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RESIDENTIAL ELECTRICITY DEMAND IN MEXICO: A MODEL DISTINGUISHING ACCESS FROM CONSUMPTION

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WP#1416-83 March 1983

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I. Introduction

Within the last decade the demand for electricity has been the focus of numerous econometric studies; see, for example, the surveys by Lester Taylor [1975], Raymond S. Hartman [1979], Douglas Bohi [1981] and Marie Corio [1981]. Typically, these demand studies have related electricity consumption per household to a variety of economic and demographic variables, and have yielded estimates of short- and long-run price and income elasticities.

The procedures used in these studies to obtain elasticity estimates usually do not distinguish the demand by households newly "hooked up" to electricity from the electricity consumption by households already enjoying access. For industrialized countries such as the United States, Canada, the United Kindgom and Japan, this distinction between access and consumption may be superfluous since, for already some considerable time, virtually all households have enjoyed access to electricity. But for a developing country such as Mexico, universal access by households to electric services is a goal rather than a reality.[1] Indeed, in Mexico government-supported electrification programs into suburbs and rural communities represent an important policy instrument with significant economic and political implications. Hence it is important in studying electricity demand growth in a developing country such as Mexico, to distinguish access from consumption, and to model in different ways the ultimate saturation of hook-ups and the consumption per customer having access.

In this paper we report results of our empirical research that focusses on the electricity access-consumption distinction for housholds in Mexico. We are fortunate in that data of unusually high quality, by region and over time, have been made available to us, a circumstance which greatly enhances the credibility of our research results.

The plan of the paper is as follows: In Section II we provide a brief background on residential electricity and energy consumption in Mexico, discuss important demographic phenomena and the goals of electrification programs, and summarize features of the electricity tariff schedules. In Section III we extend typical residential electricity demand models to include separately the demand for electricity hook-ups, and then in Section IV we present empirical results. In Section V we summarize and provide suggestions for future research.

II. Background

The residential sector is a relatively small but growing user of energy in Mexico. In 1980, for example, the residential sector accounted for about 9% of total Mexican energy demand, and it is predicted that by 2000 this share will rise to 12%.[2] Within the residential sector, the share of electricity in total primary energy demand has increased steadily over the last fifteen years, from 16.3% in 1965 to 36.2% in 1979. This increase in electricity's share has come at the expense of LPG and especially kerosene, whose shares in 1965 were 41.7 and 36.4%, respectively, but in 1979 had fallen to 35.2 and 21.5%; the natural gas share has grown only slightly from 5.5% in 1965 to 6.2% in 1979.[3] In 1980, total residential electricity sales to 8.4 million hookups reached 10,000 GWH, implying an average monthly consumption of about 100 KWH per hookup. Currently electricity is used primarily for lighting and small appliance operation; almost all cooking is still done using fossil fuels.

In terms of demography, the 67 million inhabitants of Mexico are becoming increasingly urbanized; the proportion of population living in cities of more than 2500 inhabitants rose from 58% in 1970 to 67% in 1980. The electrification of rural homes has been and continues to be an important

objective of government policy. In 1980 approximately one million urban (2% of the national urban population) and nine million rural inhabitants (more than 40% of the national rural population) did not have access to electric hook-ups. By 1987, however, the CFE plans to have undertaken sufficient investment programs in order to have such electricity available to 99 and 80.4% of the urban and rural population, respectively, and 93.4% of the total Mexican population.

The distribution of urban populations without electricity in 1980 is 77% in suburbs of large cities and 23% in smaller communities with limited electrical services. A total of 12,560 urban communities are envisaged to benefit from further electrification by 1987, 9586 of which will have access to electricity for the first time. The rural population without any electricity is scattered into 79,871 small communities (ranging from one to 2,499 inhabitants). The above figures indicate, therefore, that the electrification of homes in Mexico is a substantial challenge, and if successful, will create considerable new demands for electricity.[4]

