Electricity Deregulation:
What's in Store for the Environment?

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Presented at the
American Agricultural Economics Association Annual Meeting – 1998

Maine Agricultural and Forest Experiment Station Publication No. 2230

Electricity generation is one of the largest sources of air pollution in the United States: during 1994 it created more than one-third of all carbon dioxide and nitrogen oxide emissions and more than 70 percent of all sulfur dioxide emissions (US EPA 1995). Spurred by the Energy Policy Act of 1992, the deregulation of the U.S. electricity supply is happening quickly. By the end of 1998 millions of retail customers and small businesses around the country will have the opportunity to choose among competing electricity suppliers. Like any other consumer service or product, consumers will evaluate attributes and prices and choose the service most to their liking; products with attributes more pleasing to consumers will be able to charge a premium for their service.

Disclosing the environmental attributes of competing electricity services allows consumers who hold preferences over these attributes to choose products concordant to these preferences. From a policy perspective, one aim of environmental disclosure is to educate consumers about the environmental impacts of product consumption, thereby leading to changes in purchasing behavior, and ultimately, achieving customer-preferred outcomes. For example, disclosure might provide the stimulus for consumers who have not formed preferences over environmental attributes to do so. If consumers prefer low air emission generation sources over high-emission sources, the short-run effect might be to bid up the price of services with low-emissions sources. The long-run effect might be to increase the share of generation sources that are relatively low in emissions as more low-emission plants are built and high-emission plants are retired.

However, whether labeling electricity products will lead to lower emissions or improved environmental quality is uncertain because consumer preferences for the environmental attributes of electricity services is relatively unknown. While several small-scale pilot programs featuring competing electricity services have been conducted, the market data is proprietary and unavailable for analysis.

The current deregulation of the electricity supply market has presented utility and environmental regulators with a need to better understand public preferences regarding the environmental characteristics of electricity generation. As a result, the National Council on Competition and the Electric Industry, with assistance from the Regulatory Assistance Project (RAP), initiated a research effort designed to: 1) determine the types of information electricity consumers desire during a purchase decision, 2) indicate how that information should be presented and 3) elicit consumer preferences for electricity products that vary in terms of their environmental characteristics. The results presented here focus on the third goal of the research effort.

Methods

We used a mall-intercept sample and a conjoint analysis approach to examine how various attributes (both price and environmental) of electricity may affect consumer choice. The survey consisted of several different experimental tasks. For brevity, we only describe the conjoint analysis design; one can obtain a description of the entire experiment by visiting the RAP's home page (www.rapmaine.org).

Survey design

The conjoint table used in the survey was designed to allow consumers to choose among two electricity products. Each product was composed of randomly assigned levels of each of the five following attribute categories: product price; percent of generation fuel mix from renewable, nuclear and fossil fuel sources (constrained to sum to 100 percent); and ambient air emissions. Although the general categories of price, fuel mix and emissions are randomly assigned, we purposely correlated the attributes within the fuel mix and emissions categories. Specifically, within the fuel mix category, we correlated the variation in the fossil fuel (oil, coal and natural gas) and renewable fuel (solar and hydroelectric) subcategories. Hence this experimental design will only allow a respondent to reveal preferences for fossil fuels relative to price, renewable resources or emissions; it will tell us nothing about a respondent's relative preferences among different fossil fuels, renewable resources or air emissions. Contract terms, while part of the informational display provided respondents (Figure 1), were never varied.

Sample

The sample consists of 1,001 adult respondents from shopping malls in eight different cities around the United States: Cincinnati, Ohio; Holyoke, Massachusetts; Houston, Texas; Jacksonville, Florida; Riverside, California; Philadelphia, Pennsylvania; Portland, Oregon; Salt Lake City, Utah. Mall intercept studies are typically not statistically representative of the U.S. population at large; the convenience samples drawn at malls typically under-represent those from the highest and lowest socio-economic classes. However, the malls and locations chosen for this study do provide a sample that represents a wide variety of socio-economic circumstances (Table 1). Nearly all respondents regularly deal with the household bills and, therefore, should be somewhat familiar with electric bills. Less than one in five say they belong, or have recently made a donation, to an environmental organization.

