Does the Provision of Free Technical Information Really Influence Firm Behavior?

Richard D. Morgenstern

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1616 P Street, NW
Washington, DC 20036
Telephone 202-328-5000
Fax 202-939-3460

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Abstract

Significant environmental benefits are often associated with the rapid diffusion of new energy-saving technologies. Over the past decade, the federal government, as well as electric and gas utilities, have begun to provide free technical information to potential buyers to stimulate private investment in certain technologies, particularly for retrofitting existing buildings. Yet it has not been demonstrated that this provision of technical information can truly accelerate the rate of technology diffusion. This study develops a model of firm behavior that incorporates multiple factors in the decision to retrofit high efficiency lighting technologies. Technology retrofit and the acceptance of technical information are modeled as jointly determined dichotomous variables, and their determinants are estimated using a bivariate probit specification. The principal conclusion is that information programs make a significant contribution to the diffusion of high efficiency lighting in commercial office buildings, although these programs are less important than basic price signals.

Key Words: technology diffusion, energy conservation, policy instruments

JEL Classification No(s).: H59, Q48, O38

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I. INTRODUCTION

Over the past decade, the federal government, as well as electric and gas utilities, have begun to provide free technical information to potential buyers to stimulate private investment in certain technologies, particularly for retrofitting existing buildings. The "Green Lights" program sponsored by the U.S. Environmental Protection Agency (EPA), for example, has been providing nonproprietary information on the performance, cost, and availability of high efficiency lighting to thousands of corporations and other institutions to encourage retrofit lighting investments since 1991. Similarly, utilities across the country have been sponsoring commercial-sector demand-side management (DSM) programs -- which provide site-specific information on performance, costs, and availability of energy-saving equipment -- as a means of stimulating the diffusion of such technologies in existing buildings. Yet, little is known about the extent to which information, as opposed to other factors, affects firms' decisions to retrofit the new technologies.

It has been argued, for example, that a principal motivation for Green Lights participants is the desire to curry favor with a regulatory agency and that the subsidies offered by some utilities are the real driving force for firms' participation in DSM programs. If either

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[1] Visiting Scholar, Quality of the Environment Division, Resources for the Future, and Associate Assistant Administrator for Policy, Planning and Evaluation at the U.S. Environmental Protection Agency (currently on leave). The author would like to acknowledge helpful comments and assistance from Saadeh Al-Jurf, Howard Gruenspecht, Winston Harrington, David Ribar, and members of RFF's Pizza Seminar.

hypothesis were true, the provision of information by itself may not be an important part of the program's success. Empirical research has not established whether the firm's decision to adopt the new technology is a consequence of receiving the technical information or, alternatively, whether the firm's technology adoption decision along with its decision to receive the technical information are co-determined by other underlying factors. Since there is clearly an element of self-selection in the decision to receive the technical information, there is at least some plausibility to the (latter) endogeneity argument.

It is well known that the diffusion of new technologies -- often following a classic s shaped or 'sigmoid' curve -- is tied to the flow of information regarding the existence and profitability of the innovation. It is also understood that differences in economically relevant characteristics, such as energy prices and hours of appliance use, can be important factors in the decision to adopt new technologies (Griliches, 1957; David, 1986). Yet it has not been demonstrated that the mere provision of technical information via government or utility sponsored programs can truly accelerate the rate of technology diffusion. Certainly such programs are popular among recipients of the free information, but there is considerable skepticism in the economics community about firms' true motivations for adopting the new technologies. How many firms, for example, would have adopted the technologies anyway -- perhaps because they also receive subsidies, face high electricity prices, are intensive appliance users, or have a preference for high tech solutions -- but decide to take advantage of the free information because it is available?