Electricity tariffs in Mexico are set by the CFE (Comision Federal de Electricidad), and consist essentially of two rate schedules, the normal residential service tariff and a lower residential tariff applicable to regions with hot summer weather, the latter introduced in 1973 and applicable only in the hottest months of the year.[5] Since electricity is distributed only by the CFE, the task of obtaining reliable data on consumption and prices is facilitated considerably. Although the normal service tariff in effect from 1962 to 1973 provided a slight decline in price per KWH as quantity consumed increased (from 50 Mexican cents per KWH at 20 KWH per month to 44¢ at 50 KWH and 40.04¢ at 5000 KWH per month), since 1973 the rate schedule has been altered a number of times, with a relatively flat unit price to about 80

KWH per month, and a rising unit price thereafter. In June 1981, as quantity consumed increased from 100 to 300 and 1000 KWH per month, price per KWH rose from 112 to 206 and 240 Mexican units per KWH, respectively. However, at the same time, the hot climate rate was approximately 40% lower than the normal service tariff, assuming a monthly consumption of 100 KWH; at 500 KWH per month, the reduction increased to about 60%.[6] Finally, over the 1962-81 time period, the real price of electricity has fallen considerably; at 20 KWH per month consumption, the 1981 unit price was only a fifth of the 1962 unit price in constant pesos.[7]

Having provided a very brief background to the residential electricity market in Mexico, I now turn to a discussion of modelling issues.

III. Theoretical Considerations

Econometric models of residential demand for electricity have varied in the way they incorporate the fact that consumption is largely "tied" to the engineering and design characteristics of electricity-using equipment and appliances.

Some researchers have incorporated measures of various types of appliance holdings explicitly into the electricity demand equations (see, for example, Houthakker [1951b] and Taylor, Blattenberger and Verleger [1977]), and have distinguished short-run (given the stock of appliances) from long-run responses (when appliance stocks are fully adjusted to long-run equilibrium levels). Good empirical results have been difficult to obtain with such models, due partly to the lack of sufficiently reliable data by households on appliance holdings and utilization rates over time, although recent work by Cowing, Dubin and McFadden [1982] appears very promising. For Mexico, however, such detailed microdata are not yet available, although efforts in that direction are currently underway.

Because of such data availability problems, most analysts have chosen to treat the utilization and accumulation of electricity-using capital stock implicity rather than explicity. One of the simplest ways of introducing gradual adjustment is to employ the Koyck partial adjustment specification

$$(1) \qquad E_t - E_{t-1} = \lambda(E_t^* - E_{t-1})$$

for $0 < \lambda \leq 1$, where E_t is the actual amount of electricity demanded during time period t, E_t^* is the long-run equilibrium or "desired" level of electricity demand, and λ is the proportional speed-of-adjustment parameter. According to (1), the actual change in the quantity of electricity demanded between time periods t and t-1 is equal to a proportion λ of the long-run change.[8]

Economic theory is typically called upon to provide guidance in the specification of variables affecting E_t^*. Based on the economic theory of consumer demand,[9] the quantity demanded is specified to be a function of prices, income, and other socio-economic variables. For example, it is reasonable to specify a log-log equation of the form

$$(2) \qquad \ln E_t^* = \alpha_o + \sum_{i=1}^{m} \beta_i \ln p_{it} + \beta_y \ln Y_t$$

where p_i is the price of the ith good or service and Y_t is total expenditure on goods and services. Note that β_i is the uncompensated price elasticity of demand for electricity with respect to a change in p_i. From the well-known Slutsky equation we have that[10]

(3) $$\beta_i = \beta_i^* - \beta_y s_i$$

where β_i^* is the compensated price elasticity of electricity demand with respect to price i and s_i is the share of good i in total expenditures. Substituting (3) into (2), we obtain

(4) $$\ln E_t^* = \alpha_o + \sum_{i=1}^{m} \beta_i^* \ln p_{it} + \beta_y (\ln Y_t - \sum_{i=1}^{m} s_i \ln p_{it}),$$

and defining $\sum_{i=1}^{m} s_i \ln p_{it} \equiv \ln p_t$ -- an index of the general price level -- we have

(5) $$\ln E_t^* = \alpha_o + \sum_{i=1}^{m} \beta_i^* \ln p_{it} + \beta_y \ln (Y_t/P_t) \quad .$$

