

## Information Disclosure Policies: Evidence from the Electricity Industry

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ABSTRACT

We show that mandatory information disclosure programs can be an effective means of achieving policy goals. This result holds when the provided information already exists in the public domain. Further, the result holds when the program targets an impure public good with private consumption benefits that are not correlated with public benefits. We find that the average proportion of fossil fuels decreases and the average proportion of clean fuels increases in response to disclosure programs in the electricity industry. However, customer composition and pre-existing fuel mix affect program response, suggesting that effective information disclosure policies may not be efficient.

Keywords: disclosure, information, fuel mix, electric utilities

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## **1. Introduction**

Policies that emphasize information provision are prominent and expanding. Here, government regulation is replaced or augmented by public announcements presumed to assist more cost effective market and legal forces. For example, OECD countries' equity markets generally require firm-level financial information provision. In many countries, agricultural goods require country of origin and other health labels. Similarly, numerous products carry eco-labels promoting environment-friendly goods. Restaurants are increasingly required to display hygiene grade cards. Domestic colleges and universities are required by law to inform current and prospective students of crime statistics, equity data, and performance metrics. Even significant medical errors must now be disclosed to the community. The empirical effectiveness of such information programs, however, remains largely undetermined. This paper examines the impact of a prominent mandatory disclosure program on the fuel mix outcomes of large electric utility corporations.

There are several potential advantages of information provision policies. For example, such programs allow different outcomes for agents with varying risk exposure, risk susceptibility, and risk preferences. Information provision may also be particularly useful to address persistent problems and problems that are difficult to enforce in a regulatory context. Indeed, theory suggests that disclosure programs may effectively achieve their goals. Healy and Palepu (2001) provide a survey of the evidence in capital markets. In the environmental area, Kennedy et al. (1994), Arora and Gangopadhyay (1999), Maxwell et al. (2000), Kirchoff (2000), and Khanna (2001) showed that the provision of information about pollution can correct a market failure, improve performance, and be welfare improving.

Despite the literature's theoretical findings, the empirical effects of disclosure programs remain inconclusive. Early studies of securities regulation found mixed results. See Stigler (1964), Robbins and Werner (1964), and Benston (1973). A more recent literature suggests that disclosure programs in financial markets can achieve their desired effects; La Porta et al. (2006) and Greenstone et al. (2006) found that both market size and market returns were positively influenced by mandatory disclosure programs. In product quality settings, Chipty and Witte (1998) established that resource and referral agencies significantly influenced child care prices, but had no impact on the quality of care. In contrast, Jin and Leslie (2003) found that mandatory hygiene grade cards positively affected restaurant quality and health outcomes. Broadly, Weil *et al.* (2006) performed eight case studies of regulatory disclosure programs and concluded that transparency policies can be effective, but results are highly sensitive to context.

Studies of environmental performance yielded similarly mixed results. Desvousges, Smith, and Rink (1992) found that information-based programs influenced attitudes favorable to radon testing, but testing itself only increased when mass media dissemination was coupled with community-based implementation programs. Konar and Cohen (1997) and Khanna et al. (1998) found that stock movements associated with Toxic Release Inventory (TRI) announcements led to increased abatement and reduced emissions. However, Bui (2005) found that the declines in emissions after TRI reporting events were more likely attributable to regulation than investor pressure. Bennear and Olmstead (2006) found that drinking water quality notices lowered violations for some systems, but not others.

The effects of information disclosure programs are particularly uncertain for the case of impure public goods, where private attributes are bundled with public characteristics. For example, 'green' products provide both environmental benefits and private consumption

benefits.<sup>1</sup> Kotchen (2006) theoretically demonstrated that markets for impure public goods have ambiguous implications for environmental outcomes. It is quite difficult to understand impure public good markets empirically, since it is challenging to disentangle information responses attributable to public good preferences from information responses attributable to changes in perceived product quality. For example, if eco- or organic- labeled products gain market share, it is not easy to establish whether consumers are expressing environmental preferences or whether consumers perceive other differences in product attributes like health, safety, and taste.

This paper is the first empirical economic study of the effectiveness of information provision in the electric utility industry. Environmental disclosure programs in electricity markets are a promising area of exploration for the efficacy of information policies for several reasons. First, while electricity can be an impure public good, it is a homogeneous commodity. From a consumption point of view, there are no differences in the characteristics of green or brown electricity. Second, information programs are rapidly pervading environmental policy.<sup>2</sup> In addition to those discussed above, common examples include lead paint disclosures and methyl-mercury advisories. For the environment, electric utilities are crucial. For example, about 40.5 percent of domestic CO<sub>2</sub> and 67 percent of SO<sub>2</sub> emissions are attributable to electricity generation. Utilities are also the largest source of anthropogenic mercury emissions. Third, electric disclosure programs exhibit a number of features desirable for econometric

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<sup>1</sup> As Kotchen (2006) notes, socially responsible investment is another common example.

<sup>2</sup> The growth of information-based policies has been so dramatic that they are now commonly referred to as the “third wave” of environmental protection. Early pollution control programs, the “first wave,” involved command and control approaches. The “second wave” included pollution charges, tradable permits, and other market based instruments.

identification. For example, the programs were adopted at the state-level and progressively introduced over time, so all firms were not impacted uniformly.

To what extent did mandatory disclosure laws affect the environmental performance of the electric utility industry? We address the question by examining monthly firm-level fuel mix and program data from 145 of the largest investor-owned electric utility companies for the period 1995-2003. We first analyze how firms' fuel mix percentages respond to mandatory disclosure programs. Panel data techniques allow us to identify disclosure program effects separately from the effects of other state and local programs like Renewable Portfolio Standards. We also correct for the potential statistical endogeneity of the program variable using instrumental variables. We then explore the detected response in more detail. We use OLS and IV interaction models to explore the effect of customer composition on disclosure responses and standard and IV conditional quantile regressions to examine how the entire fuel mix distribution shifts.

We find three main results. First, *mandatory disclosure programs can affect fuel-mix outcomes*. We find that the average proportion of fuel usage attributable to fossil fuels substantially decreases and the average proportion of fuel usage attributable to clean fuels significantly increases in response to disclosure programs in the electric utility industry. Second, *customer composition significantly impacts disclosure response*. We find that firms' clean fuel program responses become considerably stronger (more positive) as the firm proportionately serves more residential customers. Firms' fossil fuel program responses become weaker (less negative) as they proportionately serve more residential customers. In other words, as firms proportionately serve more residential consumers, any nuclear program responses become weaker (less positive). Third, *pre-existing fuel mix significantly impacts disclosure program response*. Our results suggest that firms that already use substantial amounts of clean fuels most

significantly increase clean fuel percentages in response to disclosure programs. Similarly, firms that already use relatively small amounts of fossil fuels most significantly decrease fossil fuel usage in response to disclosure programs.

The paper proceeds as follows. Section 2 provides background information on the electric utility industry and its disclosure programs. Section 3 discusses economic theories explaining why information disclosure programs may alter environmental performance. Section 4 describes our Energy Information Administration and Interstate Renewable Energy Council data. Section 5 presents an empirical foundation. In Section 6, we first analyze how firm-level fuel mix percentages respond to mandatory disclosure programs. We then explore the detected response in more detail. Section 7 provides a concluding discussion.

