SHORT-RUN RESIDENTIAL ELECTRICITY DEMAND IN HOUSTON

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INTRODUCTION

There are several classes of energy models such as Hudson and Jorgensen's input-output model (1974), Chatterji's programming model (1980), Burbank's engineering model (1979) and many econometrics models. In this paper we use a simple econometric method to estimate the short-run residential demand for electricity in Houston. An econometric model defines endogenous variables (electricity demand) in terms of exogenous variables (electricity price, temperature, number of customer, ext.) in a system of regression equation based on theory, experiment and intuition. The regression coefficients are then estimated on historical consumer behavior. The general goal of the researcher in this method is to:

1. Provide estimates of the endogenous variable from a set of exogenous variables
2. Gain knowledge regarding the degree of association between exogenous and endogenous variables.

Modelers must also recognize the difference between short-run and long-run demand. The stock of appliances and its efficiency characteristics are relatively fixed in the short-run and generally should not be included in the short-run demand for electricity. However, in the long-run consumers have time to adjust and could use more efficient appliances to an increase in energy price. For a survey of various energy models see Holub (1985).

PRIOR RESERCH

Empirical estimations of econometric demand for electricity have received much attention since the first oil crisis in 1973/74. Estimating the coefficients of exogenous variables in the residential electricity demand are extremely important for assessing proposals to revise electricity rate structures and for projecting future electricity demand growth. Therefore, estimating econometric models of electricity demand offers an interesting approach for analyzing the potential impacts of alternative energy policies. Many econometrics models have been developed to estimate residential demand for electricity, for a survey of these studies see Halvorsen (1974), Taylor (1975) and Nelson and Peck (1986).

Previous short-run demand models have included personal income and electricity price as the two most important determinants of electricity demand. Table 1 presents the results of selected prior research on short-run demand for electricity:

Table 1

Study	Income Elasticity	Price Elasticity
Branch (1993)	.23	-.20
Shin (1985)	.17	-.14
Barnes, Gillingham, and Hagemann (1981)	.20	-.55
Houthakker (1980)	.14	-.11
Acton, Mitchell, and Mowill (1976)	.40	-.35

As it can be seen from Table 1, most income elasticities are low, implying low responsiveness of electricity demand to a change in consumer income. Also, most price elasticities are low, implying low responsiveness of electricity demand to a change in electricity price in the short-run. Given that most prior research have implied low income elasticities, we therefore have not included personal income as an exogenous variable in our model. We can also justify the exclusion of personal income in our model on the ground that electricity is mainly a basic necessity good and therefore will not respond to change in income in the short-run.

We specify the following models:

$$Y = a + b1*X1 + b2*X2 + b3*X3 + b4*X4 + b5*X5 + e \quad (1)$$

$$Log(Y) = a + b1*Log(X1) + b2*log(x2) + b3*Log(X3) + b4*Log(X4) + b5*Log(X5) + e \quad (2)$$

Y = residential electricity demand
X1 = electricity price
X2 = number of customers
X3 = number of cooling hours
X4 = number of heating hours
X5 = natural gas price
e = white noise

The data that is used in this paper is publicly available information and is provided by Reliant Energy Company (Houston Lighting and Power Company). Heating and cooling hours provide a measure of temperature influence. Using a temperature base of 72 degree F, the integrated degree hours above the base is related to the need for air conditioning which we refer as cooling hours. Similarly, the integrated degree hours below 65 degree F is related to the need for heating which we refer to heating hours. For example, a period of ten hours at a temperature of 80 degree F results in 80 cooling hours, and a period of ten hours at a temperature of 58 F results in 70 heating hours. All the daily cooling and heating hours values are summed over a month to give total cooling and heating hours for the month.

Electricity price is the total residential revenue divided by total residential supply per period. Natural gas price is the retail natural gas price for the period. Also note that the estimated coefficient b1 of equation (2) would be the short run price elasticity of demand.

EMPIRICAL RESULTS

Table 2 presents the estimated coefficients of the model 1(equation 1) and model 2 (equation 2). As it can be seen from equation 1, the estimated coefficient for gas price (b5), is not significant, therefore we drop the gas price and the result is equation (3). From equation (3) we can see that all coefficients are significant at the 99% confidence level except the coefficient of electricity price which is significant only at 90 % confidence level. Surprisingly, the coefficient of electricity price is positive in contrast to previous studies cited above and in contrast to the theory of demand. As for equation (2), we see that electricity price coefficient is not significant nor are heating degree hours and gas price coefficients, therefore, we drop these variables and the result is equation (4). The estimated coefficients for equation (4) are significant at 99% level. Equations 3 and 4 both have high r-square, implying that our independent variables explain most of the variation in electricity demand. Since b1 in equation 2 is not significant, we therefore conclude that the short-run price elasticity of residential electricity is zero.