The literature on the effectiveness of information based programs is quite limited. EPA's Green Lights program, for example, counts the amount of building space committed to install new technology but is not able to determine how much retrofit would have occurred in the absence of the program (U.S. EPA, 1995). Many electric utilities have conducted *ex post* program evaluations and have attempted to estimate the number of "free riders," i.e., those participants likely to have taken the same or an equivalent action in the absence of the program. Based largely on after-the-fact judgments of surveyed DSM participants, free ridership in utility sponsored programs has been variously estimated to range between 5 and 70 percent. The average rate of free ridership estimated in recent studies is about 25 percent.[2] Yet, even these studies, with a dubious method of establishing a baseline, fail to distinguish between those utility customers accepting information only and those accepting explicit subsidies.[3]

This study addresses these issues by developing a model of firm behavior that incorporates multiple factors in the firm's decision to retrofit high efficiency lighting technologies. Technology retrofit and the acceptance of technical information are modeled as jointly determined dichotomous variables, and their determinants are estimated using a bivariate probit specification. The acceptance of technical information is modeled as a potentially endogenous determinant of technology retrofit. A large 1992 Department of Energy survey of commercial office buildings is used to estimate the alternative models. The sample includes firms which

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[2] These estimates are based on all DSM programs including residential and commercial which provide technical information and/or subsidies to customers. See Saxonis (1991) for the pre-1991 estimates. The 25 percent estimate is derived by the author in a review of recent papers presented at meetings of the American Council for an Energy Efficient Economy (ACEEE, 1992, 1994).

[3] Some utilities may offer information only and no subsidies. Where utilities offer subsidies along with their information programs some customers may decline the subsidies because of other (onerous) program requirements. In either case the interesting question is whether the provision of technical information (without subsidies) actually motivates firms to adopt new technologies.

retrofitted their lighting systems after receiving technical information from their local utilities as well as those which retrofitted without receiving such information.

The principal conclusion is that in the context of a behavioral model, multiple factors including electricity prices, time of day pricing, and the provision of technical information are all significant determinants of the retrofit of high efficiency lighting technologies in commercial office buildings. Despite its theoretical attractiveness, an examination of alternative specifications of endogeneity does not provide the basis to reject a model in which the provision of information is exogenous. Overall, information programs make a significant contribution to the diffusion of high efficiency lighting in commercial office buildings, although these programs are less important than basic price signals.

Part II of this paper develops a model of a firm's decision to make retrofit investments in high efficiency lighting technology, including the possibility of endogeneity in the decision to accept utility provided information. Part III describes the data. Part IV presents the empirical results. Part V discusses the implications of the findings and draws some overall conclusions from the research.

II. THEORETICAL CONSIDERATIONS

Economic models of firm decision-making are typically based on rational choice. Firms are assumed to make choices which maximize expected benefits and minimize expected costs. In the case of retrofit investment in high efficiency lighting, the primary benefit is the reduction in operating costs. Thus, the *i*th firms' revenues associated with new lighting investments,

REV_i, can be modeled as a vector of firm characteristics, $\mathbf{X}_{1i}$, which includes electricity prices, weekly hours of operation and other factors. That is,

$$REV_i = \mathbf{X}_{1i}\mathbf{B}_1+\varepsilon_{1i}. \quad (1)$$

where ε_{1i} is a random error term.

The principal costs of the retrofit investment in high efficiency lighting, $COST_i$, depend on a vector, $\mathbf{X}_{2i}$, which includes the initial capital expenditures, labor costs and other factors. In addition, $COST_i$ is dependent on the benefits of receiving any free technical information from a reputable source like a local utility, $INFO_i$. That is,

$$COST_i = \mathbf{X}_{2i}\mathbf{B}_2 + INFO_i\xi_1 + \varepsilon_{2i}\ . \quad (2)$$

where ε_{2i} is a random error term.

