Deviation	1.596	1.874	0.576
Min	0.011	0.226	0.011
Max	8.906	8.906	3.626
Heatrate (Btu/kWh)			
Mean	9899.740	9900.724	9898.682
Standard Deviation	1801.146	1332.374	2199.402
Min	0	1103.420	0
Max	14379.810	11859.420	14379.810
Capacity Factor			
Mean	0.529	0.514	0.545
Standard Deviation	0.140	0.133	0.145
Min	0.065	0.154	0.065
Max	0.880	0.821	0.880
Fraction of Hydro and Nuclear			
Mean	0.141	0.174	0.105
Standard Deviation	0.273	0.270	0.272
Min	0	0	0
Max	1.392	1.392	1.000
LCV scores: Senate			
Mean	39.242	42.634	35.589
Standard Deviation	31.537	31.056	31.696
Min	0	0	0
Max	100	100	100
LCV scores: House			
Mean	39.773	42.922	36.383
Standard Deviation	19.628	18.148	20.604
Min	0	4	0
Max	100	94	100

RPS index			
Mean	0.085	0.082	0.088
Standard Deviation	0.270	0.268	0.271
Min	0	0	0
Max	1.833	1.833	1.429
Lagged fuel Switch Saving (10^6 $)			
Mean	0.020	0.028	0.010
Standard Deviation	0.088	0.099	0.073
Min	0	0	0
Max	1.205	0.815	1.205
Lagged SO_2 emissions (10^9 lbs)			
Mean	0.137	0.195	0.075
Standard Deviation	0.178	0.221	0.078
Min	0	0	0
Max	1.148	1.148	0.466
Lagged 1605(b) participation trend			
Mean	106.292	106.220	106.369
Standard Deviation	5.226	5.192	5.271
Min	99	99	99
Max	115	115	115
Growth in net generation (t-1)			
Mean	0.023	0.007	0.040
Standard Deviation	0.206	0.157	0.248
Min	-0.933	-0.933	-0.317
Max	3.207	1.067	3.207
Growth in net generation (t-2)			
Mean	0.053	0.027	0.082
Standard Deviation	0.289	0.205	0.357
Min	-0.930	-0.930	-0.412
Max	3.628	1.233	3.628
Growth in net generation (t-3)			
Mean	0.528	0.887	0.141
Standard Deviation	10.653	14.789	0.513
Min	-0.917	-0.917	-0.452
Max	259.973	259.973	4.423
Interaction between lagged CO_2 Emissions and Sierra subscription ((10^9 lbs)× (thousands))			
Mean	87.135	133.600	37.108
Standard Deviation	104.083	122.511	39.120
Min	0.009	0.371	0.009
Max	514.013	514.013	170.394

Table 2-3 Variable Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)																
(2)	0.153															
(3)	-0.0972	-0.0615														
(4)	0.5034	-0.1936	-0.1285													
(5)	0.1543	0.2869	-0.3816	-0.1288												
(6)	0.0594	-0.2104	-0.1107	-0.0068	0.0644											
(7)	-0.1291	-0.3506	0.2874	0.3588	-0.679	-0.1841										
(8)	-0.1508	-0.0582	0.2706	0.139	-0.1211	-0.096	0.1799									
(9)	-0.1079	-0.0351	0.3958	0.1409	-0.2019	-0.0486	0.1593	0.6624								
(10)	-0.0607	-0.0079	-0.196	0.1517	-0.0024	-0.0244	0.0379	0.0685	0.1208							
(11)	0.0953	-0.0123	-0.0119	0.1545	-0.0201	-0.0325	0.0521	0.0604	0.0405	0.1284						
(12)	0.7395	-0.0218	-0.0761	0.3656	0.0524	0.1656	-0.1183	-0.1208	-0.0678	-0.1442	0.058					
(13)	-0.0776	-0.0465	-0.0234	-0.0503	0.0056	-0.013	-0.0047	0.0648	0.0401	-0.2183	-0.0627	0.0124				
(14)	-0.0524	-0.0997	0.1227	-0.1031	-0.0171	0.0945	0.0105	-0.0535	-0.06	-0.0568	0.0031	0.0123	0.0506			
(15)	-0.0681	-0.1002	0.1944	-0.1368	-0.0458	0.0488	0.0598	-0.0474	-0.0286	-0.0793	-0.0184	0.0039	0.0954	0.5757		
(16)	0.0005	0.0127	-0.0066	-0.0224	0.012	-0.0651	-0.0181	-0.0491	-0.0255	-0.0164	-0.0095	0.0139	-0.0292	-0.0126	0.0357	
(17)	0.8812	0.1203	-0.0515	0.5343	0.0676	0.0833	-0.077	-0.0117	0.0825	0.0291	0.072	0.7268	-0.0483	-0.0604	-0.0793	-0.0143

(1) Lagged CO_2 emissions (2) CO_2 emissions intensity (3) Sierra magazine subscription per thousand population (4) Electric operating revenue (5) Heatrate (6) Capacity factor (7) Fraction of Hydro and Nuclear (8) LCV scores: Senate (9) LCV scores: House (10) RPS index (11) Lagged fuel switch saving (12) Lagged SO_2 emissions (13) Lagged 1605(b) participation trend (14) Growth in net generation (t-1) (15) Growth in net generation (t-2) (16)) Growth in net generation (t-3) (17) Interaction between lagged CO_2 emissions and Sierra subscription

Table 2-4 Number of Firms Reporting at the Entity and Project Levels*

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Project[1]	58	56	57	57	58	60	59	60	82
Entity Only	6	6	5	5	5	5	5	4	4
Entity $\neq$ Project[2]	8	10	10	10	10	10	10	10	10

[*] Includes 1605b participants categorized as Electric Providers.
[1] indicates the 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.
[2] indicates the number of firms whose reported entity-level reductions are not equal to the sum of project-level reductions.

Table 2-5 1605b Participation Probit

Variable	Model 1	Model 2	Model 3	Model 4
Lag CO_2 Emissions	4.179e-02* (2.234e-02)		2.54e-02 (2.355e-02)	5.78e-03 (3.418e-02)
Lag CO_2 Emissions Intensity		5.639e-04*** (2.031e-04)	4.614e-04** (2.083e-04)	4.141e-04** (2.015e-04)
Sierra Subscription per thousand population	-1.419** (0.680)	-1.492** (0.619)	-1.489** (0.617)	-1.526** (0.679)
Electric Operating Revenue	6.447e-01** (0.316)	1.029*** (0.277)	8.171e-01** (0.349)	8.400** (0.371)
Heatrate	-1.96e-05 (9.787e-05)	-2.75e-05 (1.010e-04)	-3.96e-05 (9.762e-05)	-2.17e-05 (9.752e-05)
Capacity factor	-1.84 (1.207)	-1.36 (1.107)	-1.39 (1.136)	-1.43 (1.137)
Fraction of hydro & nuclear	0.531 (0.881)	0.705 (0.946)	0.779 (0.919)	0.820 (0.894)
LCV score: Senate	4.90e-03 (5.590e-03)	5.32e-03 (5.637e-03)	5.39e-03 (5.567e-03)	5.31e-03 (5.554e-03)
LCV score: House	2.391e-02** (1.075e-02)	2.052e-02** (1.047e-02)	2.301e-02** (1.081e-02)	1.924e-02* (1.082e-02)
RPS index	-1.162** (0.480)	-1.178** (0.493)	-1.179** (0.505)	-1.442*** (0.492)
Lag Fuel Switch Saving	0.111 (0.751)	0.414 (0.814)	0.154 (0.748)	0.203 (0.811)
Lag SO_2 Emissions	0.569 (1.735)	2.21 (1.861)	1.25 (1.915)	
Lag 1605b reporting Trend	-6.87e-03 (8.871e-03)	-8.77e-03 (8.298e-03)	-6.70e-03 (8.842e-03)	-7.16e-03 (8.908e-03)
Growth in net generation (t-1)	2.19e-02 (0.128)	5.14e-02 (0.133)	6.77e-02 (0.129)	9.68e-02 (0.129)
Growth in net generation (t-2)	-3.03e-02 (0.287)	-8.15e-02 (0.273)	-4.92e-02 (0.268)	-3.08e-02 (0.268)
Growth in net generation (t-3)	1.150e-02** (5.252e-03)	1.033e-02*** (2.587e-03)	1.079e-02*** (2.784e-03)	1.149e-02*** (2.881e-03)
Interaction between Lag CO_2 Emissions and Sierra subscription				5.43e-03 (5.335e-03)
Constant	0.417 (1.629)	-2.08e-02 (1.636)	-0.153 (1.644)	4.81e-02 (1.701)
Observations	596	596	596	596
Count R^2	0.795	0.820	0.817	0.826
Adjusted Count R^2	0.575	0.627	0.620	0.638
Log Likelihood	-252.723	-247.784	-245.159	-242.729
χ^2[15]	67.96{0}	83.92 {0}		
χ^2[16]			85.81 {0}	85.06 {0}

Table 2-6 Treatment Effect Models

Variable	Model 1: 2nd stage: CO_2 Intensity	Model 1: 1st stage: 1605b Participation	Model 2: 2nd stage: CO_2 Intensity	Model 2: 1st stage: 1605b Participation	Model 3: 2nd stage: CO_2 Intensity	Model 3: 1st stage: 1605b Participation
Sierra Subscription per thousand population	63.2 (2.337e+02)	-1.358** (0.536)	32.4 (2.421e+02)	-1.381** (0.548)	34.1 (2.230e+02)	-1.381** (0.549)
Heatrate	3.59e-02 (3.267e-02)	-1.45e-05 (1.044e-04)	3.31e-02 (3.168e-02)	-1.49e-05 (1.054e-04)	3.30e-02 (3.158e-02)	-1.45e-05 (1.021e-04)
Capacity factor	-1.379e+03** (5.423e+02)	-2.041* (1.158)	-1.412e+03*** (5.360e+02)	-2.059* (1.166)	-1.409e+03*** (4.641e+02)	-2.056* (1.139)
Fraction of hydro & nuclear	-8.456e+02*** (2.737e+02)	0.191 (0.873)	-8.661e+02*** (2.600e+02)	0.182 (0.873)	-8.679e+02*** (2.247e+02)	0.183 (0.874)
LCV score: Senate	-1.23 (1.798)	4.36e-03 (5.508e-03)	-1.13 (1.80)	4.42e-03 (5.535e-03)	-1.13 (1.780)	4.43e-03 (5.537e-03)
LCV score: House	1.92 (5.316)	2.007e-02** (9.941e-03)	2.13 (5.457)	2.028e-02** (1.002e-02)	2.09 (4.712)	2.027e-02** (1.001e-02)
RPS index	-12.5 (1.687e+02)	-1.078** (0.487)	-7.48 (1.693e+02)	-1.082** (0.484)	-4.88 (1.645e+02)	-1.083** (0.472)
Lag Fuel Switch Saving	57.6 (1.850e+02)	0.338 (0.759)	48.0 (1.783e+02)	0.347 (0.769)		0.320 (0.753)
Growth in net generation (t-1)	-1.72e+02 (1.263e+02)	-6.08e-02 (1.673e-01)		5.68e-02 (0.139)		5.65e-02 (0.138)
Growth in net Generation (t-2)	-1.16e+02 (1.311e+02)	-0.156 (0.295)		-7.65e-02 (0.252)		-7.66e-02 (0.253)
Growth in net generation (t-3)	-0.647 (0.653)	8.889e-03*** (3.114e-03)		9.403e-03*** (2.944e-03)		9.427e-03*** (2.534e-03)
Lag SO_2 Emissions	24.5 (4.103e+02)	2.04 (1.726)	4.49 (4.004e+02)	2.04 (1.731)		2.04 (1.738)
1605b Participation	-1.09E+02 (3.784e+02)		-90.4 (3.715e+02)		-85.0 (2.116e+02)	
Electric Operating Revenue		0.944*** (0.308)		0.950*** (0.303)		0.951*** (0.275)
Lag 1605b reporting		-7.90e-03 (7.824e-03)		-7.95e-03 (7.804e-03)		-7.97e-03 (7.706e-03)
Trend						
Constant	1.655e+03*** (4.579e+02)	0.923 (1.640)	1.695e+03*** (4.571e+02)	0.936 (1.653)	1.694e+03*** (4.511e+02)	0.931 (1.609)
Observations	596	596	596	596	596	596
Log likelihood	-4917.197		-4919.943		-4919.957	
$\chi^2[13]$	220.99 {0}					
$\chi^2[10]$			58.00 {0}			
$\chi^2[8]$					55.25 {0}	
ρ	0.429 (0.352)		0.413 (0.350)		0.408 (0.206)	
$\chi^2[1]$, ρ=0	1.13 {0.29}		1.08 {0.30}		3.05 {0.08}	

Robust standard errors are in parenthesis. Degrees of freedom are in square brackets. P values are in curly brackets. χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero. ρ is the correlation coefficient between the error terms of the first-stage participation and the second-stage outcome equations. $\chi^2[1]$, ρ=0 tests the independence of the two equations. * Significant at 10%; ** Significant at 5%; *** Significant at 1% (all two-tailed tests).

Table 2-7 1605(b) Participation Probit after Adjusting for Indirect Reduction and Sequestration

Variable	Model 1	Model 2	Model 3	Model 4
Adjusted Lag CO_2 Emissions	3.861e-02* (2.236e-02)		2.31e-02 (2.345e-02)	5.77e-04 (3.382e-02)
Adjusted Lag CO_2 Intensity		5.182e-04*** (2.009e-04)	4.230e-04** (2.063e-04)	3.744e-04* (1.993e-04)
Sierra Subscription per thousand population	-1.397** (0.679)	-1.456** (0.620)	-1.446** (0.617)	-1.500** (0.691)
Electric Operating Revenue	6.744e-01** (0.319)	1.028e+00*** (0.277)	8.368e-01** (0.350)	8.614e-01** (0.372)
Heatrate	-1.98e-05 (9.788e-05)	-2.72e-05 (1.002e-04)	-3.90e-05 (9.715e-05)	-1.69e-05 (9.772e-05)
Capacity factor	-1.85 (1.200)	-1.41 (1.107)	-1.44 (1.134)	-1.50 (1.137)
Fraction of hydro & nuclear	0.484 (0.887)	0.644 (0.943)	0.699 (0.922)	0.767 (0.894)
LCV score: Senate	4.79e-03 (5.600e-03)	5.13e-03 (5.646e-03)	5.17e-03 (5.578e-03)	5.16e-03 (5.570e-03)
LCV score: House	2.364e-02** (1.072e-02)	2.060e-02** (1.043e-02)	2.288e-02** (1.075e-02)	1.855e-02* (1.065e-02)
RPS index	-1.156** (0.476)	-1.173** (0.490)	-1.172** (0.500)	-1.462*** (0.489)
Lag Fuel Switch Saving	0.146 (0.756)	0.419 (0.816)	0.182 (0.753)	0.241 (0.828)
Lag SO_2 Emissions	0.681 (1.739)	2.18 (1.846)	1.30 (1.897)	
Lag 1605(b) reporting Trend	-7.12e-03 (8.787e-03)	-8.78e-03 (8.238e-03)	-6.93e-03 (8.738e-03)	-7.60e-03 (8.805e-03)
Growth in net generation (t-1)	2.09e-02 (0.125)	4.64e-02 (0.130)	6.29e-02 (0.126)	9.39e-02 (0.126)
Growth in net generation (t-2)	-3.32e-02 (0.286)	-8.35e-02 (0.273)	-5.29e-02 (0.268)	-3.58e-02 (0.267)
Growth in net generation (t-3)	1.143e-02** (5.013e-03)	1.032e-02*** (2.600e-03)	1.077e-02*** (2.786e-03)	1.149e-02*** (2.872e-03)
Interaction between Lag CO_2 Emissions and Sierra subscription				6.07e-03 (5.325e-03)
Constant	0.464 (1.623)	5.50e-02 (1.624)	-5.46e-02 (1.629)	0.169 (1.688)
Observations	594	594	594	594
Count R^2	0.793	0.816	0.820	0.825
Adjusted Count R^2	0.571	0.620	0.627	0.638
Log Likelihood	-253.960	-249.695	-247.493	-244.191
$\chi^2[15]$	68.21 {0}	82.61 {0}		
$\chi^2[16]$			84.41 {0}	83.53 {0}

Table 2-8 Treatment Effect Models after Adjusting for Indirect Reductions and Sequestration

	Model 1		Model 2		Model 3	
Variable	2nd stage: Adjusted CO_2 intensity	1st stage: 1605(b) Participation	2nd stage: Adjusted CO_2 intensity	1st stage: 1605(b) Participation	2nd stage: Adjusted CO_2 intensity	1st stage: 1605(b) Participation
Sierra Subscription per thousand population	32.4 (2.403e+02)	-1.347*** (0.520)	3.50 (2.487e+02)	-1.368** (0.532)	13.4 (2.287e+02)	-1.367** (0.547)
Heatrate	4.09e-02 (3.264e-02)	-1.62e-05 (1.037e-04)	3.83e-02 (3.181e-02)	-1.66e-05 (1.048e-04)	3.70e-02 (3.119e-02)	-1.46e-05 (1.013e-04)
Capacity factor	-1.400e+03** (5.534e+02)	-2.065* (1.158)	-1.434e+03*** (5.483e+02)	-2.084* (1.168)	-1.409e+03*** (4.625e+02)	-2.061* (1.138)
Fraction of hydro & nuclear	-7.942e+02*** (2.778e+02)	0.188 (0.874)	-8.158e+02*** (2.663e+02)	0.177 (0.874)	-8.341e+02*** (2.246e+02)	0.176 (0.880)
LCV score: Senate	-1.07 (1.813)	4.33e-03 (5.496e-03)	-0.992 (1.816)	4.38e-03 (5.521e-03)	-1.01 (1.779)	4.38e-03 (5.555e-03)
LCV score: House	2.08 (5.340)	2.032e-02** (9.987e-03)	2.29 (5.495)	2.052e-02** (1.008e-02)	2.06 (4.651)	2.048e-02** (1.006e-02)
RPS index	-26.5 (1.70e+02)	-1.078** (0.487)	-20.9 (1.708e+02)	-1.081** (0.485)	-19.9 (1.654e+02)	-1.095** (0.470)
Lag Fuel Switch Saving	25.5 (1.998e+02)	0.288 (0.765)	16.2 (1.924e+02)	0.297 (0.775)		0.319 (0.760)
Growth in net generation (t-1)	-1.73e+02 (1.253e+02)	-6.63e-02 (0.176)		5.52e-02 (0.142)		5.34e-02 (0.137)
Growth in net Generation (t-2)	-1.10e+02 (1.330e+02)	-0.158 (0.298)		-8.06e-02 (0.251)		-8.05e-02 (0.253)
Growth in net generation (t-3)	-0.590 (0.668)	8.841e-03*** (3.159e-03)		9.321e-03*** (3.023e-03)		9.481e-03*** (2.518e-03)
Lag SO_2 Emissions	87.7 (4.315e+02)	2.04 (1.712)	69.7 (4.246e+02)	2.04 (1.717)		2.01 (1.741)
1605(b) Participation	-1.48e+02 (3.941e+02)		-1.31e+02 (3.896e+02)		-94.5 (2.085e+02)	
Electric Operating Revenue		0.943*** (0.311)		0.948*** (0.307)		0.959*** (0.272)
Lag 1605(b) reporting Trend		-7.81e-03 (7.835e-03)		-7.86e-03 (7.814e-03)		-7.98e-03 (7.708e-03)
Constant	1.623e+03*** (4.560e+02)	0.933 (1.635)	1.662e+03*** (4.558e+02)	0.946 (1.650)	1.659e+03*** (4.437e+02)	0.919 (1.598)
Observations	594	594	594	594	594	594
Log likelihood	-4904.654		-4907.236		-4907.287	
χ^2[13]	204.65					
χ^2[10]			52.41			
χ^2[8]					51.93	
ρ	0.441 (0.362)		0.427 (0.362)		0.393 (0.203)	
χ^2[1], ρ=0	1.11 {0.29}		1.06 {0.30}		3.00 {0.08}	

Robust standard errors are in parenthesis. Degrees of freedom are in square brackets. P values are in curly brackets. χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero. ρ is the correlation coefficient between the error terms of the first-stage participation and the second-stage outcome equations. χ^2[1], ρ=0 tests the independence of the two equations.
* Significant at 10%; ** Significant at 5%; *** Significant at 1% (all two-tailed tests).

Figure 2-1 1605(b) Reported Reductions (IOUs) vs. Actual Reductions (IOUs)

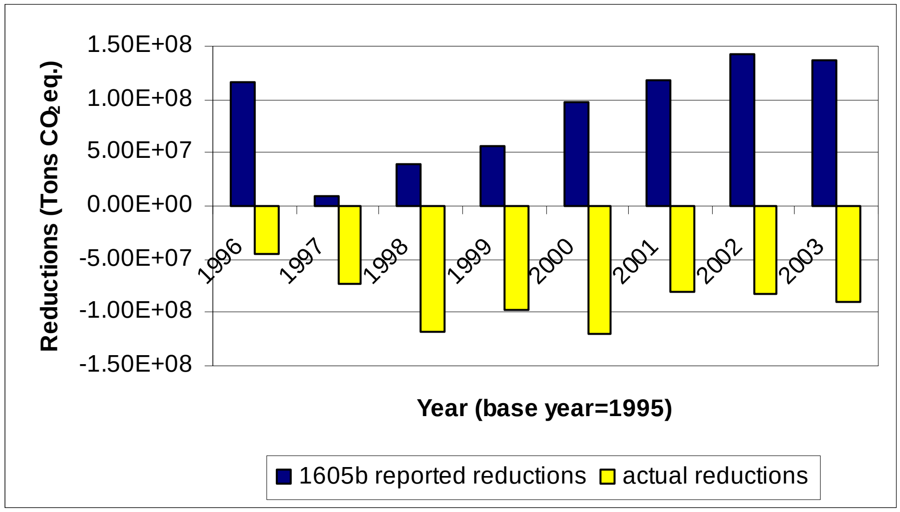
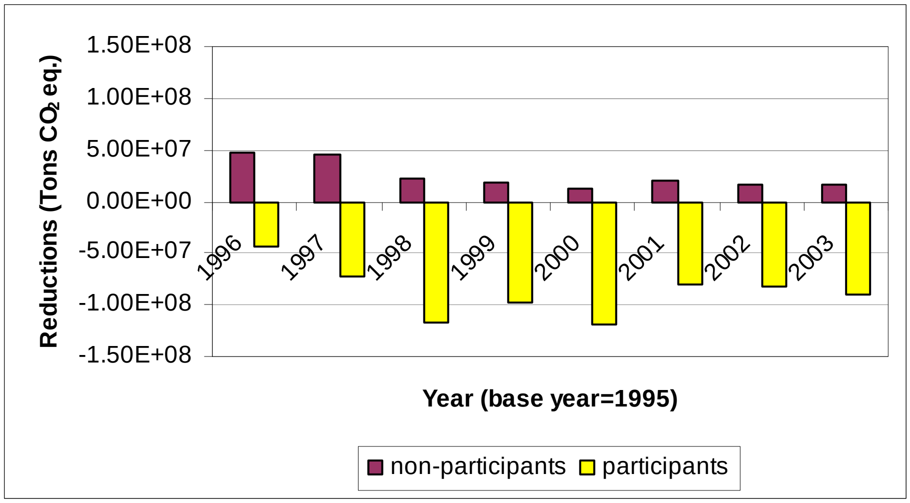


Figure 2-2 Actual Reductions: IOU Participants vs. IOU Non-Participants



References

Al-Tuwaijri, Sulaiman A., Theodore E. Christensen, and K. E. Hughes II. 2004. "The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach," *Accounting, Organizations and Society,* 29: 447-171.

