A Comparative Analysis of Energy Demand and Expenditures by Minority and Majority Households within the Context of a Conditional Demand System

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Analysis and evaluation of the impact that programs and policies have on energy consumption and expenditures are confounded by many intervening variables. A clear understanding of how these variables influence energy consumption patterns should be grounded in a rigorously developed framework. In this regard much is documented in the literature. However, an analysis of the comparative relationship between energy demand and variables which influence it among different socioeconomic groups has not been thoroughly explored with any theoretical rigor.

It is proposed that differences in patterns of energy use between black, Hispanic, and majority households (where the household head is neither black nor Hispanic) are due to both structural and distribution differences. It is felt that the structural dissimilarities are primarily due to the dynamic nature in which energy consumption patterns evolve, with differences in changing housing patterns playing a significant role. For minorities, this implies a potential difference in the effect of policy and programs on their economic welfare when compared to majority households.

To test this hypothesis, separate conditional demand systems are estimated for majority, black, and Hispanic households. With the use of separate variance/covariance matrices, various parameter groups are tested for statistically significant differences.

Introduction

The evolution of patterns of energy use are closely related to urban and housing development (Poyer 1991). The historical, social, and economic processes that have governed the development of relationships among different socioeconomic groups have also dominated the evolution of patterns of energy use by different groups. This is premised on the idea that energy consumption and patterns of energy use are connected to the age and type of housing in which one lives. In a sense, energy consumption and use patterns can play the role of a social indicator -- with households living in older homes having different energy consumption patterns as compared with households living in newer homes (Poyer 1991).

The social and economic history of blacks and Hispanics in America have particular ingredients that are distinct from the majority population not only socially, politically, and economically, but also spatially. Within the general context of the development of the American political economy, differences in the dynamic process of inter- and intra-area migration have led to differences in housing patterns among these groups. Consequently, variations in the distribution of population by region and urban area have appeared among black, Hispanic, and majority population groups. The proposition that energy consumption and patterns of energy use among these groups have evolved differently as a consequence of differing changes in housing patterns, as well as in geographic and urban location, therefore, seems reasonable. Do these differences in changing housing patterns and location lead to different energy demand structures for these groups? If so, what are the policy implications?

As an initial attempt to answer these questions, the energy demand structure for each group is determined within the context of a complete demand system. Standard consumer demand theory, in which the household is the primary unit of measure, is used for this purpose. Within this context structural differences between groups for various sets of demand parameters are tested.

The paper is organized as follows: in the next section, "The Theoretical Framework: Linear Expenditure Demand System," a brief description of the theoretical model is presented; in the section entitled "Data," an examination of the data sources and a description of the historical patterns of energy consumption, cross-tabulated by each population group and by poverty status, is offered; this is followed by "The Empirical Framework," in which empirical estimates of the model are presented, along with the results of a number of chi-square tests for structural differences in the estimated demand systems for the three groups; and finally in "Summary and Policy Implications," a summary of the empirical findings and their policy implications are presented.

The Theoretical Framework: Linear Expenditure Demand System

In a paper written by Skumatz (1987), strong empirical evidence is provided for the proposition that systematic differences in patterns of energy consumption do exist among different racial/ethnic/class groups. The Skumatz paper addresses differences at both the appliance-holding and energy utilization stages -- where it is found that significant differences among population groups exist. Unfortunately, the Skumatz model is not couched within a theoretical, behavioral context and thus is subject to the same criticism that was levelled against Parti and Parti (1980) by Khazzoom (1986).

To better conceptualize the process of energy consumption and expenditures, this paper takes a complete demand system approach.[1] A complete demand system is an analytical framework in which conditions required for the rational consumption of goods are met. There are four conditions: adding-up, homogeneity, symmetry, and semi-negative definitiveness. These requirements are automatically met with the expenditure-constrained maximization of a well-defined utility function. In this case, energy and electricity demand are determined by solving a set of first-order condition equations that have been obtained from expenditure-constrained utility maximization problems (see Deaton and Muellbauer 1980, chapter 2).

To capture the impact of changing explanatory variables on both total energy consumption and expenditures and on the composition of energy consumption and expenditures, a multistage budgeting framework is adopted. The budgeting framework is presented in Figure 1. At the top of the budgeting hierarchy is income, which is allocated between consumption and savings. Consumption is then allocated between energy and nonenergy consumption, with energy consumption then allocated between electricity and nonelectric energy consumption.[2]

The conceptual framework in which this analysis is conducted is based upon the well-established theoretical work of Stone (1954), Samuelson (1947-48), Klein and Rubin (1947-48), and Geary (1950-51). Subsequent theoretical work by Phlips (1983), Pollak and Wales (1981), and Muellbauer (1975) is used to develop a dynamic and more general model, which allows us to trace the time path associated with energy consumption and to determine the effect of other factors on energy consumption besides income and prices.

It is assumed that a household attempts to maximize utility subject to an expenditure constraint. As a result of a recursive optimization process, the following demand system is obtained:

$$q_{et}=(1-\beta_e)(\gamma_e+\alpha_e s_{et})+\frac{\beta_e}{p_{et}}(m_t-p_{ct}\gamma_c) \tag{1}$$

where:

- q_{et} = energy consumption in period t (10^6 Btu/household-year);
- s_{et} = state variable for energy demand in period t (10^6 Btu/household-year);
- p_{et} = energy price in period t (\$/10^6 Btu);
- m_t = total expenditures in period t (\$/household-year);
- p_{ct} = nonenergy commodity price index (1979 base);
- β_e = marginal energy expenditure share of all expenditures;
- γ_e = nondiscretionary energy demand (10^6 Btu/household-year);
- γ_c = nondiscretionary non-energy demand (1979\$/household-year); and
- α_e = energy demand's dynamic effect parameter.

The state variable is defined as:

$$s_{et}=(1-\theta_e)p_{e(t-1)}+\theta_e s_{e(t-1)} \tag{2}$$

where:

θ_e = energy demand's dynamic lag effect parameter.

Nondiscretionary energy demand is assumed to be a function of household characteristics, climatic, and demographic variables. It is expressed as:

$$\gamma_e=a'x \tag{3}$$

where:

- a = column vector of parameters; and
- x = column vector of climatic, housing, and demographic factors.