## **2. Background**

### **2.1 Fuel Mix in the Electric Utility Industry**

In 2004, domestic electricity generation totaled 3,953,407 gigawatt hours. Of total generation, 50 percent was attributable to coal, 18 percent was attributable to gas, and 3 percent was attributable to oil. Nuclear sources generated nearly 20 percent of electricity. Cleaner energy sources, like hydropower, biomass, geothermal, solar and wind, generated approximately 9 percent (Edison Electric Institute 2005).

Renewable fuel use has trended upward since the fuels' widespread debut in 1993. More than 600 electric utilities currently offer green power options to their customers. Renewable capacity is quite variable across both space and time. For example, in 2003, many states, including CA, NY, ME, and VT, had green energy generation proportions in excess of 20

percent (USDOE (2003)). In 2004, although it remained a small portion of total electricity generation, wind power usage increased 27 percent.

Green power generation is driven by both supply-side and demand-side factors. On the consumption side, Lamarre (1997) and Delmas et al. (2007) find a distinct market niche for renewable energy even at a price premium. The number of customers participating in green pricing programs increased nearly five-fold between 1999 and 2003, to nearly 900,000 (Bird et al. (2004), US Dept of Energy (2004)).

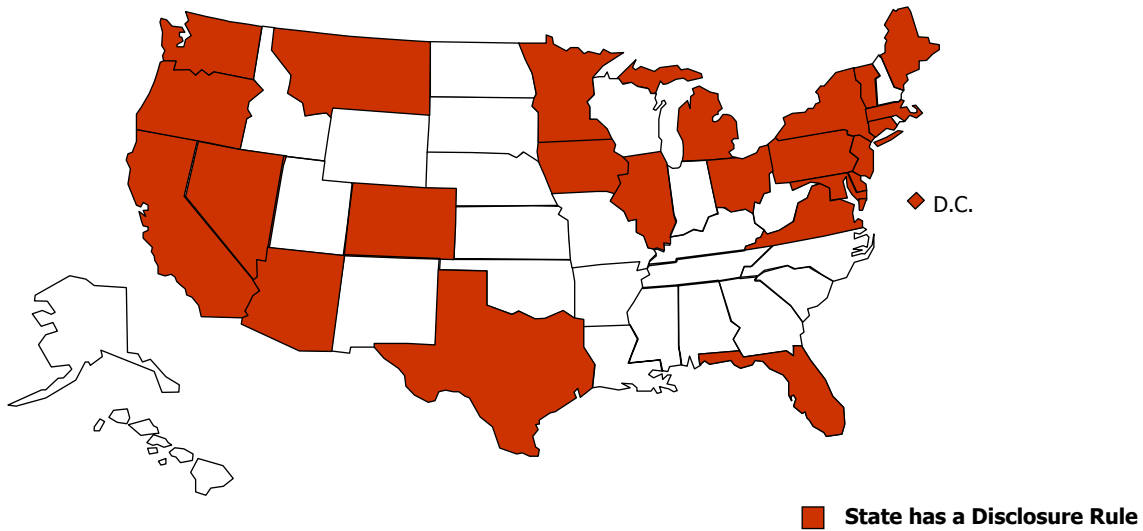
## **2.2 Mandatory Information Disclosure Programs in the Electric Utility Industry**

In the U.S. electricity industry, information disclosure refers to the mandatory provision of fuel mix percentages and pollution discharge statistics to utility consumers. For example, Minnesota's Public Utilities Commission decreed:

*“The Commission recognizes that there is a need for the consumer to be informed and educated on environmental issues and that all Minnesota utilities’ customers ... should have similar access to information.” (Minnesota PUC, 2002)*

The state issued an order requiring regulated utilities to disclose information on fuel mix and emissions to customers. Twice annually, utilities must include a bill insert that contains a pie chart depicting the mix of fuel sources, a bar chart of air pollutant emissions, a chart of costs associated with different generating sources, and a discussion of energy efficiency measures. Further, the utility must list a phone number and web address on all bills so that consumers can access environmental information. Other states' disclosure programs are similarly motivated and implemented, although specific details may vary. For example, several states' disclosure programs require quarterly (rather than biannual) inserts.

**Figure 1. State Generation Disclosure Rules – September 2005**



Source: Database of State Incentives for Renewable Energy (DSIRE).  
Accessible online at <http://www.dsireusa.org/>.

Figure 1 indicates which states had disclosure programs in 2005. By that year, 25 states had adopted generation disclosure rules, and these states represented over 65 percent of the United States population. Since consumer preferences may factor into disclosure effectiveness, programs may be particularly meaningful in deregulated states. Indeed, 23 of the 25 state-level disclosure programs were enacted in deregulated states, including NY, IL, TX, MI, AZ, NM, and much of the mid-Atlantic and northeastern regions. Additionally, Colorado and Florida instituted mandatory disclosure programs despite failing to deregulate their industries.

### **2.3 Other Information Programs in the Electric Utility Industry**

In addition to the mandatory state-level disclosure programs that are the focus of this study, many electric utilities must comply with other information requirements. Most notably, “major” firms are required to file Federal Energy Regulatory Commission Form Number 1, the

Annual Report for Major Electric Utilities, each and every year.<sup>3</sup> These reports average 140 pages and contain general corporate information, financial statements, supporting schedules, and information on environmental investments. In addition, electric utilities are required to provide information about their environmental performance to the U.S. Environmental Protection Agency (EPA) and the Energy Information Administration (EIA). Although all of the aforementioned data is publicly accessible through government databases, users typically must have environmental and database expertise to interpret the information. In marked contrast, disclosure programs are designed explicitly to produce easily accessible and readily interpretable environmental information. Further, they are designed to provide such information directly to consumers.

### **3. Theories Linking Disclosure and Environmental Performance**

We will present evidence that information disclosure programs alter fuel mix outcomes in the electricity industry. Indeed, this improved environmental performance was the declared intention of the state agencies that issued the policies. Several theories allow for a link between mandatory information disclosure programs and environmental performance.<sup>4</sup>

Perhaps the simplest theoretical explanations entail increased community coercion or investor or employee pressure. In the presence of information on the relative environmental

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<sup>3</sup> Major electric utilities are classified as those with annual sales or transmission service that exceeds one of the following: (1) one million megawatt hours of total annual sales, (2) 100 megawatt hours of annual sales for resale, (3) 500 megawatt hours of gross interchange out, or (4) 500 megawatt hours of wheeling for others (deliveries plus losses).

<sup>4</sup> See Khanna (2001) for an excellent overview of the literature on non-mandatory environmental policies, including information disclosure programs.

performance of a given firm, community activists may lobby for future regulation or attempt to harm the firm's reputation with the consuming public (indirectly reducing demand). Employee turnover and dissatisfaction may result from disclosed poor environmental performance (Tietenberg (1998)). Investors may express environmental preferences or concerns over future environmental regulation by decreasing demand for shares (Khanna *et al.* (1998)). However, the information provided by disclosure programs in the electricity industry is typically already available to highly motivated and trained experts like lawyers, investors, and community activists.

A more compelling theory, then, for the link between information and environmental performance in the electricity industry might involve the threat of future regulation or legal action. In a dynamic political economy context, disclosure programs may simply signal the state's willingness to impose future regulations on the industry unless firms self-regulate. Similarly, disclosure programs may increase a reporting firm's susceptibility to liability under legal statutes. Segerson and Miceli (1998) and Maxwell, Lyon, and Hackett (2000) explore firms' incentives to preempt future regulation or legal liability.