Arora, Seema and Timothy N. Cason. 1995. "An experiment in voluntary environmental regulation: Participation in EPA's 33/50 Program," *Journal of Environmental Economics and Management*, 28: 271-286.

Arora, Seema and Timothy N. Cason. 1996. "Why do firms volunteer to exceed environmental regulations? Understanding participation in EPA's 33/50 program," *Land Economics*, 72: 413-432.

Blackman, Allen, Shakeb Afsah and Damayanti Ratunanda. 2004. "How Do Public Disclosure Pollution Control Programs Work? Evidence from Indonesia," *Human Ecology Review*, 11: 235-246.

Cameron, A. Colin and Pravin K. Trivedi. 2005. "Microeconometrics: Methods and Applications," New York, NY: Cambridge University Press.

Carbon Trust. 2006. "Allocation and Competitiveness in the EU Emissions Trading Scheme: Options for Phase II and Beyond."

Clarkson, Peter M., Yue Li, Gordon D. Richardson, and Florin P. Vasvari. 2008. "Revisiting the Relation Between Environmental Performance and Environmental Disclosure: An Empirical Analysis," *Accounting, Organizations and Society*, 33: 303-327.

Clinton, Bill and Al Gore. 1995. "Reinventing Environmental Regulation" National Performance Review.

Dasgupta, Susmita, David Wheeler, and Hua Wang. 2007. Disclosure strategies for pollution control. In *International Yearbook of Environmental and Resource Economics 2006/2007: A Survey of Current Issues*. Tom Teitenberg and Henk Folmer (eds). Edward Elgar: Northhampton, MA, 93-119.

DeCanio, Stephen J. and William E. Watkins. 1998. "Investment in Energy Efficiency: Do the Characteristics of Firms Matter?," *The Review of Economics and Statistics*, 80: 95-107.

Delmas, Magali A, Maria Montes-Sancho and Jay P. Shimshack. 2007. "Information Disclosure Policies: Evidence from the Electricity Industry," Discussion Papers Series, Department of Economics, Tufts University.

Domencich, Tom and Daniel L. McFadden, *Urban Travel Demand – A Behavioral Analysis*, North-Holland, Amsterdam (1975).

Karamanos, P. 1999. "Voluntary Environmental Agreements for the Reduction of Greenhouse Gas Emissions: Incentives and Characteristics of Electric Utility Participants in the Climate Challenge Program" working paper, School of Public and Environmental Affairs, Indiana University, Bloomington.

Khanna, Madhu and Lisa A. Damon. 1999. "EPA's voluntary 33/50 program: Impact on Toxic Releases and Economic Performance of firms," *Journal of Environmental Economics Management*, 37(1): 1-25.

Kennedy, Peter W. 2002. “Optimal early action on greenhouse gas emissions,” *Canadian Journal of Economics*, 35: 16-35.
Lyon, Thomas P. and John W. Maxwell. 2004. *Corporate Environmentalism and Public Policy*, Cambridge, UK: Cambridge University Press.
Lyon, Thomas P. and John W. Maxwell. 2008. “Greenwash: corporate environmental disclosure under threat of audit,” Working paper, Ross School of Business, University of Michigan.
Lyon, Thomas P. and John W. Maxwell. 2007. “Environmental Public Voluntary Programs Reconsidered,” *Policy Studies Journal*, 35: 723- 750.
Maxwell, John W., Thomas P. Lyon and Steven C. Hackett. 2000. “Self-Regulation and Social Welfare: The Political Economy of Corporate Environmentalism,” *Journal of Law and Economics*, 43: 583-617.
Michaelowa, Axel and Chris Rolfe. 2001. “Early Action to Reduce Greenhouse Gas Emissions Before the Commitment Period of the Kyoto Protocol: Advantages and Disadvantages,” *Environmental Management*, 28: 281-292.
Milgrom, Paul. 1981. “Good News and Bad News: Representation Theorems and Applications,” *Bell Journal of Economics*, 12(2): 380-191.
Parry, Ian W. H. and Michael Toman. 2002. “Early Emission Reduction Programs: An Application to CO_2 policy,” *The Energy Journal*, 23: 73-95.
Patten, Dennis M. 1991. “Exposure, Legitimacy, and Social Disclosure,” *Journal of Accounting and Public Policy*, 10(4): 297-308.
Patten, Dennis M. 1992. “Intra-Industry Environmental Disclosures in Response to the Alaskan Oil Spill: A Note on Legitimacy Theory,” *Accounting, Organizations and Society*, 17: 471-475.
Rabe, Barry G. 2004. *Statehouse and greenhouse: the Emerging Politics of American Climate Change Policy*, Broookings Institution Press, Washington, D.C.
Rivera, Jorge and Peter de Leon. 2004. “Is Greener Whiter? Voluntary Environmental Performance of Western Ski Areas,” *The Policy Studies Journal*, 32(3): 417-437.
Sam, Abdoul G. and Robert Innes. 2005. “Voluntary Pollution Reductions and the Enforcement of Environmental Law: An Empirical Study of the 33/50 Program,” Working paper, University of Arizona.
Shin Hyun Song. 2003. “Disclosures and Asset Returns,” *Econometrica*, 71: 105-133.
Sinclair-Desgagne, Bernard and Estelle Gozlan. 2003. “A Theory of Environmental Risk Disclosure,” *Journal of Environmental Economics and Management*, 45: 377-393.
U.S. Energy Information Administration. 2004. “Emissions of Greenhouse Gases in the United States 2003,” DOE/EIA-0573(2003), Office of Integrated Analysis and Forecasting.
U.S. Energy Information Administration. 2005. “Documentation for Emissions of Greenhouse Gases in the United States 2003,” DOE/EIA-0638(2003), Office of Integrated Analysis and Forecasting.
U.S. Energy Information Administration. 2005. “Voluntary Reporting of Greenhouse Gases 2003,” DOE/EIA-0608(2003), Office of Integrated Analysis and Forecasting.
U.S. General Accounting Office. 1998. “Basic Issues in Considering a Credit for Early Action Program,” Reporting to the Ranking Minority Member, Committee on

Government Reform and Oversight, House of Representatives, GAO/RCED-99-23, Resources, Community, and Economic Development Division.
Verrecchia, Robert E. 1983. "Discretionary disclosure," *Journal of Accounting and Economics*. 5(1): 179-194.
Videras, Julio and Anna Alberini. 2000. "The appeal of voluntary environmental programs: which firms participate and why?," *Contemporary Economic Policy*, 18(4): 449-461.
Welch, Eric W., Allan Mazur and Stuart Bretschneider. 2000. "Voluntary Behavior by Electric Utilities: Levels of Adoption and Contribution of the Climate Challenge Program to the Reduction of Carbon Dioxide," *Journal of Policy Analysis and Management*, 19(3): 407-425.
Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press.

CHAPTER 3

When Does Institutional Investor Activism Increase Shareholder Value?: The Carbon Disclosure Project

I. Introduction

The Carbon Disclosure Project (CDP) is a consortium of over 300 institutional investors with over $57 trillion in assets in 2008, including Barclays Group, California Public Employees' Retirement System (CalPERS), Goldman Sachs, Merrill Lynch, Morgan Stanley, and UBS, among others. Since 2002, the CDP has asked the world's 500 largest companies every year to disclose their greenhouse gas (GHG) emissions, risks, opportunities, and management strategies. Some companies participate in the CDP, while others do not. The CDP publicly discloses company responses on its website, presumably in the hope that publicized information will affect investment behavior.

Despite the financial clout of the CDP investors, it is unclear whether CDP disclosure is material. The CDP is somewhat different from typical institutional investor activism. Institutional investor activism often interferes with management decisions with the intention of increasing shareholder value. For example, CalPERS annually announces the so-called focus list, a list of poorly performing firms, aiming to improve their stock performance and corporate governance through active engagement with management. The majority of prior studies find a "CalPERS effect," that is, positive abnormal stock returns of firms included in the focus list around the day of its announcement.[45] Positive shocks suggest that these types of activism create shareholder value. The CDP, however, does not actively interfere with management decisions. Instead, it simply encourages disclosure of environmental performance. A natural question is then exactly what the CDP accomplishes with its monitoring function. Does a firm's CDP participation affect shareholder value?

We empirically examine the circumstances under which participation in the CDP affects shareholder value.[46] For this purpose, we pose a series of empirical research questions. We first explore the broad question of whether firms' CDP participation has a direct impact on stock prices. Then, we ask two situation-specific questions by making use of Russia's ratification of the Kyoto Protocol on October 22, 2004, which caused the Protocol to go into effect in all the nations that had ratified it. We ask whether upon Russia's ratification, prior CDP participation affected stock prices, either in countries that had already ratified the Protocol or in countries that had not yet ratified it. We hypothesize that CDP participants experienced no abnormal returns in countries that had already ratified the Protocol, because firms in these countries had already taken measures in anticipation of Kyoto. On the other hand, we posit that CDP participation paid in countries that had not yet ratified Kyoto, especially for firms in greenhouse gas emitting industries likely to be affected by future regulations. Our results suggest that Russia's

---

[45] For a recent example, see Barber (2006).

[46] We ask the question of when, instead of whether, institutional investor activism pays. This is based on our sense that the latter question may be too broad, especially for environmental activism. One of the important questions the empirical literature on corporate environmental strategy seeks to answer is whether going "green" pays or not. There have been numerous studies trying to link firms' environmental and financial performance, but the evidence is mixed (Margolis and Walsh, 2003). Perhaps one of the reasons it is difficult to establish a more definite link is that the question is simply too broad. Instead of asking whether going green pays or not, researchers have begun to ask when going green pays (King and Lenox, 2001). The same point would seem to apply to institutional investor activism.

ratification increased the pressure on countries that had not yet ratified Kyoto to take some action on climate change, and accordingly the likelihood of regulatory action on climate change rose in these countries. Under this circumstance, CDP participants were apparently viewed as better prepared for the exogenous shock.

The paper is organized as follows. Section 2 describes the CDP. Section 3 poses research questions and surveys the relevant literature. Section 4 describes methods, and section 5 describes our data. Section 6 reports results and section 7 concludes.

II. The Carbon Disclosure Project

Investors have expressed concerns over the financial risks to which companies might be exposed due to their greenhouse gas emissions.[47] Two types of potential financial risks are present. One is the direct effect of climate change via changes in weather patterns and rising sea levels. The other is the effect of regulation, such as abatement and liability costs. In 2002, institutional investors started to address these concerns collectively via the CDP. Each year, the CDP asks the world's 500 largest companies (the FT Global 500)[48] to disclose their greenhouse gas emissions, risks, opportunities, and management strategies by answering the CDP questionnaire.[49]

---

[47] See, for example, the Wall Street Journal, "Moving the Market: Investors Urge Large Companies to Disclose Data on Emissions," 02/02/05.

[48] The information requests have historically been sent to the FT Global 500, but in 2006 the CDP expanded and in 2007 the information request was sent to 2,400 companies globally. www.cdproject.net.

[49] The CDP questionnaire itself has evolved since 2002. The CDP4 questionnaire includes the following: 1) *General*: How does climate change represent commercial risks and/or opportunities for your company? 2) *Regulation*: What are the financial and strategic impacts on your company of existing regulation and proposed future regulation? 3) *Physical risks*: How are your operations affected by extreme weather events, changes in weather patterns, etc.? What actions are you taking to adapt to these risks, and what are the associated financial implications? 4) *Innovation*: What technologies, products, processes or services has your company developed, or is developing, in response to climate change? 5) *Responsibility*: Who at board level has specific responsibility for climate change related issues and who manages your company's climate change strategies? 6) *Emissions*: What is the quantity of annual emissions of the six main GHG's produced

Company responses to the CDP questionnaire are made publicly available on the CDP website. The results from the first cycle of the project (CDP1), which was endorsed by 35 institutional investors with $4.5 trillion in assets, were made available on February 17th 2003. Of the FT Global 500 companies, 71% responded and 45% answered the questionnaire in full. Since then, both the number of institutional investors who endorsed the CDP project and the response rate have steadily increased over time.[50] By the fourth cycle of the project (CDP4), the number of endorsers had increased to 225 institutional investors with more than $31 trillion in assets. The CDP4 results were made available on September 18th 2006. Of the FT Global 500 companies, 91% responded and 72% answered the questionnaire in full.

This paper makes use of companies' responses to the first four cycles of the CDP, CDP1 through CDP4, to investigate under what circumstances firms' participation in CDP, a positive response to environmental activism by institutional investors, increases shareholder value. For our event study analysis, we re-categorize the CDP response categories. The CDP places corporate responses into five categories: Questionnaire Forthcoming (QF), Answered Questionnaire (AQ), Provided Information (IN), Declined to Participate (DP), and No Response (NR).[51] We combine the five categories into two

---

by your owned and controlled facilities? 7) *Products and services*: What are your estimated emissions associated with use and disposal of your products and services, and supply chain? 8) *Emissions reduction*: What is your firm's emissions reduction strategy? 9) *Emissions trading*: What is your firm's strategy for, and expected cost/profit from, trading in the EU Emissions Trading Scheme? 10) *Energy costs*: What are the total costs of your energy consumption, e.g. fossil fuels and electric power? Please quantify the potential impact on profitability from changes in energy prices and consumption. http://www.cdproject.net/questionnaire.asp.

[50] The CDP2 request was endorsed by 95 institutional investors with $10 trillion in assets. Of the FT500, 86% responded and 60% answered in full. The results were disclosed on May 19th 2004. The CDP3 request was endorsed by 155 institutional investors with more than $21 trillion in assets; 89% of firms responded and 71% answered in full. The results were disclosed on September 14th 2005.

[51] QF = Questionnaire Forthcoming, which means a company has confirmed that it does intend to answer the CDP questions. AQ = Answered Questionnaire, which means a company has answered the questions as they are set out in the CDP documents. IN = Provided Information, which means a company has responded

categories based on the similarity of responses: CDP participants and CDP non-participants. CDP participants include companies in the QF or AQ categories. CDP non-participants include companies in the DP or NR categories. We do not include the IN category in either of our two categories, because the IN category seems quite distinct either from the CDP participant group or the CDP non-participant group, and because the IN category is so broad as to be difficult to interpret.

III. Research Questions and Literature Review

As we discussed in the Introduction, the CDP does not interfere with management decisions. Instead, it monitors environmental performance and management. We are interested in whether, and when, this type of institutional investor activism affects shareholder value. In this section we pose a series of three research questions, offering a review of the relevant literature after each one. We begin with:

Question 1: Does corporate participation in the CDP affect stock prices?

From a theoretical perspective, Verrecchia (1983) and others have shown that a manager only discloses information voluntarily when the firm has "good news," that is, when it performs better than market expectations. In a broader theory of corporate governance, Tirole (2001) shows how passive monitoring of firm performance, i.e.,

---

by providing an Environment / CSR / Annual report or a web link to such a report. It could also be a more detailed email or letter that provides some information but does not actually answer the questions as they are set out in the CDP documents. DP = Declined to Participate, which means a company has responded saying that they will not be answering the CDP questions. NR = No Response, which means a company has not responded at all. http://www.cdproject.net/faq.asp.

monitoring without interfering with management, might increase the rate of return for investors. The basic idea is that stock prices are affected by various events beyond a manager's control, so there may exist a signal that provides more accurate information about managerial performance than does the firm's stock price. Acquiring the signal allows investors to increase the pledgeable income from the firm, that is, the residual available to investors after the manager's incentive compatibility constraint has been satisfied. Together, these papers suggest that firms' CDP participation is good news and may positively affect their stock prices around the date of CDP disclosure.

Applying the theoretical literature to the case of the CDP is not straightforward, however, since firms' CDP participation presents a somewhat special setting that limits the applicability of the predictions of the foregoing papers. First of all, firms' CDP participation may not be entirely discretionary, whereas Verrecchia (1983) focuses on purely discretionary disclosure. Considering the large stakes of the institutional investors in these companies, the CDP request may be seen as a threat by some companies, making it hard to argue that a firm's decision to participate in the CDP is purely discretionary. Furthermore, to the extent that the disclosed information is not proprietary (Verrecchia, 1983), firms with good news should have already disclosed their information without being asked. Second, while in Tirole (2001) passive monitoring more accurately reveals managerial behavior, i.e., whether the manager is pursuing private benefits or investor benefits,[52] the CDP may not be so informative. In particular, the link between a firm's

[52] In Tirole (2001) interim performance revealed by passive monitoring informationally dominates the final outcome. This means that when a signal changes from good to bad, the percentage decrease in probability of project success is higher in terms of interim signals than in terms of initial probabilities, i.e., $\frac{q_H - q_L}{q_H} > \frac{p_H - p_L}{p_H}$, where p_H = Initial probability of project success with no shirking, p_L = Initial probability of project success with shirking, q_H = Good interim signal with no shirking ($q_H > p_H$), and

CDP participation status and the manager's private benefits is simply not clear. This in turn makes it difficult, from a theoretical perspective, to establish a clear link between a firm's CDP participation status and its financial performance.

On the empirical side, two strands of research are relevant. One examines the relation between environmental information disclosure and environmental performance, while the second studies the relation between environmental performance and financial performance. There is mixed evidence on both. Regarding the link between disclosure and environmental performance, Patten (2002) finds a negative association between the extent of discretionary disclosures and environmental performance, and argues that the mixed results of earlier studies may have to do with omitted variable and sample selection biases. In contrast, Clarkson, et al. (2008) find a positive association between disclosures and environmental performance, and argue that earlier studies were not careful enough in restricting themselves to purely voluntary disclosures. Regarding the link between corporate environmental and financial performance, Margolis and Walsh (2003) review numerous studies that examine the link between these two variables, with the majority of studies finding positive associations. However, the direction of causality is unclear: better environmental performance may increase investor returns, or better financial performance may create enough managerial slack to allow managers to indulge

---

q_L = Bad interim signal with shirking ($q_L < p_L$). Under passive monitoring, the manager's incentive compatibility constraint is $(q_H - q_L)w \geq B$, where w is managerial compensation in case of success, and B is the manager's private benefit in case of shirking. Return to investors is then $p_H R - \frac{q_H}{q_H - q_L} B - C_p$, where R is project income in case of success (zero otherwise) and C_p is the cost of passive monitoring. Return to investors is higher with passive monitoring as long as C_p is sufficiently small, i.e., $C_p < \left(\frac{p_H}{p_H - p_L} - \frac{q_H}{q_H - q_L} \right) B$. In sum, passive monitoring works to lower the incentive constraint of the manager, increasing return to investors. This leads to a lower cost of capital.

their personal environmental preferences at the expense of shareholders. Margolis and Walsh do not distinguish between studies focusing on voluntary disclosure and studies focusing on voluntary overcompliance. In the context of environmental information disclosure, previous studies have consistently found that at times of regulatory threat the market rewards greater prior environmental information disclosure (Bowen, Castanias, and Daley, 1983; Hill and Schneeweis, 1983; Blacconiere & Patten, 1994; Blacconiere & Northcut, 1997; Patten & Nance, 1998). Whether greater disclosure increased shareholder value in the case of the CDP is our first empirical question.

Next, we ask two situation-specific questions by making use of an exogenous event, Russia's ratification of the Kyoto Protocol on October 22, 2004. We expect Russia's ratification to have had significant effects on the likelihood of climate change regulation. For the Protocol to go into force in all the nations that had ratified it, the Protocol needed to be ratified by at least 55 countries that accounted for at least 55% of global GHG emissions. The threshold was met when Russia ratified the Protocol on October 22, 2004. Thus, we ask whether upon Russia's ratification, CDP participation affected stock prices, either (a) in countries that had already ratified the Protocol or (b) in countries that had not yet ratified it.

Question 2: Upon Russia's ratification of the Kyoto Protocol, did firms' CDP participation affect stock prices in countries that had already ratified the Protocol?

Previous literature on the effects of international institutions discusses how international institutions can affect domestic policy through various channels even without legal obligations (Keohane, et al., 1993; Cortell and Davis, 1996; Bernstein, 2002; Martin and Simmons, 2005; Simmons and Hopkins, 2005). This literature suggests that the Kyoto Protocol, an international environmental institution, is likely to have exerted pressure on national governments and other actors before Russia's ratification of the Protocol. For example, Bernstein (2002) and Simmons and Hopkins (2005) specifically discuss how signing an international treaty might affect national policy even before the treaty goes into effect. This indicates that an individual nation's decision to ratify the Kyoto Protocol is likely to have exerted pressure on other aspects of domestic policy.

This indeed seems to be the case. For instance, the European Union (EU) implemented the European Union Emission Trading Scheme (EU ETS) to comply with the Kyoto Protocol.[53] Although the EU ETS officially started operation in January 2005, it was designed well before Russia's ratification on October 22, 2004. The EU ETS is based on Directive 2003/87/EC, which entered into force in 2003.[54] This was after the EU ratified the Kyoto Protocol in May 2002. Also, the second phase of the EU ETS, 2008-2012, exactly coincides with the Kyoto target period. It seems clear that once the EU ratified Kyoto, the EU ETS was designed in anticipation of Kyoto becoming binding. The EU's preparation for Kyoto is likely to have been facilitated by the specific reduction targets stipulated in the Kyoto Protocol for developed countries. The EU is expected to reduce emissions 8% below the 1990 level during 2008-2012 and has reached agreement

---

[53] www.environment-agency.gov.uk.
[54] http://ec.europa.eu/environment/climat/emission.htm.

on how its targets are to be allocated amongst its members.[55] This in turn implies that the EU member countries had prepared themselves in anticipation of Kyoto well before Russia's ratification of Kyoto. Furthermore, Bernstein (2002) provides an interesting case study of how the Kyoto Protocol shaped the domestic climate change policy of Kyoto signatory Canada before Russia's ratification.

The literature surveyed above suggests that upon Russia's ratification of the Kyoto Protocol, firms' participation in the CDP likely had little measurable impact if the firms were in countries that had already ratified Kyoto, because in these countries firms presumably had already taken measures in anticipation of Kyoto. In these countries, we might expect that future regulatory costs changed upon their own ratification of the treaty, not upon Russia's ratification of the Kyoto Protocol.

Question 3: Upon Russia's ratification of the Kyoto Protocol, did firms' CDP participation affect stock prices in countries that had not yet ratified it, especially if firms were in greenhouse gas intensive industries?