Table 2

Equation	a	b1	b2	b3	b4	b5	R^2 %
(1)	-1747.18	37.39	1705.79	.20	.05	- 115.58	98.69
t-statistics	-3.69*	1.77**	5.56*	43.03*	12.44*	.64	
(2)	2.74	.25	2.27	.01	-.08	-2.6	86.04
t-statistics	6.63*	.73	2.89*	.64	5.12*	-1.02	
(3)	-1661.39	32.92	1622.23	.20	.05		98.69
t-statistic	-3.83*	1.76**	6.55*	43.53*	12.60*		
(4)	3.15		1.76		-.08		85.64
T-statistic	42.34*		3.14*		-17.70*		

* means significant at 99% and ** means significant at 90% confidence level

We have also estimated the following equations:

$$Y= a + b1* Z1 + b2*Z2 + b3*Z3 + b4*Z4 \qquad (5)$$

$$Y = a + b1*LOG(Z1) + b2*LOG(Z2) + b3*LOG(Z3) + b4*LOG(Z4) \qquad (6)$$

Where Z1, Z2 and Z3 are electricity price, number of customer and price of natural gas as before, however Z4 is the sum of cooling degree hours and heating degree hours combined. Table 3 presents the estimated coefficients of equations 5 and 6. As it can be seen the natural gas price coefficient, b3, of equation (5) is not significant and should be dropped from the equation, and we get equation 7. Again here we have a positive relationship between price of electricity and quantity demanded.

Table 3

Equation	**a**	**b1**	**b2**	**b3**	**b4**	**R^2 %**
(5)	-10771.50	501.50	5576.07	-198.36	.12	75.33
t-statistics	-6.69*	7.77*	4.62*	-.19	7.27*	
(6)	-1.16	2.49	4.29	.01	.39	73.35
t-statistics	-2.44*	7.33*	4.25*	.03	6.89*	
(7)	-10626.92	493.97	5433.83		.12	75.32
t-statistics	-7.59*	9.91*	5.86 *		7.38*	
(8)	-1.17	2.50	4.31		.39	73.35
t-statistics	-3.33*	9.40*	5.50*		6.99*	

* means significant at 99% confidence level.

Looking at the estimated coefficients of equation 6, we conclude again that the coefficient of natural gas price is not significant and therefore should be dropped, the result is equation (8). All estimated coefficients of equation 8 are significant at 99% confidence level. Again surprisingly the price elasticity of demand, 2.50, is very high and positive which is not normal.

The positive price elasticity of demand is explained at least in part by the tariff rules by which regulated electric utilities are allowed to set the price for residential electricity. The principle behind these rules is that the utility is allowed to recover all reasonable and prudent costs that it incurs in producing the electricity required by the rate-payers, and the utility is allowed to charge up to a predetermined rate-of-return for its operating costs and its unrecovered capital costs. The utility must submit long-term revenue requirement (cost of service) schedules for approval by the Public Utility Commission. One of the features of the residential rate schedules is that higher rates are called for in the historical peak-demand periods of the summer. The reason for this is that extra cost is incurred for the utility to bring on additional generating stations to supply the peak demand. A utility runs its lowest cost generating stations to the greatest extent possible, supplying the "base load" requirements in all seasons. Higher cost generating stations, which are normally held in a standby status, are brought into service for peak demand periods- thus raising operating costs.

As it can be seen from our empirical work above, the dominant exogenous variable that determines demand is the cooling hours experienced in the service area; and this rises dramatically in the summer months. Concurrently, the tariff rate schedule set by the Public Utility Commission allows for a small rise in residential electricity rates in the summer to compensate the utilities for their higher peak-demand operating costs.

SUMMARY AND CONCLUSIONS

This paper uses time series data and traditional econometric models to estimate the short-run demand for electricity in Houston. We used economic theory to form a general class of models with appropriate explanatory variables. Our models presented by (1) and (2) have better explanatory power than (5) and (6) when we combine heating and cooling hours. In addition models (2) and (4) imply a zero price elasticity consistent with prior research, whereas model (6) & (8) imply a positive and high (+2.5) price elasticity contrary to prior research. We therefore select equation (3) or (4) as our short-run estimated electricity demand in Houston with zero price elasticity of demand, implying no responsiveness of demand to a change in price in the short-run. We also conclude a very high responsiveness of demand to weather influence and number of customers.

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