Model and statistical analysis

One method of assessing whether the effects of product attributes on choice vary across individuals is to specify a model where choice is a function of product attributes and of interaction terms between the product attributes and individual characteristics. Here each individual has only two products in their choice set so we can model the choice decision based on relative differences in attributes. Specifically, we can denote one of the products in each respondent's choice set as Product X and the other as Product Y. Due to the singularity of the fuel mix category we cannot estimate the model with all three fuel types directly. However, we can estimate the model if we define the model as:

$$(1) \quad Z_i = \alpha + \beta_1 PriceD + \beta_2 PriceD*Income + \beta_3 PriceD*Income^2$$
$$+ (\eta_1 - \eta_k)\ RenewD + (\eta_j - \eta_k)\ FuelD_j + \eta_4 EmissD$$
$$+ (\delta_1 - \delta_k)\ RenewD*Env_i + (\delta_j - \delta_k)\ FuelD_j*Env_i + \delta_4 EmissD*Env_i$$
$$+ (\theta_j - \theta_k) RenewD*Educ_i + (\theta_j - \theta_k)\ FuelD_j*\ Educ_i + \theta_4 EmissD*Educ_i + e_i$$

where Z_i = 1 if the individual chooses product X over Product Y, 0 otherwise (the subscript 'i' denotes the individual). PriceD denotes the difference in price (measured in terms of average monthly bills) between products X and Y; PriceD*Income is a price difference-income interaction term used to determine whether the price sensitivity of consumers varies across income levels; PriceD*$Income^2$, where $Income^2$ is equal to Income*Income, is used to allow a non-linear price sensitivity across incomes.[1]

RenewD, denotes the difference, between products X and Y, in the percent of renewable (solar and hydroelectric) fuels. $FuelD_j$ denotes the difference, between products, in the percent of <u>either</u> fossil (FossilD0 or nuclear (NuclearD) fuels; subscripts j and k denote either '2' or '3' and $j \neq k$. Thus, we estimate two different regression models, one with the variable NuclearD in(ex)cluded and FossilD ex(in)cluded; the estimated model provides relative preferences across fuel types.

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[1] This price and income specification is not consistent with utility theory (Roe et al). However, a utility-consistent formulation provided similar results (in terms of signs and significance of coefficients). The above model provides more conservative willingness to pay measures.

EmissD is the difference in total emissions of SO_2, NO_x, and CO_2. RenewD*Env_i, NuclearD*Env and FossilD*Env are variables used to measure the potential difference in preferences for these energy fuels across consumers depending on their level of environmental activism (Env = 1 if the respondent indicated they belonged to, or donated money to, an environmental organization; 0 otherwise). EmissD*Env_i measures the difference in preferences for air emissions across individuals who are or are not environmentalists. RenewD*$Educ_i$, NuclearD*Educ and FossilD*Educ measure the potential difference in preferences for these energy fuels across consumers of different education backgrounds (Educ = 1 if the individual has any education beyond high school; 0 otherwise. EmissD*$Educ_i$ measures the difference in preferences for emissions across individuals of varying educational backgrounds. e_i denotes an i.i.d. random error with zero mean.

Given the dependent variable is binary, Equation (2) is estimated using binary logit regression. Although the non-linearity of a logit regression prevents direct interpretation of the estimated coefficients, the signs of the coefficients do indicate the direction of effects, holding all else constant. Thus, the signs of the β's will indicate how the choice probability varies with changes in the products' relative price, and how this price sensitivity varies across consumers with different income levels. The signs of the η's indicate how non-price attributes affects choice probabilities among the base group of consumers (less-educated, non-environmental). The signs of the δ's and θ's indicate how the effect of the product attributes differs across individuals with different levels of environmental activism and education, respectively, relative to the base group of consumers. We perform joint likelihood tests of significance to determine the total effect of combinations of parameters.

We hypothesize the signs of β_1 to be negative and β_2 to be positive (indicating that consumers are less likely to choose a good with higher prices, although this price relationship decreases with increases in income). We hypothesis that $(\eta_1 - \eta_3)$, $(\delta_1 - \delta_3)$ and $(\theta_1 - \theta_3)$ will be positive (indicating that all consumer types will prefer electricity based on renewable fuels to those based on fossil fuels). We hypothesis that η_4, δ_4 and θ_4 will be negative (indicating that all consumer types will prefer electricity with low emissions characteristics). We base these hypotheses on the results of earlier focus group (Levy et al; Teisl et al) and survey research (Winning et al.).