Finally, invoking the homogeneity of degree zero condition of consumer demand theory, which in this case is

(6) $$\sum_{i=1}^{m} \beta_i^* = 0 \quad ,$$

we can rewrite (5) as

(7) $$\ln E_t^* = \alpha_o + \sum_{i=1}^{m-1} \beta_i^* \ln (P_{it}/P_{mt}) + \beta_y \ln (Y_t/P_t) \quad .$$

Finally, assuming that there are only two goods -- electricity services and a composite of all other goods and services -- we have the equation

(8) $$\ln E_t^* = \alpha_o + \beta_E \ln(P_{Et}/P_t) + \beta_y \ln(Y_t/P_t) \quad .$$

If we now specify the adjustment mechanism (1) in log-log form and substitute in (8), we obtain the estimable equation

$$(9) \quad \ell n\ E_t = \lambda\ \alpha_o + \lambda\ \beta_E\ \ell n(P_{Et}/P_t) + \lambda\ \beta_y\ \ell n(Y_t/P_t) + (1-\lambda)\ \ell n\ E_{t-1}.$$

As noted by Houthakker-Taylor [1966] and others, short-run price and income elasticities are constant and equal to

$$(10) \quad \varepsilon_P^{SR} \equiv \frac{\partial\ \ell n\ E_t}{\partial\ \ell n(P_{Et}/P_t)} = \lambda\ \beta_E$$

$$\varepsilon_Y^{SR} \equiv \frac{\partial\ \ell n\ E_t}{\partial\ \ell n(Y_t\ /P_t)} = \lambda\ \beta_Y,$$

while the corresponding long-run elasticities (those obtained when the capital stock adjustment process is completed) are

$$(11) \quad \varepsilon_p^{LR} = \beta_E \quad , \quad \varepsilon_Y^{LR} = \beta_y\ .$$

Equation (9) is an appropriate specification for the individual consumer of electricity. In order to employ such an equation at the aggregate level, we make the assumption that (9) applies for the representative consumer who has access to electricity services.

As was noted earlier, however, at present in Mexico not all households have access to electricity services, and substantial electrification programs are planned for the future. This suggests that a variable defined as the share of population having access to electricity,

$$(12) \quad S_t \equiv N_t/POP_t.$$

be added (in logarithmic form) as a regressor to (8), where N_t is the number

of electricity hook-ups and POP_t is the population at time t, and that E_t in (9) instead be interpreted as electricity consumption per hook-up. This yields the aggregate electricity demand equation

$$(13) \quad \ell n\ (E_t/N_t) = \lambda\ \alpha_o + \lambda\ \beta_E\ \ell n(P_{Et}/P_t) + \lambda\ \beta_y\ \ell n(Y_t/P_t)$$

$$+ \lambda\beta_s\ \ell n\ S_t + (1-\lambda)\ \ell n\ (E_{t-1}/N_{t-1})$$

It is desirable, however, to model factors affecting electricity access, S_t, more directly. Here we examine two alternative specifications:

$$(14) \quad \ell n\ S_t = \ell n\ \alpha_o + \alpha_U\ \ell n(URB_t) + \alpha_Y\ \ell n\ (Y_t/P_t)$$

and

$$(15) \quad \ell n\ \frac{S_t}{1-S_t} = \ell n\ \delta_o + \delta_u \ell n\ UBB_t + \delta_y \ell n(Y_t/P_t) \quad ,$$

where URB_t is an index of urbanization. Note that in (14), the saturation of electricity access is specified to follow a log-linear relationship with increases in real income, whereas in (15) the saturation process follows the familiar logistic curve, initially increasing rapidly with increases in real income and then gradually tapering off in growth rates as complete saturation is approached. Equation (15) is perhaps preferable in a priori grounds, but we shall compare (14) and (15) empirically; when (15) is employed, we replace $\ell n\ S_t$ in (13) with the dependent variable in (15).

