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An Econometric Analysis of Electricity Demand for the Residential Sector of Pakistan

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Abstract

This article presents an attempt to estimate electricity demand through various functional forms in the case of Pakistan using household level data. A number of articles on electricity demand estimate and interpret the results through different functional forms, such as linear, log linear and translog functional forms. However, none of the studies presents a comprehensive analysis based on the all three functional forms, especially in the case of Pakistan. The present article is an attempt to fill this gap by using household level data from Pakistan. Our findings show that total expenditure, house size, household size, heating degree days and temperature above threshold level may increase the demand for electricity. On the other hand, the price of electricity may decrease demand for electricity. An elasticity analysis shows that gas is a statistical substitute for electricity.

Keywords: Electricity Demand, Residential Sector, Pakistan

JEL Classification: Q41, R22

1. Introduction

Energy is a key determinant of economic growth in modern times. An uninterrupted and affordable supply of energy is very important in maintaining the pace of economic growth. Significantly, Mehrotra and Tuomas (2005) point out that the level of energy consumption is one of the basic components of economic growth along with the other determinants. There are various renewable and non-renewable sources of energy available, but electric energy is one of the most important. Since electricity is used in almost all human activities the demand for electricity has increased dramatically in the residential and industrial sectors over the last two decades both in developed and developing countries.

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The use of electricity has increased overwhelmingly in Pakistan, as in many other developing countries. Specifically, the annual average consumption of electricity has risen by more than 22 times over the last four decades.[2] This sharp rise in demand for electricity has changed the dynamics of the economy of Pakistan and has generated an imbalance between supply and demand of electricity in the residential as well as the industrial sectors. Furthermore, this imbalance is becoming increasingly severe with the passage of time. Therefore, a study based on scientific analysis may provide a timely guide for those policy makers in the energy sector handling this imbalance of electricity demand and supply.

The present study is an attempt to estimate the demand for electricity in the residential sector of Pakistan through different functional forms using household level data. Specifically, we estimate the impact of variables which are the reasons for fluctuations in demand for electricity at the household level. To the best of our knowledge, this is not a well-researched area despite its importance. Chaudary (2010), Khattak *et al.* (2010) and Jamil and Ahmad (2011) are the major studies that look at the determinants of household electricity demand using household level data. The study of Khattak *et al.* (2010) focuses on a region of Khyber Pukhtoon Khwa by using multinomial logistic model and Chaudary (2010) analyzes demand for electricity among households in the province of Punjab by using an endogenous switching model. Since the estimates of these studies cannot be generalized for the entire residential sector of Pakistan, both studies have limited scope at national level. Therefore, there is a need for a study at the national level exploring the determinants of household electricity demand. The present study aims to bridge this gap.

We conduct a national level analysis by using micro level data from 30,203 households. This analysis is based on household level data; by utilizing monthly data from the years 2004-05 and 2007-08, it provides grass roots information regarding the determinants of electricity demand by households. In addition, this article also estimates the energy demand system for Pakistan to determine what type of energy resources can substitute for electricity in the household sector.

The rest of the article is organized as follows. Section 2 will give a brief literature review on the subject. We shall set some functional forms in

[2] Author's calculations based on Economic Survey of Pakistan (various issues)

Section 3. The construction of variables and data sources will be discussed in Section 4. A detailed discussion of empirical results will be presented in Section 5 and, finally, Section 6 will conclude the study.

2. Literature Review

Prior research provides an abundance of studies on estimating energy demand functions using a variety of functional forms and data sets. A careful survey of the literature on electricity demand reveals that this area of research is well developed in terms of selection of functional form, choice of variables and choice of estimators. Prior researchers have used income, price of electricity and price of substitute energy sources as the conventional determinants of electricity demand.

A number of important studies are summarized in Table 1. The studies are classified by data set type as cross sectional, time series or panel data sets. The negative impact of own price on the electricity demand shows that electricity is a normal good in almost all the regions of the world (see Table 1). Importantly, the magnitude of the coefficient also reveals that the electricity is a necessity good in almost all the cases. The other important determinants which impact the demand of electricity are the household size and cooling degree days (Anderson, 1973). Importantly, Siddiqui (2004) notes that fuel adjustment surcharges may also reduce electricity demand in the case of Pakistan. The price of oil is also a significantly negative factor in the demand equation in the case of the southeast area of the United States (James *et al.*,1981).