Economic theory tells us that the firm will not invest if the present value of the expected (net) revenues associated with the lighting retrofits is less than the present value of the expected costs. It has been shown that under most conditions the adoption decision for retrofit technologies depends only on current values and not on present values of future expectations.[4] Thus, the firm will adopt the new technologies if expected current revenues are less than expected current costs. Subtracting costs from revenues (equation one minus

[4] The standard condition for the purchase of a capital asset is that the instantaneous rate of earnings from the asset should be greater than or equal to the carrying cost minus the instantaneous rate of capital appreciation. Jaffe and Stavins (1995) show that as long as the second order conditions are not violated, overall costs are minimized by adopting the retrofit technology when marginal costs equal marginal benefits and the adoption condition depends only on current values.

equation two) and combining terms, one can represent a reduced form equation of the *i*th firms decision to retrofit the new lighting technology as follows:

$$TECH^*_i = \mathbf{X_i}\,\mathbf{B} + INFO_i\,\mathrm{A} + \varepsilon_i \tag{3a}$$

where

$\mathbf{X_i}$ contains all independent variables from $\mathbf{X_{1i}}$ **and** $\mathbf{X_{2i}}$, (3b)

$\mathbf{B}$ is a reduced form combination of $\mathbf{B_1}$ **and** $\mathbf{B_2}$, (3c)

$$\varepsilon_i = \varepsilon_{1i} - \varepsilon_{2i}, \tag{3d}$$

and $TECH^*_i$ represents the benefit to the *i*th firm of high efficiency lighting technology. That is,

$$TECH_i = \begin{cases} 1 \text{ (retrofits technology)} & \textit{if } TECH_i^* \geq 0 \\ 0 \text{ (does not retrofit technology)} & \textit{otherwise.} \end{cases} \tag{3e}$$

Equation (3a) brings together in a single framework a complex set of factors that enter the decision framework of the firm in deciding to retrofit the new technologies. It enables us to compare the importance of these factors to one another and it forms the basis of our econometric estimation.

A potential endogeneity problem arises, however, in the estimation of equation (3). Utilities do not discriminate among individual firms in their service area but generally offer DSM assistance to broad classes of customers. Since firms ultimately decide whether or not to participate, $INFO_i$ may be at least partially endogenous if the decision to participate in a demand-side management program is related to the decision to adopt energy efficiency lighting. A simple empirical model can be used to analyze this situation.[5]

Let $INFO^*_i$ denote the (unobserved) benefit to the *i*th firm of receiving technical information from the utility. Assume that $INFO^*_i$ is a linear function of economic and institutional determinants. Specifically, let

$$INFO^*_i = \mathbf{Z}_i\delta + \eta_i \tag{4a}$$

where $\mathbf{Z}_i$ is a vector of observed variables which includes both $\mathbf{X_i}$ and other variables, and η_i is a random error term.[6] Although $INFO^*_i$ is not observable, it is related to $INFO_i$ (which is observable) as follows:

$$INFO_i = \begin{cases} 1 \text{ (if firm receives / accepts technical information)} & \text{if } INFO_i^* \geq 0 \\ 0 \text{ (if firm does not receive / accept technical information)} & \text{otherwise.} \end{cases} \tag{4b}$$

The error terms ε_i and η_i are assumed to be distributed bivariate normal with means and standard deviations as follows:

$$\begin{bmatrix} \varepsilon_i \\ \eta \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\varepsilon^2 & \rho\sigma_\varepsilon\sigma_\eta \\ & \sigma_\eta^2 \end{bmatrix} \right). \tag{5}$$

Equations (3a) and (4a) with the distributional assumption (5) specify the probability of technology adoption as a probit model with information as an endogenous dummy determinant. The purpose of the distributional assumption in equation (5) is to allow for the measurement of

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[5] The theoretical foundations of this model are found in Maddala (1983). An interesting empirical example can be found in Ribar (1994).

[6] The determination of TECH* and INFO* are not treated symmetrically (INFO* does not include TECH as an explanatory variable). Unfortunately, the likelihood function for the symmetric specification does not, in general, integrate to one (Maddala, 1983).

correlation (ρ) between equation (3a) and (4a). By restricting $\rho = 0$, the above model can be used to estimate the specification that information is an exogenous dummy determinant.

Maximum likelihood estimation of this specification is straightforward, although there are some identification issues. First, the coefficients and error variances in equation (3a) and (4a) are only identified up to their proportions, $\beta / \sigma_\varepsilon$, A / σ_ε , and δ / σ_η . This paper applies the standard normalization $\sigma_\varepsilon = \sigma_\eta = 1$. Second, the effect of information on technology adoption is only identified subject to exclusion or covariance restrictions. This paper imposes exclusion restrictions on the vector $\mathbf{X_i}$.