Keohane, et al. (1993), Bernstein (2002) and Martin and Simmons (2005) explain how international institutions embody international norms and thus exert pressure on recalcitrant nations. Their arguments suggest that the official international adoption of the Kyoto Protocol upon Russia's ratification is likely to have exerted pressure on countries that had not yet ratified it, such as the US or Australia. Indeed, the Wall Street Journal

[55] http://unfccc.int/kyoto_protocol/background/items/3145.php

described how Russia's ratification increased the regulatory pressure in the US.[56] We expect this was especially so for firms in GHG intensive industries such as energy, ferrous metals, mineral, and pulp and paper.[57] For these firms, it seems plausible that Russia's ratification increased the probability of domestic regulatory action of climate change.

We argue that for firms in non-signatory nations, the increased likelihood of climate regulation following Russia's ratification should have affected the shareholder value of CDP participants differently from non-participants. Prior empirical studies on the effect of environmental information disclosure consistently find that at times of regulatory threat, environmental disclosure paid off. Blacconiere & Patten (1994) find that chemical firms with more extensive environmental disclosures in their financial report prior to Union Carbide's 1984 chemical leak in Bhopal, India, experienced a less negative stock market reaction than firms with less extensive prior disclosures. Blacconiere & Northcut (1997) find that chemical firms with more extensive environmental disclosures had a less negative share price reaction after the Superfund Amendments and Reauthorization Act of 1986. Patten & Nance (1998) find that petroleum firms with less extensive environmental disclosures faced more negative stock price reactions in the wake of the Exxon Valdez oil spill.[58] Freedman and Patten (2004) find that toxic emitters with less extensive environmental disclosures suffered more

---

[56] The Wall Street Journal, "As Kyoto Protocol Comes Alive, So Do Pollution-Permit Markets --- Funds Handling Trades For Emissions Credits Gain While Russia Sets Pact," 11/08/04.
[57] Refer to footnotes in Table 2 for complete list of industries included in our sample.
[58] The oil spill triggered substantial increase in gasoline prices. The unexpected price increase was interpreted as good news for petroleum companies leading to positive abnormal returns (Pattern and Nance, 1998).

negative reactions upon the unexpected proposal by President Bush in 1989 for revisions to the Clean Air Act.

Why does a greater likelihood of regulation increase the value of environmental information disclosure? Rationality-based stock valuation models suggest that a firm's stock price is the present value of expected cash flows, discounted at the appropriate rate of return. A regulatory threat has a potentially negative influence on a firm's expected cash flows because it may increase expected future regulatory costs; firms may have to incur higher compliance costs, penalties, or liability costs (Bowen et al., 1983; Hill and Schneeweis, 1983; Blacconiere & Patten, 1994; Freedman and Patten, 2004). A decrease in a firm's expected future cash flows lowers the firm's stock price. The empirical evidence suggests that investors viewed firms with more extensive prior disclosures as better prepared for possible future environmental regulations.

The foregoing lines of research suggest that upon Russia's Kyoto ratification, firms' CDP participation may have positively affected stock prices for firms in countries that had not yet ratified Kyoto, especially for firms in greenhouse gas intensive industries.

IV. Method

We employ the event study methodology that focuses on mean stock price effects to test our hypotheses.[59] The basic idea is that given rationality in the market place, the effects of an event will be immediately reflected in security prices (MacKinlay, 1997). Thus, we can measure the effect of an event on the value of a firm by observing security

[59] For overviews of this method, see MacKinlay (1997) and Kothari and Warner (2004).

prices over a short period. We use the market model[60], which assumes joint normality of security returns, and posits:[61]

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{1}$$

where R_{it} = return on security i on day t
R_{mt} = return on market portfolio on day t
$\mathrm{E}(\varepsilon_{it}) = 0, \mathrm{Var}(\varepsilon_{it}) = \sigma^2_{\varepsilon_i}$

From equation (1), the market model parameters, $\alpha_i, \beta_i, \text{and}\, \sigma^2_{\varepsilon_i}$ are first estimated using data from the period preceding the event (the estimation window) and thus not affected by the event. The market model parameters are then used to calculate abnormal returns during an event window. As shown in equation (2) the abnormal return is calculated by subtracting the normal return from the actual *ex post* return of the security during the event window.

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt}) \tag{2}$$

where AR_{it} = abnormal return on security i on day t

Our estimation window is 250 trading days starting from the sixth day prior to the event. We choose the large estimation window size to minimize out-of-sample bias. Out-

[60] The market model differs from the Capital Asset Pricing Model (CAPM), which is based on an equilibrium theory where the expected return of a given asset is determined by its covariance with the market portfolio ($R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it}$, where R_{ft} is the risk-free rate, and α_i is expected to be zero). The use of the CAPM is common in event studies of the 1970s. However, deviations from the CAPM have been discovered, implying that the validity of the restrictions imposed by the CAPM is questionable. Because this potential can be avoided at little cost by using the market model, the use of the CAPM has almost ceased (MacKinlay, 1997).

[61] The market model also assumes that $\mathrm{Cov}(R_{mt}, \varepsilon_{it}) = 0$. Other variables may be associated with security returns, especially firm size and book-to-market equity (Fama and French, 1992; 1996). For short-horizon event studies using daily data, however, the effect of these variables is not significant (Bernard, 1987; Kothari and Warner, 2004). Our use of the market model also reflects limited data availability for international firms.

of-sample bias can arise since the event study methodology applies the estimated results from estimation window to event window. The abnormal returns are essentially calculated on an out-of-sample basis. Thus, any difference between in-sample and out-of-sample periods should be taken into account (Collins and Dent, 1984). With the large estimation window, however, the increase in variance over the event window due to the sampling error in α_i and β_i becomes negligible as the sampling error of the parameters vanishes (MacKinlay, 1997). Under this circumstance, the variance of the abnormal returns over the event window can be approximated by the variance of the error term in equation (4), i.e., $\mathrm{Var}(AR_{it}) \approx \sigma_{\varepsilon_i}^2$ (MacKinlay, 1997).

To examine the effect of an event, the abnormal return for each period should be aggregated over multiple periods and over multiple securities. We use multiple event windows, which include both pre-event and post-event periods. This is to allow for the possibility of information leakage during pre-event periods and for adjustment periods following the event. Given N securities, the mean cumulative abnormal returns for period T can be calculated as shown in (3). Assuming no serial correlation and independence across securities, the corresponding variance can be represented by equation (4).[62] The standard hypothesis of event studies is that the event has no impact, i.e., the mean cumulative abnormal returns are not significantly different from zero, which can then be tested under the normality assumption.

$$\overline{CAR(t_1,\cdots,t_T)} = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=1}^{T} AR_{it} \qquad (3)$$

[62] Equation (4) follows from the fact that with our large estimation window, $\mathrm{Var}(AR_{it}) \approx \sigma_{\varepsilon_i}^2$.

$$\mathrm{Var}\left(\overline{CAR(t_1,\cdots,t_T)}\right)=\frac{1}{N^2}\sum_{i=1}^{N}\mathrm{Var}\left(\overline{CAR_i(t_1,\cdots,t_T)}\right) \tag{4}$$

where $\mathrm{Var}\left(\overline{CAR_i(t_1,\cdots,t_T)}\right)=(t_T-t_1+1)\sigma_{\varepsilon_i}^2$

Variance estimation as shown in equation (4) is based on three assumptions: 1) changes in variance during the estimation and the event windows are not significant, 2) abnormal returns are not serially correlated, and 3) abnormal returns are not cross-sectionally correlated. Deviations from these assumptions, however, should be taken into account (Patell, 1976; Collins and Dent, 1984; Bernard, 1987). To address these concerns, we use several statistics to test the standard hypothesis of event studies that the event has no impact. To control for changes in variance over time and serial correlation, we use the serial correlation adjusted Patell test and the standardized cross-sectional test. Both tests involve standardizing abnormal returns using a measure of standard deviation during the event window period (Cowan, 2006). Both tests also control for the fact that because abnormal returns during the event window are all functions of the same market model parameters, the abnormal returns during the event window are serially correlated (MacKinlay, 1997). In addition, we use the Jackknife test, which also controls for changes in variance over time using standardized abnormal returns (Cowan, 2006).[63]

To demonstrate that an event has a significant impact, event studies typically show that the mean cumulative abnormal returns change patterns before and after the event date, i.e., not significantly different from zero before the event date and

[63] Collins and Dent (1984) examine the severity of cross-sectional correlations when there is industry concentration in sample firms. Our sample, FT500, covers 27 countries and diversified industries ranging from aerospace & defense to banks and movies & entertainment. Industry concentration in our sample is expected to be less problematic. Also, Bernard (1987) points out that the degree of cross-sectional correlation increases dramatically as the event window increases from daily periods to annual periods. Our event study uses daily periods, which reduces these concerns.

significantly different from zero in one direction for a sustained period after the event date (Khanna, et al., 1998; Konar and Cohen, 1995; Hamilton, 1993).

V. Data

We obtained the CDP response data from Innovest, a company specializing in identifying non-traditional sources of risk and value potential for investors. The data includes the FT Global 500 companies in 2006, the year for their CDP4 response. The data also includes the company responses to the CDP1, CDP2 and CDP3 requests. Table 1 shows the number of companies in each response category in our sample.

As described in section 2, for our analysis we aggregate the CDP responses into two categories: CDP participants and CDP non-participants. CDP participants include companies in the QF or AQ categories. CDP non-participants include companies in the DP or NR categories. We do not include the IN category in either of our two categories because the IN category seems quite distinct either from the CDP participant or the CDP non-participant group and is broad and vague.

To construct our global benchmark, we use the Morgan Stanley Capital Investments (MSCI) database.[64] We obtain the firm-specific daily return index and other firm-specific variables from Thomson Datastream.[65] Table 2 reports summary statistics

---

[64] Used with permission of Wharton Research Data Services (WRDS). The MSCI total return index values are used. Global benchmark returns on day t are set equal to (RI_t/RI_{t-1})-1, where RI_t is the return index on day t.

[65] Used with permission of Datastream. Using the firm-specific daily return index, we construct the firm-specific daily return values as follows, where ex-date refers to the first day of the ex-dividend period (the period of time between the announcement of the dividend and the payment).

If $t \neq$ ex-date of the dividend payment D_t, $R_t = \frac{P_t}{P_{t-1}} - 1$, where P_t = adjusted closing price on date t, where P_{t-1} = adjusted closing price on previous day, and D_t = dividend payment associated with ex-date t.

for our sample, both in the aggregate and by Kyoto ratification status, i.e., whether the firm is headquartered in a country that had ratified the Kyoto Protocol when Russia ratified on Oct 22, 2004. Firm size is represented by market capitalization. Growth prospects are represented by price-to-book-value ratio and price-to-earnings ratio. Although the mean market capitalization and price-to-book value ratio are somewhat different between firms in countries that had ratified Kyoto and firms in countries that had not yet ratified it, the effect of these variables on the estimates of abnormal returns is not significant for short-horizon event studies using daily data (Bernard, 1987; Kothari and Warner, 2004). MacKinlay (1997) also points out that for event studies the additional variables other than the market factor add relatively little explanatory power. In addition, since small cap and value (low growth prospects) stocks tend to outperform the market (Fama and French, 1992) and the mean market capitalization is smaller for firms in countries that had ratified Kyoto and the mean price to book value ratio is lower for firms in countries that had not ratified it, their effects on abnormal returns, if any, are in the opposite direction, counteracting each other's effects.

VI. Results

The analysis results are presented in Tables 3 through 5. Table 3 shows results for the effects of CDP participation across the first four cycles of the project. Tables 4 and 5 show results for the effects of Russia's Kyoto ratification for firms in countries that had

---

If t = ex-date of the dividend payment D_t, $R_t = \frac{P_t + D_t}{P_{t-1}} - 1$, where P_t = adjusted closing price on ex-date.

already ratified the Kyoto Protocol and for firms in countries that had not yet ratified it, respectively.

The effects of disclosure of firms' CDP participation status

The effects of each CDP disclosure are shown in Table 3 for all firms in our sample. As discussed in section 4, to demonstrate that an event has a significant impact, event studies typically look for whether the mean cumulative abnormal returns change patterns before and after the event date, i.e., not significantly different from zero before the event date and significantly different from zero in one direction for a sustained period after the event date (Khanna, et al., 1998; Konar and Cohen, 1995; Hamilton, 1993).

Based on the foregoing criterion, CDP2 non-participants appear to have experienced a negative shock upon CDP2 disclosure, since their abnormal returns were positive and significant the day before disclosure and consistently negative and significant after disclosure. Similarly, CDP3 participants appear to have experienced a positive shock upon CDP3 disclosure, since their abnormal returns were negative and significant the day before disclosure and positive and significant (except for day 0, which was not significant) after disclosure. We do not find consistent effects for CDP1 and CDP4 disclosure, however. Overall, although we find some evidence that CDP participants experienced more positive outcomes than non-participants, we find it difficult to assert with confidence that there are systematic effects of CDP disclosure.[66]

[66] We also examine whether dropping out of CDP had any effects on firm stock prices. The results are mixed. There were 10 firms that participated in CDP2 but did not participate in CDP3 and 6 firms that participated in CDP3 but not in CDP4. We examine whether their stock prices were negatively affected upon CDP3 disclosure and upon CDP4 disclosure, respectively. We find that only dropping out of CDP3 had some negative effects, although significance is mostly limited to dates prior to CDP3 disclosure.

The effect of Russia's ratification of the Kyoto Protocol

The effects of Russia's ratification of Kyoto on stock prices are examined in Tables 4 and 5. The effects on firms in countries that had already ratified Kyoto on the date of Russia's ratification are presented in Table 4, and the effects on firms in countries that had not ratified Kyoto are presented in Table 5. Results are disaggregated by whether or not a firm is in a greenhouse-gas intensive industry, and, alternatively, whether or not it is in the energy industry.[67]

Turn first to firms in countries that had ratified Kyoto before the date of Russia's ratification. For firms in GHG-intensive industries or in the energy industry, there are clearly no significant and sustained abnormal returns. However, Table 4 appears to show significant effects for CDP2 participants that are not in GHG emitting or energy industries, with a positive abnormal return on date zero but negative abnormal returns for the windows (0,1) and (0,2). Nevertheless, to us, this jump from a positive initial effect to a negative effect in subsequent days does not qualify as a significant and sustained effect. For example, it may be that additional shocks at dates 1 and 2 affected firms in these groups. Overall, then, we find it difficult to argue there were significant and sustained effects of firms' CDP participation on stock prices in countries that had already ratified Kyoto. This is consistent with our prior that for firms in these countries, the expected regulatory response to climate change did not particularly change upon Russia's ratification, presumably because they had already prepared themselves in anticipation of Kyoto.

[67] GHG industry indicates whether a firm is in the GHG emitting industries, especially those covered by the EU ETS. The Yes category includes companies in energy, production and processing of ferrous metals, mineral, and pulp and paper industries. The No category includes all other industries. Energy Industry includes electric utilities, oil refineries and coke ovens. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.

The effects of firms' CDP participation in countries that had not yet ratified the Kyoto Protocol as of Russia's ratification are presented in Table 5. The table shows a somewhat chaotic pattern of abnormal returns for firms that were not in GHG emitting or energy industries, both for CDP participants and non-participants.[68] In both groups, there is an initial significant and negative effect on day 0, which becomes insignificant or even positive by day 2. For firms in GHG emitting industries or in energy industries, however, the effects of CDP participation are consistently positive and significant. Firms in these industries that did not participate in the CDP experienced abnormal returns that were not significantly different from zero. The impact of the CDP in this setting is our main finding. Upon Russia's Kyoto ratification, firms' participation in the CDP increased stock prices in a significant and sustained fashion if the firms were in GHG emitting industries that were expected to be regulated and in countries that had not yet ratified the Kyoto Protocol. This suggests that for these firms, Russia's official ratification of the Kyoto Protocol signaled a shift in the likelihood of future climate change regulation. Under this circumstance, CDP participants appeared to be viewed as better prepared for the exogenous change.

Valuation of the effect of Russia's Ratification

We estimated the total value created by institutional investor activism for our main finding, namely the increase in shareholder value upon Russia's Ratification for CDP participants in GHG emitting industries located in countries that had not ratified Kyoto. To obtain the most conservative estimate, we focus on the smallest significant

[68] Although not a subject in this paper, it would be interesting to study why Russia's Kyoto ratification had significant negative effects for firms not in GHG emitting or energy industries in countries that had not yet ratified Kyoto on the date of Russia's ratification.

abnormal return on Oct 22, 2004 among alternative approaches and only use the day 0 excess return. The total value created is about $2.7 billion (= 0.0037 (the smallest significant abnormal return on Oct 22, 2004) × $43705.49 million (the mean market cap for our sample firms in countries that had not ratified Kyoto) × 17 (the number of firms in GHG emitting industries located in countries that had not ratified Kyoto)).[69] This is about 27% of the size of the carbon market in 2005.[70]

VII. Conclusion

In this paper, we study when institutional investor activism towards climate change pays by making use of data from the Carbon Disclosure Project. To our knowledge, this is the first paper to examine empirically the effect of institutional investor activism on climate change issues.

Using the event study methodology, we examine when it paid for firms to participate in the CDP. We find no systematic evidence of increased value around the dates each year that participation was announced. However, we do find that CDP participants were treated better by investors when exogenous events caused the likelihood of climate change regulation to rise. We identify this effect using Russia's ratification of the Kyoto Protocol on October 22, 2004, which caused the Protocol to go into effect in all the nations that had ratified it. We argue that Russia's ratification increased the pressure on countries that had not yet ratified Kyoto to take some action on climate change, and accordingly firms in countries such as the U.S. saw the probability of a regulatory response to climate change rise. We find that in countries that had already ratified Kyoto,

[69] The numbers are taken from Table 2 and Table 5.
[70] *State and Trends of the Carbon Market 2006*, The World Bank, 2006.

CDP participants did not experience systematic abnormal returns upon Russia's ratification, presumably because firms in these countries had already taken measures in anticipation of Kyoto. In nations that had not ratified the Protocol, however, most notably the U.S., we find that firms experienced positive and significant abnormal returns on the day of Russia's ratification. We conservatively estimate the total value created at $2.7 billion, about 27% of the size of the carbon market in 2005.

Our findings demonstrate that institutional investor activism toward climate change pays when the external business environment becomes more climate conscious. This effect is particularly notable since the activism we study was passive in nature and did not involve any interference in managerial decisions. More broadly, we conclude that institutional investor activism towards issues seemingly unrelated to shareholder value can indeed be value-increasing under certain circumstances.

Table 3-1 Number of Companies in the CDP Response Categories in our Sample*

	CDP1	CDP2	CDP3	CDP4
QF	0	17	0	27
AQ	185	244	319	345
DP	62	54	41	43
NR	83	48	44	40
IN	32	23	34	44
NA*	137	114	62	1

* We obtained the CDP response data from Innovest, a company specializing in identifying non-traditional sources of risk and value potential for investors. The data includes the FT Global 500 companies in 2006, the year for their CDP4 response.

** NA: Not in FT Global 500 or Not Available.

QF = Questionnaire Forthcoming, this means a company has confirmed that it does intend to answer the CDP questions. AQ = Answered Questionnaire, this means a company has answered the questions as they are set out in the CDP documents. IN = Provided Information, this means a company has responded by providing an Environment / CSR / Annual report or a web link to such a report. It could also be a more detailed email or letter that provides some information but does not actually answer the questions as they are set out in the CDP documents. DP = Declined to Participate, this means a company has responded saying that they will not be answering the CDP questions. NR = No Response, this means a company has not responded at all. http://www.cdproject.net/faq.asp.

Table 3-2 Firm Characteristics in Aggregate & by Kyoto Ratification Status, 2004*

	CDP2 sample	Firms in countries that had ratified Kyoto as of Oct 22, 2004	Firms in countries that had not ratified Kyoto as of Oct 22, 2004
Number of firms**	358	183	175
Mean Market capitalization***	37969.01M USD	32232.52M USD	43705.49M USD
Mean Price to book value***	3.23	3.61	2.86
Mean Price to Earnings***	31.96	30.98	32.99
GHG Industry****	Yes – 60 No – 298	Yes – 37 No – 146	Yes – 23 No – 152
Countries represented	Australia – 5 Belgium – 4 Brazil – 2 Canada – 16 Denmark – 3 Finland – 1 France – 21 Germany – 13 Hong Kong – 8 India – 2 Ireland – 3 Italy – 9 Japan – 35 Mexico – 2 Netherlands – 8 Norway – 2 Russia – 3 Saudi Arabia – 5 Singapore – 2 South Africa – 1 South Korea – 2 Spain – 8 Sweden – 6 Switzerland – 7 Taiwan – 2 UK – 27 US – 161	Belgium – 4 Brazil – 2 Canada – 16 Denmark – 3 Finland – 1 France – 21 Germany – 13 Hong Kong – 8 India – 2 Ireland – 3 Italy – 9 Japan – 35 Mexico – 2 Netherlands – 8 Norway – 2 Russia – 3 South Africa – 1 South Korea – 2 Spain – 8 Sweden – 6 Switzerland – 7 UK – 27	Australia – 5 Saudi Arabia – 5 Singapore – 2 Taiwan – 2 US – 161

* Kyoto ratification status indicates whether the country had already ratified the Kyoto Protocol when Russia ratified Kyoto on Oct 22, 2004.
** Five firms are dropped because their firm-specific returns are not available.
*** The average values are calculated based on the data available from Datastream.
**** GHG industry indicates whether a firm is in the GHG emitting industries, especially those covered by the EU ETS. The Yes category includes companies in energy, production and processing of ferrous metals, mineral, and pulp and paper industries. The No category includes all other industries. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.
Note that our sample covers diverse industries including Advertising, Aerospace & Defense, Air Freight & Couriers, Automobiles, Banks, Biotechnology, Broadcasting & Cable TV, Computers & Peripherals, Diversified Financials, Electric Power Companies, Food Products, Health Care Providers & Services, Hotels, Restaurants & Leisure, Insurance, Integrated Oil & Gas, Internet Software & Services, Metals & Mining, Movies & Entertainment, Paper & Forest Products, Pharmaceuticals, Publishing, Real Estate Management & Development, Semiconductor Equipment & Products, Steel, Surface Transport, Textiles, Apparel & Luxury Goods, Wireless Telecommunication Services.

Table 3-3 The Effects of CDP Disclosure – all firms

	CDP1		CDP2		CDP3		CDP4	
CDP participation	Yes	No	Yes	No	Yes	No	Yes	No
No of firms	178	143	256	96	312	74	357	67
Event window	Mean Cumulative Abnormal Return (%)							
-1	0.52**	0.71***	0.20	0.60**	-0.17**	-0.45**	0.13*	0.15
0	0.60***	0.30	0.50***	-0.26***	0.03	-0.38*(a)	0.04	0.14
(0,1)	0.38	0.38	0.14	-0.24$	0.19*	0.03	-0.35***	-0.11
(0,2)	-0.40	-0.26	0.11	-0.25$	0.54***	0.41	-0.33	-0.41

The symbols $,*,**, and *** denote statistical significance at the 0.10, 0.05, 0.01 and 0.001 levels, respectively, using a 2-tail Patell Z test.
(a) Statistically significant at the 0.01 level using a 2-tail Cross-sectional standard deviation test and a 2-tail Jackknife test.