The electricity demand equation is

$$q_{elt}=(1-\beta_{el})(\gamma_{el}+\alpha_{el}s_{elt})+\frac{\beta_{el}}{p_{elt}}(m_{et}-p_{nelt}\gamma_{nel}) \tag{4}$$

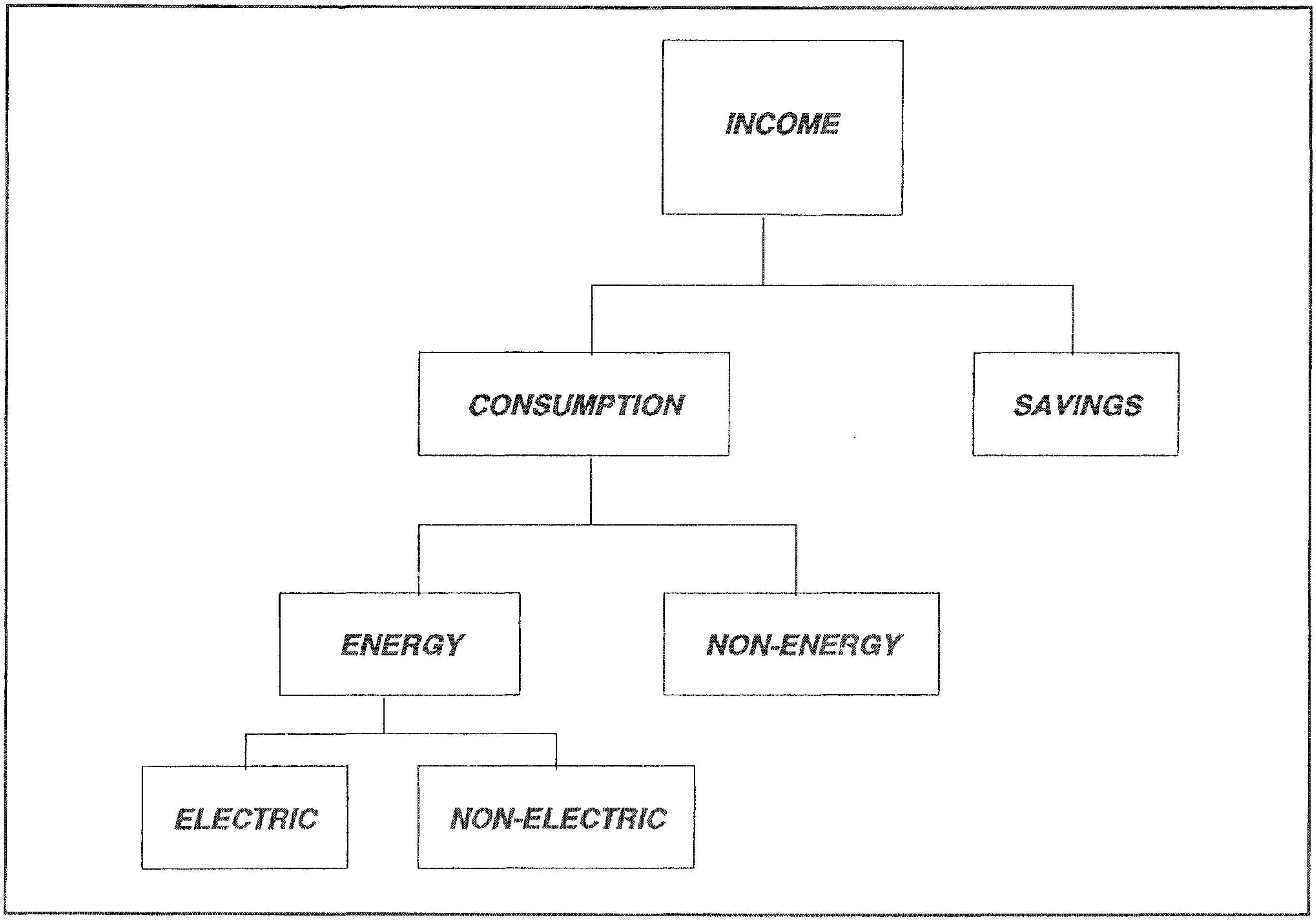

Figure 1. Multistage Expenditure Flow Model

where:

q_{elt} = electricity consumption in period t (10^6 Btu/household-year);

s_{elt} = state variable for electricity demand in period t (10^6 Btu/household-year);

p_{elt} = electricity price in period t (\$/10^6 Btu);

m_{et} = total energy expenditures in period t (\$/household-year);

p_{nelt} = nonelectric energy (\$/10^6 Btu);

β_{el} = marginal electricity expenditure share of total energy expenditures;

γ_{el} = nondiscretionary electricity demand (10^6 Btu/household-year);

γ_{nel} = nondiscretionary nonelectric energy demand (10^6 Btu/household-year); and

α_{el} = electricity demand's dynamic effect parameter.

The state variable and nondiscretionary demand parameter associated with the electricity demand function are analogous to the ones associated with the energy demand function and are shown in Equations (5) and (6):

$$s_{elt} = (1-\theta_{el})p_{el(t-1)} + \theta_{el}s_{el(t-1)} \quad (5)$$

where:

θ_{el} = electricity demand's dynamic lag effect parameter;

$s_{el(t-1)}$ = state variable for electricity demand in period t-1 (10^6 Btu/household-year); and

$$\gamma_{el} = b'z \quad (6)$$

where:

b = column vector of parameters; and

z = column vector of climatic, housing, and demographic factors.

The total demand system is a three-stage budgeting model, where total consumption is determined at the top, total energy consumption in the middle, and electricity and nonelectric energy consumption at the bottom. For this model to be complete, additional equations must be specified. Since there are four unknowns -- q_{et}, q_{elt}, p_{et}, and m_{et}, equations for the energy price and expenditures must be specified to go along with Equations (1) and (4). Both of these new equations are identities, where:

$$p_{et} \doteq \frac{(p_{elt}-p_{nelt})q_{elt}+p_{nelt}q_{et}}{q_{et}} \tag{7}$$

and

$$m_{et} \doteq p_{et}q_{et} \tag{8}$$

are the expressions for energy price and expenditures respectively.