The variables which are excluded from $\mathbf{X_i}$ should be theoretically and statistically related to obtaining information from the utility but unrelated to technology adoption. In fact, it is both logically and empirically difficult to identify factors that influence one but not the other. Notwithstanding, this paper considers three such variables -- a dichotomous variable indicating whether or not the building has participated in utility sponsored DSM programs on heating and cooling; a dichotomous variable indicating whether or not the building is owner occupied; and a variable for the electricity bill (per square foot) of the entire building (not just the lighting system).[7] Participation in another utility sponsored DSM program is taken as an indicator that the building owner is familiar with DSM programs. Assuming the firms' experience with the other program was positive, one would expect a positive sign on this variable. Owner occupancy is a more complicated factor. Inasmuch as owner-occupants are

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[7] Several other types of DSM programs were examined for inclusion as independent variables in this equation. None were statistically significant and are not reported here.

more likely to reap the full benefits from lighting retrofits, one would expect a positive sign on this variable. If, however, many owner occupants had already retrofit their lighting systems, then they might be expected to participate less often in utility DSM programs than non owner occupants. Electricity expenditures per square foot is also a complicated factor. High electricity expenditures per square foot, even if it is not related to lighting, could represent a wake-up call to acquire information about lighting retrofits. On the other hand, low expenditures per square foot in a building which did not already use efficient lighting could indicate a strong preference for energy efficiency and thus could account for an interest in technical information on lighting retrofits. None of these three variables is assumed to directly affect the probability of lighting retrofit.[8]

III. THE DATA

The basic data used in this analysis are derived from the Department of Energy's 1992 Commercial Buildings Energy Consumption Survey (CBECS), a multistage area probability sample, representing the 4.8 million commercial buildings in the U.S. as of the Spring of 1992. Information in this survey is drawn from building owners/managers/tenants as well as from local utilities.[9] In order to focus on retrofits and avoid the possibility that the high efficiency

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[8] There are some grounds for challenging this assumption. For example, owner occupancy may also affect the ability to capture savings from retrofitting lighting systems.

[9] A key data issue in CBECS is that building respondents (owners/managers/tenants) reported only about one-fourth as much participation in DSM programs as did utility respondents. Examination of the individual responses indicated that the discrepancies went in both directions: that is, utilities reported buildings had participated in DSM programs when the building respondent indicated they had not participated, <u>and</u> vice-versa. Accordingly, on the assumption that errors of omission were more likely than errors of commission, participation in DSM programs is defined on the basis of a positive indication from <u>either</u> the utility or the building respondent or both.

lighting was installed at the time of new construction, the sample is limited to buildings constructed prior to 1986. And because of the varied patterns of energy demand in different types of commercial buildings (e.g., restaurants versus warehouses), the sample is restricted to the largest and probably most homogenous building use category, namely commercial office buildings.

Table 1. Variable Means

Variable	Mean	(Std. Deviation)
Adopted Lighting Technology (TECH1)	0.643	(0.479)
Adopted Lighting Technology (TECH2)	0.275	(0.447)
Adopted Lighting Technology (TECH3)	0.065	(0.247)
Wages ($/hour)	13.814	(2.709)
Electricity Price (P, cents/kwh)	7.931	(3.270)
Hours	90.200	(44.195)
Year of Construction	1967.0	(21.441)
Size of Building (in thousands of square feet)	73.428	(52.599)
Time of Day Pricing (TOD)	0.124	(0.329)
Information Provided (INFO)	0.209	(0.407)
Owner Occupied	0.733	(0.443)
Heating-Cooling DSM	0.272	(0.445)
Annual Electricity Bill (cents/square feet)	1.572	(1.104)
Unweighted Observations	990	
Weighted Observations	990	

Note: All values are weighted by building size.

TECH1: At least one of three technologies in use.
TECH2: At least two of three technologies in use.
TECH3: All three technologies in use.