The above specification has a number of interesting features. According to the two-equation system, equation (13) and either (14) or (15), an increase

in real income in Mexico affects electricity consumption in two distinct ways (i) it affects the number of households having access to electricity -- see (14) or (15), and (ii) it affects the consumption of that part of the population already having access to electricity -- see (9).

We define the "total" income effect on electricity consumption as the sum of these two separate components, and denote the second component by itself as the "partial" income effect. For the log-linear specification (14), the total elasticity of electricity demand with respect to a change in income is

$$(16) \qquad \frac{d\,\ell n\, E_t}{d\,\ell n\,(Y_t/P_t)} = \lambda\beta_y + \alpha_y\,(1 + \lambda\beta_s)$$

in the short-run, and

$$(17) \qquad \beta_y + \alpha_y\,(1 + \beta_s)$$

in the long run. For the logistic saturation specification (15), this total income elasticity is

$$(18) \qquad \lambda\beta_y + \lambda\beta_s\delta_y + (1 - s_t)\delta_y$$

in the short-run, and

$$(19) \qquad \beta_y + (\beta_s + 1 - s_t)\delta_y$$

in the long-run.

Using (10) and (11), we can easily compute the difference between partial and total income elasticities, which turns out to be

(20) $\alpha_y (1 + \lambda\beta_s)$ and $\alpha_y (1 + \beta_s)$

in the short and long-run, respectively, for the log-linear specification, and

(21) $\lambda\beta_s\delta_y + (1 - s_t)\delta_y$ and $(\beta_s + 1 - s_t)\delta_y$

for the logistic specification. An interesting feature of the logistic hook-up saturation specification (15), incidentally, is that differences between total and partial income elasticities fall as saturation is approached, i.e., as s_t in (21) approaches unity. Such a result is plausible, for it siimply reflects the fact that as electricity hook-ups reach saturation levels, the incremental effect of increases in income on electricity demand becomes primarily the induced incremental consumption per hook-up.

IV. DATA AND EMPIRICAL RESULTS

We now turn to a discussion of data and empirical results. We have estimated the two-equation model using two alternative data sets -- an annual aggregate time series data set at the national level covering the period 1962-79, and a pooled cross-section, time series data set for the six regions of Mexico over the 1970-78 time period.

A. Aggregate Time Series Data and Empirical Results

Data on residential electricity consumption, number of residential hook-ups as of Dec. 31 for each year, and average price of residential electricity per KWH were taken from Comision Federal de Electricidad [1981c],

while data on real disposable income per capita (using the GNP deflator) population, and urbanization indices are taken from National Financiera [1981].[11]

The two-equation system has been estimated for both versions of the saturation relationship, (14) and (15), using the TSP program on a VAX-11/780 computer. Since (9) contains more than one endogenous variable, it was estimated using the procedure of two-stage least squares; the hook-up saturation equation was estimated using ordinary least squares. Results are presented in Table 1 below.

As seen in Table 1, all parameter estimates have the expected signs -- own-price responses are negative, income effects are positive in both equations, and the effect of urbanization on saturation is positive and large. A result of particular interest is that the difference between partial and total income effects is substantial, with the total income effect being approximately 40% larger than the partial effect. In the long run, for example, the partial and total income effects on the level of electricity consumption are about 1.35 and 1.80 respectively, implying that the distinction between access and consumption is an empirically significant one for Mexico over the 1962-79 time period[12] and that increases in income have an important "double whammy" effect on electricity consumption.

Another result of interest here is that results from the alternative access saturation specifications -- log-linear and logistic -- are virtually identical. Finally, own-price elasticities are negative and statistically significant -- about -0.35 in the short run and -0.81 in the long run.