Equations (1), (4), (7), and (8) represent the total demand system for energy. The variables, q_{et}, p_{et}, q_{elt}, and m_{et} are all endogenously determined. The complete model provides a framework in which the effects of changing variable values on energy consumption and expenditures can be determined. The model is now complete. How energy consumption and expenditures change in response to changes in predetermined variables is important in evaluating the comparative impact of policy on the pattern of energy demand and expenditures by different population groups or consumer classes.

With the use of comparative static techniques, price and expenditure elasticities, as well as changes in energy demand and expenditures with respect to other exogenous variables, can be determined.

Figure 2 shows the set of exogenous variables that affect energy and electricity demand. As mentioned earlier, the model is a multi-stage budgeting model (see Figure 1) in which expenditures are allocated between energy expenditures and nonenergy expenditures, and energy expenditures are allocated between electricity and nonelectric expenditures. As a consequence, energy expenditures are an explanatory variable in the structural demand equation for electricity.

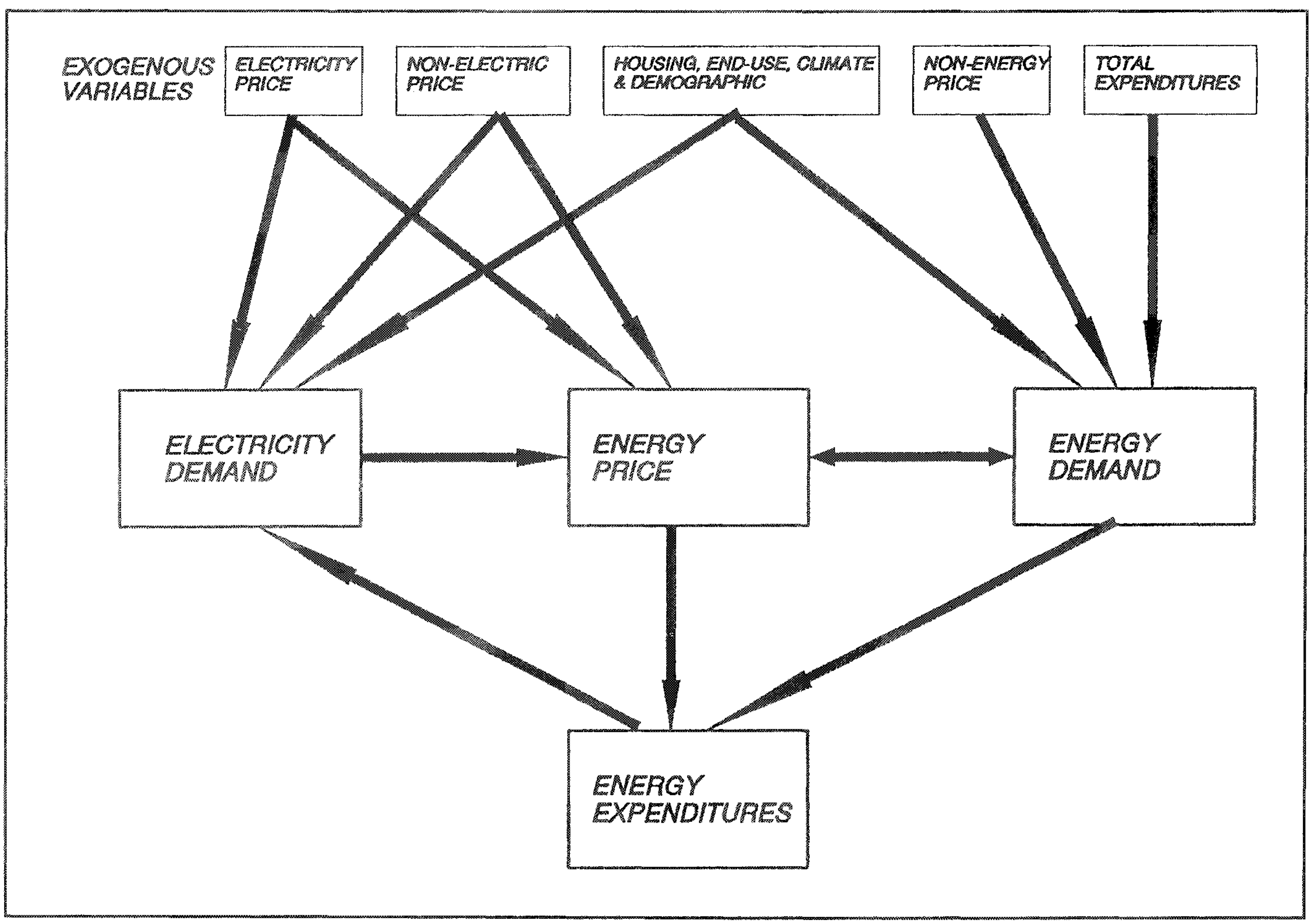

Figure 2. Multistage Budgeting Energy Demand Model

As seen in Figure 2, changes in total energy expenditures are dependent on the magnitude of the energy price change, which is dependent on the relative responsiveness of electricity and nonelectric energy[3] to an exogenous variable change.

In the section entitled "The Empirical Framework," numerical estimates of the parameters are given for each of three population groups. With this information, it is hoped that a better estimate for the comparative impact of these variables on energy consumption and expenditures by these groups will be developed.

Data

The data used in this analysis are obtained from a series of residential energy consumption surveys administered for the U.S. Department of Energy, Energy Information Administration. The energy demand models presented in this paper were estimated from a longitudinal data set constructed from the 1980-81, 1982-83, 1984-85, and 1987 surveys (U.S. DOE 1982, 1985, 1987, 1989a).

In the next few tables, energy consumption and energy expenditure share (percent of income spent on energy) for majority, black and Hispanic households by poverty status[4] are cross tabulated for 1982 and 1987. These data were obtained from the 1982-83 and 1987 Residential Energy Consumption Surveys (U.S. DOE 1984, 1989a).