On the other side, household income level, temperature, price of other energy substitutes, demand for electric appliances, household education level, weather, and urbanization are factors which increase the demand for electricity (see Table 1). However, the coefficient for these indicators varies from country to country and study to study. For example, Jamil and Ahmad (2011) present a review of the signs and magnitudes of income elasticity. The magnitudes of income elasticity and coefficient vary from country to country. Interestingly, there is no consensus about the magnitudes of the income elasticities for the same country in different studies (Silk and Joutz, 1997; Dergiades and Tsoulfidis, 2008).

Table 1: Summary of the Studies Estimating Household Electricity Demand

Study	Region	Data and Period	Findings (Effect on Electricity Demand by Household) Positive Effect	Negative Effect
Cross Sectional Studies				
Anderson (1973)	USA	HHLD 1968-69	Household income, Cost of gas, Fraction of population in non-metropolitan areas	Household size, Marginal cost of residential customers
Jarnes *et.al.*(1981)	USA	HHLD 1972-73	Electric appliances, Household income	Prices of electricity
Burney and Akhtar (1990)	Pakistan	HHLD 1985-86	Households income	Price of electricity
Maddock *et. al.* (1992)	Colombia	HHLD 1986-86	Personal characteristics of household, Households income	Price of electricity
Zarnikau (2003)	USA	HHLD 1993-94	Households income, Heating degree days, Price of natural gas, House size, Household size	Price of electricity
Reiss and White (2005)	California	HHLD 2000-01	Electric appliances, Heating degree days, Household income	Price of electricity
Khattak *et.al*.(2010)	(Pakistan)	HHLD Nov-Dec 2009	Highest education level among members of households as a proxy, House size, Dummy for weather, Household income	Price of electricity
Chaudary (2010)	(Pakistan)	HHLD 2003-04	Household income ,Urban region, Electric appliances	Price of electricity
Time Series Studies				
Anderson (1973)	California	1947-69	Household income, Temperature, Cost of gas, Fraction of population in non-metropolitan areas	Household size, Real cost to residential costumers
Westley (1984)	Paraguay	1970-77	Households income, Temperature	Marginal price of electricity, House size, Household size
Berndt and Ricardo (1984)	Mexico	1962-79	Urbanization, Household income	Price of electricity
Siddiqui (2004)	Pakistan	1980-1990	Price of kerosene oil, GDP	Fuel adjustment surcharges, Price of gas, Own price of electricity
Hondroyiannis (2004)	Greece	1986-99	Weather, Household income	Price of electricity
Kumar *et. al.* (2007)	Australia	1969-00	Price of natural gas, Temperature, Household income	Price of electricity
Halicioglu (2007)	Turkey	1968-05	Urbanization, Temperature, Household income	Price of electricity

Table 1: continued

Study	Region	Data and Period	Findings (Effect on Electricity Demand by Household): Positive Effect	Findings (Effect on Electricity Demand by Household): Negative Effect
Dergiades and Tsoulfidis (2008)	USA	1965-05	Stock of electric appliances, Household income, Price of oil	Price of electricity
Khan and Qayyum (2008)	Pakistan	1970 - 2006	Real income , Number of customers, Temperature	Price of electricity
Panel Data Studies				
Nelson (1965)	Sample markets in Nebraska,	1946-60	Home appliances. Household income	Own price of electricity
Bernard *et.al.* (1996)	Different samples for Queba,	1986-89	Home appliances, Household income, Price of oil, Price of natural gas	Own price of electricity
Haas and Schipper (1998)	OECD countries	1970-93	Heating degree days, Household income	Own price of electricity

Note: HHLD means House Hold Level Data

3. Econometric Specification and Estimation Strategy

A quick review of the literature on the subject suggests a number of factors which may drive the demand for electricity. For example it can be expressed as a function of household income, electricity price, prices of substitute energy resources, stock of energy, temperature and ownership of electric appliances. Keeping these predictors in mind, Zarnikau (2003) and Xiao *et. al.* (2007) suggest linear, log-linear and transcendental lograthemic (translog) models for quantifying the impact of these variables on electricity demand.

The present article follows Zarnikau (2003) and Xiao *et. al.* (2007) in using linear and log-linear functional forms to find how household electricity demand is explained by the price of electricity, household income, household size, house size, temperature and ownership of electric appliances in the case of Pakistan. Since the linear and log-linear functional forms are single equation models these equations look at electricity demand in isolation. In order to incorporate the role of other energy sources and other expenditures we shall estimate a translog model as well.