Perhaps the most persuasive theory for the link between disclosure and environmental performance is a direct demand effect. In the presence of simple, easily interpretable, and directly provided information, consumers may increase demand for fuels perceived as environmentally favorable and decrease demand for fuels perceived as environmentally unfavorable. Of course, this mechanism requires: (1) that information affects consumer awareness, (2) that consumer awareness can translate to changes in demand, and (3) current or future consumer choice among electricity products. However, the mechanism does not require choice among electricity providers.

An emerging literature suggests that consumer awareness changes in response to environmental information and that shifts in awareness can translate in behavioral changes. Desvousges, Smith, and Rink (1992), Blamey et al. (2000), Loureiro (2003), Loureiro and Lotade (2005), and Leire and Thidell (2005) all demonstrate shifts in consumer awareness after exposure to environmental information or eco-labels. In our context, disclosed information may remind consumers of the consequences of their own actions, notify customers that alternative fuels exist and are widely used, and demonstrate the variability in utilities' fuel mix percentages and emissions. Teisl, Roe, and Hicks (2002) and Shimshack, Ward, and Beatty (2006) establish that changes in environmental awareness can be translated into new consumption patterns. More broadly, Stigler and Becker (1977) provide a general framework for information to enter a consumer demand framework. Here, information is viewed as an input in the household production function of Lancaster (66) and Michael & Becker (73).

Consumers increasingly have the option to purchase greener energy at a price premium, and therefore increasingly have choice among consumer products. Thirty-six states and over 600 utilities currently offer green power pricing programs where consumers can support cleaner energy usage in exchange for an electricity price increase.<sup>5</sup> Further, there are dozens of certificate programs (many at the national level) that allow consumers to purchase green certificates or green tags that require the replacement of traditional types of energy with greener alternatives. These certificates are available whether or not the consumer has direct access to green power options from their own provider. Note also that the direct demand mechanism does not require customer choice across electricity providers, i.e. if information provision shifts

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<sup>5</sup> U.S. Department of Energy, Energy Efficiency and Renewable Energy pages. Retrieved October 2006 from <http://www.eere.energy.gov/greenpower/markets/>.

consumers' relative marginal willingness to pay curve for different energy products, firms' marginal revenue calculations change and a new equilibrium will result. In fact, many utilities were very interested in disclosure programs when they were being considered since such policies allowed firms to “distinguish their price structure, fuel mix, or environmental profile in the eyes of the consumer and found mandatory standard labels to be a credible way to do that.” (NCCEI 2002) In other words, disclosure programs were perceived as an effective and particularly convincing way to price discriminate.

Of course, all theories linking disclosure programs and fuel mix percentages in the electric utility industry require that supply of a given fuel type category is not completely inelastic. In other words, firms must be able to realistically alter their fuel mix portfolios in the short- to medium- run. On the margin, at least, they can. While purchasing or building new facilities may be required to dramatically alter fuel mix portfolios, relatively small portfolio shifts are easily obtainable.<sup>6</sup> First, utilities can alter their capacity utilization. Second, major electric utilities can buy and sell power generation in response to changing market conditions.

Thus, several theories can explain the link between information disclosure and environmental performance. Empirically, we will follow the literature and estimate the reduced-form impact of mandatory information programs. Such a reduced-form regression of quantity on

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<sup>6</sup> While expanded production on the margin is more transparent for traditional fuel sources, nuclear facilities also regularly increase generation on the margin. First, net unit capability is altered by reducing unplanned outages and decreasing planned outage time through improved maintenance. In the mid-1990s, average nuclear unit capability was approximately 82 percent. By the early 2000s, capability increased to approximately 90 percent. Second, nuclear power output is frequently increased via the use of more productive inputs, more efficient use of feedwater flow, and equipment modifications.

information variables (and other covariates) is identified under any of the mechanisms discussed above, and an identified response represents the impact of disclosure programs on the equilibrium quantity of electricity generated from the specifically analyzed fuel source.

## **4. Data**

### **4.1 Data sources and content**

Our research assesses the impact of environmental disclosure programs on the fuel mix percentages of major electric utility firms. We focus on fuel mix indicators from the electric power industry for three reasons. First, utilities are among the nation's leading sources of pollution. Second, fuel mix is the most readily identifiable and interpretable measure of environmental performance on disclosure program bill inserts and web postings. Third, information disclosure programs are heterogeneous, yet all require generation mix provision.

We analyze data from the Energy Information Administrations (EIA)'s Annual Electric Power Industry Database and the Interstate Renewable Energy Council (IREC)'s Database of State Incentives for Renewable Energy. Fuel mix data come from forms EIA-906 (and its predecessor EIA-759), the monthly utility electric power plant reports. We focus on production-based fuel mix rather than sales-based fuel mix to identify actual changes in environmental quality.<sup>7</sup> Firm characteristics are obtained from forms EIA-861, the annual electric power industry reports. Disclosure program information comes directly from IREC's Database. Since it is possible that other state-level programs like Renewable Portfolio Standards and Green Power

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<sup>7</sup> Sales-based fuel mix data could result in a "shell game" type outcome, where cleaner energy is simply reported in states with disclosure programs without real shifts in fuel mix or environmental performance.

initiatives may impact utilities' fuel mix percentages, we also analyze other program data from the IREC database.

## **4.2 The Sample**

Our final sample includes monthly information from the 145 major investor-owned electric utility companies with relatively complete data in EIA databases. We focus on large investor-owned firms because these companies represent the majority of industry electricity and pollution generation. Further, EIA data (EIA-906 and EIA-759) is imputed for smaller companies based upon information from these larger firms. All firms with at least one plant with a capacity of 50 megawatts or more (25 megawatts or more prior to 1999), all firms with nuclear generation, and all firms with significant renewable capacity file reports with the EIA for each and every month of operation. Since our data represent the big incumbents in the electric utility industry, the results of our analysis should be extrapolated to smaller firms with a degree of caution. We focus on the firm level (as opposed to the plant-level) since management decisions are centralized and disclosure program requirements operate at the company-level.

We observe fuel mix percentages and program variables for our 145 firms for the 108 months spanning 1995-2003. Our sample begins in 1995 in order to obtain pre-program information for all impacted states; the first disclosure program was enacted in mid-1997. The sample concludes in 2003 because we were unable to obtain reliable data for 2004.

## **4.3 Summary Statistics**

Fuel mix mean summary statistics are presented in Table 1. Standard errors appear in parentheses. Conditional on positive generation, fossil fuels represent approximately 74 percent

and clean fuels represent approximately 9 percent of generation over our entire sample.<sup>8</sup> For aggregated fuel mix categories, the table indicates that the percentage of generation attributable to fossil fuels is lower after the introduction of disclosure programs and the percentage of generation attributable to clean fuels is higher after the introduction of disclosure programs. This is true despite increasing fossil fuel usage, across all firms, in the later years of the sample. Disaggregated fuel mix summary statistics generally parallel the aggregated results.