TABLE 1

Estimation Results - Aggregate Time Series Data, 1962-79
Residential Electricity Demand in Mexico
(t-statistics in parentheses)

Log-Linear Specification

$$\ell n(E_t/Nt) = \underset{(1.87)}{-3.190} + \underset{(1.66)}{0.324}\ \ell n\ (Y_t/P_t) \underset{(3.14)}{-0.348}\ \ell n\ (P_{Et}/P_t)$$

$$+ \underset{(1.01)}{0.099}\ \ell n\ S_t + \underset{(3.31)}{0.571}\ \ell n\ (E_{t-1}/N_{t-1}) + e_{1t}$$

$$\ell n\ S_t = \underset{(1.33)}{2.007} + \underset{(5.15)}{1.257}\ \ell n\ URB_t + \underset{(4.31)}{0.957}\ \ell n\ (Y_t/P_t) + e_{2t}$$

Logistic Specification

$$\ell n\ (E_t/N_t) = \underset{(1.28)}{-2.504} + \underset{(1.65)}{0.325}\ \ell n\ (Y_t/P_t) - \underset{(3.13)}{0.346}\ \ell n\ (PE_t/P_t)$$

$$+ \underset{(1.01)}{0.093}\ \ell n\ (S_t/1-S_t) + \underset{(3.31)}{0.571}\ \ell n\ (E_{t-1}/N_{t-1}) + e_{1t}$$

$$\ell n\ (S_t/1-S_t) = \underset{(3.33)}{-5.382} + \underset{(5.46)}{1.428}\ \ell n\ URB_t + \underset{(4.17)}{0.994}\ \ell n\ (Y_t/P_t) + e_{2t}$$

Implied Elasticity Estimates	Log-Linear Model	Logistic Model
Price - Sheet Run	-0.348 (3.14)	-0.346 (3.13)
Price - Long Run	-0.811 (5.14)	-0.807 (5.09)
Partial Income - Short Run	0.324 (1.66)	0.325 (1.65)
Partial Income - Long Run	0.753 (1.63)	0.758 (1.62)
Total Income - Short Run	1.375	1.312
Total Income - Long Run	1.806	1.791

B. Pooled Cross-Sectional, Time Series Data and Empirical Results

The Comision Federal de Electricidad (CFE) has collected data on residential electricity demand, average prices and number of hook-ups for seventeen geographical divisions in Mexico. We have grouped these seventeen discussions into six regions, each containing, divisions with similar weather and socioeconomic characteristics.[13] The electricity data by region is taken from Secretaria de Programacion y Presupuesto [1981], while regional GNP data are derived from Alvarez [1981] and Nacional Financiera [1981]. Regional deflators were constructed by employing the consumer price index of the largest city in each region, as published in Nacional Financiera [1981] and based on Banco de Mexico data.[14] Hence even though nominal average electricity prices are equal among the non-hot climate regions, real prices differ. Urbanization and population data for 1970-1978 were obtained by interpolation of 1970 and 1980 census data, as cited in Nacional Financiera [1981].

Because the regions of Mexico vary considerably in climatic conditions, for each region the variables TMIN and TMAX were computed for each year 1970-78, where TMIN and TMAX are, respectively, mean temperatures during the coldest and hottest months of the year.

For each region, a model consisting of equation (9) and either (14) or (15) was postulated, where in addition it was assumed that slope coefficients were equal across regions but intercepts differed.[15] Since evidence of heteroscedasticity was present, we weighted observations by the inverse of the standard error of the invididual regions to obtain more homoscedastic disturbances. Results of the estimation are presented in Table 2 below.

As seen in Table 2, results from the pooled regional, time series data differ considerably from those based on the national time series data.

TABLE 2

Estimation Results - Regional Data from 1970-78
Residential Electricity Demand in Mexico
(t-statistics in parentheses)

Log-Linear Specification

$$\ell n\ (E_t/N_t) = \text{intercepts} + \underset{(3.46)}{0.232}\ \ell n\ (Y_t/P_t) - \underset{(1.11)}{0.048}\ \ell n\ (P_{E,t-1}/P_{t-1})$$

$$+ \underset{(3.70)}{0.436}\ \ell n\ S_t + \underset{(3.016)}{0.434}\ \ell n\ TMAX - \underset{(1.13)}{0.048}\ \ell n\ TMIN + \underset{(7.27)}{0.650}\ \ell n\ (E_{t-1}/N_{t-1}) + e_{1t}$$

$$\ell n\ S_t = \text{intercept} + \underset{(5.89)}{0.447}\ \ell n\ URB_t + \underset{(59.48)}{2.261}\ \ell n\ (Y_t/P_t) + e_{2t}$$