Defining "high efficiency lighting" involved a number of key decisions. A total of seven different categories of lighting upgrades are defined in CBECS.[10] The three most commonly used, compact fluorescents, occupancy sensors and specular reflectors, are selected as indicators of high efficiency lighting. TECH1 is defined as a dichotomous variable indicating whether or not a building contains one or more of these three technologies. As shown in Table 1, 64.3 percent of the commercial office buildings (on a floorspace basis) had one or more of these technologies in place. TECH2 and TECH3 are defined as dichotomous variables indicating whether or not a building contains at least two (27.5 percent), or all three (6.5 percent), respectively, of these technologies.

Defining "technical information" also involves some key decisions. CBECS asks about DSM participation over the three previous years and categorizes responses into "site-specific information," and "financial assistance."[11] In fact, these two types of DSM assistance involve very different behavioral responses. Since receipt of financial assistance is predicated on actually installing specified equipment, one cannot use this information to examine the effect which accepting financial assistance has on the decision to retrofit lighting systems. Accordingly, all respondents indicating they had received financial assistance from the utility were dropped from the sample.[12] In contrast, receipt of site specific information does not bind the recipient to any

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[10] Compact fluorescent bulbs, high intensity discharge lights, specular reflectors, daylighting controls, occupancy sensors, time clocks or timed switches, and manual dimmer switches.

[11] There was also a category for "general information." However, that is most likely a bill stuffer and not part of any systematic transfer of information.

[12] Dropping those buildings which received financial assistance (n = 340) raises the possibility of introducing selectivity bias into the sample. To test for this possibility, the models presented in Table 3 were re-estimated on the full sample by coding "financial assistance" as if it were the same as "information." The basic results were unchanged; although, as expected, the coefficient on the information variable was slightly larger.

action. Although the building owner/tenant has to request or at least accept the offer of site specific information from the utility, there is no requirement to actually install the equipment. Perusal of Table 1 indicates that 20.9 percent of the building floorspace received site-specific information. However, as shown in Table 2 only 79.3 percent of those buildings actually retrofit at least some high efficiency lighting versus 60.3 percent who retrofit such lighting without receiving any help from the local utility (TECH1). For TECH2 and TECH3, the corresponding percentages are 42.8 and 23.4, and 13.2 and 4.8, respectively. Thus the sample contains considerable variation that provides the basis on which to model the importance of technical information as a determinant of the firm's decision to upgrade lighting systems.

Table 2. Technology Adoption According to Information Provided

	TECH1 Percent Adopted	**TECH2** Percent Adopted	**TECH3** Percent Adopted
INFO Provided	79.32%	42.81%	13.15%
INFO Not Provided	60.34%	23.39%	4.78%

All other variable definitions are relatively straightforward. Average electricity prices are defined as the annual electricity bill divided by the annual kilowatt hours, as reported by the utility.[13] As shown in Table 1, the average electricity price in the sample is 7.93 cents per KWH. The presence of time of day pricing (also as reported by the utility) is defined as a dichotomous variable. It is used in 12.4 percent of the buildings. The typical building was

[13] Because of confidentiality issues, it was not possible to identify the actual utilities serving individual buildings. Thus it was not possible to develop estimates of marginal electricity prices.

constructed in 1967, is almost three-quarters of a million square feet and is in use 90.2 hours per week. Almost three-fourths of the buildings are owner occupied, 27.2 percent received some form of DSM assistance from the utility for heating or cooling, and the average annual electric bill per square foot of building space is 1.57 cents.[14] Average hourly wages in the region for electrical equipment installers are $13.81.[15]

IV. ECONOMETRIC RESULTS

Tables 3 and 4 present the results for the exogenous and the endogenous specifications estimated using the bivariate probit model with TECH1, TECH2 and TECH3 as dependent variables.[16] All the observations have been weighted by building size so the parameter estimates reflect the actual stock of commercial buildings in the U.S. as of 1992.