**Table 1. Fuel Mix Percentage Summary Statistics**

	Entire Sample	Firms Subject to Disclosure During	
	(145 firms)	Sample Period (98 firms)	
	All Periods	Pre-Disclosure	Post-Disclosure
<u>Aggregated</u>			
Fossil Fuels	.739 (.322)	.736 (.299)	.687 (.365)
“Clean” Fuels	.094 (.248)	.096 (.238)	.098 (.250)
Nuclear	.167 (.254)	.168 (.235)	.215 (.311)
<u>Disaggregated</u>			
Hydroelectric	.085 (.233)	.080 (.210)	.089 (.234)
Renewables	.009 (.076)	.016 (.104)	.009 (.096)
Nuclear	.167 (.254)	.168 (.235)	.215 (.311)
Oil	.064 (.204)	.066 (.199)	.052 (.170)
Coal	.569 (.377)	.567 (.371)	.548 (.396)
Gas	.106 (.210)	.103 (.192)	.087 (.188)

<sup>8</sup> Here and throughout the paper, we refer to fuels as “clean” if they generate low levels of common air pollutants relative to fossil fuels and are not nuclear. This definition is debatable, but consistent with issuing agencies’ goals that emphasize air quality over other environmental or social objectives.

None of the differences between pre-disclosure and post-disclosure fuel mix proportions, however, are statistically significant. Further, fuel mix changes may be attributable to a variety of factors other than disclosure programs. Consequently, we must conduct a more careful analysis in order to understand the impact of information disclosure programs on the environmental performance of the electric utility sector.

## **5. Primary Methods**

Our overall empirical strategy is to use panel data techniques to analyze the effect of mandatory disclosure programs on fuel mix percentages. First, using ordinary least squares and instrumental variables regression methods, we demonstrate that disclosure programs significantly reduce the proportion of fossil fuel usage and significantly increase the percentage of clean fuel usage. Second, we examine the disclosure response in more detail. We use OLS and IV regressions with interactions to demonstrate that the impact of information programs on the proportion of clean fuel usage is significantly greater when firms have proportionately greater sales to residential customers. We then use standard and IV conditional quantile regressions to explore the impact of disclosure programs on the entire range of the fuel mix distribution. We establish that firms that use relatively small amounts of fossil fuels most significantly decrease fossil fuel percentages in response to mandatory programs.

### **5.1 Primary Variables**

Our key dependent variables represent fuel mix percentages. For example, the dependent variable may signify the percentage of the firm's generation in a given month attributable to fossil fuels, including coal, oil, and natural gas. The dependent variable may also frequently denote the percentage of the firm's generation in a given month attributable to the clean fuels,

including hydroelectricity and renewable fuels like wind, solar, and biomass. In other cases, the dependent variable represents disaggregated fuel mix percentages, including the percentage of the firm's electricity generation attributable to coal, oil, gas, renewables, hydroelectricity, or nuclear.

Our key explanatory variable represents the proportion of the firm's sales that are subject to an operational or effective mandatory disclosure program. If all of a firm's sales are subject to disclosure requirements in a given month, this explanatory variable takes a value of 1. If only 80 percent of a firm's electricity sales are subject to disclosure in a given month (such that 20 percent of company sales go to states without operational disclosure programs), this variable takes a value of 0.80.

Analyses also include several other explanatory variables. Fixed effects allow us to capture systematic firm differences due to factors such as size, age, community characteristics, management profiles, average regulatory stringency, and ownership type. Fixed effects also capture differences in input and output prices due to factors like distance to fossil fuel markets and state-level variation in taxation. Plant production varies seasonally, so we include quarterly dummy variables. Finally, we include flexible annual dummies to account for broad trends in prices, technological change, and other factors.

## **5.2 Basic Regression Model**

The basic regression model is  $y_{it} = D_{it}\delta + \mathbf{X}_{it}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}$ , where  $i$  indexes the unit of observation (a firm) and  $t$  indexes time (months).  $y_{it}$  represents the percentage of firm  $i$ 's generation in period  $t$  attributable to the fuel source being analyzed.  $D_{it}$  represents the proportion of firm  $i$ 's sales that are subject to an effective disclosure program in period  $t$ . The elements of

the vector  $\mathbf{X}_{it}$  include all of the non-program explanatory variables discussed above.  $\alpha_i$  is an unobserved time invariant individual effect and  $\varepsilon_{it}$  is the usual time variant idiosyncratic shock.

### 5.3 Consistency Considerations

A potential concern with our key program  $D_{it}$  variable is that it may be statistically endogenous. For example, consider the possibility that the likelihood of program adoption is a function of the average environmental performance of the large electric utilities operating within the state. In terms of the basic regression model, the concern is that the time invariant individual effect  $\alpha_i$  is correlated with the program variable  $D_{it}$ . However, fixed effects prevent bias from this type of correlation. In our context, the inclusion of fixed effects prohibits the possibility of bias introduced when program adoption is a function of the *temporal average* fuel mix of the firm.

Fixed effects do not, however, account for the possibility that the program variable  $D_{it}$  is correlated with the time variant error term  $\varepsilon_{it}$ . For example, consider the possibility that states choose to adopt disclosure programs in periods in which large electric utilities operating within that state are utilizing more fossil fuels *than usual*. A standard correction for this type of statistical endogeneity is instrumental variables.

An effective instrument must be correlated with the state's choice of disclosure but not with the error term in our primary fuel mix decision equation. Therefore, our chosen instrument is the weighted average of program status in states near to, but neither upwind nor downwind from, those states in which the particular firm operates. The maintained hypothesis is that state policymakers pay attention to policy choices made in nearby states, but it is unlikely that a state decides to adopt a program based upon the environmental performance of firms in other states

(since it cannot regulate those firms). To be conservative, we eliminate states that are upwind from the states in which the firm operates, since it is possible that emissions from upwind states influence program adoption in the state of interest. Similarly, we eliminate states that are downwind from the states in which the firm operates, since it is possible that emissions from the given state's plants influence program adoption in the downwind state, inducing correlation with the primary error term.<sup>9</sup> Upwind and downwind states are determined by following prevailing westerly, southwesterly, and southerly winds. Pollution transport follows these winds fairly closely.<sup>10</sup> In a later sensitivity analysis, we experiment with alternate instrument constructions.

## **6. Empirical Analysis**

### **6.1 Ordinary Least Squares and Instrumental Variables Regressions**

Do disclosure programs affect fuel mix percentages on average? Our goal here is to investigate the relationship between disclosure programs and firm's fossil fuel and clean fuel usage. Thus, we regressed fuel mix proportion measures on the percent of a firm's sales subject to disclosure requirements and other covariates. We first ran fixed effects linear regressions. Fixed effects control for systematic firm differences and account for any potential time-invariant statistical endogeneity of the disclosure program variable. Since it is possible that the program variable remained correlated with the error term in a time variant fashion, we also ran

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<sup>9</sup> In order to avoid making the instrument itself statistically endogeneous, constructed instruments do not contain any information from any state in which the particular firm operates.