Table 3-4 The Effects of Russia's Kyoto Ratification in countries that had ratified Kyoto

	CDP2		CDP2		CDP2		CDP2	
No of firms	183				183			
GHG Industry[1]	Yes		No					
Energy Activities Industry[2]					Yes		No	
CDP participation	Yes	No	Yes	No	Yes	No	Yes	No
No of firms	31	6	127	19	27	6	131	19
Event window	Mean Cumulative Abnormal Return (%)							
-1	0.37	0.49	-0.13	-0.46	0.36	-0.58	-0.11	-0.13
0	0.58*(a)	0.30	0.40***(a)	0.67$(b)	0.46*(a)	0.51	0.43***(a)	0.61$(b)
(0,1)	0.23	-0.34	-0.38*(b)	-0.07	0.04	0.46	-0.32*(b)	-0.32
(0,2)	-0.44	0.73	-0.74***(a)	-0.25	-0.73*	1.19	-0.67***(a)	-0.39

[1] GHG industry indicates whether a firm is in the GHG emitting industries, especially those covered by the EU ETS. The Yes category includes companies in energy, production and processing of ferrous metals, mineral, and pulp and paper industries. The No category includes all other industries. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.

[2] Energy Industry includes electric utilities, oil refineries and coke ovens. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.

The symbols $,*,**, and *** denote statistical significance at the 0.10, 0.05, 0.01 and 0.001 levels, respectively, using a 2-tail Patell Z test.

(a) Statistically significant at the 0.001 level using a 2-tail Cross-sectional standard deviation test and a 2-tail Jackknife test.

(b) Statistically significant at the 0.01 level using a 2-tail Cross-sectional standard deviation test and statistically significant at the 0.001 level using a 2-tail Jackknife test.

Table 3-5 The Effects of Russia's Kyoto Ratification in countries that had not ratified Kyoto

	CDP2		CDP2		CDP2		CDP2	
No of firms	169				169			
GHG Industry[1]	Yes		No					
Energy Activities Industry[2]					Yes		No	
CDP participation	Yes	No	Yes	No	Yes	No	Yes	No
No of firms	17	5	81	66	13	4	85	67
Event window	Mean Cumulative Abnormal Return (%)							
-1	0.18	-0.58	0.13	-0.28*	-0.02	-0.68$	0.17	-0.28*
0	0.37$	0.47	-0.78***(a)	-0.66***(c)	0.59*(b)	0.61	-0.76***(a)	-0.65***(c)
(0,1)	0.91**(b)	0.63	-1.31***(a)	-1.03***(c)	1.13***(b)	0.09	-1.24***(a)	-0.97***(c)
(0,2)	1.76***(a)	0.62	-0.39	0.42**	2.09***(a)	0.28	-0.33	0.45**

[1] GHG industry indicates whether a firm is in the GHG emitting industries, especially those covered by the EU ETS. The Yes category includes companies in energy, production and processing of ferrous metals, mineral, and pulp and paper industries. The No category includes all other industries. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.

[2] Energy Industry includes electric utilities, oil refineries and coke ovens. *Application of the emissions trading directive by EU Member States*, European Environmental Agency (2006), p.43.

The symbols $,*,**, and *** denote statistical significance at the 0.10, 0.05, 0.01 and 0.001 levels, respectively, using a 2-tail Patell Z test.

(a) Statistically significant at the 0.001 level using a 2-tail Cross-sectional standard deviation test and a 2-tail Jackknife test.

(b) Statistically significant at the 0.01 level using a 2-tail Cross-sectional standard deviation test and a 2-tail Jackknife test.

(c) Statistically significant at the 0.01 level using a 2-tail cross-sectional standard deviation test and statistically significant at the 0.001 level using a 2-tail Jackknife test.

References

Barber, Brad M. 2006. "Monitoring the Monitor: Evaluating CalPERS' Activism," working paper, Graduate School of Management, University of California at Davis.

Bernard, Victor L. 1987. "Cross-Sectional Dependence and Problems in Inference in Market-Based Accounting Research," *Journal of Accounting Research*, 25(1): 1-48.

Bernstein, Steven. 2002. "International Institutions and the Framing of Domestic Policies: The Kyoto Protocol and Canada's Response to Climate Change," *Policy Sciences*, 35(2): 203-236.

Blacconiere, Walter G. and Dennis M. Patten. 1994. "Environmental Disclosures, Regulatory Costs, and Changes in Firm Value," *Journal of Accounting and Economics*, 18(3): 357-377.

Blacconiere, Walter G. and W. Dana Northcut. 1997. "Environmental Information and Market Reactions to Environmental Legislation," *Journal of Accounting, Auditing and Finance*, 12(2): 149-178.

Bowen, Robert M., Richard P. Castanias and Lane A. Daley. 1983. "Intra-Industry Effects of the Accident at Three Mile Island," *Journal of Financial and Quantitative Analysis*, 18(1): 87-111.

Clarkson, Peter M., Yue Li, Gordon D. Richardson and Florin P. Vasvari. 2008. "Revisiting the Relation Between Environmental Performance and Environmental Disclosure: An Empirical Analysis," *Accounting, Organizations and Society*, 33: 303-327.

Collins, Daniel W. and Warren T. Dent. 1984. "A Comparison of Alternative Testing Methodologies Used in Capital Market Research," *Journal of Accounting Research*, 22: 48-84.

Cortell, Andrew P. and James W. Davis, Jr. 1996. "How Do International Institutions Matter? The Domestic Impact of International Rules and Norms," *International Studies Quarterly*, 40(4): 451-478.

Cowan, Arnold R. 2006. *Eventus 8.0 User's Guide*, Standard Edition 1.0.

European Environmental Agency. 2006. *Application of the emissions trading directive by EU Member States*, EEA Technical Report, Copenhagen, Denmark.

Fama, Eugene F. and Kenneth R. French. 1992. "The Cross-Section of Expected Stock Returns," *Journal of Finance*, 47(2): 427-465.

Freedman, Martin and Dennis M. Patten. 2004. "Evidence on the Pernicious Effect of Financial Report Environmental Disclosure," *Accounting Forum*, 28(1): 27-41.

Hamilton, James T. 1995. "Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data," *Journal of Environmental Economics and Management*, 28(1): 98-113.

Hill, Joanne and Thomas Schneeweis. 1983. "The Effect of Three Mile Island on Electric Utility Stock Prices: A Note," *Journal of Finance*, 38(4): 1285-1292.

Keohane, Robert O., Peter M. Hass and Marc A. Levy. 1993. "The Effectiveness of International Environmental Institutions," In Hass, Peter M., Robert O. Keohane and Marc A. Levy, eds., *Institutions for the Earth*, The MIT Press, Cambridge & London.

Khanna, Madhu, Wilma Rose H. Quimio and Dora Bojilova. 1998. "Toxic Release Information: A Policy Tool for Environmental Protection," *Journal of Environmental Economics and Management*, 36: 243-266.

King, Andrew A. and Michael J. Lenox. 2001. "Does it Really Pay to be Green?," *Journal of Industrial Ecology*, 5: 105-116.

Konar, Shameek and Mark A. Cohen. 1997. "Information as Regulation: The Effect of Community Right to Know Laws on Toxic Emissions," *Journal of Environmental Economics and Management*, 32(1): 109-124.

Kothari, S. P. and Jerold B. Warner. 2006. Econometrics of Event studies, in B. Espen Eckbo, Ed., *Handbook of Empirical Corporate Finance*, Elsevier-North-Holland.

MacKinlay, A. Craig. 1997. "Event Studies in Economics and Finance," *Journal of Economic Literature*, 35: 13-39.

Margolis, Joshua D. and James P. Walsh. 2003 "Misery Loves Companies: Rethinking Social Initiatives by Business," *Administrative Science Quarterly*, 48: 268-305.

Martin, Lisa L. and Beth A. Simmons. 1998. "Theories and Empirical Studies of International Institutions," *International Organization*, 52: 729-757.

Patell, James M. 1976. "Corporate Forecasts of Earnings Per Share and Stock Price Behavior: Empirical Test," *Journal of Accounting Research*, 14(2): 246-276.

Patten, Dennis M. 2002. "The Relation between Environmental Performance and Environmental Disclosure: A Research Note," *Accounting, Organizations, and Society*, 27(8): 763-773.

Patten, Dennis M. and Jon R. Nance. 1998. "Regulatory Cost Effects in a Good News Environment: The Intra-industry Reaction to the Alaskan Oil Spill," *Journal of Accounting and Public Policy*, 17: 409-429.

Simmons, Beth A. and Daniel J. Hopkins. 2005. "The Constraining Power of International Treaties: Theory and Methods," *American Political Science Review*, 99(4): 623-631.

Tirole, Jean. 2001. "Corporate Governance," *Econometrica*, 69, 1-35.

Verrecchia, Robert E. 2001. "Essays on Disclosure," *Journal of Accounting and Economics*, 32: 97-180.

CHAPTER 4

Does Competition Promote Environmental Investments?: Retail Electricity Restructuring and Renewable Generation

I. Introduction

For traditionally regulated firms, deregulation represents perhaps the most significant change in their external environment. From a managerial perspective, one of regulation's most salient features is that it shields firms from competition (Stigler, 1971; Jordan, 1972; Peltzman, 1976; 1989; Winston, 1998). Although not allowed to make excessive profits, these firms are often guaranteed to earn a reasonable rate of return as long as their investments are not judged imprudent by regulators (Lyon, 1991). Thus, managing their relationships with regulators becomes a top priority for any regulated firm (Mahon and Murray, 1980; 1981). Upon deregulation, however, the focus shifts from regulators to competitors and customers (Mahon and Murray, 1980; 1981). Not surprisingly, prior research finds that formerly regulated firms make strategic changes in response to deregulation (Smith & Grimm, 1987; Zajac & Shortell, 1989; Rajagopalan & Finkelstein,1992, Reger et al., 1992; Haveman,1993; Zajac et al., 2000; Pettus, 2001). The overall finding is that deregulation provides incentives for greater efficiency, for example, exerting downward pressure on costs, reducing slack, and even driving innovation forward.[71]

Interestingly, another stream of research suggests that deregulation may do something good for the natural environment as well. These studies find that the intensity of competition is positively associated with environmental differentiation, i.e., production of green goods or better management of environmental performance (Arora and Gangopadhyay, 1995; Delmas et al., 2007; Fernandez-Kranz, 2008). In particular, firms that produce final goods engage in environmental differentiation because final customers are more responsive to "being green" (Arora and Cason, 1995 and Khanna and Damon, 1999). In this paper, I study whether this relationship holds true for traditionally regulated firms within an industry context.

Among recently deregulated industries, the electric utility industry provides the best possible setting to study this question. Of all industrial sectors, the electric utility industry emits the greatest amount of greenhouse gases that cause climate change and has access to a range of technologies for producing its product, electricity. These technologies vary in terms of production costs and environmental impacts. In particular, renewable generation technologies are on average more expensive but far less polluting compared to other technologies that use more conventional energy sources such as coal (Burtraw, Palmer, Heintzelman, 2000). This paper examines how retail electricity restructuring, which allows customers to choose their own electricity suppliers, affects the renewable investment decisions of electric utility companies (investor-owned utilities (IOUs)) in the United States. The first retail competition programs began operating in

[71] With the recent crisis in financial markets and the subsequent economic downturn, regulations are being tightened. Deregulation might not be wholly responsible for the weakening economy, but this certainly brings attention to the cost side of economic deregulation.

Massachusetts, Rhode Island, and California in early 1998 (Joskow, 2005). As of July 2000, twenty four states and the District of Columbia passed legislation or issued regulatory orders to promote retail competition (see Figure 1). The California electricity crisis of 2000-2001, however, slowed down restructuring initiatives (Wolfram, 2005). Only in about fifteen states did restructuring remain active in 2007 (see Figure 2).

I identify three factors that can affect firms' investment decision on renewables: customer switching to alternative electricity suppliers, renewable sales in competitive electricity markets, and differences in returns to renewable investments between restructured and regulated states. I argue that all three factors work in a way that discourages renewable investments in a restructured market environment. First of all, the evidence shows that upon restructuring, most retail customers switched their electricity suppliers searching for low cost (Joskow, 2005). Even residential customers appear to have changed their electricity suppliers mostly out of economic motivation, not out of environmental stewardship. To the extent that renewables are more costly, this customer switching behavior should discourage renewable investment. Second, IOUs have little incentives to take advantage of the additional channel through which consumers can purchase green electricity under restructuring, i.e., competitive renewable electricity markets. This market is not only small, but also not profitable because competition with independent power producers (IPPs), whose traditional strength is in renewable generation, drives down renewable electricity prices. Also, green power marketers play a major role in the competitive renewable electricity markets. Third, rate-of-return regulation should provide IOUs with a greater incentive to invest in renewables than competitive restructured markets since there is no precedence of disallowing renewable investment cost. Also, the Averch-Johnson effect (Averch and Johnson, 1962) suggests that rate-of-return regulation should actually encourage renewable investment to a greater extent because for renewable generation, fixed capital cost is high and operating cost is low. Green premiums under green pricing programs appear similar in a regulated and restructured environment.

I test the hypothesis using data from 1998 to 2000, which is the period preceding the repeal of restructuring legislation in many states due to the California electricity crisis.[72] I also supplement regression analysis with phone interviews of representatives at three major electric utility companies, Duke Power, PSE&G, and DTE Energy. In addition, a conversation with Sam Wyly, owner of Green Mountain Energy, a green power marketer, provided insights into how large incumbent electric utility companies compete with smaller green power marketers and independent power producers in restructured states.

The major finding of this paper is that retail electricity restructuring is associated with lower probability of entry into renewable generation by electric utility companies. This negative impact on initial investment is likely to persist over time, since I also find that a utility is more likely to increase the share of renewables in its portfolio once it has made an initial investment in renewables. These findings are robust to the inclusion of a host of control variables that proxy for other relevant factors: green demand, green pressure, substitutes for IOU renewables, generation statistics, electricity market conditions, and changes in firm boundaries.

I find also that initial renewable investment decisions by large incumbent regulated IOUs are affected more by regulatory (retail restructuring and renewable

[72] This is to avoid any confounding effects due to the repeal of restructuring legislation.

portfolio standards (RPS)) and technological (wind power potential) factors than pressures from environmental activists. This finding contrasts with the study of Sine and Lee (2008) who find that environmental activists have a significant effect on renewable development by unregulated independent power producers (IPPs). It appears that investment decisions by large incumbent regulated IOUs are less responsive to pressure from environmental activists.

This paper contributes to the literature on regulation/deregulation and individual firm behavior, corporate environmental strategy, and renewable energy. First of all, it is related to a relatively small body of literature which studies the role of regulatory institutions in shaping individual firm strategy. My paper adds to this literature by showing how competition-enhancing deregulation leads firms to choose lower cost production technologies, which might have negative environmental implications. Secondly, the prior literature on corporate environmental strategy identifies three main drivers for corporate environmentalism: green customers, cost reduction and non-market strategy. I demonstrate how economic regulation/deregulation affects corporate environmental strategy. Thirdly, most prior research on renewable energy tends to be policy-oriented and studies state-level renewable development. Instead, this paper is private firm-oriented and focuses on how electric utility companies make renewable investment decisions. It is important to understand how these large companies, the dominant players in the electricity market, make strategic decisions on renewable investments.

The remainder of the paper is organized as follows. Section 2 develops testable hypotheses. Section 3 describes the data and method. Section 4 reports results and section 5 discusses further research. Section 6 concludes.

II. Hypotheses Development

Deregulation and Firm Behavior

The causes of economic deregulation are contentious, reflecting alternative theories of regulation (Joskow and Noll, 1981; Stiger, 1971; Peltzman, 1976). Changes in demand or supply might eliminate the market failure that originally motivated regulation, or the politics and the economics of the regulated industries might shift over time (Peltzman et al., 1989). The consequences of economic deregulation, however, are less debatable. Economic deregulation increases competition because the primary function of regulation is to limit competition among firms (Peltzman, 1989; Winston, 1998).[73] When an industry is deregulated, competition arises from new entrants as well as among incumbent firms. In the case of the airline industry, for example, low-cost carriers such as Southwest Airlines and Valuejet entered the market and drove down the average air fares of the entire industry. Overall, deregulated industries substantially improved their productivity and reduced operating costs from 25 to 75 percent (Winston, 1998), perhaps partly by shedding X-inefficiency (Leibenstein, 1966) accumulated under regulation. In general, these cost savings have not significantly increased industry profitability

[73] Deregulation may also directly foster efficient input allocation. For example, as demonstrated by Averch and Johnson (1962), a particular form of regulation, rate-of-return regulation, induces regulated firms to overinvest in capital because the regulators determine a firm's profits as a percentage of the firm's capital investment, or rate base. Deregulation removes this incentive.

(Winston, 1998). Instead, the intensity of competition under deregulation has forced much of the savings to be passed on to consumers in lower prices.

Mahon and Murray (1980; 1981) discuss how firms actually manage the transition from a regulated to a deregulated environment.[74] In regulated industries, firms are typically overseen by one or more industry-specific regulatory agencies or commissions. For example, electric utilities are regulated by the Federal Energy Regulatory Commission (FERC) and by the state public utility commissions (PUCs). Regulators can allow or forbid a firm's action that affects profitability. In the case of the airline industry, for instance, before deregulation the Civil Aeronautics Board (CAB) regulated virtually every business decisions from entry and exit from individual city-pair markets to airfares (Creager, 1983). Also, regulators often directly determine a firm's allowed rate of return. Under the circumstances, managing the relationships with regulators becomes inevitably a very significant part of a firm's strategy. Deregulation, however, changes who the firm's primary stakeholders are. Under deregulation, maintaining good relationships with regulators is no longer as important. Instead, deregulation requires the firm to deal more directly with its competitors and customers. This transition so fundamentally changes managerial assumptions and criteria for decision making that it represents a genuine transformation of the business (Mahon and Murray, 1980).

Not surprisingly, previous studies find that deregulation has significant effects on firms' strategic choices. For example, Zajac and Shortell (1989) and Smith and Grimm

[74] Mahon and Murray (1980) consider regulation as an administrative and legal process designed to ensure that the public interest is represented and served by means other than market forces. This view is consistent with Joskow and Noll (1981). As discussed earlier, however, how to define regulation does not seem to affect what the consequences of deregulation are and thus how firms might respond to deregulation.

(1987) show that firms make overall strategic changes upon deregulation to realign their internal resources with a changing environment.[75]

A more interesting question than *whether* firms make strategic changes upon deregulation is *what* kind of changes they make. Zajac et al. (2000) examine the extent to which firms in the savings and loan industry changed their core strategy, residential mortgage lending, in response to deregulation. They argue that differences in organizational characteristics such as cost of funds explain most of the differences in how firms responded to deregulation. Haveman (1993) studies which firms in the savings and loan industry are most likely to change after deregulation. She finds that medium-sized firms changed to a greater degree than small or large firms. Haveman posits that large firms have more market power and slack resources, but at the same time are more bureaucratic and thus more prone to inertia. Reger et al. (1992) show that deregulation of the banking industry led firms in this industry to change their product and market mix, and diversification and risk-related decisions. Pettus (2001) argues that upon deregulation of the trucking industry firms that used their resources and capabilities in a specific sequence outperformed other firms. In a more general context, Johnson and Myatt (2003) shows that whether an incumbent chooses to expand or contract its product line upon new firm entry depends on whether the incumbent wishes to increase or decrease its total output.

For the electric utility industry, Rajagopalan and Finkelstein (1992) find that as environmental uncertainty increased due to deregulation, a greater number of investor-owned electric utilities (IOUs) adopted outcome-based compensation plans to reduce monitoring costs and paid managers more to reduce managerial risk. Rajagopalan (1996)

[75] What is strategic change vs. strategic adjustment may be debatable (see Ginsberg, 1988).

further finds that the relationship between executive pay and performance is contingent upon the extent to which the specific characteristics of the compensation mechanisms in place within a firm are consistent with the firm's strategic context. Delmas et al. (2007) argue that deregulation opened up the green electricity market and accordingly some IOUs chose to differentiate by producing renewable energy. Although not directly related to deregulation, interestingly, Russo (1992) finds that the tension between IOUs and regulators following the Arab oil embargo of 1973 led IOUs to expand into activities not subject to regulatory oversight.

Retail Electricity Restructuring

I begin by reviewing the developments that have led to the restructuring of the electric utility industry in many states in the US.[76] Traditionally, major electric utility companies were vertically integrated, owning generation, transmission, and distribution facilities. These utilities operated as natural monopolies in exclusive franchised areas. The bundled rates they charge (one price for electricity generation, transmission and distribution) were determined by cost-of-service regulation, under which utilities were allowed to recover their costs and to earn a fair rate of return on the capital invested. Like any restructuring or deregulation initiatives, the electricity restructuring movement is based on the widespread view that competition promotes efficiency and consumer welfare (EIA, 2000).

[76] Restructuring entails a change in approach to economic regulation, reducing reliance on regulation and increasing reliance on market forces. Restructuring does not result in the elimination of all regulations. In the case of the electric power industry, for example, even under retail electricity restructuring, state authorities still decide who pays for stranded costs, i.e., costs incurred by utilities under a regulated environment that may not be recoverable in a competitive market. Borenstein and Bushnell (2000) argue that electricity is especially vulnerable to the exercise of market power, even by firms with relatively small market shares, so there will be continued need for regulatory oversight in these markets, at least until there is much more real-time demand responsiveness. They note that restructuring in electricity market is not now, and is unlikely to be, synonymous with deregulation.

This is partly exemplified by state-level retail restructuring which occurred in states with high electricity prices in the hope that it would bring down electricity prices.

Although regional competitive wholesale power markets have been promoted by the Public Utility Regulatory Policy Act (PURPA) of 1978, the Energy Policy Act of 1992, and the subsequent Federal Energy Regulatory Commission (FERC) orders 888 and 889,[77] retail markets were not open to competition until state-level retail restructuring in the late 1990s.[78]

The first retail competition programs began operating in Massachusetts, Rhode Island, and California in early 1998 (Joskow, 2005). As of July 2000, twenty four states and the District of Columbia passed legislation or issued regulatory orders to promote retail competition within their borders. Figure 1 demonstrates how popular the idea of restructuring was as of February 2001.

Except for eight states, all other states took some actions to address the issue of restructuring. The California electricity crisis of 2000-2001, however, has slowed down restructuring initiatives in the United States (Wolfram, 2005).[79] Figure 2 shows the status of restructuring as of April 2007.

Only in about fifteen states did restructuring remain active in 2007. Furthermore, nine states which had restructuring legislation enacted as of 2001 suspended it thereafter.

---

[77] PURPA of 1978 made it possible for nonutility generators to enter the wholesale power market (A nonutility is a power producer that owns electric generating capacity but is not an electric utility, i.e., not regulated). The Energy Policy Act of 1992 and FERC orders 888 and 889 in 1996 promoted greater competition in the wholesale electricity market, most of all, by requiring open and equal access to utilities' transmission lines for all electricity producers within their jurisdiction. http://www.eia.doe.gov/cneaf/electricity/page/fact_sheets/restructuring.html.