Logistic Specification

$$\ell n\ (E_t/N_t) = \text{intercepts} + \underset{(3.51)}{0.247}\ \ell n\ (Y_t/P_t) - \underset{(0.82)}{0.036}\ \ell n\ (P_{Et}/P_{t-1}) + \underset{(3.29)}{0.352}\ \ell n\ (S_t/1-S_t)$$

$$+ \underset{(3.07)}{0.446}\ \ell n\ TMAX - \underset{(0.45)}{0.018}\ \ell n\ TMIN + \underset{(7.34)}{0.663}\ \ell n\ (E_{t-1}/N_{t-1}) + e_{1t}$$

$$\ell n\ \frac{S_t}{1-S_t} = \text{intercept} + \underset{(4.13)}{0.309}\ Pn\ URB + \underset{(1.93)}{0.328}\ Pn\ (Y_t/P_t) + e_{2t}$$

Implied Elasticity Estimates	Log Linear Model	Logistic Model
Price - Short Run	-0.048 (1.12)	-0.036 (0.82)
Price - Long Run	-0.138 (1.17)	-0.107 (0.86)
Partial Income - Short Run	0.232 (3.46)	0.247 (3.51)
Partial Income - Long Run	0.664 (3.01)	0.732 (3.00)
Total Income - Short Run	3.479	0.661
Income - Long Run	5.744	1.373

Short-run price-elasticities in the regional models are only about -0.036 to -0.048, while with the national time-series data these elasticities were about -0.345; based on the regional data, long-run price elasticity estimates for electricity demand varied from -0.107 to -0.138, while with the national time series data the estimated elasticities were about six times larger, -0.81. Although the estimated standard errors of the price elasticity estimates are smaller with the regional data, the coefficient estimates are also smaller (in absolute value), and hence in the regional models the price elasticity estimates are statistically insignificantly different from zero.

Partial income elasticity estimates are also smaller with the pooled regional data, but differences are not as large as for the price elasticity estimates. For example, while the pooled and time-series estimates of the short-run partial income elasticity are about 0.32 and 0.24, respectively, the long-run partial income elasticity estimates are very similar, especially for the logistic specification, 0.732 (pooled) and 0.758 (time series). Note also that t-statistics on the partial income elasticities are larger with the pooled data.

Estimates of the speed of adjustment parameter (one minus the coefficient on the lagged dependent variable) are slightly smaller with the pooled data, about 0.37 as compared to 0.43 with the time-series data. As expected, estimates of the LTMAX and LTMIN coefficients are positive and negative, respectively, with the former being statistically significant.

The discussion to this point has suggested that although the time-series and pooled data yield somewhat different results, not much difference occurs in estimates based on the log-linear (14) versus the logistic specification

(15) of the electric access saturation relationship. As seen in the bottom entries of Table 2, however, this approximate agreement in empirical results breaks down completely in the case of total income elasticities. With the log-linear specification, the short and long-run total income elasticity estimates jump to unreasonably high levels of 3.479 and 5.744, respectively. By contrast, with the logistic specification the short and long-run elasticity estimates are smaller and much more reasonable, 0.661 and 1.373, respectively.

These results suggest to us that on empirical grounds there is a clear preference for the logistic specification. Note also that, as with the time-series data, the difference between partial and total income elasticities based on the pooled data is substantial; for the logistic specification, the long-run total income elasticity is about 87% larger than the corresponding partial elasticity.

We conclude, therefore, that in modelling the demand for electricity in Mexico, the distinction between access and consumption is an empirically important one. Results based on both the time-series and the pooled regional data support this conclusion.