<sup>10</sup> See, for example, the Ozone Transport Assessment Group (OTAG)'s Map of Ozone Pollution Transport, available online as the Air Quality Analysis Workgroup Results Summary at <http://capita.wustl.edu/OTAG/>.

instrumental variables regressions. Results are presented in Table 2. All computed standard errors are heteroskedastic-consistent. T-statistics appear in parentheses.<sup>11</sup>

**Table 2. Firm-Level Regression Results: Aggregate**

Variable Description	Dependent Variable: Percentage of Fuel Mix <u>Attributable to Fossil Fuels</u>		Dependent Variable: Percentage of Fuel Mix <u>Attributable to Clean Fuels</u>	
	Linear Regression	Instrumental Variables Regression	Linear Regression	Instrumental Variables Regression
Disclosure Program	-.050*** (-8.39)	-.127*** (-2.59)	.020*** (4.59)	.148*** (3.83)
Season 2 Dummy	.004 (1.25)	.005 (1.49)	.002 (0.48)	-.001 (-0.03)
Season3 Dummy	.017*** (4.68)	.018*** (4.93)	-.013*** (-4.16)	-.016*** (-4.72)
Season4 Dummy	-.001 (-0.04)	.003 (0.62)	-.003 (-0.79)	-.007* (-1.94)
Year2 Dummy	-.009* (-1.77)	-.009* (-1.73)	-.037*** (-7.26)	-.038*** (-7.27)
Year3 Dummy	.007 (1.39)	.007 (1.42)	-.036*** (-7.04)	-.036*** (-7.04)
Year4 Dummy	.017*** (3.32)	.024*** (3.52)	-.051*** (-10.17)	-.063*** (-9.84)
Year5 Dummy	-.030*** (-5.31)	-.012 (-0.95)	-.064*** (-12.02)	-.094*** (-8.55)
Year6 Dummy	-.048*** (-8.56)	-.024 (-1.63)	-.065*** (-11.54)	-.104*** (-7.61)
Year7 Dummy	-.022*** (-3.68)	.011 (0.52)	-.023*** (-4.38)	-.079*** (-4.39)
Year8 Dummy	-.002 (-0.33)	.041 (1.48)	.004 (0.64)	-.067*** (-2.91)
Year9 Dummy	.012* (1.92)	.053* (1.99)	-.007 (-1.20)	-.077*** (-3.46)
Fixed Effects	144Firm-Level Fes	144Firm-Level FEs	144Firm-Level Fes	144Firm-Level Fes

<sup>a</sup> The dependent variables are the percentage of fuel mix attributable to the source indicated in the column heading. The key independent variable, the disclosure program variable, ranges from 0 to 1. It indicates the percentage of firm sales subject to operational disclosure programs.

<sup>b</sup> Superscripts \*, \*\*, and \*\*\* indicate statistical significance at the 10%, 5%, and 1% level.

<sup>c</sup> All analyses consist of 14,168 observations from 145 firms over the 108 sample months.

<sup>11</sup> Later quantile regressions suggest that slope parameters are sensitive the distribution of the dependent variables, suggesting the presence of heteroskedasticity.

Results in Table 2 indicate that the estimated impact of an operational disclosure program is negative and significant at the 1 percent level for fossil fuel production. The results are also economically significant. As the proportion of the average firm's sales subject to disclosure increases 1 percent, the average proportion of generation attributable to fossil fuels drops between 0.05 percent (OLS point estimate) and 0.13 percent (IV point estimate).

Similarly, results in Table 2 indicate that the estimated impact of an operational disclosure program is positive and significant at the 1 percent level for clean sources like hydroelectric and renewables. As the proportion of the average firm's sales subject to disclosure increases 1 percent, the average proportion of generation attributable to clean fuels increases between 0.02 percent (OLS point estimate) and 0.15 percent (IV point estimate).

These results can perhaps be reasonably extrapolated. As the proportion of the average firm's sales subject to disclosure increases 10 percent, the average proportion of generation attributable to fossil fuels decreases approximately 1.3 percentage points (IV point estimate). As the proportion of the average firm's sales subject to disclosure increases 10 percent, the average proportion of generation attributable to clean fuels increases approximately 1.5 percentage points (IV point estimate). As always, however, care should be exercised interpreting the coefficients in Table 2 for non-marginal changes. Large-scale fuel mix changes may require considerable investments over long time horizons. However, results seem plausible for modest changes, as large investor owned utilities have the ability to buy and sell generation of any sort, on the margin, to meet customer, investor, or community demands.

Results in Table 2 also demonstrate the potential statistical endogeneity of the program variable. In the ordinary least squares regressions, clean fuel coefficients were negatively biased and fossil fuel coefficients were positively biased. Results suggest the presence of time variant

correlation between the program variable and the error term. Specifically, disclosure program adoption may have been most likely when fossil fuel usage was particularly high and clean fuel usage was particularly low.

As expected, seasonality appears to play a role in fuel mix percentages. The proportion of fossil fuel usage is higher and the proportion of clean fuel usage is lower in the late summer and fall months. We also find that fuel mix decisions appear to trend over time, although non-linearly. Systematic differences across firms also exist, as firm specific intercepts differ substantially.

Table 3 presents instrumental variables results disaggregated to the specific fuel source. Again, all standard errors are heteroskedastic-consistent and t-statistics appear in parentheses. Results are similar to the aggregate results presented in Table 2. There is a statistically significant negative relationship between disclosure programs and the proportional use of the fossil fuels coal and gas. As the proportion of the average firm's sales subject to disclosure increases 1 percent, the average proportion of generation attributable to coal decreases approximately 0.09 percent (IV point estimate) and the average proportion of generation attributable to gas decreases 0.05 percent (IV point estimate). There is a statistically significant positive relationship between disclosure programs and the proportional use of clean fuels. For example, as the proportion of the average firm's sales subject to disclosure increases 1 percent, the average proportion of generation attributable to renewable sources increases approximately 0.03 percent (IV point estimate). Results also suggest a positive relationship between disclosure programs and the proportional use of nuclear electricity generation (categorized as neither fossil fuel nor clean fuel and therefore unanalyzed in Table 2), but the relationship is statistically insignificant.

**Table 3. Firm-Level Instrumental Variable Regression Results: Disaggregated**

	Dependent variables					
	% of Sales Attributable to Coal	% of Sales Attributable to Oil	% of Sales Attributable to Gas	% of Sales Attributable to Renewables	% of Sales Attributable to Hydroelectric	% of Sales Attributable to Nuclear
Disclosure	-.085** (-2.16)	.005 (0.18)	-.047* (-1.64)	.031* (1.89)	.117*** (3.35)	.060 (1.40)
Season2	-.011*** (-3.57)	-.006*** (-2.98)	.022*** (9.40)	-.001 (-0.89)	.001 (0.30)	-.008** (-2.49)
Season3	-.016*** (-5.10)	-.004* (-1.93)	.038*** (15.52)	.001 (0.58)	-.017*** (-5.12)	-.010*** (-3.04)
Season4	.005 (1.62)	-.006** (-2.38)	.003 (1.25)	-.001 (-0.89)	-.006* (1-.69)	-.003 (-0.98)
Year Dummies Fixed Effects	8 Year Dummies 144 Firm-Level Fixed Effects					

<sup>a</sup> The dependent variables are the percentage of fuel mix attributable to the source indicated in the column heading. The key independent variable, the disclosure program variable, ranges from 0 to 1. It indicates the percentage of firm sales subject to operational disclosure programs.

<sup>b</sup> Superscripts \*, \*\*, and \*\*\* indicate statistical significance at the 10%, 5%, and 1% level.

<sup>c</sup> All analyses consist of 14,168 observations from 145 firms over the 108 sample months.

## 6.2 Sensitivity Analysis

The obvious concern with the preceding results is omitted variables. Perhaps other factors and government programs impacting fuel mix outcomes in the electric utility industry are driving the results in Tables 2 and 3. However, omitted variables will not bias our results unless they are systematically correlated with disclosure program introductions. Disclosure programs exhibit considerable heterogeneity across both space and time. Therefore, significant bias requires that other government programs impacting fuel mix are passed at approximately the same time as disclosure in each state. Other concerns with the preceding results may include variable definitions, model structure, and the precise nature of the ‘event.’ Below, we provide evidence that the results in Tables 2 and 3 are robust to a number of sensitivity considerations.