Average household energy consumption estimates are shown in Table 1. Between 1982 and 1987, energy consumption for each population group falls, with the exception of poor black households. For poor blacks, there is a slight increase in the estimated change in energy consumption. The fall in total energy consumption is accounted for by a large decline in nonelectric energy consumption. Over the same period, electricity consumption increased for each population group. Overall,

Table 1. Estimated Household Energy Consumption by Poverty Status: 1982 and 1987 (10^6 btu/household-year)*

	Poverty Status					
	Nonpoor		Poor		Total	
Population Group	Electricity	Total Energy	Electricity	Total Energy	Electricity	Total Energy
Majority						
1982	31.30	105.22	24.17	87.92	30.15	102.42
1987	32.70	103.09	25.60	85.97	31.55	100.33
%Difference	4.47	-2.02	5.92	-2.22	4.64	-2.04
Black						
1982	26.43	116.06	19.60	102.18	23.26	109.62
1987	27.44	114.86	21.47	104.71	24.89	110.53
%Difference	3.82	-1.03	9.54	2.48	7.01	0.83
Hispanic						
1982	26.93	102.08	18.04	92.46	23.90	98.80
1987	29.13	87.65	18.80	86.61	25.81	87.31
%Difference	8.17	-14.14	4.21	-6.33	7.99	-11.63
Total						
1982	30.70	106.00	22.39	92.26	28.97	103.14
1987	32.08	103.37	23.97	90.72	30.45	100.82
%Difference	4.50	-2.48	7.06	-1.67	5.11	-2.25

Sources: The 1982 and 1987 data are obtained from U.S. DOE 1985 and 1989a respectively.
* Poor households are defined as having a combined household income less than 125% of the poverty line as defined by the U.S. Bureau of the Census (see U.S. DOE 1989b Table C3).

energy consumption declines for majority and Hispanic households and increases slightly for black households. The Hispanic household decline is particularly striking given the very large increase in electricity consumption.

In Table 2, estimated energy expenditure share by population group in 1982 and 1987 is shown. In general, the percent of household income spent on energy over the period fell for each population group. This occurred as a result of declining energy prices and fuel substitution. Black and Hispanic households spend a larger percent of their household income on energy than the average, and the majority households spend a smaller percent.

Table 2. Estimated Household Energy Expenditure Share of Income by Poverty Status: 1982 and 1987 (10^6 btu/household-year)*

	Poverty Status		
Population Group	Nonpoor	Poor	Total
Majority			
1982	4.06	15.44	4.51
1987	3.16	12.57	3.51
%Difference	-22.17	-18.59	-22.17
Black			
1982	5.18	17.93	7.43
1987	4.17	15.81	5.85
%Difference	-19.50	-11.82	-21.27
Hispanic			
1982	3.82	13.96	4.93
1987	3.14	9.68	3.85
%Difference	-17.80	-30.66	-21.91
Total			
1982	4.13	15.96	4.77
1987	3.23	12.99	3.70
%Difference	-21.79	-18.61	-22.43

Sources: The 1982 and 1987 data are obtained from U.S. DOE 1985 and 1989a respectively.

* Poor households are defined as having a combined household income less than 125% of the poverty line as defined by the U.S. Bureau of the Census (see U.S. DOE 1989b Table C3).

The Empirical Framework

In Tables 3-5, the parameter definitions are given. The parameters are placed into three broad categories: the first parameter category is essential in the determination of

Table 3. Energy Demand Model: Parameter Definitions

Parameter	Definition
β_e	Marginal energy expenditure share out of total household expenditures
γ_e	Nondiscretionary demand for energy
θ_e	Energy dynamic adjustment parameter
α_e	Energy dynamic effect parameter
β_{el}	Marginal electricity expenditure share out of total household energy expenditures
γ_{el}	Nondiscretionary demand for electricity
θ_{el}	Electricity dynamic adjustment parameter
α_{el}	Electricity dynamic effect parameter

Table 4. Energy Demand Scale Factor: Parameter Definitions

Parameter	Definition
a_1	Heating Degree Days (65°F) x Area Heated x Non-Electric Space Heat
a_2	Number of Household Members
a_3	Number of Household Members x Female-Head of Household
a_4	House was built before 1950
a_5	House was built between 1949 and 1975
a_6	Single Family Home
a_7	Nonelectric Cooking
a_8	Nonelectric Water Heat

Table 5. Electricity Demand Scale Factor: Parameter Definitions

Parameter	Definition
b_1	Heating Degree Days (65°F) x Area Heated x Electric Space Heat
b_2	Number of Household Members
b_3	Number of Household Members x Female-Head of Household
b_4	Electric Cooking
b_5	Electric Water Heat
b_6	Single Family Home
b_7	House was built before 1950
b_8	House was built between 1949 and 1975

price and expenditure elasticities, and the second parameter category, with the exclusion of expenditures, identifies the extent to which specific variables impact the energy demand.

The parameter estimates are shown in Tables 6-8. The results of statistical test on differences of individual parameters are shown. A very interesting fact is that no statistically significant differences are found among the scale factor parameters. However, critical parameters governing energy and electricity demand elasticities and the profile of energy consumption change over time are statistically different for majority households, as compared with black and Hispanic households.

Table 6. Parameter Estimates: Energy Demand Model

Variable	Population Group		
	Majority	Black	Hispanic
	0.0016	0.0078*	0.0055*
β_e	(0.0004)	(0.0025)	(0.0036)
	-10.404	-58.704	4.9305
γ_e	(5.5455)	(25.208)	(23.5610)
	0.6206	0.6262	0.4550*
θ_e	(0.01040)	(0.0334)	(0.0619)
	2.2180	5.2921	-0.0662
α_e	(0.2823)	(1.1658)	(0.9136)
	0.5759	0.5987*	0.4025*
β_{el}	(0.0190)	(0.0469)	(0.0689)
	2.8303	-10.201	5.5738
γ_{el}	(2.5014)	(9.8786)	(9.3072)
	0.5473	0.4773*	0.6778*
θ_{el}	(0.01077)	(0.0324)	(0.0557)
	-0.025	0.3580*	-0.0063
α_{el}	(0.0746)	(0.1936)	(0.2152)

* The difference with the corresponding value for majority households is statistically significant at the 0.05 significance level.
Values in the parentheses are the standard errors of the estimates.