In selecting the preferred model, we observe that the coefficients on the independent variables in both the exogenous and the endogenous specifications are remarkably similar to one another in size and statistical significance. Note also that all three of the excluded variables in the endogenous model are highly significant and of the expected signs in all three equations.[17]

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[14] Heating and Cooling DSM could consist of information, (either general or site-specific), or financial assistance as reported by either the utility or the building owner/manager.

[15] Wage data were constructed using the Census Bureau's Data Extraction System by dividing annual earnings of electrical equipment installers by their hours worked per year. Wages were averaged for metropolitan and non-metropolitan statistical areas in each census division.

[16] For the exogenous model ρ is constrained to be zero which is equivalent to a conventional probit specification.

[17] The only other variable which is statistically significant in the estimation of DSM program participation is electricity prices and it has a negative coefficient. Sensitivity analysis showed that estimating this equation separately without the three excluded variables also produced a significant and negative coefficient. The most obvious explanation for this finding is that buildings in areas with high electricity prices had disproportionately (and previously) installed high efficiency lighting and were thus less likely to get involved in DSM lighting programs.

Table 3 is available from Resources for the Future.

Table 4 is available from Resources for the Future.

The values of the correlation coefficients which measure endogeneity (ρ), however, are all quite small (.133, -.004 and .274, respectively). In no case is the "t" value of these correlation coefficients more than .8. Similarly, statistical comparison of the log likelihood ratios indicates there are no significant differences between the exogenous and the endogenous specifications. These findings suggest, contrary to expectations, extremely weak evidence to support use of the endogenous model. Thus, despite the theoretical appeal of the endogenous specification, there is no empirical basis on which to reject the exogenous model which, in turn, is used as the basis of the parameter estimates discussed below.[18]

For the exogenous model, all the independent variables are significant in at least one of the equations and the coefficients generally conform to expectations. The coefficients on average electricity prices are positive and significant in all three technology adoption equations. The coefficients for time of day pricing are also positive in all equations and significant in two of the three equations. As expected, buildings that operate longer hours per week and those which were constructed more recently have a greater likelihood of adopting high efficiency lighting technologies, although the coefficients on these variables are only significant in the TECH1 equation. Larger buildings are more likely to adopt high efficiency lighting, at least for TECH1 and TECH2.

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[18] One possibility is that some firms have a preference for high technology solutions and that that preference is an important determinant of both the decision to adopt high efficiency lighting and to participate in the lighting DSM program. To check for the possibility of such a misspecification, a total of 22 different measures of "high technology" equipment, relating to energy management equipment, heating and cooling, shell measures and others were examined as possible variables. Few of these variables were significant and none of them statistically altered the size or significance of the coefficient on the information variable.

Wages are a more complex story. If labor were only a factor in the installation of the high efficiency lighting one would expect the coefficient to be negative. However, since labor is also required to change lightbulbs and high efficiency lighting tends to require less frequent bulb replacement, there is also a labor saving element associated with high efficiency lighting. For TECH3 the negative and highly significant coefficient indicates the first effect dominates. For TECH1 the reverse is true. This suggests that marginal labor costs for installation are a more important factor than marginal labor savings from reduced maintenance in the presence of a larger number of high efficiency lighting appliances.

Of key interest in this study is the information variable which is both positive and highly significant in all three technology adoption equations. This finding indicates that even after adjusting for a complex set of factors that rational models suggest would influence adoption, the provision of technical information by the local utility remains an important determinant of technology choice.

It is instructive to make cross comparisons among average prices, time of day pricing and information programs to determine their relative importance in technology choice.[19] Of course, the appropriate way to compare them is in the context of an economic model which includes a full accounting of the costs and benefits of each policy. Unfortunately, such an analysis is beyond the scope of this research. Notwithstanding, a useful way to analyze the comparative effects of the three policy relevant variables is to calculate the relevant elasticities

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[19] Changes in average prices can be brought about by some form of energy taxes (which would increase end use prices) or, alternatively, by policies that increase competition in the electricity industry, e.g., restructuring (which would reduce end use prices).