## Deregulation

As noted in the background section, the vast majority of disclosure programs were enacted in deregulated states at some point after restructuring. Only two states, CO and FL, instituted mandatory disclosure programs without restructuring their electricity industries. Consequently, it is possible that omitting deregulation may bias our results. Table 4 reports results from robust instrumental variable regressions augmented with the percent of firm's sales in deregulated states.

**Table 4. Instrumental Variable Regressions: Deregulation**

	Dependent variables		
	<u>Percent Fossil Fuels</u>	<u>Percent Clean Fuels</u>	<u>Percent Nuclear</u>
Disclosure Program	-.227** (-2.45)	.268*** (3.43)	.118 (1.46)
Deregulation	.078** (2.33)	-.094*** (-3.21)	-.045 (-1.53)
Season Dummies		3 Season Dummies	
Year Dummies		8 Year Dummies	
Fixed Effects		144 Firm-Level Fixed Effects	

<sup>a</sup> The dependent variables are the percentage of fuel mix attributable to the source indicated in the column heading. The key independent variable, the disclosure program variable, ranges from 0 to 1. It indicates the percentage of firm sales subject to operational disclosure programs.

<sup>b</sup> Superscripts \*, \*\*, and \*\*\* indicate statistical significance at the 10%, 5%, and 1% level.

<sup>c</sup> All analyses consist of 14,168 observations from 145 firms over the 108 sample months.

Results in Table 4 indicate that disclosure programs impacts are similar in sign and significance, and larger in magnitude, when deregulation variables are added to the analysis.<sup>12</sup> As

<sup>12</sup> Ideally, one might also interact disclosure program variables with deregulation indicators to see if program responses become stronger in restructured markets. However, since only 2 states implemented disclosure without restructuring, such results are quite sensitive to model specification.

the proportion of the average firm's sales subject to disclosure increases 1 percent, the average proportion of generation attributable to fossil fuels decreases approximately 0.23 percent and the average proportion of generation attributable to clean fuels increases 0.27 percent. The average proportion of generation attributable to nuclear seems to increase, but changes are not statistically significant.

### **Renewable Portfolio Standards and Other Programs**

Other state and local regulations and financial incentives may also impact firms' fuel mix percentages. Examples include Renewable Portfolio Standards, Mandatory Green Power Initiatives, and Tax Incentives. However, the adoption of these programs does not generally closely coincide with the adoption of disclosure across time. As a sensitivity analysis, however, we tested whether other prominent state-level programs targeting utilities' fuel mixes impacted our key results.

Renewable Portfolio Standards (RPS) typically mandate tradeable credit programs with fixed quotas for renewable generation. We examined whether the inclusion of a variable for the introduction of RPS changed our disclosure results, suggesting the presence of omitted variable bias. Instrumental variable coefficients for the disclosure program variable were extremely similar (signs, significance, and point estimates) to the results presented in Tables 2 and 3. For example, when variables indicating the percent of the firm's sales subject to RPS are included, the disclosure program coefficient for the clean fuel response is 0.159 (t-statistic 3.96) and the coefficient for the fossil fuel response is -0.128 (t-statistic -2.51).

Mandatory green power policies require utilities operating in the state to offer and publicize green power options to consumers. When variables indicating the percent of the firm's sales subject to mandatory green power initiatives are included in the analysis, results were once

again very similar (signs, significance, and point estimates) to the results presented in Tables 2 and 3. The disclosure program coefficient for the clean fuel response is 0.145 (t-statistic 3.78) and the coefficient for the fossil fuel response is -0.129 (t-statistic -2.64).

State and local sales and corporate tax credits and exemptions for green energy generation are becoming increasingly prominent. Again, the adoption of these programs does not generally closely coincide with the adoption of disclosure across time. When variables indicating the percent of the firm's sales subject to state corporate or sales taxes for green power are included in the analysis, results were once again very similar (signs, significance, and point estimates) to the results presented in Tables 2 and 3. When sales tax incentives for green power are included, the disclosure program coefficient for the clean fuel response is 0.123 (t-statistic 3.86) and the coefficient for the fossil fuel response is -0.103 (t-statistic -2.42). When corporate tax incentives for green power are included, the disclosure program coefficient for the clean fuel response is 0.170 (t-statistic 4.63) and the coefficient for the fossil fuel response is -0.127 (t-statistic -2.75).

Not surprisingly, when all other program variables (RPS, Mandatory Green Power, Sales Tax Exemptions, and Corporate Tax Incentives) are included in the analysis, results remain very similar (signs, significance, and point estimates) to the results presented in Tables 2 and 3. The disclosure program coefficient for the clean fuel response is 0.155 (t-statistic 4.93) and the coefficient for the fossil fuel response is -0.101 (t-statistic -2.44).

### **Sensitivity to Other Assumptions**

In addition to omitted variable concerns, one possible worry is the robustness of our results to the chosen instrument. Consequently, we experimented with an instrument that contains program information from all states adjacent to those in which the firm operates (not

just states that are neither upwind nor downwind). We further experimented with instruments that contained program information from nearby, yet non-upwind, states and nearby, yet non-downwind, states. For all regression analyses, these more general instrument generated results similar in sign and significance to those reported in Tables 2, 3, and 4. Coefficients, however, were consistently larger in magnitude, perhaps suggesting some influence of upwind emissions on downwind states' policy choices.

Another possible concern is the sharpness of our study's program variables. Perhaps utilities were broadly aware of the disclosure programs prior to their effective date and changed their behavior ahead of time. Of course, if utilities had already completely responded to disclosure programs before the effective dates, it would be difficult to reconcile the observed responses in our analyses. However, as a sensitivity test, we repeated all analyses with program variables that reflect the dates the programs were enacted. In general, we find qualitatively similar results (in signs and significance) to those reported here, but magnitudes are frequently smaller.

Our key program variable is constructed by weighting each firm's state-level disclosure program status by the percentage of sales that occur in each state. A possible apprehension is that the percentage of a firm's sales attributable to each state may change in response to the program itself. This would introduce bias. However, if we replace our program variable with a 0/1 dummy indicating whether *any* of a firm's sales are subject to disclosure, we find qualitatively similar results.

Finally, in our analysis we control for the possibility of persistence with fixed effects and the possibility of systematic changes in technology with time dummies. However, as a sensitivity check, we include an auto-regressive term lagged one year to help control for unobserved

technology shifts. Including this lagged discharge variable did not substantively change the results; signs, significance, and approximate magnitude are similar to those reported.

### **6.3 The Impacts of Disclosure: Further Exploratory Analysis**

The regressions in Tables 2 and 3 demonstrate that disclosure programs reduce fossil fuel usage and increase clean fuel usage on average. However, it may be informative to explore these effects in more detail. Consequently, in this section, we first use regressions with interactions to explore whether the impact of information programs on fuel mix depends upon customer composition. We then explore the impact of disclosure policies beyond the mean; we utilize conditional quantile regressions to investigate program effects on the entire range of the fuel mix distribution.

#### **Regression Models with Interactions**

Are disclosure program impacts conditional on customer composition? Our goal here is to examine whether the effect of disclosure programs depends upon a firm's proportion of sales to residential consumers. Consequently, we regress fuel mix proportion measures on the percent of the firm's sales subject to disclosure, the proportion of the firm's sales to residential consumers, an interaction of the policy variable with the residential variable, fixed effects, and other covariates. More formally, we consider the basic regression model  $y_{it} = D_{it}\delta + R_{it}\gamma + D_{it}R_{it}\eta + \mathbf{X}_{it}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}$ .  $D_{it}$  still represents the proportion of firm  $i$ 's sales that are subject to an effective disclosure program in period  $t$ ,  $R_{it}$  represents the proportion of firm  $i$ 's sales going to residential customers, and the elements of the row vector  $\mathbf{X}_{it}$  include all of the non-program explanatory variables.