In addition to estimating the effect of product attributes and individual characteristics on product choice, the estimated model can be used to calculate the willingness of consumers to pay for products with different combinations of the above attributes. To do this, we follow the procedures outlined in Roe et al.

Results and Discussion

The results indicate that individuals are less likely to choose Product X, *ceterus paribus,* if its price was higher relative to Product Y. Further, the size of the price response decreases with increase in income (i.e., individuals with higher incomes are less price sensitive) and this decrease in price sensitivity declines with increases in income.

The coefficients on the fuel mix variables across the two models indicate that ‘non-environmentalist’, less educated consumers do not have strong preferences for particular fuel types; these consumers are indifferent between renewable, fossil or nuclear-fueled electricity. However, these consumers do prefer electricity products with lower emissions.

The fuel mix-environmentalist interaction terms indicate that less-educated environmentalists prefer renewable fuels to fossil fuels, relative to similar non-environmentalist consumers. However, preferences for other fuels are not significantly different whether or not the individual was an environmentalist. Joint tests of significance confirms that less-educated environmentalist consumers prefer renewable fuels to fossil fuels ($\chi^2_{0.05, 2} = 5.16$). However, these consumers are indifferent between renewable and nuclear-fueled electricity ($\chi^2_{0.05, 2} = 3.82$), and between nuclear and fossil-fueled electricity ($\chi^2_{0.05, 2} = 1.36$). The emissions-environmentalist interaction term indicates that less-educated environmentalists are not significantly different from their non-environmentalist counterparts; less-educated environmentalists prefer low-emissions products ($\chi^2_{0.05, 2} = 19.98$).

The fuel mix-education interaction terms indicate that more educated, non-environmental individuals prefer nuclear fuels to fossil fuels, relative to their less-educated counterparts. Preferences for other fuels are not significantly different across education levels. However, joint tests of significance indicate that the total effect is that more educated consumers prefer renewable fuels to fossil fuels ($\chi^2_{0.05, 2} = 7.62$) and prefer nuclear to fossil-fueled electricity ($\chi^2_{0.05, 2} = 7.24$). However, these consumers are indifferent between renewable and nuclear-fueled electricity ($\chi^2_{0.05, 2} = 2.07$). Finally, more educated individuals have stronger preferences for electricity products with lower emissions characteristics, relative to their less-educated counterparts; more educated consumers prefer low-emissions products ($\chi^2_{0.05, 2} = 59.16$). Finally, joint tests indicate that more educated environmentalists prefer renewable fuels to fossil fuels ($\chi^2_{0.05, 2} = 18.74$) and prefer nuclear to fossil-fueled electricity ($\chi^2_{0.05, 2} = 10.1$). However, these consumers are indifferent between renewable and nuclear-fueled electricity ($\chi^2_{0.05, 2}$ = 4.46). Again, these consumers prefer low-emissions products ($\chi^2_{0.05, 2}$ = 85.48).

Given the non-significance of the (η_1 - η_2), (η_1 - η_3) and (η_2 - η_3) parameters, less-educated, non-environmental consumers are not willing to pay more for electricity that is produced with more renewable fuels (Table 3). Except for this group, all other consumers are, on average, willing to pay more for electricity that is based on increased used of renewable fuels (when the increase in renewable fuels comes at the expense of fossil fuel use). However, all consumers, on average, are willing to pay more for 'cleaner' (lower air emissions) electricity. Environmentalists and more educated individuals are willing to pay significantly more for both increased renewable fuel use and for decreased emissions.

Conclusions

The results suggest that consumers are willing to pay a premium for electricity services that feature more renewable resources and lower ambient air emissions and that this willingness to pay differs significantly across consumers. In general, consumers seem more concerned with the overall cleanliness of electricity, measured in terms of reduced air emissions, rather than the fuels used in electricity production. Although less important to some, fuel mix does influence the choices of some consumers. Some consumers are willing to pay more for renewable content if it replaces the fossil fuels. These differences in preferences across consumers seem to indicate that electricity choice may not necessarily lead to the demise of fossil-based electricity, especially if technologies are placed in fossil fueled plants to make their emissions profile comparable to non-fossil fueled plants. However, deregulation may lead to cleaner air emissions and may lead to some interesting dynamics in the trading of SO_2 emissions permits.