*Table 7. Parameter Estimates: Energy Demand Scale Factor**

Variables	Population Group		
	Majority	Black	Hispanic
	3.8×10^{-6}	5.3×10^{-6}	6.2×10^{-6}
a_1	(1.8×10^{-7})	(8.4×10^{-7})	(1.3×10^{-6})
	7.9492	15.2941	4.6502
a_2	(0.9745)	(3.8538)	(2.5338)
	7.3459	6.9336	6.8447
a_3	(3.0759)	(4.9832)	(3.8975)
	14.2615	18.5145	3.2798
a_4	(3.8292)	(18.0828)	(13.0979)
	9.6004	-3.4144	13.7239
a_5	(3.5397)	(17.5362)	(13.2993)
	15.2194	-5.2381	24.4278
a_6	(3.1519)	(10.5479)	(9.6404)
	-1.017	6.4935	-6.4249
a_7	(2.9979)	(13.5293)	(14.1771)
	35.4582	54.7195	19.1494
a_8	(3.2324)	(15.5762)	(15.9544)

* Values in the parentheses are the standard errors of the estimates.
None of the differences were statistically significant at the 0.05 significance level.

Chi-square tests are also made for different parameter groups. The complete demand system[5] for black or Hispanic households and the system for majority households are statistically different. The parameters are further divided into other parameter subsets, and chi-square tests on differences are performed on them. In each case, the differences are found to be statistically significant.

The expenditure share estimates for black and Hispanic households are much larger than the estimate for majority households. Furthermore, the difference in share values for Hispanics or blacks and majority is significantly different.[6] This parameter is very important in determining the magnitude of the elasticities. The electricity marginal energy expenditure share parameters for blacks and Hispanics are also different than the majority's parameter. The value of the parameter for blacks is slightly larger and for Hispanics is much smaller.

There are statistically significant differences in the dynamic parameters -- the α and θ parameters. The difference in the adjustment parameters for the energy demand model, θ_e, for Hispanics and majority households is statistically significant. There are also differences in the

*Table 8. Parameter Estimates: Electricity Demand Scale Factor**

Variables	Majority	Black	Hispanic
	Population Group		
	$3.1x10^{-6}$	$3.2x10^{-6}$	$2.4x10^{-6}$
b_1	$(2.0x10^{-7})$	$(9.6x10^{-7})$	$(1.4x10^{-6})$
	5.7898	6.9114	1.8428
b_2	(0.3965)	(4.9832)	(1.1546)
	-0.3247	0.4586	2.7929
b_3	(1.2501)	(1.7322)	(1.8646)
	6.3024	7.0181	14.3745
b_4	(1.2062)	(4.6722)	(6.2389)
	3.6471	-5.4567	5.7946
b_5	(1.4690)	(6.5636)	(5.7946)
	8.9588	3.8080	11.1006
b_6	(1.2682)	(3.7294)	(4.6956)
	-0.9784	-4.7757	-2.1488
b_7	(1.5677)	(6.4397)	(6.2205)
	-0.127	-2.4250	3.1848
b_8	(1.4603)	(6.3208)	(6.2218)

* Values in the parentheses are the standard errors of the estimates.
None of the differences were statistically significant at the 0.05 significance level.

adjustment parameters for the electricity demand models -- θ_{el}. For this parameter, the difference in the black and majority and the Hispanic and majority parameters are both statistically significant. Finally, the difference in the electricity demand model's dynamic effect parameter, α_{el}, for black and majority households is statistically significant.

To understand how changing variables affect energy expenditures by these groups, four different scenarios are reviewed. The assumptions underlying these cases are given in Table 9. The point of departure in this analysis is in the levels of energy expenditures, which are *assumed* constant across population groups. For each of the three population groups there are two income groups identified: high and low (see Table 9).

Not surprisingly, the responsiveness of total energy demand to price changes depends on patterns of energy use. In the case where electricity use is high, total energy demand is more responsive to changes in electricity price and the same is true for nonelectric energy demand.

In Figures 3-6, the response in total energy expenditures is simulated for four cases:

1) The effect of an increase in nonenergy price on the energy expenditures in the "nonelectrified" (see Table 9) case;

*Table 9. Energy Prices and Household Assumptions**

	Electric		Nonelectric	
Variables	High Income	Low Income	High Income	Low Income
Expenditures ($/household-year)	40,000	10,000	40,000	10,000
Energy Expenditures* ($/household-year)	1,150	1,150	1150	1150
Electricity Price ($/$10^6$ btu)	20	20	21	21
NonElectric Price ($/$10^6$ btu)	5	5	3	3
Female Household Head (=1)	0	1	0	1
Housing Vintage	>1974	>1974	>1974	>1974
Housing Type	Single Family Detached	Multifamily	Single Family Detached	Single Family Detached
Electric Heat (=1)	1	1	0	0
Electric Cooking (=1)	1	1	0	0
Electric Water Heat	1	1	0	0

* In order to make the results of the comparative static analysis analogous among the different population groups, energy prices and energy expenditures were held constant in each case. To ensure similar energy expenditure levels, the number of household members, heating degree days, and area heated were adjusted for each of the groups until the $1150 energy expenditure figure was obtained.