[78] In the case of local exchange telephone markets, Kaserman and Mayo (1997) argue that competition may not need to await the development of full facilities-based wholesale competition before the benefits of retail-level competition can be realized. Specifically, to the extent that public policy rules can be fashioned to promote efficient resale policies, competition at the retail level can be fostered.

[79] During summer 2000, the wholesale price of electricity in California shot from an average of about $30 a megawatt (MW) hour to over $150 a megawatt hour with prices in some hours reaching $750. Since the California debacle, the electricity deregulation movement has stalled (Griffin and Puller, 2005).

Also, many states that were considering restructuring as of 2001 did not eventually implement it.

Retail restructuring basically allows customers to choose their own electricity suppliers.[80] The customer choice is expected to lower electricity prices by driving competition among suppliers. Retail electricity restructuring presents a tough challenge for electric utility companies that had traditionally been shielded under rate-of-return regulation. Under rate-of-return regulation, electricity prices are set so as to cover the firm's operating costs and reward its investors with a fair rate of return on the capital invested.[81] After restructuring, electricity prices are determined in a competitive market without the fair rate of return guarantee. Although the real effect of restructuring on electricity price is controversial,[82] at least the plant-level evidence shows that after retail restructuring the efficiency of electric generating plants has on average increased (Fabrizio, Rose and Wolfram, 2007; Zhang, 2007). These findings support the view that retail electricity restructuring drives competition and accordingly provides electric utilities with an incentive to become more efficient.

---

[80] Implementation details may vary across states. For example, some states opened retail competition for different customer classes, i.e., residential, commercial, and industrial, at the same time whereas other states opened retail competition in sequence.
http://www.eia.doe.gov/cneaf/electricity/page/fact_sheets/restructuring.html

[81] Under rate-of-return regulation, the firm is assumed to maximize profit subject to regulatory constraint that its rate of return does not exceed the allowed rate. $\underset{K,L}{Max}\left(pq - rK - wL\right)$ *subject to* $\frac{pq - wL}{K} \leq s$ where, *p*=electricity price, *q*=electricity sales, *w*=wage, *L*=labor input, *r*=cost of capital, *K*=capital investment, and *s*=allowed rated of return (Crew and Kleindorfer, 1986).

[82] A New York Times article, "A New Push to Regulate Power Costs (09/04/07)" argues that electricity prices in deregulated states are not only higher than pre-deregulation period in the same states, but also higher than those in regulated states. However, many academic papers argue otherwise. For example, Klitgaard and Reddy (2000) suggest that high electricity prices around 2000 in some deregulated states are largely attributable to higher prices for oil and natural gas. Gagan (2006) finds that prices for industrial customers in restructured states were lower than in non-restructured states. Wolak (2005) argues that the California electricity crisis was fundamentally a regulatory crisis rather than an economic crisis.

Retail Electricity Restructuring and IOU Renewable Fuel Mix

How would retail electricity restructuring affect renewable fuel mix of investor-owned electric utilities (IOUs)?[83] I identify three factors that can affect this decision: customer switching to alternative electricity suppliers, renewable sales in competitive electricity markets, and differences in returns to renewable investments between restructured and regulated states. I discuss the effects of the three factors in turn below. These discussions lead to the hypothesis that retail electricity restructuring discourages renewable investment by IOUs.

Customer Switching

Under restructuring, retail customers can choose their own electricity suppliers. How they change their electricity suppliers should affect IOU renewable fuel mix. Electricity customers are generally classified into three groups: industrial, commercial and residential. Below I discuss the extent to which and the patterns in which these classes of customers switched their electricity suppliers upon restructuring.

During phone interviews, representatives at DTE energy explained that switching is more common among industrial and large commercial consumers.[84] This is partly because alternative electricity providers, due to economies of scale, approach these

[83] Fuel mix portfolio, the proportions of each fuel type used by a company to generate electricity, perhaps represents one of the most important strategies for electric utility companies. On its website, American Electric Power (AEP), the largest generator of electricity in the US, states what percentage of its total electricity is generated from different energy sources ("AEP believes strongly in the merits of fuel diversity in generating electricity, and its own generating fleet reflects that belief. Today, coal-fired plants account for 73 percent of AEP's generating capacity, while natural gas represents 16 percent and nuclear 8 percent. The remaining 3 percent comes from wind, hydro, pumped storage and other sources. AEP's recent investments in wind facilities have made it one of the nation's leaders in that renewable resource."). Also, the Energy Policy Act of 2005 emphasizes the importance of fuel diversity for electric utilities ("Each electric utility shall develop a plan to minimize dependence on one fuel source and to ensure that the electric energy it sells to consumers is generated using a diverse range of fuels and technologies, including renewable technologies." (http://www.doi.gov/iepa/EnergyPolicyActof2005.pdf)).

[84] Two phone interviews with two DTE Energy representatives were conducted on 08/18/08.

classes of customers instead of residential or small commercial customers. Joskow (2005) confirms that it was mostly large commercial and industrial customers who took advantage of retail competition and switched electricity suppliers upon retail restructuring. Typically, these customers seek to minimize their input costs by lowering the cost of electricity.

Switching among residential and small commercial customers was limited, perhaps because the expected gain was small.[85] As a matter of fact, even residential customers appear to have changed their electricity suppliers mostly out of economic motivation, not out of environmental stewardship.[86] In Ohio, for example, residential customers whose default electricity suppliers were subsidiaries of America Electric Power (AEP) or Dayton Power and Light did not change their suppliers, whereas more than 50% of residential customers whose default suppliers were First Energy subsidiaries changed their suppliers (Joskow, 2005).[87] It turned out that AEP and Dayton subsidiaries had very low retail prices, lower than the wholesale-market price, whereas First Energy subsidiaries had high retail prices to recover their stranded costs (costs incurred by utilities for power plants and contracts under a regulated environment that may not be recoverable in a competitive market).

---

[85] In 1998, the year California started retail electricity restructuring, Datamonitor surveyed a random sample of 109 California residents. Only 2% of them actually switched suppliers. Even this small percentage, however, turned out to be an overestimate. According to Terry Winter, the California Independent System Operator's chief officer, only about 40,000 of a possible 8 million residential customers have actually switched suppliers. This corresponds to less than 0.5% of the residential customers (Business Insight, 1999).

[86] Of course, some residential customers voluntarily contribute to support financing for green electricity development or purchase green electricity for consumption. See Kotchen and Moore (2007).

[87] The high switching rate, 50%, contrasts with very low residential customer switching rate in other restructured states: 3% (Massachusetts, 2002), 5% (New York, 2002), <1% (Maine, 2003), and <1% (New Jersey, 2002) (Joskow, 2005).

If the majority of customers switch their electricity suppliers searching for low cost, [88] IOUs should respond to this change by choosing lower cost production technologies.[89] Since renewable generation technologies are on average more costly (see Table 1[90]) compared to other technologies that use more conventional energy sources such as coal (Burtraw, Palmer, Heintzelman, 2000), holding other things equal, IOUs would be expected to invest less in renewables upon retail electricity restructuring.

Competitive Renewable Electricity Markets

Delmas, et al. (2007) argue that retail restructuring encouraged some IOUs to increase renewables to serve customers whose green demand was not met under traditional rate-of-return regulation. It is unclear, however, whether retail restructuring provides IOUs with additional incentives to take advantage of green consumers.

Even under rate-of-return regulation, green consumers have ways to express their preferences. They can either purchase green electricity through utilities' green pricing programs if their utilities provide such programs, or purchase renewable energy certificates (RECs), which is available nationwide, even if their utilities do not provide green pricing programs.[91]

Under retail electricity restructuring, there is an additional channel through which consumers can purchase green electricity, i.e., competitive markets. Competitive markets,

---

[88] According to phone interviews with representatives at Duke Energy, PSE&G, and DTE Energy conducted during summer 2008, switching costs are not high. Theoretically, it could affect the extent of switching. For example, Toolsema (2008) shows how interfirm switching costs may facilitate monopoly pricing and how intrafirm switching costs may hinder it.

[89] Typically, green electricity is marketed at prices ranging from 10% to 30% above the price of conventional electricity (Kotchen and Moore, 2007).

[90] Note that Table 1 compares average capital and generation costs of different power sources as of 2007.

[91] http://www.eere.energy.gov/greenpower/markets/index.shtml

however, account for only small fraction of the total green power sales.[92] Also, these new competitive markets open additional channels to sell green power not only to large incumbent utilities but also to small independent power producers (IPPs) and green power marketers. Indeed, these smaller players appear to have profited handsomely in restructured markets (Wyly, 2008).[93] IPPs may especially have a comparative advantage in competitive markets because they could produce renewable electricity at a lower cost than large incumbent utilities, taking advantage of learning effects accumulated since the opening of the whole sale market to nonutilities in 1978 (Sine and Lee, 2008). Under this circumstance, IOUs may choose to focus on their relative strength, low-cost large-scale electricity generation from traditional sources such as coal or nuclear.

Changes in Returns to Renewable Investment

Under regulation electric utilities are allowed to recover a fair rate-of-return as long as their investments are not judged imprudent by regulators.[94] This includes investments in renewable capacity. Thus, under regulation, a higher cost of renewable generation is reflected on a broad rate base. Furthermore, the Averch-Johnson effect (over-investment in capital because of a fair-rate of return on capital investment, Averch and Johnson, 1962) suggests that rate-of-return regulation might actually encourage renewable

---

[92] This is based on the discussion with a representative at DTE energy (08/18/08). Also, Bird et al. (2007) suggest that in 2006, utility green pricing accounted for 29% of green power sales, competitive markets 14% and RECs 57%.

[93] Sam Wyly is a self-made billionaire who owns Green Mountain Energy, a green power marketer. In a small meeting hosted by the Erb Institute for Global Sustainable Enterprise at the University of Michigan on September 18, 2008, I had a chance to present the results of this paper to Sam Wyly and learn from his experience owning/running Green Mountain Energy. He said restructuring opens the door for IPPs and green power marketers to sell directly to retail customers. Indeed, Green Mountain Energy made a large profit after Texas implemented restructuring legislation.

[94] During a phone interview, a representative at PSE&G clarified that electric utilities are less concerned about the risk of cost disallowance for renewables because there has not been a case where cost recovery for renewable investment was disallowed by regulatory authorities.

investment to a greater extent. This is so because for renewable generation, fixed capital cost is high and operating cost is low. In fact, interviews with a representative at PSE&G[95] indicated that IOUs in regulated states prefer to invest in renewable capacity themselves because they can get a fair rate of return on their investment, whereas if they purchase renewables from IPPs they can only pass through the cost to consumers as an expense.

Green power sold through green pricing programs sells for a higher price than non-green electricity, but green premiums are typically determined by the state public utility commissions even in restructured states.[96] To the extent that the regulators would allow reasonable, but not excessive, profits, incentives for utilities to sell renewable electricity through green pricing programs do not seem materially different in restructured vs. regulated states. The difference seems to lie in who pays for the green pricing premium, whether it is a broad consumer base under regulation, or green consumers who opt for green electricity under retail restructuring. Thus, holding everything else the same, the incentive for IOUs to produce renewable electricity seems higher in regulated states compared to restructured states.[97]

---

[95] Two interviews were conducted with a representative at PSE&G. One was via email on September 18, 2008 and the other was a phone interview on September 23, 2008.

[96] This is based on the discussion with a representative at Duke Power (08/06/08) and an email correspondence with a representative at the National Renewable Energy Laboratory (NREL). As of 08/06/08, Duke Power and three other utilities in Ohio (restructuring Senate Bill 3 passed in 1999) were waiting to hear the decisions of the PUC Ohio regarding the appropriate renewable premiums.

[97] In addition, in states with strong environmental activists, traditional rate-of-return regulation, which amounts to average-cost pricing, provided a supportive environment for renewables penetration. Environmental activists could easily take advantage of the collective action problem faced by consumers as a group, and press for increased renewables purchases; under average-cost pricing this would have too small an effect on rates to elicit much protest from typical consumers. In a deregulated environment, however, activists have no tool for imposing higher costs on other consumers; each consumer makes his own choice about how green his power will be.

The above discussions suggest that all three factors, i.e., customer switching, competitive renewable electricity markets, and changes in returns to renewable investments, work in a way that discourages IOU renewable investments in a restructured market environment. This tendency could be manifested in two related but distinct ways: (i) entry into renewable generation and (ii) proportion of renewables in the firm's fuel mix portfolio. This leads to the following hypotheses.

Hypothesis 1: Retail electricity restructuring is associated with lower probability of entry into renewable generation by electric utility companies.

Hypothesis 2: Retail electricity restructuring is associated with less proportion of renewables in the fuel mix portfolio of electric utility companies.

Since renewable generation is far less polluting compared to conventional power sources such as coal--for instance, most renewable sources do not emit greenhouse gases that cause climate change--these hypotheses imply that retail electricity restructuring leads to greater pollution problems than otherwise.

On a side note, it appears that suspension of retail restructuring, although only suggestive, provide a useful natural experiment to study the effect of retail restructuring on the deployment of renewables. For example, California suspended its retail competition in 2001. Table 2 compares two-year growth rates in total generation and in renewable generation (excluding hydro) in California during the retail restructuring period (1998-2000) and after the suspension of retail restructuring (2001-2003).

During the retail restructuring period, total generation increased by 10% and renewables only by 4%. On the contrary, after the suspension of retail restructuring, whereas total generation decreased by 3%, renewables increased by almost 9%. Although the statistics ignores the role of other variables such as renewable portfolio standards (RPS)[98], which was introduced in California in 2002, this simple comparison suggests that overall retail restructuring might have discouraged renewable generation.

III. Data & Methodology

I hand collected data from multiple sources. The data source for each variable is described in the Data Appendix. Three main sources include the U.S. Energy Information Administration (EIA), the U.S. Environmental Protection Agency (EPA), and the Federal Energy Regulatory Commission (FERC). As previously discussed, the first retail competition programs began in 1998, but the California electricity crisis of 2000-2001 has slowed down restructuring initiatives in the United States. Nine states which had restructuring legislation enacted as of 2001 suspended it thereafter. Also, many states that were considering restructuring as of 2001 did not eventually implement it. To avoid any confounding effects due to the repeal of restructuring legislation, this paper uses data

[98] RPS requires that electric utilities generate or purchase a certain fraction of their total electricity generation from renewable resources. Also, various federal and state incentives have promoted the deployment of renewables. For example, the Energy Policy Act of 1992 established a 10-year 1.5 cents per kWh inflation-adjusted production tax credit for tax-paying privately and investor-owned wind projects and closed-loop biomass plants brought online between 1994 and 1999.The incentive later renewed twice and extended through 2005. The latest extension increased the number of renewable technologies that are coved by the incentive (EIA, 2005). State financial incentives include public benefits fund, corporate income tax credits, exemptions, and deductions for investments in renewable technologies (EIA, 2001).

before 2001. The sample includes 119 investor-owned utilities (IOUs) in 45 states for years 1998 to 2000. These IOUs sell to industrial, commercial, or residential retail customers.[99] The dependent variables and the methodology used to test the two hypotheses are discussed in turn below. The independent variables are described in the results section as well as in the data appendix.

Entry into renewable generation

During the two year period 1999-2000, there were a total of eleven new IOU entrants in renewable electricity generation market.[100] Ten of them were located in non-restructured states. This simple statistic, however, does not take into account the effects of other variables. Thus, I use probit models with cross-sectional data to see whether this trend is robust after controlling for other effects. That is, I examine whether a dummy variable that indicates IOU initial investment as of 2000 is negatively associated with restructuring status as of 2000. To address potential endogeneity of the restructuring variable, I instrument the restructuring variable with state-level industrial retail electricity prices weighted by the share of the company's electricity sales in each state. Other independent variables included are mostly in terms of their 1998 values to avoid potential endogeneity.

[99] Stand-alone wholesale generating companies are not included in the sample. Excluding these IOUs, the sample represents about 65% of the total IOU population during the period. This is calculated based on a total of 177 IOUs during the period (Delmas et al., 2007). Considering IOUs produced about 84% of the total US electricity generation from 1998 to 2000, the sample covered in this paper represents about 55% of total electricity generation during the period.

[100] Because the dataset starts from year 1998, it is hard to know whether IOUs that produced renewables in 1998 also produced renewables in 1997. Thus, the paper examines new entrants only during 1999-2000. For the cross-sectional analysis, those IOUs that had renewable capacity in 1998 are dropped from the sample.

Renewable share in the fuel mix portfolio[101]

To capture electric utilities' strategy towards renewables, I use the proportion of renewables in IOU fuel mix as a dependent variable.[102] The share of renewables can be represented by the ratio of renewable capacity to total capacity. Renewable capacity instead of renewable generation better captures electric utilities' strategy since once renewable capacity is in place, renewable generation tends to be driven by weather conditions. For example, the amount of wind power generation depends upon wind availability although wind turbines are always in place once they are installed.

I use pooled OLS and fixed effect models for estimation. The independent variables are lagged by one year to avoid endogeneity concerns.

IV. Results

<u>Descriptive statistics</u>

Table 5 shows summary statistics for the explanatory variables used in the analysis, both in the aggregate and by restructuring status as of 2000.[103] Out of 232 firm-year observations, 46% are headquartered in states which are restructured as of 2000. IOUs in

---

[101] This paper examines how retail electricity restructuring affects the development of more costly, but less polluting renewable generation. Accordingly, the paper focuses on non-hydro renewable sources such as biomass, geothermal, solar and wind. Hydro generation is one of the cheapest electricity generation options and has been in operation since 1882 (http://www.americaslibrary.gov/cgi-bin/page.cgi/jb/gilded/hydro_1). Hydroelectric plants operate where suitable waterways are available and many of the best sites have already been developed (http://www.eia.doe.gov/cneaf/solar.renewables/page/hydroelec/hydroelec.html). Also, unlike other renewable sources, hydro generation has limitations that constructing and operating dams, especially large ones, incur environmental impacts which affect the habitats of the local plant, fish and animal life.

[102] Percentage variables are often used to capture firm strategy. For example, to measure geographic and traditional product/market diversification strategy in the banking industry, Reger et al. (1992) use foreign loans as a percentage of total loans, and assets in non-banking subsidiaries as a percentage of total assets, respectively. Zajac et al. (2000) measure strategic change as change in residential mortgage lending from year to year as a fraction of total assets.

[103] The correlations between each of the variables are shown in appendix.

restructured states are on average associated with smaller percentage of renewables, less wind potential, large size, higher toxic emissions per area, less previous renewable generation, higher LCV scores, higher capacity factor, lower residential sales fraction, higher natural gas price, lower environmental activists concentration, and greater level of merger and divestiture activities than those in non-restructured states.

Entry into renewable generation

The results of cross-sectional analysis for IOU initial investment in renewables is presented in Table 4. Panel A shows probit coefficients and panel B shows marginal effect.

The effect of retail electricity restructuring on IOU entry into renewable electricity investment is significant and negative. This supports hypothesis 1 that retail electricity restructuring is associated with lower probability of entry into renewable generation by electric utility companies. Based on model (4), the change in the probability of initial investment at the mean due to restructuring is -0.1.[104]

As expected, RPS is positively associated with IOU initial investment in renewables. This is consistent with recent state-level studies, which find that various state policies, especially renewable portfolio standards (RPS), encouraged renewable energy development. Interestingly, wind power potential alone does not have a significant effect on IOU initial investment. This is consistent with Sine and Lee (2008) who argue that wind energy development has not taken place in areas with the best wind resources. As shown in model (4), controlling for the effects of retail electricity restructuring and RPS, wind availability is positive and significant. This is not too surprising, reflecting the fact

[104] The observed probability is 0.1. The predicted probability at the mean is 0.06.

that the major source of renewables during the period studied was wind energy. Holding other things constant, those IOUs with access to wind resources were more likely to make initial investments in wind energy.

Entry into renewable generation – Robustness checks

The robustness checks are displayed in Table 5. The additional factors that I consider can be classified into six categories: green demand, green pressure, substitutes for IOU renewable generation, generation statistics, electricity market conditions, and changes in firm boundaries.[105] I explain in turn how these factors might affect entry into renewable generation by electric utility companies and discuss the regression results.

Green demand

Although the restructuring variable should capture the effects of changes in renewable demand due to customer switching or customer participation in competitive renewable electricity markets under restructuring, the restructuring variable does not proxy for the level of renewable demand. The renewable demand level can affect IOU initial investment in renewables because enough green demand can prompt utilities to invest in renewables. Model (1) shows the effects of green demand, measured as the average of the League of Conservation Voters (LCV)' scorecards and the renewable capacity to total capacity, on IOU initial investments in renewables. These variables are not significant either in Model (1) or in the most comprehensive model, Model (7).

Green pressure

[105] The variables used to measure these factors are discussed in the Data Appendix.

The previous literature on corporate environmentalism finds some empirical regularities that I expect to hold here as well (Arora and Cason, 1995; DeCanio and Watkins, 1998; Khanna and Damon, 1999). Firms facing greater pressure from environmental groups, dirty firms or large firms are more likely to undertake voluntary environmental actions. Thus, I control for these possibilities. Following the prior literature, I proxy pressure from environmental activists with Sierra magazine subscription per thousand populations. I measure utilities' environmental performance with the percentage of coal generation since coal is the most polluting fuel source used for electricity generation in terms of various environmental problems such as climate change or acid rain. Firm size is measured by the log of net generation. I find that only firm size has a positive effect on IOU initial investment in renewables, holding everything else constant (see Model (7)). Large utilities may have better access to capital markets and hence lower costs of new investments. This also suggests that large utilities may better tolerate risks associated with renewable investment than their smaller counterparts.[106]

In the context of renewable energy, Lyon and Yin (2008) find that the nonattainment index predicts states' RPS adoption. This means that negative environmental performance at the state level can predict future renewable regulation. Thus, I control for state-level environmental performance. Using Toxic Release Inventory (TRI) emissions, I find that utilities in states with higher level of toxic emissions are more likely to invest in renewables, controlling for other factors (see Model (7)). The positive effect can be interpreted as firms' response to the threat of future renewable regulation.

[106] According to the phone interviews with representatives at Duke Power, PSE&G, and DTE Energy, one of the factors that hinder utility investment in renewables during the period studied were risks associated with renewable operations and technology.

It is worth noting that holding other things constant, pressure from environmental activists does not have a significant effect on the likelihood of IOU initial investment in renewables. This finding contrasts with the study of Sine and Lee (2008). Examining the behavior of unregulated independent power producers (IPPs), they find that environmental activists have a significant effect on renewable development. It appears that investment decisions by large incumbent regulated IOUs are more affected by regulatory (retail restructuring and RPS) and technological factors (wind power potential) and less responsive to pressure from environmental activists.

Substitutes for IOU Renewable Generation

Two kinds of substitutes exist for IOU renewable generation. One is IOU natural gas-fired generation and the other is renewable generation by independent power producers (IPPs). Among fossil fuels used to generate electricity, natural gas has the least environmental problems. This led some people to argue that natural gas-fired generation and renewable generation are substitutes. Indeed, Palmer and Burtraw (2005) posit that higher natural gas prices lower the cost of greater reliance on renewables. I control for the possible low-carbon substitution effect using natural gas price. As shown in models (3) and (7), however, the effect of natural gas is not significant.