for the effect of these variables on technology adoption. Perusal of Table 5, which presents the elasticity estimates for TECH1, TECH2 and TECH3, suggests two noteworthy findings. First, for all three policy measures, the elasticities with respect to technology adoption increase as the number of high efficiency lighting appliances in place rises. This suggests that all three policy measures are more potent determinants of "very high tech" solutions (TECH3) than of "moderately high tech" solutions (TECH2 or TECH1). Second, estimates of price elasticity are considerably higher than for information programs or time of day pricing. This suggests that while technology adoption is sensitive to information and time of day pricing, it is considerably more sensitive to (average) electricity prices.[20]

Table 5. Elasticities of Technology Adoption with Respect to Electricity Prices, Time of Day Pricing, and Information Programs

	TECH1 Elasticity	TECH2 Elasticity	TECH3 Elasticity
Price	0.378	0.548	1.761
Time of Day	0.040	0.034*	0.490
Information	0.066	0.141	0.849

Derivation of Elasticities (E) as follows:

$E_P = \beta\phi(XB) / \overline{TECH}$

$E_{TOD} = (\Phi(XB^a) - \Phi(XB^b)) * \overline{TOD} / \overline{TECH}$

$E_{INFO} = (\Phi(XB^c) - \Phi(XB^d)) * \overline{INFO} / \overline{TECH}$

*Parameter estimate used for this elasticity was not significantly different than zero.
a Value of Time of Day is assumed to be 1.
b Value of Time of Day is assumed to be 0.
c Value of Information is assumed to be 1.
d Value of Information is assumed to be 0.

[20] One possible explanation for these elasticity differences is the relative newness of the time of day pricing and information programs vs. price effects. However, no data is available to test this hypothesis and it is not explained further here.

The model results can also be used to examine the free rider issue. Model simulations indicate that the percent of program participants likely to have adopted high efficiency lighting in the absence of the program range from zero to 80 percent.[21]

V. CONCLUSIONS

This paper has examined the effectiveness of the free provision of technical information as a policy tool to accelerate diffusion of new technologies and has compared that tool to other available policy instruments. The provision of technical information by electric utilities is clearly found to be a significant determinant of the adoption of high efficiency lighting technology in commercial office buildings. At the same time, it is also clear that electricity prices are a far more important determinant of technology adoption. Certainly information programs can complement pricing approaches, but it would take an enormously aggressive information program to substitute for price effects.

Finally, these results can be interpreted as bolstering some of the claims made by providers of technical information, including both local utilities and the EPA's Green Lights

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[21] The probit results in Table 3 can be used to derive estimates of TECH with INFO = 0 and, alternatively, with INFO = 1. If the estimated value of TECH > .5, the firm is assumed to adopt the technology. Among the firms receiving INFO, those which have predicted values of TECH > .5 when INFO =0 are defined as free riders. Firms likely to have invested in one or more high efficiency lighting appliances (TECH1) without receiving site-specific technical information from the local utility account for 80 percent of the recipients of such information. Comparable simulations of the case of firms adopting two or more of the high efficiency appliances (TECH2), or all three appliances (TECH3) finds that none of the firms are likely to have done so in the absence of the technical information. While one would expect more free riders in the case of TECH1 than TECH2 or TECH3, the finding of zero free riders for the latter equations most likely results from the small sample of firms that adopted two or more of the lighting appliances and also received technical information. Note that equations three and four are based on comparisons among firms that adopted the technologies and firms that did not adopt them. The free rider comparison is based on a further restricted sample of those firms that received technical information (see Table 2).

Program. Although it does not directly provide for site visits by lighting experts, Green Lights is similar to utility DSM programs in many respects. Typically Green Lights works with managers of large amounts of commercial floor space and provides evaluation tools for the firm to undertake a set of detailed assessments. These assessments, in turn, provide the basis for the firm to make its own site-specific decisions to determine which lighting upgrades are most appropriate and cost effective in particular applications. While this research does not address the cost-effectiveness or net economic benefits of such information based programs, it is clear that the provision of technical information has a demonstrably positive effect on the decision to adopt high efficiency lighting technologies.

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