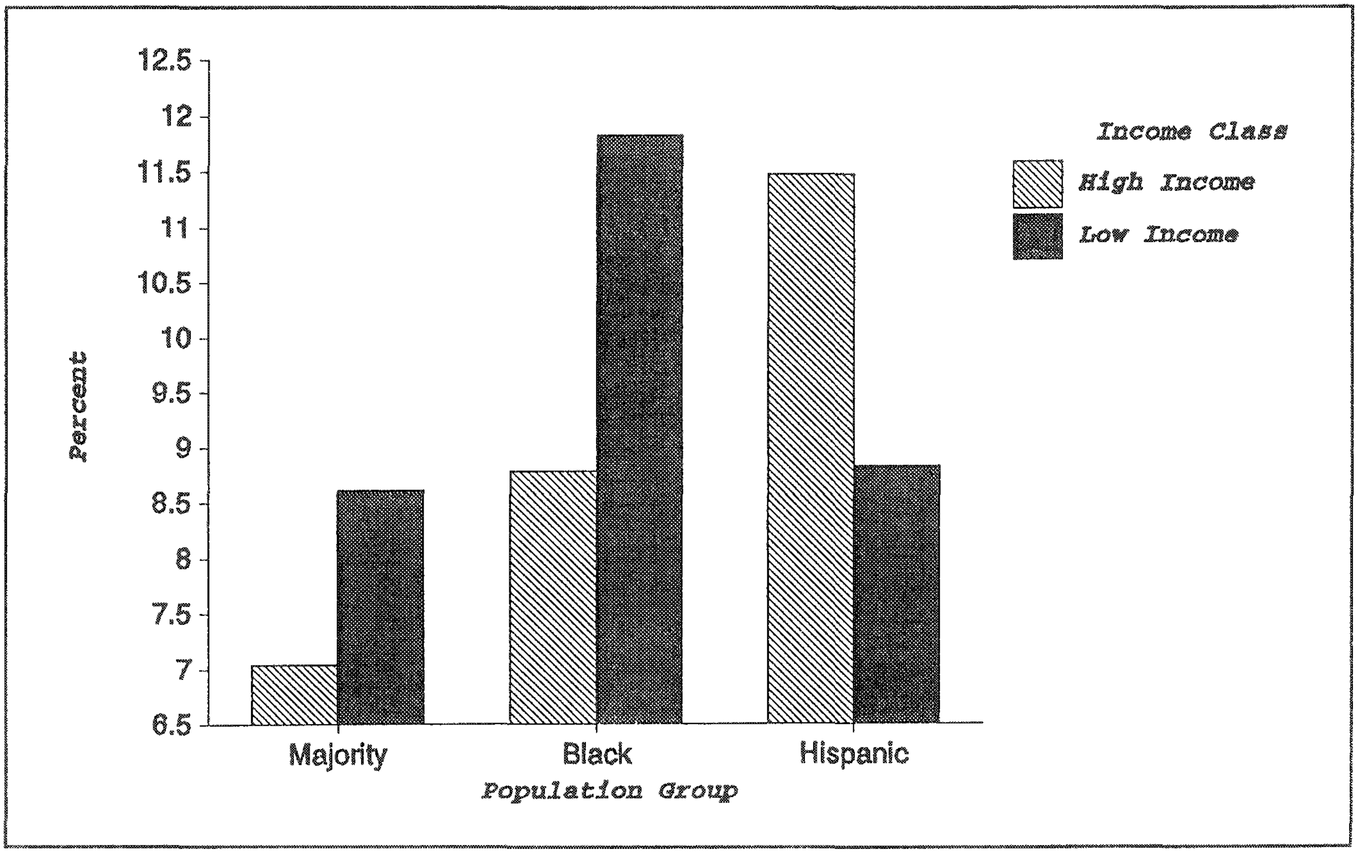

Figure 3. Estimated Percentage Change in Energy Expenditures: One Dollar Increase in Nonelectric Energy Price

2) The effect of an increase in electricity price on the energy expenditures in the "electrified" (see Table 9) case;

3) The effect of a change in housing vintage on energy expenditures -- moving from a home built after 1974 to one built before 1950;

4) The effect of increasing the number of household members on energy expenditures.

The estimated impact of an increase in nonelectric energy price falls hardest on black households and on low-income blacks in particular. The estimated effect of a dollar increase (33% increase) in the nonelectric energy price pushes total energy expenditures up by almost 12%. It is also estimated that high-income Hispanic energy expenditures increase by over 11%. Least affected by a rise in nonelectric energy expenditures are high-income majority households.

In the second case, shown in Figure 4, black households are least affected by a rise in electricity price (5% rise). High-income majority and Hispanic households are the most affected by a rise in electricity price. The relative effects of a rise in nonelectric energy and electricity price by income are reversed, with the rise in nonelectric energy price adversely affecting low-income majority and black households, and the rise in electricity price affects both low- and high-income Hispanics about the same.

In Figure 5, the effect of living in housing of different vintage is simulated for the "nonelectrified" case. In this case, energy expenditures by black households rise the most, in particular high-income black energy expenditures. In general, the fact that energy expenditures rise in older vintage homes is an important factor, because lower-income households occupy older homes in disproportionate numbers.

In the final case, the effect of changing household size on energy expenditures is simulated. Once again energy expenditures by black households are estimated to increase the most, with low-income black energy expenditures increasing more than high-income black expenditures. Generally, energy expenditures by low-income households increase more than by high-income households.