Although IOUs can be major drivers of renewable generation in the future, they are not yet the main producers of renewable electricity in the US. IOUs typically generate electricity from coal, nuclear or natural gas that allows them to take advantage of large economies of scale. Instead, independent power producers (IPPs) account for over 60% of total renewable generation in the US. Thus, I control for the IOU portion of renewable generation. The effect of this variable, however, is not significant in the most comprehensive model (7).

Generation statistics

Firm heterogeneity amongst IOUs is often characterized by their generation statistics. These variables might affect utilities' decision to enter the renewable generation market. I control for generation efficiency, utilization rate, and vintage.

Generation efficiency in terms of fossil fuel combustion is measured by heatrate. It is interesting to find that the likelihood of entering the renewable generation business is higher for IOUs with a higher heatrate. This means that IOUs whose fossil fuel combustion efficiency is low are more likely to enter the renewable market than their more-efficient counterparts. This finding suggests how lack of a certain capability might encourage companies to extend into business areas that do not require this capability.

Also, utilities with a high utilization rate or an older fleet of power plants are more likely to enter into renewable energy investments. These results suggest, respectively, that renewables may be part of growth strategy and may displace older power plants to a certain extent.

Electricity market conditions

Electricity market conditions considered include growth in electricity demand, the fraction of new entrants in the electricity market, the fraction of residential sales at the utility level and transmission grid interconnections. Electricity demand growth can affect utilities' fuel mix. For instance, if demand is growing rapidly, utilities may prefer to invest in large-scale fossil or nuclear power plants instead of small-scale renewables. Also, new entrants in the electricity market, regardless of their types (e.g., IOU, IPPs, etc.), can affect utilities' fuel mix portfolio. They might alter the competitive environment or spread new technology such as renewables. The fraction of residential sales controls for differences in customer characteristics at the firm level. As discussed earlier, industrial and commercial customers may behave differently than residential customers. Transmission grid interconnections controls for whether an electric utility belongs to Eastern/Western/Texas interconnected system.[107] The regression results show that holding other things constant, utilities in the western interconnected system are more likely to make an initial investment in renewables.

Changes in firm boundaries

In response to increased competition in power generation due to retail electricity restructuring, investor-owned utilities have engaged in mergers and acquisitions. There were two types of mergers. The first category includes mergers between IOUs or between IOUs and IPPs, motivated by increasing the size of the company. The second type includes mergers between electric utilities and natural gas companies, taking advantage of the synergy between them (EIA, 1999)). Also, many states that have restructured their electric utility industry required utilities to divest their assets. Thus, I control for these effects.[108] They are not significant, however.

[107] Texas interconnection equal to 1 predict failure perfectly and thus not included.

[108] Merger process with gas utility or Divestiture equal to 1 predict failure perfectly, and thus not included in the regression.

Overall, I find that initial renewable investment decisions by large incumbent regulated IOUs are affected by regulatory (retail restructuring and RPS) and technological factors (wind power potential). These results are robust to the inclusion of other control variables. [109] Also, green pressure, generation statistics and electricity market conditions have some effect on IOU initial investment in renewables.

Renewable share in the fuel mix portfolio

Table 6 shows how retail electricity restructuring in year t-1 is associated with the renewable share in IOU fuel mix portfolio in year t.

With pooled OLS, the negative correlation between retail electricity restructuring and the renewable share in IOU fuel mix is significant (see model (1)). The estimated coefficients of pooled OLS models could be biased, however. This is so because the independent variables do not include unobservable firm-specific characteristics such as green preference of the management, which must be correlated with observable firm-specific independent variables.[110]

[109] One might argue that restructuring is endogenous, i.e., the restructuring variable is correlated with the error term. To address this possibility, I instrument the restructuring variable with state-level industrial retail electricity prices obtained from the EIA website. The industrial price variable seems to satisfy the requirements for instrumental variables. First, industrial prices are correlated with restructuring because states with high electricity prices often restructured their electricity markets to lower prices (the first-stage F statistic for the most comprehensive model (model (7)) shows that the instruments are jointly significant (χ^2[19]=54.7 and p-value=0.0). For the industrial price variable, χ^2[1]=5.76 and p-value=0.02). Second, industrial retail prices are not likely to be correlated with the dependent variable, IOU entry into renewable electricity generation because industrial customers most exclusively depend on low-cost non-renewable electricity sources (this is why I use industrial prices alone instead of including other types of retail prices such as commercial or residential prices). The Wald test of the exogeneity of the instrumented variable (restructuring), does not reject the null hypothesis that there is no endogeneity (For model (7), χ^2[1]=1.97 and p-value=0.161). With the instrumental variable, the major finding of this paper, the significant negative effect of retail restructuring, does not change. Also, wind power potential, TRI emissions, and western interconnection have significant effect on IOU initial investment in renewables.

[110] Hausman statistics are presented at the bottom of Table 6. Note that the Hausman tests are significant only when the lagged renewable generation dummy is included in the regression. This is not surprising since this variable is the only firm-specific independent variable. Other independent variables included are

With fixed effect models, the effect of restructuring is no longer significant (see models (2)-(5) in Table 6). This finding does not support hypothesis 2. Retail electricity restructuring is not associated with less proportion of renewables in the fuel mix portfolio of electric utility companies. Retail electricity restructuring seems more important in explaining entry into renewable generation by electric utility companies than growth in the share of renewables in their fuel mix.

Furthermore, previous renewable generation has a significant and positive effect on the within-firm renewable percentage growth. Holding everything else constant, firms that previously generated renewables increased renewables in their fuel mix portfolio by as much as 7% than the other firms. Probably, this large influence of previous renewable generation indicates learning effect over time. The phone interviews with representatives at Duke Power, PSE&G, and DTE Energy suggest that one of the risks associated with renewable investment is risks associated with renewable operation and technology, and there exist a significant learning effect in terms of renewable electricity generation.

Renewable share in the fuel mix portfolio – Robustness checks

The robustness checks are presented in Table 7. Additional factors considered are the same as for the initial renewable investment regression: green demand, green pressure, substitutes for IOU renewable generation, generation statistics, electricity market conditions, and changes in firm boundaries. To avoid redundancy, in this section I only explain the significant results.

---

state-level variables (restructuring, RPS and wind), although they are adjusted for each firm using firm-level electricity sales data.

Natural gas price is negatively associated with growth in renewables in IOU fuel mix portfolio. This contrasts with Palmer and Burtraw (2005) who argue that higher natural gas prices lower the cost of greater reliance on renewables. It appears that high costs incurred due to high natural gas price discourage the deployment of even higher cost technology such as renewable generation. One-dollar increase in natural gas price is associated with 0.2% reduction in renewable percentage in IOU fuel mix.

As expected, electricity demand growth has negative effect on the share of renewables. With growing demand, electric utility companies prefer to invest in large-scale fossil or nuclear power plants instead of small-scale renewables. The magnitude of the effect, however, is not large. If electricity generation is doubled so that the annual growth in electricity generation fraction is equal to 1, then the effect on the share of renewables would be 1%. Since the average of this variable is about 0.03, the effect seems to be on average less than 0.1%.

Interestingly, the number of new entrants per total number of electricity producers in a state has a positive effect on the within-firm renewable percentage growth. Since new entrants do not bring extra competition to franchised IOUs in regulated states, it is difficult to argue that new entrants measure the effect of competition.[111] Instead, since this measure includes all kinds of entrants including IPPs which mainly uses renewables as their power source, this variable may indicate the extent to which renewable technology was additionally introduced at the state level. More use of renewables in a state may encourage IOUs to increase renewables in their fuel mix since state PUCs become more comfortable with risks involved with using renewable technology. Again,

[111] To see if new entrants had differential effects in restructured vs. regulated states, an interaction term between retail restructuring and new entrants was added to the regressions in Table 7. The effect was found not to be significant, however.

the magnitude of the effect is not large, however. If the number of the total electricity producers is doubled so that the entrant fraction is equal to 1, then the effect on annual growth in renewables in IOU fuel mix would be 0.8%. Since the average of this variable is about 0.1, the effect seems to be on average less than 0.1%.

Relation to Prior Literature

In a recent pioneering study, Delmas et al.(2007) find that retail restructuring is associated with greater renewables. Although their dependent variable, percentage change in *all renewable generation including hydro*[112], is a little different from this paper, it would be interesting to find out where the discrepancy might be coming from.[113]

In the first three columns (without Divestiture) in Panel A of Table 7, I show the key estimation results, which I obtained by replicating the regressions of Delmas, et al.(2007) to the extent possible using the dataset I collected.[114] Two out of their three key independent variables, retail restructuring and percentage generation from coal, have the same signs and similar magnitudes.

These results, however, are obtained without controlling for the effect of divestiture. Many states that have restructured their electric industry required utilities to

---

[112] The dependent variable used is equal to $\left(\frac{Renewable\,Generation_t}{TotalGeneration_t} - \frac{Renewable\,Generation_{t-1}}{TotalGeneration_{t-1}}\right) \times 100.$

[113] I use *percentage of renewable capacity excluding hydro* as a dependent variable. I use *Renewable capacity* instead of *renewable generation* because renewable generation is often driven by weather conditions once renewable capacity is built. I use *non-hydro renewables* because I am interested in how retail electricity restructuring affect the deployment of more expensive non-hydro renewables such as biomass, geothermal, solar and wind. As mentioned earlier in the paper, hydro is one of the cheapest energy sources and has been used since 1882.

[114] These models correspond to models (B), (C), (D) in Delmas et al. (2007). Model (A) is not used because it does not include the restructuring variable.

divest their assets.[115] Figure 3 shows the extent of power generation divestitures of IOUs by fuel type as of September 1999. Coal- and gas-fired plants top the list of divested power plants. About 46 gigawatts of coal-fired capacity (15 percent of total coal-fired capacity) and 41 gigawatts of gas-fired capacity (28 percent of total gas-fired capacity) have been divested or were up for sale as of 1999.

Thus, it is necessary to take divestiture into account when examining the effect of retail electricity restructuring on renewable generation as a percentage of total generation. Otherwise, divestiture of non-renewable assets such as coal or natural gas units could lead to potentially misleading results, i.e., an increase in renewables in a company's fuel mix because of the decrease in total generation even if the amount of renewable generation remained the same.[116] For example, if a company initially had 200MW renewable including hydro, 2400MW coal, and 400MW natural gas assets, its renewable percentage is 7%. If the company divested its coal assets, its renewable percentage becomes 33%. Without controlling for divestiture, we may erroneously conclude that the company increased its renewables by 26%.

---

[115] This is different from FERC Order 888, which separates operation of power generation from operation of transmission system (see Lyon (2000) for a discussion of alternative regulatory approach to minimize market power due to vertical integration). State restructuring initiatives intended to encourage competition among electric generating companies by increasing the number of generation companies in the electricity market (EIA, 1999). State restructuring legislation has often either required or encouraged the divestiture of generation assets as a condition for the recovery of stranded costs. For example, Connecticut law required utilities to divest nuclear generation assets as a condition of stranded cost recovery. In New York, although no legislation was required for the Public Service Commission to approve restructuring plans of each utility, the utilities were using divestiture to reduce stranded costs. Also, the Federal Energy Regulatory Commission (FERC) may request divestiture as a condition for merger approval. For example, FERC required divestiture as a condition for the merger between Sierra Power and Nevada Power. From late 1997 through April 2000, 51 IOUs (32 percent of the 161 IOUs owning generation capacity) have divested or were in the process of divesting 157 gigawatts of power generation capacity, representing approximately 22 percent of total U.S. electric utility generation capacity (EIA, 2000). Of the 157 gigawatts, more than 50%, 86 gigawatts, have been sold or are pending completion of the sale, 32 gigawatts are up for sale, and 38 gigawatts will be transferred by an IOU to its nonutility subsidiary.

[116] Retail electricity restructuring and divestiture activities are highly correlated. Indeed, in my dataset, all divestiture activities occurred in restructured states.

Since electric utility-specific information on divestiture is not publicly available, I create a dummy variable that indicates divestiture. The divesture dummy is 1 if the total generation capacity in year t is smaller than 70% of the total generation capacity in year t-1, and 0 otherwise.[117] The last three columns in Panel A of Table 8 show the results with the divestiture variable included. The coefficients of the retail restructuring and the percentage coal generation variables become statistically insignificant once the divestiture variable is included.[118] It appears that the positive effect of retail restructuring found in Delmas, et al. (2007) may be attributable to decreases in total generation because of divestiture of generation assets.

Panel B and C show the estimation results of the same specification models as in Panel A, with alternative dependent variables. In Panel B, the dependent variable is the percentage change in renewable generation[119], which does not subject to bias due to divestiture. As expected, the restructuring variable is not significant either with or without the divestiture variable. In Panel C, the dependent variable is the change in percentage of renewable generation *excluding hydro*. Without hydro generation, the significance of the restructuring variable disappears.

V. Discussion

The major finding of this paper is that retail electricity restructuring is associated with lower probability of entry into renewables by electric utility companies. This negative

---

[117] An alternative cutoff point, 50%, was also tried, and did not affect the regression results.
[118] The same pattern is observed when the corresponding capacity variable, total renewable capacity including hydro, is used as a dependent variable instead of total renewable generation including hydro.
[119] The dependent variable used is equal to $\left(\frac{Renewable\,Generation_t - Renewable\,Generation_{t-1}}{TotalGeneration_{t-1}}\right) \times 100.$

impact on initial investment could have a persistent effect as a utility is more likely to increase the share of renewables in its portfolio once it has made an initial investment in renewables. Although these findings are robust to the alternative specifications described in the paper, there are some key points to be kept in mind.

First, this paper focuses on the pre-2000 period to avoid the possible confounding effects due to the repeal of restructuring legislation. However, the total renewable capacity in the US has increased rapidly after 2000. The phone interviews with representatives at Duke Power, PSE&G, DTE Energy revealed two main factors that drove this change: RPS and improvement in renewable technologies.[120] RPS legislation not only alleviates regulatory uncertainty but also drives up the expected future price of renewables because of limited supply. Under this circumstance, the expected cost of compliance is lower when IOUs produce renewables themselves compared to purchasing a renewable contract from IPPs. Advancement in renewable generation technologies mitigates risks associated with operations and technology. It is worth noting, however, the focus of this paper is not what drives renewable development, but whether restructuring had any effect on IOU renewable investment, holding everything else constant. This paper finds that retail restructuring discouraged IOU initial investment on renewables. It will be interesting to see whether the finding in this paper can be generalized into the post-2000 period.

Secondly, this paper uses a restructuring dummy variable that indicates either the date of the legislative enactment or the date on which the regulatory order was issued. This is to address the concern that firm behavior might be affected prior to actual

[120] According to the phone interviews, other factors behind this change include the cost of alternative power sources such as the prices of coal, oil, or natural gas. Green consumer demand is still too small to induce investment in renewables.

implementation of the restructuring legislation. The restructuring dummy constructed this way, however, does not consider the scope or stringency of deregulation (Cook, et al., 1983).[121] This could be an important issue since the details of restructuring is not necessarily the same across different states. In Michigan, for example, although retail restructuring has allowed customers to switch electricity suppliers, DTE energy still has an obligation to serve in case its customers return to their default service, DTE.[122] This customer switching behavior affects 2% to 20% of DTE's generation assets.[123] Also, DTE is still fully regulated on the retail side. Although Michigan is unique in that it is in the in-between status, this example suggests that the restructuring dummy may be too crude to capture the details of retail restructuring. Also, the dummy variable does not capture the fact that deregulation happens through a series of regulatory steps. It may take time for lawmakers and regulators to dismantle regulatory regimes, and then it may take more time for the deregulated industries to adjust to their new competitive environment (Winston, 1998).[124]

Thirdly, although IOUs can be major drivers of renewable generation in the future, they are not yet the main producers of renewable electricity in the US. IOUs typically generate electricity from coal, nuclear, or natural gas that allows them to take advantage of large economies of scale. Instead, IPPs account for over 60% of total renewable

---

[121] Regulatory scope refers to the extensiveness of regulation and regulatory stringency refers to the degree of constraint imposed by regulation.

[122] Electric utilities in other restructured states do not generally have the obligation to serve returning customers. This is based on the discussion with representatives at DTE Energy.

[123] DTE Energy sells leftover electricity coming from demand fluctuation to the wholesale market. The competitive wholesale market is not as profitable as the retail market, however, because DTE Energy earns a fair rate-of-return in the retail market.

[124] For example, deregulation often involves a gradual reduction in the level of activities by the regulatory agencies. In the case of the airline industry, in 1978 the US Congress enacted the Airline Deregulation Act of 1978. Under the Act, the authority of the Civil Aeronautics Board (CAB) to regulate airlines gradually disappeared. For instance, the CAB's authority over routes ended in 1981. Its authority to declare fares unlawful expired in 1983. The CAB itself was scheduled to go out of existence in 1985 (Creager, 1983).

generation in the US. This suggests that less IOU's renewable capacity does not necessarily mean that the overall renewable capacity is lower in restructured states compared to non-restructured states. Also, IOUs may contribute to renewable development by purchasing renewable contracts from IPPs instead of generating renewable electricity themselves. Duke Power's two green pricing programs, for example, offers its customers an option to buy green electricity it has purchased from either multiple short-term contracts with IPPs or an exclusive long-term contract with an IPP. These in turn suggest that less IOU's renewable capacity does not necessarily indicate lower environmental quality in restructured states compared to non-restructured states.

VI. Conclusion

The central idea behind economic deregulation is that increased competition provides firms with incentives for greater efficiency. This paper explores how the incentives for greater efficiency might bring about unintended consequences–negative environmental externalities–which could ultimately complicate the strategic choices of firms. It examines this question in the context of renewable electricity generation by investor-owned utilities (IOUs) in the United States. In particular, the paper studies how state-level retail electricity restructuring, which began operating in early 1998, influences IOU investment decisions on renewables.

The major finding of this paper is that retail electricity restructuring is associated with lower probability of entry into renewable generation by electric utility companies. Furthermore, once a utility makes its initial investment in renewables, it is more likely to increase the share of renewables in its portfolio. Together, these findings suggest that examining the effect of retail electricity restructuring on initial investment alone underestimates the extent of the negative effect of retail electricity restructuring on renewable investment. Since firms with previous renewable generation tend to increase the share of renewables over time, the negative effect of restructuring could persist over a prolonged period of time.

The finding that IOUs responded to competition-enhancing retail restructuring by choosing lower cost production technologies suggests that market pressures for low prices outweighed demand for green electricity for most utilities. To the extent that low-cost production technologies are often more polluting, this finding implies that deregulation might lead to greater pollution problems than otherwise.

Data Appendix

I describe here details on the construction of the independent variables.

Regulatory factors

Retail electricity restructuring

The EIA provides the status of retail electricity restructuring in each state.[125] To take into account the possibility that firm behavior may be affected earlier than the actual implementation of retail restructuring legislation, I create a dummy variable that indicates either the enactment of legislation or the issuance of regulatory order, whichever is earlier. That is, for the year under consideration, the dummy variable takes a value of 1 if the state enacted retail restructuring legislation or issued regulatory order that year or in prior years, and 0 otherwise. This dummy variable is then adjusted for each IOU to reflect the fact that utilities often sell electricity in multiple states. Following Delmas et al. (2007), for each company, I weight the dummy variable by the share of the electricity sales in each state. For example, if a company sells 50% of its electricity sales in a restructured state and the remaining 50% in a non-restructured state, the weighted restructuring variable for this company takes the value of 0.5. The weighted variable is used as the retail electricity restructuring variable for analysis. The weighted variable not only captures both temporal and cross-sectional variation in retail restructuring but also reflects the extent to which a company is exposed to retail restructuring due to its varying electricity sales in different states, i.e., restructured vs. non-restructured states.

Renewable portfolio standards (RPS)

Recent state-level studies have shown that various state policies, especially renewable portfolio standards (RPS), encouraged renewable energy development (Blair, et al., 2006; Kneifel, 2006; Menz and Vachon, 2006; Bird, et al., 2005). An RPS requires that electric utilities generate or purchase a certain fraction of their total electricity generation from renewable sources. Thus, it is important to control for state adoption of RPS to examine the effect of retail electricity restructuring on renewables. The RPS dummy variable is created based on the data obtained from the Database of State Incentives for Renewables & Efficiency (DSIRE). The RPS dummy takes a value of 1 starting from the enacted or effective year, whichever comes first. For each company, the RPS dummy variable is then weighted by the share of the electricity sales in each state. The weighted variable is used as the RPS variable for analysis. The weighted variable not only captures both temporal and cross-sectional variation in RPS adoption but also reflects the extent to which a company is exposed to RPS due to its varying electricity sales in different states, i.e., RPS vs. non-RPS states.

Technological access/constraint

Wind power potential

Wind energy has been the major driver of renewable electricity generation in the US since late 1990s.[126] Since IOUs which have access to wind resources are more likely to develop wind power plants, I control for wind power potential at the state level. I obtained the wind variable from Lyon and Yin (2008). They classified the states into three categories (1-3) based on their wind energy potential, with category 1 the lowest wind potential and 3 the highest. For each IOU, this wind variable is then weighted by the share of the electricity sales in each state and used for analysis. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Green demand

Average LCV scores

The League of Conservation Voters (LCV)' scorecards are often used to proxy for the environmental preference of the constituents of the state in which a firm operates (see, for example, Delmas et al.(2007)). The LCV scores represent the voting records of the Representatives and Senators in the U.S. Congress in

---

[125] http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf

[126] This claim is based on the electric net summer capacity data (1989-2006) obtained from the EIA website.

favor of environmental agenda. The score ranges from 0 to 100, with 100 being the highest score. The data are obtained from the LCV website (http://www.lcv.org/scorecard/). Consistent with prior literature, I use the average of the environmental scores of the members of the U.S. House of Representatives and Senate. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Renewable capacity fraction

Alternatively, renewable demand can be proxied by the renewable fraction of the total capacity at the state level. The state level generating capacity data by fuel type is obtained from Form EIA-860. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Green pressure

Sierra magazine subscription per thousand populations

The extant literature on corporate environmentalism finds that firms facing greater pressure from environmental groups are more likely to undertake voluntary environmental actions (see, for example, Khanna and Damon, 1999). In the case of the electric utility industry, Sine and Lee (2008) find that environmental activists had a significant effect on renewable development by independent power producers (IPPs). Thus, I control for the effect of environmental groups. Pressure from environmental activists is measured by the number of subscriptions to Sierra magazine per thousand populations at the state level in 2000. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Percentage of coal generation

The previous literature on corporate environmentalism finds that dirtier firms are more likely to engage in voluntary environmental actions (see, for example, Arora and Cason, 1995). Among the fuel sources used for electricity generation, coal is the most polluting one in terms of various environmental problems such as climate change or acid rain. Accordingly, I control for the percentage of electricity generated by coal at the firm level. This data is obtained from EPA eGRID.