V. CONCLUDING REMARKS

A principal finding of this paper is that for a developing country like Mexico, increases in income have an important "double-whammy" impact on electricity consumption, first in terms of increasing the number of households hooked-up to electricity services, and second in terms of increasing the consumption of households already having access to electricity. While each of the components has estimated long-run income elasticity values of less than unity, their joint effect has been estimated to be considerably larger than

one. We believe this structural distinction between access and consumption helps in understanding and making more credible the large "reduced form" residential energy income elasticity estimates for developing countries that have been reported in the literature.[16]

One empirical result requiring further investigation is why own-price elasticity estimates are smaller (in absolute value) with the pooled regional, time-series data than with the aggregate time series data.[17] Part of the reason for this result may be due to the fact that contemporaneous cross-sectional variations in electricity prices are minimal (except for the regional divisions with hotter climates), and that annual data were available by region only over the 1970-78 time period, whereas for the aggregate national data a longer time span of data was available, 1962-79. It is comforting, however, that the difference in estimated partial and total income elasticities is not as large based on the pooled regional and national time series data, especially for the logistic specification.

Finally, in this paper we have found that on empirical grounds there is a clear preference for results based on the logistic electricity hook-up specification (15). Since this specification is also preferable intuitively, we suggest its use be extended in future studies of electricity demand in developing countries.

FOOTNOTES

[1]For other discussions of energy, and especially electricity issues in developing countries, see the various papers in Dunkerley [1980], as well as Dunkerley et al. [1981].

[2]Source: SEPAFIN, Programa de Energia, Metas a 1990 y Proyecciones al Ano 2000 (Balances de Energia y Estadisticas Complementarias), Mexico, 1981, pp. 15-20, 30-31, and 44-45. The 1980 percentage shares for industrial, transportation, non-energy, and other uses are, respectively, 40, 37, 7, and 6.

[3]Source: From 1965 to 1977, SEPAFIN, Comision Nacional de Energeticos, Boletin del Sector Energetico, Feb. 1978, Year 2, No. 3. Reprinted in SPP, La Industria Petrolera en Mexico, Mexico, 1980, p. 185. For 1978 and 1979, calculations are based on data provided by CFE and PEMEX. The conversion factor used for electricity is 3074 Kcal/KWH, which reflects an approximate first-law thermal efficiency of 28%.

[4]See CFE, El Programa de Electrificacion Rural en Mexico, Mexico, 1981.

[5]See CFE, Evolucion de las Tarifas de Electricidad, Mexico, 1981.

[6]Ibid.

[7]In terms of international comparisons, in April 1980 the unit price per KWH in Mexico under the normal tariff was about 1/6 of that in Argentina, 1/2 that in California and Nicaragua, and 2/3 that in Texas and Costa Rica. Source: CFE, Comparacion Internacional de Tarifas de Energia Electrica, Mexico, April 1981.

[8]For a discussion and assessment of this and other dynamic models, see Berndt, Morrison and Watkins [1981].

[9]See, for example, Deaton-Muellbauer [1980].

[10]Ibid., especially chapter 3, pp. 62-64.

[11]In turn, these data are drawn from primary sources such as the Banco de Mexico and Censos Generales de Poblacion. Also, the average electricity price is a share-weighted average of normal and hot climate rates. Note that the differences between regression results based on average and marginal prices of electricity are likely to be negligible; for a discussion, see Berndt [1978].

[12]The total income elasticities with the logistic specification have been calculated assuming $S_t = .09$, which is the approximate saturation level at the mid-point of the sample.

FOOTNOTES (Continued)

[13]Region 1 (Baja California Peninsula) consists of the CFE division Baja Calif., Region 2 (North) includes Noreste, Norte, Golfo Norto, Region 3 (West) includes Bajio, Jalisco, Cent. Occid., Region 4 (Central) includes Cent. Sur, C.L.F.C., Region 5 (Southeast) encompasses Cent. Oriente, Oriente, while Region 6 (Yucatan Peninsula) includes Sureste and Peninsular.

[14]For regions one to six, the city CPI measures used were, respectively, from Mexicali, Monterey, Guadalajara, Mexico City, Morelia and Merida.

[15]Note also that TMIN and TMAX were added as regressors to (9).

[16]See, for example, the studies cited in Pindyck [1979].

[17]Note that this result differs from that often heard in which it is stated that time-series data yield only short-run price elasticity estimates, while cross-section data yield (larger) long-run elasticity estimates. For a critical review of this argument, see Stapleton [1981].

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