Since both the program variable  $D_{it}$  and its interaction  $D_{it}R_{it}$  may be statistically endogenous, we again employ instrumental variables regressions. One instrument remains the same, i.e. the weighted average of the program status in states near to, but neither upwind nor downwind from, those in which the particular firm operates. Our second instrument is the interaction of the first with the residential variable. Since this interaction is not a linear combination of the first instrument, it is as valid as the primary instrument itself. Results for aggregate categories are presented in Table 5.<sup>13</sup> Computed standard errors are heteroskedastic-consistent. T-statistics appear in parentheses.

**Table 5. Disclosure & Customer Composition Instrumental Variable Regression Results**

	Dependent variables		
	Percent Fossil Fuels	Percent Clean Fuels	Percent Nuclear
Percent of Sales to Residential Disclosure Program	-.146 (-1.03)	-.649*** (-3.82)	.562*** (3.88)
Disclosure/Residential Interaction	-.502*** (-3.96)	-.333** (-2.09)	.632*** (4.70)
Season Dummies	.889*** (3.75)	1.27*** (3.24)	-1.42*** (-5.26)
Year Dummies		3 Season Dummies	
Fixed Effects		8 Year Dummies	
		144 Firm-Level Fixed Effects	

<sup>a</sup> The dependent variables are the percentage of fuel mix attributable to the source indicated in the column heading. The key independent variable, the disclosure program variable, ranges from 0 to 1. It indicates the percentage of firm sales subject to operational disclosure programs.

<sup>b</sup> Superscripts \*, \*\*, and \*\*\* indicate statistical significance at the 10%, 5%, and 1% level.

<sup>c</sup> Analyses use 13,957 observations from 143 firms over the 108 sample months. 2 firms are missing residential data.

Table 5 coefficients on the un-interacted residential variable indicate that, in the absence of any disclosure program, an increase in sales to residential customers increases the proportion of fuel mix attributable to nuclear energy and decreases the proportion attributable to clean fuels.

<sup>13</sup> Disaggregated results are similar and are omitted to conserve space.

Coefficients on the un-interacted disclosure program variable indicate that, when firms sell to no residential customers, programs reduce the proportion of usage attributable to fossil fuels, reduce the proportion of usage attributable to clean fuels, and increase the proportion of usage attributable to nuclear energy. As always, however, some care should be exercised interpreting coefficients conditioned on zeroed variables. There are relatively few observations in which firms sell to no residential customers.

The interaction results in Table 5 indicate that the impact of disclosure programs on both clean fuel usage and fossil fuel usage becomes more positive as the percentage of residential customers rises. In other words, as firms proportionately serve more residential customers, clean fuel program responses become stronger (more positive). Alternatively, as firms proportionately serve more residential customers, fossil fuel program responses become weaker (less negative). These results are not inconsistent. Examining the last column of Table 5, we see that the interaction coefficient for nuclear energy is negative and statistically significant. As firms proportionately serve more residential customers, any nuclear program responses become weaker (less positive). In other words, disclosure programs induce considerably smaller increases in nuclear fuel usage when firms' residential customer proportions are high (relative to the average program response).

*Marginal* disclosure program impacts clarify the interpretation of the results in Table 5. At the first quartile of the residential customer variable, the marginal impact of disclosure on clean fuel usage is +0.024.<sup>14</sup> At the median of this variable, the marginal impact of disclosure is +0.086, at the third quartile, the marginal impact of disclosure is +0.142, and at the 90<sup>th</sup>

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<sup>14</sup> For the percent of firm's sales subject to residential consumers, Q25=0.281, Q50=.330, Q75=.374, and Q90=.430.

percentile, the marginal impact of disclosure is +0.213. Thus, clean fuel program response becomes stronger (more positive) as firms proportionately serve more residential customers. The marginal impact of disclosure on fossil fuel usage is -0.252 at the first quartile of the residential variable, -0.209 at the median, -0.170 at the third quartile, and -0.120 at the 90<sup>th</sup> percentile. Therefore, fossil fuel program response becomes weaker (less negative) as firms proportionately serve more residential customers. Finally, the marginal impact of disclosure on nuclear fuel usage is +0.223 at the first quartile of the residential variable, +0.163 at the median, +0.101 at the third quartile, and +0.021 at the 90<sup>th</sup> percentile. Any nuclear fuel program response becomes weaker (less positive) as firms proportionately serve more residential customers.

### **Conditional Quantile Regressions**

Do disclosure program impacts vary across the fuel-mix distribution? Our goal here is to examine whether the effect of disclosure programs depends upon firms' pre-existing fuel mix portfolios. For example, do disclosure programs impact dirty firms the same way they impact cleaner firms? Therefore, we use Koenker and Bassett (1978)'s conditional quantile regressions. In our context, quantile regressions decompose the mean response revealed by the linear regression results in Tables 2 and 3 into changes across the entire probability distribution of fuel mix levels. In particular, conditional quantile regressions allow us to estimate different slope coefficients for different fuel mix quantiles. For example, a regression on the 50<sup>th</sup> percentile estimates the effect of disclosure on the sample median of the dependent variable in question.

An additional advantage of conditional quantile regressions in our context relates to censoring. In our data, some observations have proportional clean fuel usage at or near 0 and proportional fossil fuel usage at or near 1. Less commonly, some observations have proportional clean fuel usage at or near 1 and proportional fossil fuel usage at or near 0. Such censoring may

bias least squares regressions, but the weighted least absolute deviation estimation underlying the quantile regression method minimizes or eliminates the impact of censoring on the uncensored quantiles.

More formally, we consider the linear model for the conditional quantile function,  $Q_{y_{it}}(\tau | D_{it}, \mathbf{X}_{it}) = \alpha(\tau) + D_{it}\delta(\tau) + \mathbf{X}_{it}\boldsymbol{\beta}(\tau)$  for  $\tau$  between 0 and 1.  $D_{it}$  still represents the proportion of firm  $i$ 's sales that are subject to an effective disclosure program in period  $t$  and the elements of the row vector  $\mathbf{X}_{it}$  include all of the non-program explanatory variables. Note that we omit firm-level fixed effects. Including firm-level fixed effects in quantile regressions would yield coefficients that indicate an average firm's program responses across the distribution of *departures* from that individual firm's typical fuel mix levels. So, a 75<sup>th</sup> percentile coefficient would be the disclosure response when firms are using a particularly large proportion of fuel from source  $Y$ , relative to their own typical levels of fuel  $Y$ . In contrast, our purpose is to investigate what happens to the overall emissions distribution. In other words, we wish to examine if the fuel mix distribution shifts more strongly for firms that typically use high proportions of fuel  $Y$ .