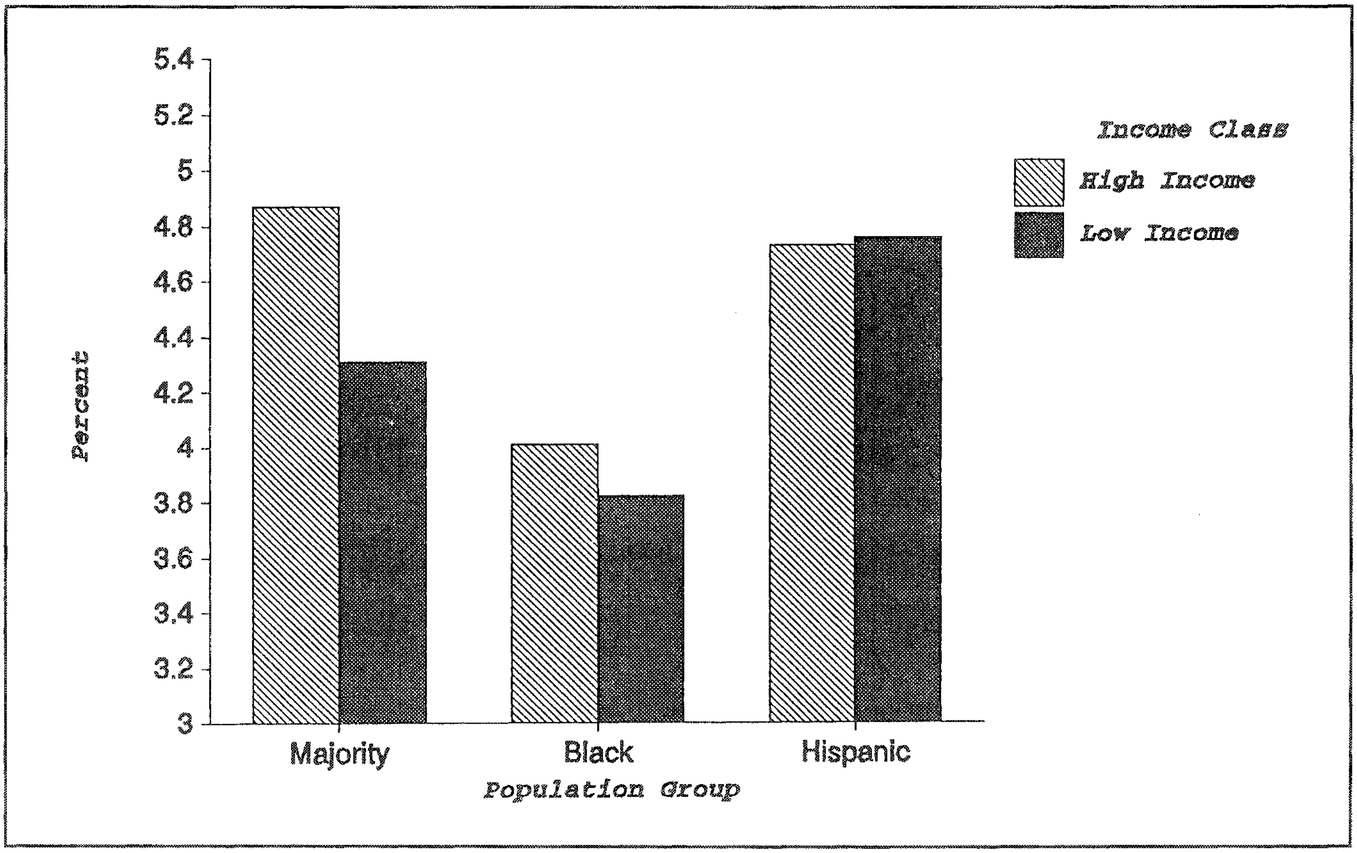

Figure 4. Estimated Percentage Change in Energy Expenditures: One Dollar Increase in Electricity Price

Summary and Policy Implications

The primary purpose of this paper is to investigate the potential existence of structural differences in energy demand among majority, black, and Hispanic households. The statistical results indicate the existence of structural differences in the overall demand for energy. They also indicate statistically significant differences in the key marginal expenditure share parameters, β_e and β_{el}, which play a critical role in determining the magnitude of the elasticity values. As a consequence of these differences, it is anticipated that policies or regulations which lead to changes in relative prices would impact these groups differently.

There is very strong evidence that the nature of energy consumption is different for black households from that for majority households. The strongest rejection of the null hypothesis -- no difference in the structure of energy demand -- occurs at the top of the energy budgeting hierarchy.

For Hispanics, as it is with blacks, the nature of energy demand is also statistically different from majority households. From a general perspective, the way in which demographic, housing, and climatic factors impact energy demand is the major difference in energy demand between majority and Hispanic households.

In particular, blacks and Hispanics are more vulnerable to a rise in the nonelectric energy price, whereas majority households are more vulnerable to a rise in the electricity price. These results also indicate that Hispanics and blacks are likely to increase their level of energy expenditures at a faster rate under a scenario of rapidly growing income. This might indicate that blacks and Hispanics are prime targets for demand-side management programs.

The data and statistical analysis compiled in this paper will be scrutinized further. It is certain that additional information can be drawn from these data and that the analysis presented in this paper is only a beginning.