Net generation

The other empirical regularity in the previous literature on corporate environmentalism is that large firms are more likely to take voluntary environmental actions (see, for example, DeCanio and Watkins, 1998). Firm size is measured by the amount of net generation, i.e., gross generation less the electrical energy consumed at generating stations. ln(net generation (MWh)) is used.

TRI emissions per area

At the state level, Lyon and Yin (2008) find that the nonattainment index predicts states' RPS adoption. This suggests that poor environmental quality at the state level could indicate the threat of future renewable regulation. Thus, I control for state environmental performance. It is measured by toxic emissions per land area in a state (lbs/square miles). The data is obtained from the EPA website. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Substitutes for IOU renewable generation

Natural gas price

Palmer and Burtraw (2005) argue that higher natural gas prices lower the cost of greater reliance on renewables. To control for the possible low-carbon substitution between renewable generation and natural gas-fired generation, I include natural gas price for electric power at the state level as a control variable. The data is obtained from the EIA website. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

IOU renewable generation fraction

Although IOUs can be major drivers of renewable generation in the future, they are not yet the main producers of renewable electricity in the US. IOUs typically generate electricity from coal, nuclear or natural gas that allows them to take advantage of large economies of scale. Instead, independent power producers (IPPs) account for over 60% of total renewable generation in the US. Thus, I control for the IOU portion of renewable generation using the ratio of IOU renewable capacity to total renewable capacity at the state level. The renewable capacity by producer type data is obtained from the EIA website. The variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Generation statistics

Heatrate

Heatrate is the ratio of heat input to electricity generated (Btu/kWh) and thus a direct measure of combustion inefficiency of fossil fuels such as coal, oil and natural gas. This data is obtained from EPA eGRID.

Capacity factor

The ratio of electricity generated to the maximum that could have been generated. It is calculated by dividing net generation (MWh) by (nameplate capacity(MW)×8760(hours)). Capacity factor at the firm level thus represents the average utilization rate of generating units. This data is obtained from EPA eGRID.

Average unit years in service

A typical coal or nuclear unit runs for 30-40 years. Average unit years are estimated as the average years since operation. This data is obtained from Form EIA-860.

Learning in renewable electricity generation

Previous renewable generation

The phone interviews with representatives at Duke Power, PSE&G, and DTE Energy suggest that one of the risks associated with renewable investment is risks associated with renewable operation and technology, and there exist a significant learning effect in terms of renewable electricity generation. Thus, to control for the learning effect, I include a dummy variable that indicates whether a firm generated non-hydro renewable electricity in year t-1. This data is obtained from EPA eGRID.

Electricity market conditions

Growth in electricity generation at the state level

Growth in electricity demand may affect utilities' fuel mix portfolio. The growth in electricity generation at the state level data is obtained from the EIA website. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

New entrant fraction

New entrants in the electricity market regardless of their types (e.g., IOU, IPPs, etc.) may affect utilities' fuel mix portfolio. The number of new entrant in a state data is obtained from the EIA website, and then divided by the total number of electricity producers in the state. This variable is then weighted by the share of the company's electricity sales in each state. Refer to description of the restructuring or the RPS variable for reasons for weighting variables.

Residential sales fraction

This variable represents customer characteristics at the firm level. Industrial and commercial customers may behave differently than residential customers. Thus, I control for residential sales fraction. For each utility, residential sales fraction is calculated as the residential sales (MWh) divided by the total sales (MWh). This data is obtained from Form EIA-861.

Transmission grid interconnections

This variable controls for transmission grid interconnections, i.e., whether an electric utility belongs to Eastern/Western/Texas interconnected system.

Changes in firm boundaries

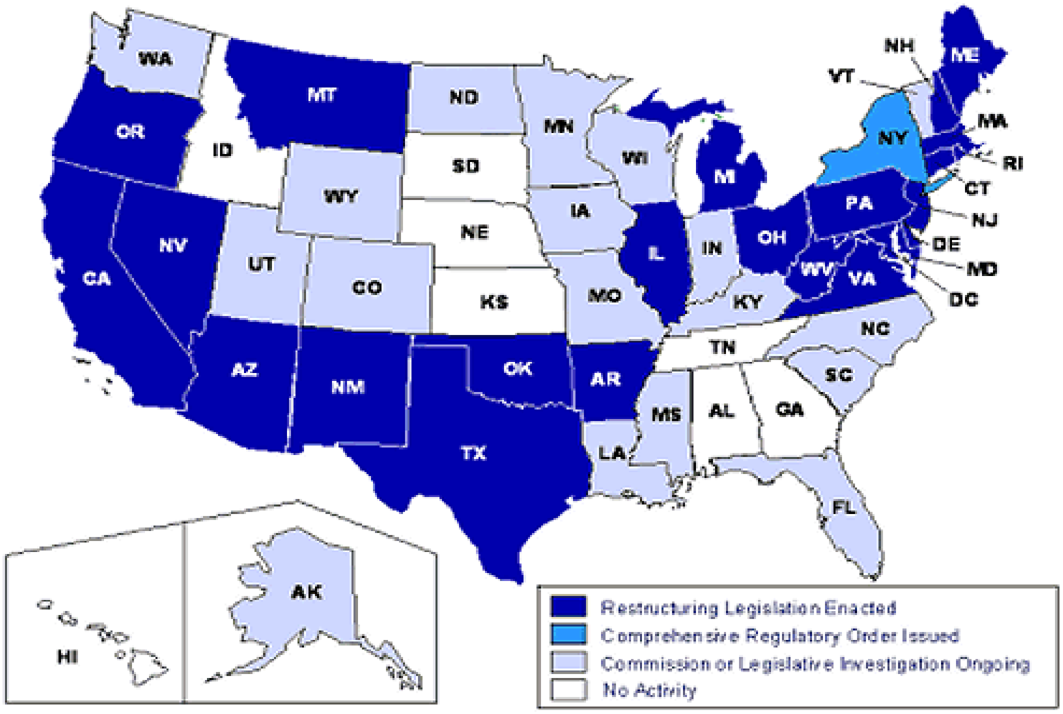
Merger with gas or electric utilities

In response to increased competition in power generation due to retail electricity restructuring, investor-owned utilities have engaged in mergers and acquisitions. There were two types of mergers. The first category includes mergers between IOUs or between IOUs and IPPs, motivated by increasing the size of the company. The second type includes mergers between electric utilities and natural gas companies, taking advantage of the synergy between them (EIA, 1999)). I create two separate dummy variables that indicate the two types of mergers, i.e., whether an electric utility went through a merger process with other electricity producers or with gas producers.

Divestiture

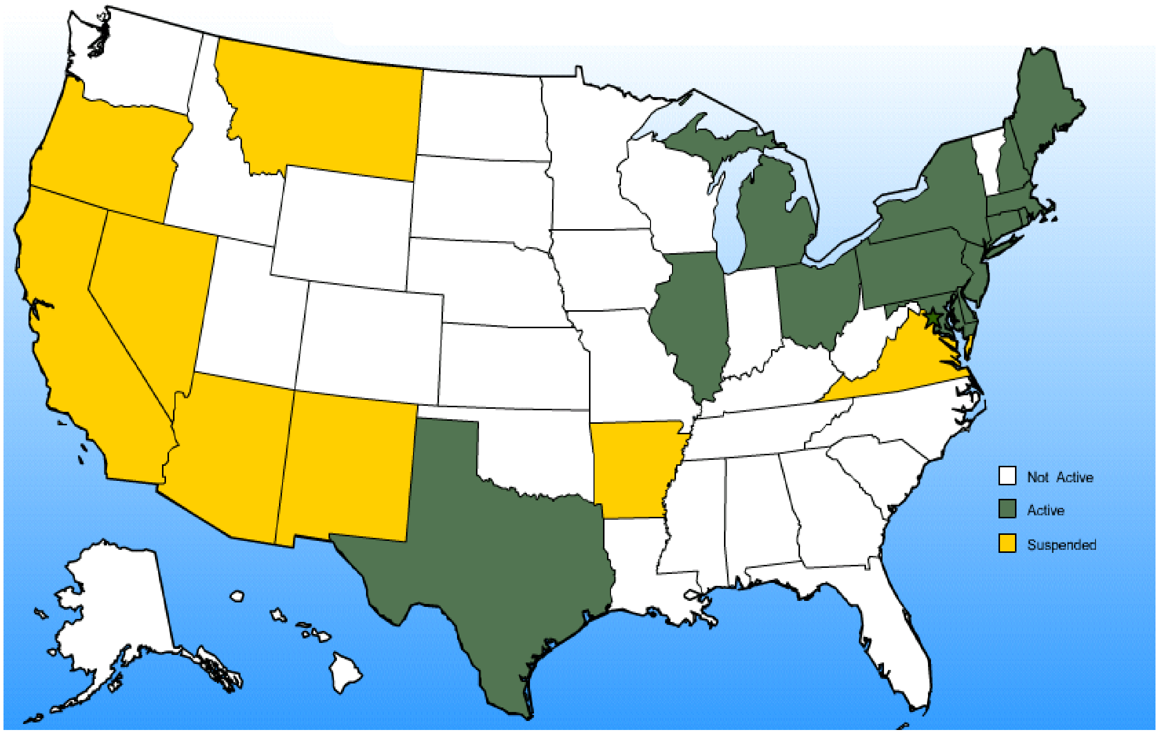
Many states that have restructured their electric utility industry required utilities to divest their assets. Thus, it is necessary to take divestiture into account when examining the effect of retail electricity restructuring on renewables as a percentage of total capacity or generation. Otherwise, divestiture of a non-renewable asset such as coal or natural gas units can make it seem that a company falsely increased renewables in its fuel mix because the denominator, total capacity or generation, decreased, although the amount of renewables may remain the same. Since electric utility-specific information on divestiture is not publicly available, this paper creates a dummy variable that indicates divestiture. The divesture dummy is 1 if the total generation capacity in year t is smaller than 70% of the total generation capacity in year t-1, and 0 otherwise. An alternative cutoff point, 50%, was also used, and did not affect the regression results.

Figure 4-1 Status of Restructuring as of February 2001



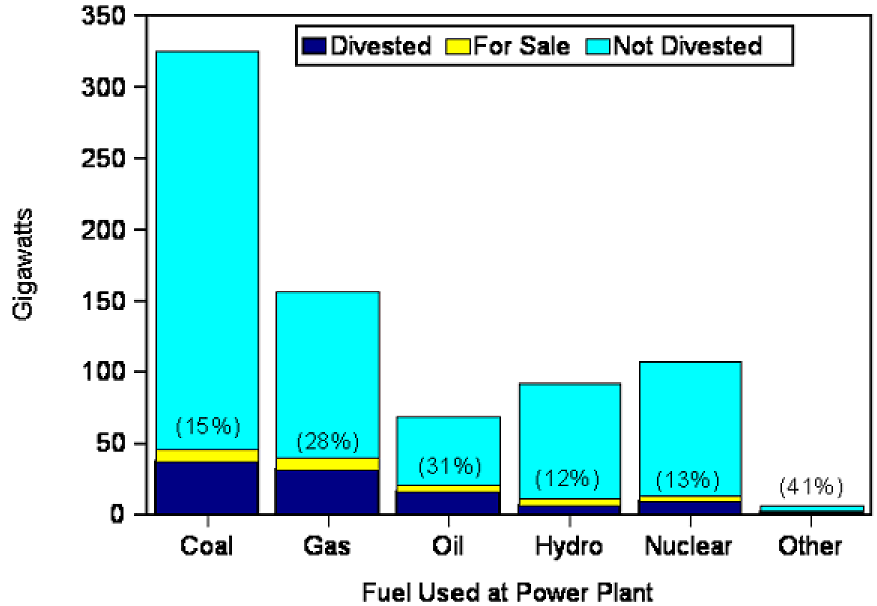
(source: Energy Information Administration,
http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf)

Figure 4-2 Status of Restructuring as of April 2007



(source: Energy Information Administration,
http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html)

Figure 4-3 Power Generation Divestitures of Investor-owned Electric Utilities by Fuel Type, as of September 1999*



* The percentages shown above refer to the divested portions.
(source: Energy Information Administration. December 1999. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations,* DOE/EIA-0562(99), US Department of Energy)

Table 4-1 Capital and Generation Costs of Alternative Power Sources

Source	Capital Cost ($/kW)	Generation Cost (Cents/kWh)
Coal	1250	2.6-3.0
Conventional Gas	400	3.8-12.1
Wind	1700-1800	4.0-6.0
Solar	6000-9000	20.0-32.0
Biomass	1500-3000	8.0-12.0
Geothermal	2770	5.5-7.5
Hydro	1200-3600	3.0-4.0

(Source: Green Energy in the US. 2007. Business Insights, p.40)

Table 4-2 Two-year Growth Rates in Total Generation and in Renewable generation in California during Retail Restructuring (1998-2000) and after the Suspension of Retail Restructuring (2001-2003)

Period	Two-year Growth Rate	
	Total Generation	Renewable Generation*
1998-2000	9.74%	3.95%
2001-2003	-2.92%	8.86%

* Renewable generation excluding hydro.
(Data source: Electric Power Annual 2006)

Table 4-3 Descriptive Statistics for Explanatory Variables

Proxy for	Variable (unit)	Entire sample (N=232)	Restructured States[1] (N=106)	Non-Restructured States[1] (N=126)	Difference
Renewables in fuel mix	Percentage of renewable capacity (%)	0.161	0.003	0.293	0.290***
		(0.832)	(0.023)	(1.114)	(0.108)
Regulatory factors	Lagged restructuring[2]	0.336	0.713	0.018	-0.694***
		(0.460)	(0.437)	(0.089)	(0.040)
	Lagged Renewable Portfolio Standard	0.066	0.066	0.066	-0.00011
		(0.240)	(0.238)	(0.243)	(0.032)
Technological access	Lagged wind power potential	1.390	1.264	1.497	0.233**
		(0.692)	(0.452)	(0.830)	(0.090)
Green demand	Lagged average LCV score	44.052	50.717	38.444	-12.273***
		(26.797)	(24.852)	(27.181)	(3.446)
	Lagged renewable capacity fraction	0.021	0.023	0.020	-0.003
		(0.034)	(0.042)	(0.024)	(0.004)
Green pressure	Lagged Sierra magazine subscription per thousand membership	0.878	0.682	1.043	0.361***
		(0.631)	(0.432)	(0.721)	(0.080)
	Lagged percentage of coal generation (%)	48.820	49.514	48.236	-1.278
		(40.046)	(39.302)	(40.808)	(5.289)
	Lagged ln(net generation) (MWh)	14.766	15.190	14.410	-0.780**
		(2.988)	(2.329)	(3.415)	(0.391)
	Lagged TRI emissions per area (lbs/km^2)	9.475	11.771	7.543	-4.228***
		(9.279)	(9.646)	(8.527)	(1.193)
Substitutes for IOU renewable generation	Lagged natural gas price	2.438	2.545	2.347	-0.197*
		(0.845)	(0.736)	(0.920)	(0.111)
	Lagged IOU renewable generation fraction	0.139	0.158	0.122	-0.035
		(0.252)	(0.287)	(0.218)	(0.033)
Generation statistics	Lagged heatrate (Btu/kWh)	7.780	7.214	8.252	-6.185
		(4.143)	(4.294)	(3.969)	(6.644)
	Lagged capacity factor	0.477	0.528	0.433	-0.095***
		(0.186)	(0.180)	(0.181)	(0.024)
	Lagged average unit age (years)	38.731	40.082	37.594	-2.488
		(14.483)	(13.272)	(15.389)	(1.906)
Learning effect	Lagged renewable generation dummy	0.082	0.038	0.119	0.081**
		(0.275)	(0.191)	(0.325)	(0.036)
Electricity market conditions	Annual growth in electricity generation at the state level	0.033	0.034	0.031	-0.003
		(0.077)	(0.099)	(0.050)	(0.010)
	Lagged new entrant fraction	0.086	0.090	0.083	-0.006
		(0.133)	(0.124)	(0.140)	(0.018)
	Lagged residential sales fraction	0.324	0.310	0.337	0.027*
		(0.109)	(0.109)	(0.108)	(0.014)
	Western interconnected system	0.138	0.208	0.079	-0.128***
		(0.346)	(0.407)	(0.271)	(0.045)
	Texas interconnected system	0.009	0.019	0.000	-0.019
		(0.093)	(0.137)	(0.000)	(0.012)
Changes in firm boundaries	Merger process with gas utility	0.078	0.142	0.024	-0.118***
		(0.268)	(0.350)	(0.153)	(0.035)
	Merger process with electric utility	0.237	0.255	0.222	-0.032
		(0.426)	(0.438)	(0.417)	(0.056)
	Divestiture	0.052	0.113	0.000	-0.113***
		(0.222)	(0.318)	(0.000)	(0.028)

Standard errors in parenthesis. *significant at 10%; **significant at 5%; ***significant at 1%

[1] Restructured states refer to those states which enacted retail restructuring legislation or issued the regulatory order by 2000. These states are AZ, CA, CT, DE, DC, IL, ME, MD, MA, MI, MT, NV, NH, NJ, NM, NY, OH, OK, OR, PA, RI, TX, VA and WV (http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf).

[2] All lagged variables are lagged one year.

Table 4-4 Entry into Renewable Generation

Panel A: Probit Coefficients

Independent variables	Dependent variable: Entry as of 2000 (Probit)			
	(1)	(2)	(3)	(4)
Restructuring status as of 2000	-1.073**	-1.008**	-1.041**	-0.938**
	(0.452)	(0.459)	(0.457)	(0.473)
Renewable Portfolio Standard 98		0.691		0.962*
		(0.469)		(0.493)
Wind power potential 98			0.252	0.401*
			(0.201)	(0.214)
Constant	-0.989***	-1.094***	-1.382***	-1.768***
	(0.192)	(0.211)	(0.382)	(0.435)
Observations	113	113	113	113
$\chi^2[1]$	5.63 {0.02}			
$\chi^2[2]$		6.99 {0.03}	9.18 {0.01}	
$\chi^2[3]$				12.34 {0.006}

Robust standard errors in parenthesis.
* significant at 10%; ** significant at 5%; *** significant at 1%
Degrees of freedom are in square brackets. p values are in curly brackets. χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero.

Panel B: Marginal Effect

Independent variables	Marginal Effect			
	(1)	(2)	(3)	(4)
Restructuring status as of 2000	-0.142**	-0.130**	-0.132**	-0.110**
	(0.051)	(0.051)	(0.051)	(0.050)
Renewable Portfolio Standard 98		0.091		0.115*
		(0.064)		(0.064)
Wind power potential 98			0.033	0.048*
			(0.028)	(0.030)

Robust standard errors in parenthesis.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4-5 Entry into Renewable Generation - Robustness Checks

Proxy for	Independent variables	Dependent variable: Entry as of 2000 (Probit)						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulatory factors	Restructuring status as of 2000	-1.138*	-1.202**	-1.255**	-1.524***	-1.440***	-1.166***	-3.193***
		(0.584)	(0.509)	(0.531)	(0.456)	(0.551)	(0.399)	(1.011)
	Renewable Portfolio Standard 98	0.454	1.696**	0.291	1.120	1.453**	0.905*	5.096*
		(0.574)	(0.683)	(0.584)	(0.717)	(0.592)	(0.492)	(2.872)
Technological access	Wind power potential 98	0.547**	0.625*	0.391*	0.606**	0.411*	0.447*	2.738***
		(0.225)	(0.339)	(0.230)	(0.299)	(0.228)	(0.234)	(1.015)
Green demand	Average LCV score 98	0.013						0.0005
		(0.009)						(0.015)
	Renewable capacity to total capacity	2.675						9.456
		(3.234)						(16.61)
Green pressure	Sierra subscription per thousand membership 98		0.428					0.404
			(0.384)					(0.928)
	Percentage of coal generation 98		0.001					-0.0261
			(0.005)					(0.0171)
	ln(net generation) 98		0.356***					0.531*
			(0.112)					(0.313)
	TRI emissions per area 98		-0.056					0.153*
			(0.059)					(0.083)
Substitutes for IOU Renewable Generation	Natural gas price 98			-0.160				-0.593
				(0.349)				(0.488)
	IOU renewable generation fraction 98			2.200**				-0.993
				(0.900)				(3.713)
Generation statistics	Heatrate 98				0.196**			0.328*
					(0.086)			(0.170)
	Capacity factor 98				1.540			5.207*
					(1.264)			(3.019)
	Average unit age 98				0.070***			0.084**
					(0.019)			(0.042)
Electricity market conditions[1]	Growth in state electricity generation					-1.342		1.419
						(1.693)		(3.846)
	New entrants fraction 98					-1.633		-9.495
						(1.033)		(5.910)
	Residential sales fraction 98					-3.093*		1.644
						(1.696)		(3.317)
	Western interconnection					1.402***		1.256*
						(0.521)		(0.738)
Changes in firm boundaries[1]	Merger process with electric utility 98						0.811*	0.918
							(0.417)	(0.621)
	Constant	-2.554***	-7.719***	-1.592	-7.440***	-0.744	-1.940***	-21.43**
		(0.657)	(2.703)	(0.968)	(1.501)	(0.748)	(0.518)	(9.907)
	Observations	113	111	113	111	113	113	111
	χ^2	15.5{0.01}	22.2{0.0}	17.0{0.01}	41.1{0.0}	21.39{0.0}	22.4{0.0}	51.4{0.0}

Robust standard errors in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero. p values are in curly brackets.

[1]Merger process with gas utility, Divestiture, or Texas interconnection equal to 1 predict failure perfectly, and thus not included.

Table 4-6 Proportion of Renewables in IOU Fuel Mix Portfolio

Independent variables	Dependent variable: Percentage of renewable capacity (%)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lagged restructuring status	-0.288** (0.115)	-0.195 (0.214)	-0.259 (0.231)	-0.197 (0.215)	-0.115 (0.132)	-0.261 (0.232)	-0.164 (0.143)
Lagged Renewable Portfolio Standard			0.175 (0.229)			0.174 (0.230)	0.125 (0.142)
Lagged wind power Potential				-3.244 (20.05)		-2.889 (20.10)	-4.076 (12.39)
Lagged renewable generation dummy					7.016*** (0.514)		7.006*** (0.517)
Constant	0.356** (0.138)	0.314*** (0.105)	0.332*** (0.107)	4.742 (27.37)	-0.305*** (0.079)	4.275 (27.43)	5.271 (16.91)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	238	238	238	238	238	238	238
R^2	0.03	0.04	0.04	0.04	0.64	0.04	0.64
Hausman statistic (χ^2)		0.27{0.87}	0.08{0.99}	0.22{0.97}	107.67{0}	0.06{0.99}	106.47{0}

Standard errors in parenthesis
* significant at 10%; ** significant at 5%; *** significant at 1%
Hausman statistics test the null hypothesis that the difference in coefficients between fixed and random effect models are not systematic. p values are in curly brackets.