Of course, it is still possible that the program variable  $D_{it}$  is statistically endogenous. Therefore, in addition to standard conditional quantile regressions, we perform instrumental variable quantile regression. In these instances, the instrument remains the weighted average of the program status of states near to, but neither upwind nor downwind from, those in which the particular firm operates. For basic quantile regressions, estimation and inference follows

Koenker and Bassett (1982) and Rogers (1993). For instrumental variable quantile regression, we use the implementation by Chernozhukov and Hansen (2004a) for estimation and inference.<sup>15</sup>

Table 6 presents quantile regression results for the impact of disclosure programs on proportional fossil fuel usage. Here, we conduct quantile regressions at the 20<sup>th</sup>, 30<sup>th</sup>, 40<sup>th</sup>, 50<sup>th</sup>, and 60<sup>th</sup> percentiles because these represent the relevant range for this distribution. There is little variation below the 20<sup>th</sup> percentile, as 15 percent of observations reflect proportional fossil fuel usage at or near 0. Similarly, there is little variation above the 60<sup>th</sup> percentile, as nearly 40 percent of observations reflect fossil fuel usage at or near 1 (100%).

**Table 6. Conditional Quantile Regressions: Fossil Fuels**

	Std. Quantile Regression					Instrumental Var. Quantile Regression				
	Q20	Q30	Q40	Q50	Q60	Q20	Q30	Q40	Q50	Q60
Disclosure Program	-.323*	-.294*	-.201*	-.149*	-.017*	-.525*	-.985	-.467*	-.326*	.094
	(-19.9)	(-19.2)	(-13.5)	(-21.1)	(-19.2)	(-9.18)	(-0.04)	(-9.34)	(-4.35)	(0.24)
Season2 Dummy	-.001	.024	.023	.015	.001	.003	.001	.018	.002	-.001
	(-0.02)	(1.60)	(1.61)	(2.16)	(0.01)	(0.18)	(0.01)	(1.64)	(0.20)	(-0.02)
Season3 Dummy	.056*	.049*	.041*	.019*	.001	.040	.025	.033*	.002	.001
	(3.51)	(3.33)	(2.89)	(2.79)	(0.01)	(2.40)	(0.30)	(3.22)	(0.21)	(0.02)
Season4 Dummy	.001	-.001	.012	-.010	.001	.026	.003	.017	.002	-.001
	(0.04)	(-0.01)	(0.86)	(-1.47)	(0.01)	(1.58)	(0.03)	(1.60)	(0.20)	(-0.02)
Year Dummies	8 Year Dummies					8 Year Dummies				

<sup>a</sup> The dependent variables are the percentage of fuel mix attributable to the source indicated in the column heading. The key independent variable, the disclosure program variable, ranges from 0 to 1. It indicates the percentage of firm sales subject to operational disclosure programs.

<sup>b</sup> A superscript \* indicates statistical significance at the 1% level.

<sup>c</sup> All analyses consist of 14,168 observations from 145 firms over the 108 sample months.

Results in table 6 demonstrate that the disclosure program point estimates tend to decrease as one moves up the distribution of fossil fuel emissions. These differences are

<sup>15</sup> Empirical examples of this technique can be found in Chernozhukov and Hansen (2004b) and Hausman and Sidak (2004).

frequently both statistically and economically significant. For example, all matched pair differences except (Q20, Q30) are statistically significant for the standard quantile regressions. Further, the fossil fuel program response at the 20<sup>th</sup> percentile is 1.6 (IV QREG point estimates) to 2.2 (standard QREG point estimates) times greater than the response at the 50<sup>th</sup> percentile. Results in Tables 2 and 3 indicated that disclosure programs induce reductions in fossil fuel usage on average. The quantile regression results in table 6 suggest that it is firms that already use relatively limited amounts of fossil fuels that reduce fossil fuels the most in response to disclosure programs.

Results for clean fuel responses to disclosure programs largely mirror the results in Table 6. Point estimates generally increase as one moves up the distribution of clean fuel usage, suggesting that disclosure programs induce firms that already use substantial amounts of clean fuel to increase clean fuel usage the most. For both fossil fuel and clean fuel responses, care should be taken interpreting these results. Technically, the quantile regressions compare differences in the absent-disclosure and present-disclosure *distributions*. Rank preservation is not guaranteed. While it is practically quite likely that firms that are at high quantiles of the absent-disclosure distribution also appear at similarly high quantiles of the corresponding present-disclosure distribution, this is not required. Thus, quantile regression results merely suggest that firms that already use substantial amounts of fossil fuels reduce fossil fuel usage the most in response to disclosure programs.

## **7. Discussion and conclusion**

On the margin, we find a statistically and economically significant impact of information disclosure programs in the electricity industry. We find that mandatory disclosure programs decrease firms' percentage of generation attributable to fossil fuels and increase firms'

percentage of generation attributable to clean fuels like hydroelectric and renewables. As the proportion of the average firm's sales subject to disclosure requirements increases 10 percent, the average proportion of generation attributable to fossil fuels drops approximately 1.3 percentage points. Further, as the proportion of the average firm's sales subject to disclosure increases 10 percent, the average proportion of generation attributable to clean fuels rises approximately 1.5 percentage points.

We also find that disclosure program responses are sensitive to customer composition and pre-existing fuel mix levels. Firms' clean fuel program responses become considerably stronger (more positive) as the firm sells to more residential consumers. Fossil fuel program responses become considerably weaker (less negative) as the proportion of sales to residential consumers increases. Further, disclosure program responses differ across the fuel mix distribution. Results suggest that firms that already use relatively low levels of fossil fuels decrease their fossil fuel percentages the most in response to information disclosure policies. For example, the program-induced decrease in fossil fuel usage is approximately 2 times greater for firms generating approximately 38 percent of their energy from fossil fuels than for firms generating approximately 83 percent of their energy usage from fossil fuels.

The key implication arising from our results is that information disclosure programs that regularly provide easily interpretable information can be an effective and low cost means of achieving policy goals. This result holds even when the provided information already exists in the public domain. Further, the result holds when the program targets an impure public good with private consumption attributes that are not correlated with public benefits. We find a significant impact of mandatory information policies for electricity, and green electricity is equivalent to brown electricity as a final consumption product. Information policies like eco- and

organic- labels frequently target impure environmental public goods, but it is very difficult to disentangle disclosure responses attributable to environmental preferences from disclosure responses attributable to perceived changes in product quality (like health, safety, and taste).

Other significant policy implications follow from our results. First, particular attention must be paid to customer composition when introducing disclosure programs in the electricity industry. When utilities serve high proportions of residential consumers, mandatory information programs may spur particularly significant increases in clean fuel usage. However, in these circumstances, these increases come at the relative expense of nuclear fuel usage and not fossil fuel usage. This may be consistent with stakeholder preferences, but it is unlikely to be consistent with air pollution-oriented policy goals. Second, the pre-existing fuel mix results suggest that disclosure programs make “clean” firms cleaner while leaving “dirty” firms relatively unchanged. If the marginal benefits of pollution abatement are larger at dirty firms than at clean firms, disclosure programs may induce inefficient abatement allocations.

This paper suggests promising avenues for future research that are beyond the present scope. First, what is the impact of mandatory information disclosure programs on firm- and plant-level emissions of carbon dioxide and other air pollutants? Policy-induced changes in fuel usage are very likely to translate into environmental improvements, but the extent of these changes remains unknown. Second, what is the precise mechanism that provides the link between mandatory information disclosure programs and environmental performance? Our results and anecdotal evidence suggest direct demand and political economic theories, but more precise structural identification when data becomes available will be important to fully understand the implications of information-based policies. Third, what is the impact of information disclosure programs on other countries’ electric industries? While our results are

suggestive for other settings, mandatory provision programs are becoming increasingly common in other countries, and the extent of policy induced changes may be sensitive to cross-country institutions.

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