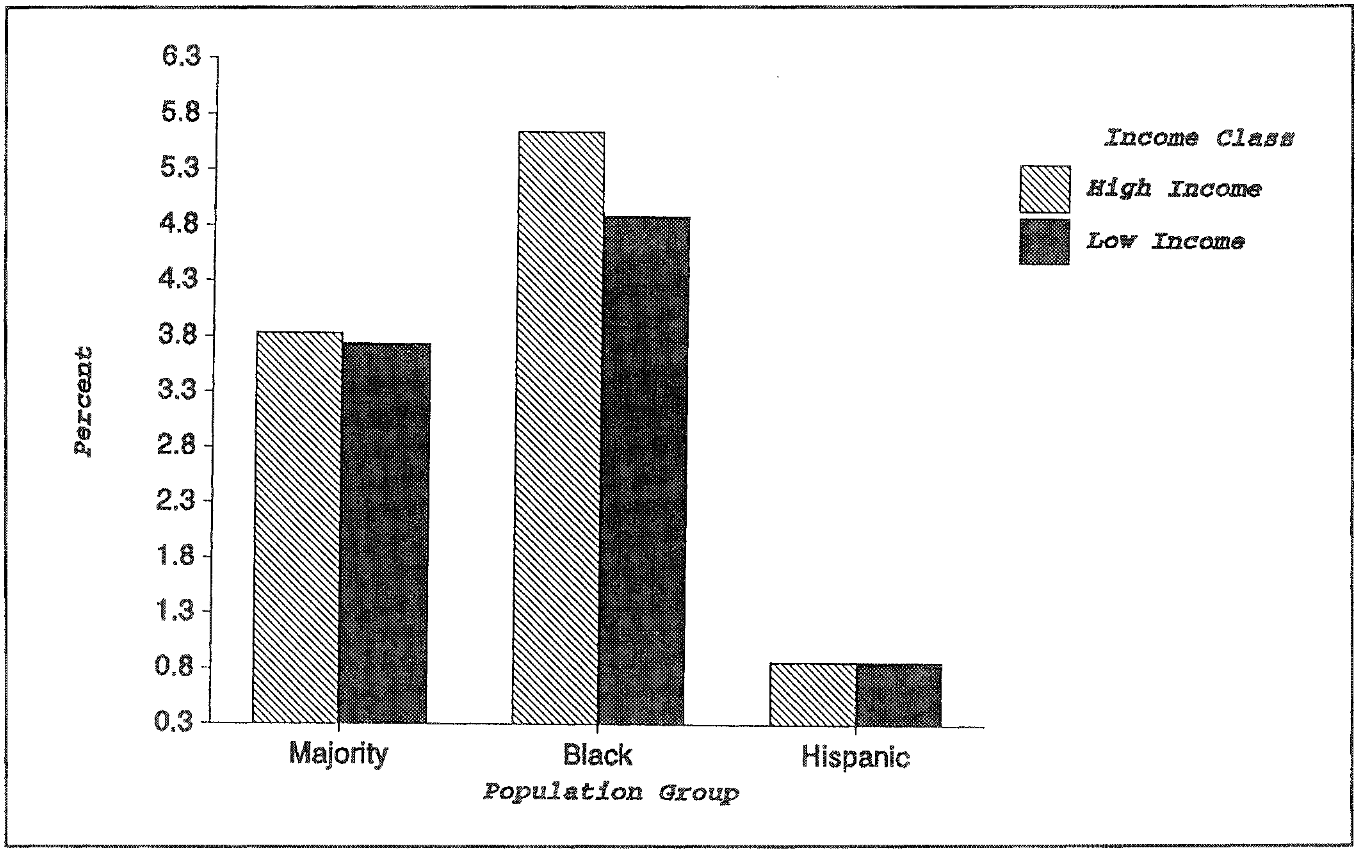

Figure 5. Estimated Percentage Change in Energy Expenditures: Households Living in Homes Built Before 1950

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Endnotes

1. The theoretical considerations associated with appliance holdings are not addressed in this paper. As indicated in the title of the paper, my concern is an analysis of energy consumption among different population groups within the context of a conditional energy demand model. The model is based on the assumption that the utility function is weakly separable. This assumption allows for the separate treatment of household investment and appliance utilization decisions.

2. For a detailed discussion on multi-stage budgeting models see Deaton and Muellbauer (1980), Chapter 5.

3. Although nonelectric energy is not directly specified in Figure 2, the effect of an exogenous variable change on non-electric energy demand can be determined by taking the difference in the measured effects on total energy and electricity demand.

4. A poor household is defined as a household with a household income below 125% of the poverty line as defined by the U.S. Bureau of the Census. The definition used is given in U.S. DOE 1989b Table C3.

5. A complete demand system is composed of all the parameters shown in tables 5 to 7.

6. A F-statistic is calculated with (1,n-1) degrees of freedom. The null hypothesis is that the difference in the estimated values is zero.

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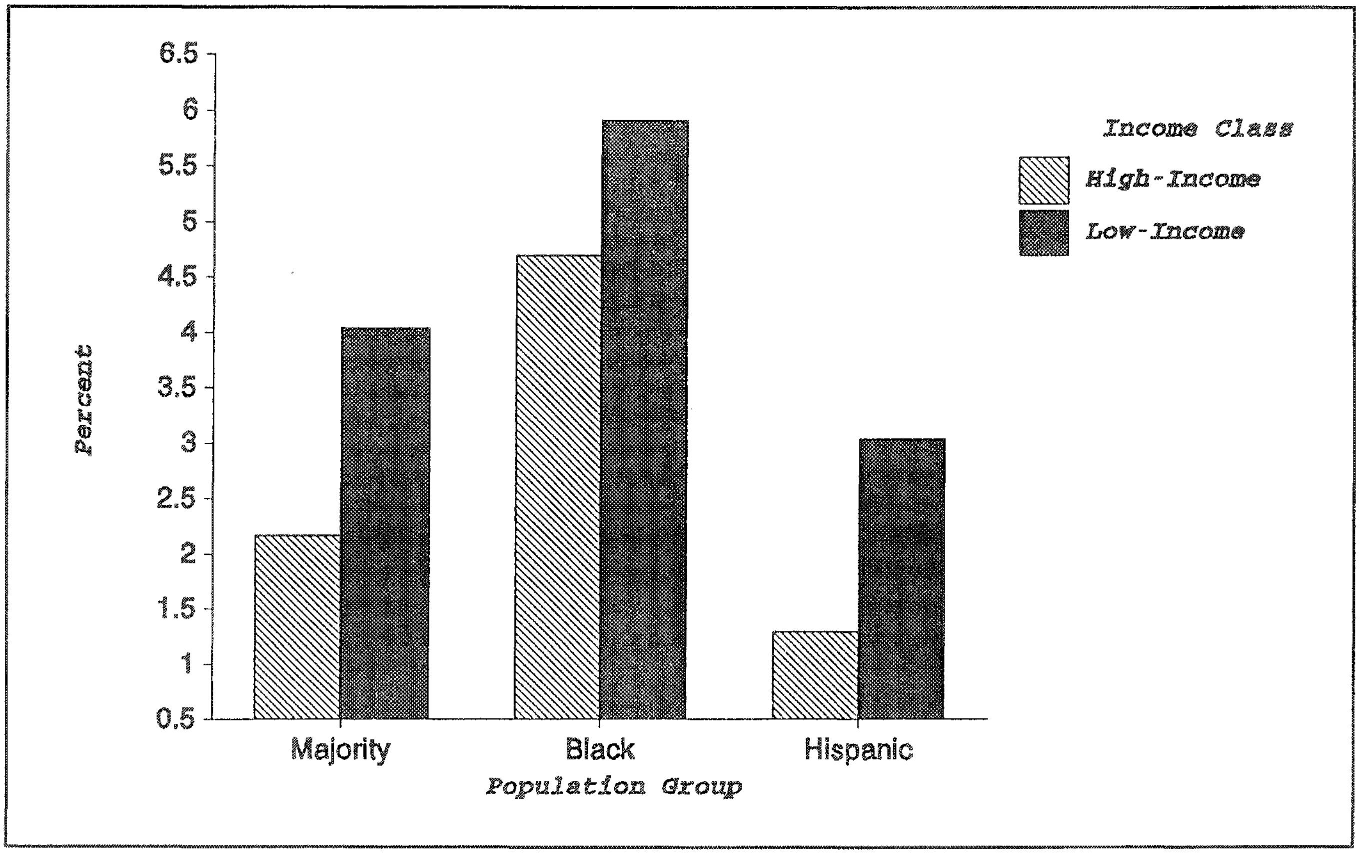

Figure 6. Estimated Percentage Change in Energy Expenditures: Increase in Household Members: Nonelectric Case

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