Table 4-7 Proportion of Renewables - Robustness Checks (Fixed Effect)

Proxy for	Independent variables	Dependent variable: Percentage of renewable capacity (%)						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulatory factors	Lagged restructuring status	-0.144	-0.131	-0.139	-0.169	-0.113	-0.176	-0.017
		(0.156)	(0.159)	(0.140)	(0.146)	(0.143)	(0.146)	(0.172)
	Lagged Renewable Portfolio Standard	0.115	0.113	0.097	0.123	0.134	0.134	0.094
		(0.149)	(0.153)	(0.139)	(0.146)	(0.143)	(0.144)	(0.165)
Technological access	Lagged wind power potential	-4.485	17.50	-1.729	-3.92	-0.721	-5.663	21.45
		(12.43)	(21.13)	(12.17)	(12.61)	(12.44)	(13.04)	(21.72)
Learning effect	Lagged renewable generation dummy	6.779***	6.991***	7.054***	7.003***	7.078***	6.994***	6.914***
		(0.561)	(0.524)	(0.507)	(0.526)	(0.511)	(0.524)	(0.566)
Green demand	Lagged average LCV score	0.003						-0.001
		(0.005)						(0.006)
	Lagged renewable capacity fraction	16.78						17.13
		(16.70)						(17.51)
Green pressure	Lagged Sierra subscription		-37.31					-42.01
			(29.33)					(31.50)
	Lagged percentage of coal generation		-0.001					-0.004
			(0.006)					(0.006)
	Lagged ln(net generation)		0.035					0.045
			(0.063)					(0.082)
	Lagged TRI emissions per area		0.025					0.068
			(0.042)					(0.050)
Substitutes for IOU Renewable Generation	Lagged natural gas price			-0.184**				-0.209**
				(0.071)				(0.086)
	Lagged IOU renewable generation fraction			-0.141				0.043
				(0.315)				(0.338)
Generation statistics	Lagged heatrate				-0.0002			0.0004
					(0.001)			(0.001)
	Lagged capacity factor				0.165			0.156
					(0.503)			(0.540)
	Lagged average unit age				0.002			0.016
					(0.019)			(0.020)
Electricity market conditions[1]	Annual growth in electricity generation at the state level					-1.020*		-1.059*
						(0.527)		(0.619)
	Lagged new entrant fraction					0.593*		0.812**
						(0.333)		(0.355)
	Lagged residential sales fraction					-1.834		-3.015
						(1.763)		(2.015)
Changes in firm boundaries[1]	Merger process with gas utility						0.133	-0.010
							(0.373)	(0.372)
	Merger process with electric utility						0.108	0.265
							(0.228)	(0.260)
	Divestiture						-0.048	0.116
							(0.146)	(0.200)
	Constant	5.360	7.151	2.516	4.897	1.299	7.416	6.039
		(16.96)	(17.35)	(16.60)	(17.23)	(17.34)	(17.79)	(19.00)
	Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Observations	238	238	238	238	234	238	232
	Within R^2	0.64	0.65	0.66	0.64	0.66	0.64	0.7

Standard errors in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4-8 Relation to Prior Literature

Panel A: Replication of Delmas, Russo, and Montes-Sancho (2007) (Pooled OLS)

Independent variables	Dependent variable: Change in percentage of renewable generation including hydro (%) $\left\{\left(\frac{R_t}{T_t}-\frac{R_{t-1}}{T_{t-1}}\right)\times 100\right\}$					
	without Divestiture			with Divestiture		
	(1)	(2)	(3)	(1)	(2)	(3)
Lagged restructuring status	5.133*	5.048*	5.167*	2.75	2.70	2.79
	(2.909)	(2.843)	(2.930)	(2.120)	(2.058)	(2.139)
Lagged percentage of coal generation	-0.048*	-0.048*	-0.047*	-0.023	-0.023	-0.022
	(0.025)	(0.025)	(0.024)	(0.021)	(0.021)	(0.020)
Divestiture				23.66***	23.64***	23.67***
				(8.544)	(8.568)	(8.562)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	232	232	232	232	232	232
R^2	0.13	0.13	0.13	0.30	0.31	0.31

Robust standard errors in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

Panel B: Alternative Dependent Variable (Pooled OLS)

Independent variables	Dependent variable: *Percentage change* in renewable generation including hydro (%) $\left\{\left(\frac{R_t - R_{t-1}}{T_{t-1}}\right)\times 100\right\}$					
	without Divestiture			with Divestiture		
	(1)	(2)	(3)	(1)	(2)	(3)
Lagged restructuring status	3.86	3.36	4.08	3.59	3.28	3.97
	(2.416)	(2.144)	(2.488)	(2.458)	(2.243)	(2.655)
Lagged percentage of coal generation	0.004	0.010	0.009	0.010	0.011	0.011
	(0.005)	(0.050)	(0.046)	(0.050)	(0.051)	(0.049)
Divestiture				2.939	0.955	1.115
				(4.064)	(3.939)	(5.317)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	232	232	232	232	232	232
R^2	0.05	0.05	0.05	0.05	0.05	0.05

Panel C: Alternative Dependent Variable (Pooled OLS)

Independent variables	Dependent variable: Change in percentage of renewable generation *excluding hydro (%)* $\left\{\left(\frac{R_t}{T_t}-\frac{R_{t-1}}{T_{t-1}}\right)\times 100\right\}$					
	without Divestiture			with Divestiture		
	(1)	(2)	(3)	(1)	(2)	(3)
Lagged restructuring status	0.931	0.745	0.958	1.052	0.918	1.128
	(0.747)	(0.581)	(0.771)	(0.886)	(0.754)	(0.964)
Lagged percentage of coal generation	0.006	0.008	0.006	0.003	0.004	0.004
	(0.007)	(0.008)	(0.007)	(0.006)	(0.006)	(0.006)
Divestiture				-1.330	-2.192	-1.698
				(1.579)	(2.323)	(1.992)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	232	232	232	232	232	232
R^2	0.23	0.25	0.23	0.23	0.26	0.24

Appendix

The table below presents the correlations between each of the variables.[127]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
(2)	-0.140																						
(3)	0.036	0.072																					
(4)	0.038	-0.142	-0.078																				
(5)	0.175	0.219	0.259	-0.355																			
(6)	0.141	0.133	0.070	-0.094	0.412																		
(7)	0.300	-0.273	-0.030	0.196	0.169	0.221																	
(8)	-0.021	-0.032	-0.117	-0.113	-0.176	-0.331	-0.353																
(9)	0.001	0.028	-0.101	-0.298	-0.124	0.019	-0.446	0.597															
(10)	-0.131	0.057	-0.050	-0.483	-0.062	-0.296	-0.316	0.373	0.284														
(11)	-0.009	0.147	0.001	-0.302	-0.001	-0.333	-0.150	0.261	0.210	0.440													
(12)	0.202	-0.023	0.100	-0.176	0.224	0.021	0.274	0.068	0.018	0.216	0.256												
(13)	-0.016	0.087	-0.032	-0.027	0.105	0.000	-0.061	-0.028	-0.143	-0.014	0.012	-0.050											
(14)	0.003	0.201	-0.071	-0.190	-0.019	0.000	-0.396	0.546	0.671	0.275	0.183	0.061	-0.151										
(15)	0.182	0.088	0.110	-0.284	0.451	0.273	0.066	-0.002	0.153	-0.068	0.179	0.184	0.108	0.262									
(16)	0.554	-0.131	0.049	-0.003	0.221	0.183	0.300	-0.083	0.046	-0.183	-0.072	0.210	-0.027	0.003	0.289								
(17)	0.056	0.160	0.236	-0.030	0.234	0.185	0.040	-0.045	-0.057	-0.045	0.092	0.005	-0.080	0.017	0.218	0.172							
(18)	-0.078	-0.097	0.110	-0.015	0.071	-0.052	-0.161	0.154	0.148	0.047	-0.027	0.046	-0.030	0.021	-0.026	-0.087	0.012						
(19)	-0.101	-0.030	-0.004	-0.021	-0.137	-0.059	-0.084	-0.111	-0.096	-0.125	-0.046	-0.132	-0.125	-0.231	-0.367	0.004	-0.167	-0.015					
(20)	0.000	0.182	-0.068	0.197	-0.048	0.127	-0.115	0.025	0.195	-0.305	-0.139	0.059	-0.030	0.293	0.095	0.063	0.018	0.104	0.069				
(21)	-0.018	0.033	0.169	0.082	-0.097	-0.051	-0.088	-0.088	0.044	-0.030	-0.004	-0.050	-0.013	0.120	0.002	-0.028	-0.002	-0.037	0.013	-0.037			
(22)	-0.056	0.173	0.114	-0.164	0.213	0.269	-0.001	-0.088	0.025	-0.058	-0.125	-0.101	-0.031	0.001	0.224	0.031	0.196	0.065	-0.083	-0.116	-0.027		
(23)	-0.108	0.075	-0.049	-0.045	-0.056	-0.157	-0.145	0.220	0.157	0.036	0.182	-0.050	-0.021	0.103	0.024	-0.130	-0.039	0.110	-0.092	0.042	0.167	-0.162	
(24)	-0.045	0.307	0.017	-0.048	0.261	0.296	0.004	-0.222	-0.094	-0.061	0.032	-0.061	-0.027	0.009	0.054	0.001	-0.081	-0.056	0.015	0.076	-0.022	0.151	0.007

(1) Percentage of renewable capacity (2) lagged restructuring (3) lagged RPS dummy (4) lagged wind potential (5) lagged average LCV score (6) lagged renewable capacity fraction (7) lagged Sierra magazine subscription per thousand membership (8) lagged percentage of coal generation (9) lagged ln(net generation) (10) lagged TRI emissions per area (11) lagged natural gas price (12) lagged IOU renewable generation fraction (13) lagged heatrate (Btu/kWh) (14) lagged capacity factor (15) lagged average unit age (years) (16) lagged renewable generation dummy (17) Annual growth in electricity generation at the state level (18) lagged new entrants fraction (19) lagged residential sales fraction (20) Western interconnected system (21) Texas interconnected system (22) merger process with gas utility (23) merger process with electric utility (24) Divestiture

[127] Most correlations are relatively low. However, there is a significant correlation between net generation and capacity factor. This probably indicates that large power plants run all year round since they provide baseload electric power. The percentage of coal generation is significantly correlated with capacity factor and net generation. This appears to suggest that coal-fired power plants are in general large baseload power plants running at higher capacity factors.

References

Arora, Seema and Subhashis Gangopadhyay. 1995. "Toward a Theoretical Model of Voluntary Overcompliance," *Journal of Economic Behavior and Organization*, 28(3): 289-309.

Arora, Seema and Timothy N. Cason. 1995. "An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program," *Journal of Environmental Economics and Management*, 28: 271-286.

Averch, Harvey and Leland L. Johnson. 1962. "Behavior of the Firm Under Regulatory Constraint," *American Economic Review*, 52(5): 1052-1069.

Bird, Lori, Mark Bolinger, Troy Gagliano, Ryan Wiser, Matthew Brown and Brian Parsons. 2005. "Policies and Market Factors Driving Wind Power Development in the United States," *Energy Policy*, 33: 1397-1407.

Bird, Lori, Leila Dagher, and Blair Swezey. 2007. "Green Power Marketing in the United States: A Status Report (Tenth Edition)," Technical Report NREL/TP-670-42502, National Renewable Energy Laboratory.

Blair, Nate, Walter Short, Paul Denholm, and Donna Heimiller, "Long-Term National Impacts of Statel-Level Policies," NREL/CP-620-40105, National Renewable Energy Laboratory.

Borenstein, Severin and James Bushnell. 2000. "Electricity Restructuring: Deregulation or Reregulation?," *Regulation*, 23(2): 46-52.

Burtraw, Dallas, Karen Palmer and Martin Heintzelman. 2000. "Electricity Restructuring: Consequences and Opportunities for the Environment," Resources for the Future Discussion Paper (00-39), Washington, D.C.: Resources for the Future.

Business Insight. 1999. *Marketing Green Energy*.

Business Insight. 2007. *Green Energy in the US*.

Creager, Stephen E. 1983. "Airline Deregulation and Airport Regulation," *The Yale Law Journal*, 93(2): 319-339.

Crew, Michael A. and Paul R. Kleindorfer. 1986. *The Economics of Public Utility Regulation*. Houndmills, Basingstoke, Hampshire, and London, UK: Macmillan Press.

DeCanio, Stephen J. and William E. Watkins. 1998. "Investment in Energy Efficiency: Do the Characteristics of Firms Matter?" *The Review of Economics and Statistics*, 80(1): 95-107.

Delmas, Magali, Michael V. Russo and Maria J. Montes-Sancho. 2007. "Deregulation and Environmental Differentiation in the Electric Utility Industry," *Strategic Management Journal*, 28: 189-209.

DiMaggio, Paul J. and Walter W. Powell. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," *American Sociological Review*, 48: 147-160.

Energy Information Administration. December 1999. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations,* DOE/EIA-0562(99), US Department of Energy.

Energy Information Administration. October 2000. *The Changing Structure of the Electric Power Industry 2000: An Update*, DOE/EIA-0562(00), US Department of Energy.

Energy Information Administration. February 2001. *Renewable Energy 2000: Issues and Trends*, DOE/EIA-0628(00), US Department of Energy.
Energy Information Administration. February 2005. *Policies to Promote Non-hydro Renewable Energy in the United States and Selected Countries*, US Department of Energy.
Fabrizio, Kira R., Nancy L. Rose, and Catherine D. Wolfram. 2007. “Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on US Electric Generating Efficiency,” *American Economic Review*, 97(4): 1250-1277.
Gagan, Mark, L. 2006. “Measuring and Explaining Electricity Price Changes in Restructured States,” *The Electricity Journal*, 19(5): 35-42.
Ginsberg, Ari. 1988. “Measuring and Modeling Changes in Strategy: Theoretical Foundations and Empirical Directions,” *Strategic Management Journal*, 9(6): 559-575.
Griffin, James M. and Steven L. Puller (eds.). 2005. *Electricity Deregulation*, Chicago, IL: University of Chicago Press.
Haveman, Heather, A. 1993. “Organizational Size and Change: Diversification in the Savings and Loan Industry after Deregulation,” *Administrative Science Quarterly*, 38(1): 20-50.
Hoffman, Andrew J. 2001. *From Heresy to Dogma: An Institutional History of Corporate Environmentalism*. Stanford, CA: Stanford University Press.
Johnson, Justin P. and David P. Myatt. 2003. “Multiproduct Quality Competition: Fighting Brands and Product Line Pruning,” *American Economic Review*, 93(3): 748-774.
Jordan, William A. 1972. “Producer Protection, Prior Market Structure and the Effects of Government Regulation,” *Journal of Law and Economics*, 15: 151-76.
Joskow, Paul L. 2005. “The Difficult Transition to Competitive Electricity Markets in the United States.” In *Electricity Deregulation*, Griffin, James M. and Steven L. Puller (eds.). Chicago, IL: University of Chicago Press; 31-98.
Joskow, Paul L. and Roger G. Noll. 1981. "Regulation in Theory and Practice: An Overview," in *Studies in Public Regulation*, Fromm, ed., Cambridge, MA: MIT Press, 1-65.
Kaserman, David L. and John W. Mayo. 1997. “An Efficient Avoided Cost Pricing Rule for Resale of Local Exchange Telephone Services,” *Journal of Regulatory Economics*, 11: 91-107.
Khanna, Madhu and Lisa A. Damon. 1999. “EPA’s Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms,” *Journal of Environmental Economics and Management*, 37(1): 1-25.
Klitgaard, Thomas and Rekha Reddy. 2000. “Lowering Electricity Prices through Deregulation,” *Federal Reserve Bank of New York: Current Issues in Economics and Finance*, 6(14): 1-5.
Kotchen, Matthew J. and Michael R. Moore. 2007. “Private provision of environmental public goods: Household participation in green-electricity programs,” *Journal of Environmental Economics and Management*, 53: 1-16.
Leibenstein, Harvey. 1966. “Allocative Efficiency vs. X-Efficiency,” *American Economic Review*, 56(June): 392-415.

Lyon, Thomas P. 1991. "Regulation with 20-20 Hindsight: "Heads I Win, Tails You Lose"?," *The Rand Journal of Economics*, 22(4): 581-595.
Lyon, Thomas P. 2000. "Preventing Exclusion at the Bottleneck: Structural and Behavioral Approaches." In *Expanding Competition in Regulated Industries*, Crew, Michael A (ed). Norwell, MA: Kluwer Academic Publishers; 55-82.
Lyon, Thomas P. and Haitao Yin. 2008. "Why Do States Adopt Renewable Portfolio Standards?: An Empirical Investigation," Working Paper, Erb Institute for Global Sustainable Enterprise, University of Michigan.
Lyon, Thomas P. and John W. Maxwell. 2008. "Corporate Social Responsibility and the Environment: A Theoretical Perspective," *Review of Environmental Economics and Policy*, 2(2): 240-260.
Mahon and Murray. 1980. "Deregulation and Strategic Transformation," *Journal of Contemporary Business*, 9(2): 123-138.
Mahon and Murray. 1981. "Strategic Planning for Regulated Companies," *Strategic Management Journal*, 2(3): 251-262.
Margolis, Joshua D. and James P. Walsh. 2003. "Misery Loves Companies: Rethinking Social Initiatives by Business," *Administrative Science Quarterly*, 48: 268-305.
Menz, Fredric C. and Stephan Vachon. 2006. "The Effectiveness of Different Policy Regimes for Promoting Wind Power: Experiences from the States," *Energy Policy*, 34: 1786-1796.
North, Douglass C. 1990. *Institutions, Institutional Change and Economic Performance*, Cambridge; New York: Cambridge University Press.
Palmer, Karen and Dallas Burtraw. 2005. "Cost-Effectiveness of Renewable Electricity Policies," Resources for the Future Discussion Paper (05-01), Washington, D.C.: Resources for the Future.
Peltzman, Sam. 1976. "Toward a More General Theory of Regulation," *Journal of Law and Economics*, 19: 211-240.
Peltzman, Sam, Michael E. Levine, and Roger G. Noll. 1989. "The Economic Theory of Regulation after a Decade of Deregulation," *Brookings Papers on Economic Activity. Microeconomics*, 1989(1989): 1-59.
Pettus, Michael L. 2001. "The Resource-Based View as a Developmental Growth Process: Evidence from the Deregulated Trucking Industry," *Academy of Management Journal*, 44(4): 878-896.
Porter, Michael, E. 1980. *Competitive Strategy*. New York: Free Press.
Prahalad, C.K. and Gary Hamel. 1994. "Strategy as a Field of Study: Why Search for a New Paradigm?" *Strategic Management Journal*, 15: 5-16.
Rajagopalan, Nandini. 1996. "Strategic Orientations, Incentive Plan Adoptions, and Firm Performance: Evidence from Electric Utility Firms," *Strategic Management Journal*, 18: 761-785.
Rajagopalan, Nandini and Sydney Finkelstein. 1992. "Effects of Strategic Orientation and Environmental Change on Senior Management Reward Systems," *Strategic Management Journal*, 13: 127-141.
Reger, Rhonda K., Irene M. Duhaime, and J.L. Stimpert. 1992. "Deregulation, Strategic Choice, Risk and Financial Performance," *Strategic Management Journal*, 13(3): 189-204.

Russo, Michael V. 1991. "Institutions, Exchange Relations, and the Emergence of New Fields: Regulatory Policies and Independent Power Production in America, 1978-1992," *Administrative Science Quarterly*, 46(1): 57-86.

Russo, Michael V. 1992. "Power Plays: Regulation, Diversification, and Backward Integration in the Electric Utility Industry," *Strategic Management Journal*, 13(1): 13-27.

Scott, W. Richard. 2001. *Institutions and Organizations*, Thousand Oaks, CA: Sage Publications; 33-62.

Sine, Wesley D., Heather A. Haveman and Pamela S. Tolbert. 2005. "Risky Business? Entrepreneurship in the New Independent Power Sector," *Administrative Science Quarterly*, 50: 200-232.

Sine, Wesley D. and Brandon H. Lee. 2008. "Tilting at Windmills? The Environmental Movement and the Emergence of the U.S. Wind Energy Sector," Working Paper, Johnson School at Cornell University.

Smith, Ken.G. and Curtis M. Grimm. 1987. "Environmental Variation, Strategic Change and Firm Performance: A study of Railroad Deregulation," *Strategic Management Journal*, 8(4): 363-376.

Stigler, George J. 1971. "The Theory of Economic Regulation," *The Bell Journal of Economics and Management Science*, 2(1): 3-21.

Stigler, George J. and Claire Friedland. 1962. "What Can Regulators Regulate? The Case of Electricity," *Journal of Law and Economics*, 5: 1-16.

Toolsema, Linda A. 2008. "Interfirm and intrafirm switching costs in a vertical differentiation setting: Green versus non-green products," Forthcoming in *Journal of Economics and Management Strategy*.

Winston, Clifford. 1998. "U.S. Industry Adjustment to Economic Deregulation," *The Journal of Economic Perspectives*, 12(3): 89-110.

Wolak, Frank A. 2005. "Lessons from the California Electricity Crisis." In *Electricity Deregulation*, Griffin, James M. and Steven L. Puller (eds.). Chicago, IL: University of Chicago Press; 145-181.

Wolfram, Catherine. 2005. "The Efficiency of Electricity Generation in the United States after Restructuring." In *Electricity Deregulation*, Griffin, James M. and Steven L. Puller (eds.). Chicago, IL: University of Chicago Press; 227-255.

Wyly, Sam. 2008. *1,000 Dollars & an Idea*, New York, NY: NewMarket Press; 226-239.

Zajac, Edward J., Matthew S. Kraatz, and Rudi K. F. Bresser. 2000. "Modeling the Dynamics of Strategic Fit: A Normative Approach to Strategic Change," *Strategic Management Journal*, 21: 429-453.

Zajac Edward J. and Stephen M. Shortell. 1989. "Changing Generic Strategies: Likelihood, Direction, and Performance Implications," *Strategic Management Journal*, 10: 413-430.

Zhang, Fan. 2007. "Does Electricity Restructuring Work? Evidence from the U.S. Nuclear Energy Industry," *Journal of Industrial Economics*, 55(3): 397-418.

CHAPTER 5

CONCLUSION

This dissertation consists of three independent essays, all of which are empirical treatments of interactions between business and its environment. The first essay demonstrates that when there is strong regulatory pressure, firms tend to take advantage of voluntary environmental information disclosure programs and engage in selective disclosure to achieve favorable regulatory outcomes. This suggests that under certain circumstances voluntary environmental disclosure made by companies may provide only a very incomplete picture of their environmental performance.

The second essay shows that when the likelihood of climate change regulation increases, firms which respond to institutional investors' call for disclosure of environmental performance experience positive abnormal stock returns. This finding suggests that those firms are viewed as better prepared for the exogenous regulatory shock. Further, institutional investor activism toward climate change, although passive in nature, can increase shareholder value when the external business environment becomes more climate conscious.

The third paper finds that when competition intensifies due to economic deregulation, large incumbent companies tend to invest less in more costly green technologies and the negative effects on green investment could persist past the initial period following deregulation. This finding is consistent with the view that deregulation promotes efficiency and stands in contrast to recent studies which argue that the intensity of competition is positively associated with environmental differentiation.