A few cautions are in order. Although respondents in our sample exhibit a wide variation in socio-economic characteristics, the possible non-representativeness of our sample may limit some of our results. For example, our sample may not accurately represent the views of more rural Americans. In addition, we hypothesis that consumer reactions to the fuel source and emissions attributes of electricity may vary substantially across different regions of the country. This hypothesis is based on the regional nature of some of the fuel sources (and thus, employment) used in electricity production and the regional nature of some of the air emissions problems. Due to the limitations of the sample and our conjoint design, we are not able to test this hypothesis.

While interpreting these results, we should be mindful of the hypothetical nature of the experiment. As intuition would suggest and as externally validated experiments often confirm, when respondents do not face a real budget constraint they often are not as sensitive to price differences as they are in real markets. However, the fact that in this experiment households with less income showed more sensitivity to price is encouraging and suggests the experimental results do mimic to some extent patterns seen in real markets. How closely real behavior follows behavior in experimental settings is always difficult to gauge. Further caution is warranted because hypothetical biases may be exacerbated when the respondent has little experience with the product in question and, to date, respondents have had little real-world experience in choosing among electricity providers.

Table 1. Sample Demographics.

Variable	
Percent:	
with at least a High School Degree	42
Female	51
White	67
Declaring Membership/Donation to Environmental Organizations	16
Primary Handler of Household Bills	88
Average:	
Annual Household Income	$37,000
Age	37

Table 2. Logit Regression Results.

	Omitted Fuel Mix	
Variable	FossilD	NuclearD
Intercept	0.0443	0.0443
PriceD	-0.1170*	-0.1170*
PriceD*Income	0.00246*	0.00246*
PriceD*Income^2	-0.00002*	-0.00002*
RenewD	0.00647	0.0144
NuclearD	-0.00792	
FossilD		0.00792
EmissD	-0.00290*	-0.00290*
RenewD*Env	0.0280**	0.0175
NuclearD*Env	0.0105	
FossilD*Env		-0.0105
EmissD*Env	-0.00234	-0.00234
RenewD*Educ	0.0130	-0.0120
NuclearD*Educ	0.0250*	
FossilD*Educ		-0.0250*
EmissD*Educ	-0.00210**	-0.00210**
Percent correct	79.0	79.0

An * denotes significance at the five percent level; an ** denotes significance at the 10 percent level.

Table 3. Consumer's willingness to pay, per month, for selected electricity products, by level of environmental activism and education.

Percent renewable fuel content[a]	Relative percent decrease in emissions		
	0	25	50
among less-educated non-environmentalists			
0	0	0.66	1.32
5	0.29	0.95	1.61
10	0.59	1.25	1.91
15	0.88	1.54	2.20
among less-educated environmentalists			
0	0	1.19	2.38
5	1.51	2.76	3.95
10	3.13	4.32	5.51
15	4.70	5.89	7.08
among more-educated non-environmentalists			
0	0	1.14	2.27
5	0.88	2.02	3.16
10	1.77	2.91	4.04
15	2.65	3.79	4.93
among more-educated environmentalists			
0	0	1.67	3.34
5	2.16	3.82	5.49
10	4.31	5.98	7.65
15	6.47	8.14	9.81

a Renewable fuels replaces fossil fuels, percent of nuclear fuels are held constant

Figure 1. Example of information provided in conjoint table.

ELECTRICITY FACTS PANEL

PRICE	Average Monthly Bill* : * For a consumer using 1000 kilowatt hours (kWh) per month. Actual bill will vary according to how much electricity you use. See contract for complete details.	$ 67.25
CONTRACT TERMS	• Minimum contract length: 2 years • Fixed price over contract period	
FUEL MIX	Coal	60%
	Oil	15%
	Gas	15%
	Nuclear	8%
	Hydro-electric	2%
	Solar and Wind	0%
AIR EMISSIONS	Type of Air Emission	Amount created as compared to regional average
	Nitrogen Oxides (NO_x)	100% higher
	Sulfur Dioxide (SO_2)	150% higher
	Carbon Dioxide (CO_2)	125% higher

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