In linear functional form, the explanatory variables are assumed to affect energy demand in a simple linear fashion. Some alternative specifications may be expressed as:

$$KWH_i = \alpha_0 + \alpha_{PE} PE_i + \alpha_{HY} HY_i + \alpha_{HS} HS_i + \alpha_{HHS} HHS_i + \alpha_{HDD} HDD_i + \alpha_D D_i + u_i \quad (1)$$

$$KWH_i = \alpha_0 + \alpha_{PE} PE_i + \alpha_{HY} HY_i + \alpha_{HS} HS_i + \alpha_{HHS} HHS_i + \alpha_{TAT} TAT_i + \alpha_D D_i + u_i \quad (2)$$

In log-linear functional form the dependent variable is transformed into logarithmic form.

$$Ln(KWH)_i = \alpha_0 + \alpha_{PE} PE_i + \alpha_{HY} HY_i + \alpha_{HS} HS_i + \alpha_{HHS} HHS_i + \alpha_{HDD} HDD_i + \alpha_D D_i + u_i \quad (3)$$

$$Ln(KWH)_i = \alpha_0 + \alpha_{PE} PE_i + \alpha_{HY} HY_i + \alpha_{HS} HS_i + \alpha_{HHS} HHS_i + \alpha_{TAT} TAT_i + \alpha_D D_i + u_i \quad (4)$$

Where KWH_i is household's electricity consumption, PE_i is the average per unit price faced by a household, HY_i is the household's income, HS_i stands for the house size, HHS_i represents the household size, HDD_i is the number of heating degree days, TAT_i is the temperature above the threshold level and D_i is a dummy variable for owning the air conditioner. Its value is one if a household own an air-conditioner(s) and zero otherwise. In log-linear functional form the coefficients of explanatory variables give the percentage change in the dependent variable due to a unit change in the explanatory variable. An outcome of this transformation is that it does not show the constant effect of one unit change in the value of an explanatory variable over the dependent variable at all values of the explanatory variables.

The single equation model has certain limitation, as it looks at demand for electricity in isolation. Therefore, we shall estimate the system based on a translog model to incorporate the role of other energy sources and other expenditures. The translog model is more acceptable due to its flexibility. This model is mostly used in production analysis. However, its application in consumer theory is also common. As mentioned above, Uri (1982), Watkins (1992), Zarnikau (2003) and Xiao *et.al* (2007) have used it to estimate demand for energy resources. The translog expenditure function is based on a second order Taylor's expansion of the indirect utility function in logarithmic form. Using Roy's identity, the budget shares are given as:

$$S_i = \alpha_i + \sum_{i=1}^{n} \alpha_{ij} \left(\ln P_j\right) + \alpha_{TE,i} (\ln TE) \quad (5)$$

Where, S_i is the share of household's total expenditures on *i*th energy source. P_j is the average per unit price of *j*th energy source, faced by a household and TE_i is the household's total expenditure.

The shares add up to one and possess following restrictions:

$$\alpha_{ij} = \alpha_{ji} \text{ (Symmetry condition)} \tag{6}$$

$$\sum_{i=1}^{n} \alpha_i = 1,\ \sum_{i=1}^{n} \alpha_{ij} = 0,\ \sum_{i=1}^{n} \alpha_{TE,i} = 1 \text{ (Adding up condition)} \tag{7}$$

These restrictions ensure the homogeneity, symmetry and adding-up properties of demand functions. We consider three energy sources, electricity, gas and other energy sources. Other energy sources include kerosene oil and firewood. Along with three energy sources a fourth share equation will be of consumption expenditures other than energy sources.

We estimate the system of equations using Iterative Zellener efficient (IZEF) procedures. This procedure takes the least squares to estimate the system of equations and construct a consistent estimate of the covariance matrix from the least square residuals. The regression parameters are then estimated by using the estimated covariance matrix in first step and a new covariance is constructed. This procedure continues to iterate from estimates of parameter to estimate the covariance matrix until convergence achieved.

4. Variable Construction and Data

To accomplish our task, we use the micro level data taken from Pakistan Social Living Standard Survey (PSLM) for the years 2004-05 and 2007-08[3]. These surveys are conducted by the Federal Bureau of Statistics, Government of Pakistan. This gives us comprehensive data from 30,203 households. The exact information of the monthly survey is also available. So, we have data from 24 months with an average of 1258 observations for each month. The information on monthly income, electricity consumption, consumption of other energy sources, household size, house size and number of electric appliances is taken from the PSLM.

The data on prices is taken from the monthly consumer price indices which are also constructed by the Federal Bureau of Statistics, Government of Pakistan. The data on monthly temperatures for each region is taken from Pakistan metrological department[4]. Finally to work out the quantity of electricity consumed by each household we took the rate brackets from the Government of Pakistan Economic Survey (2009-10).

[3] PSLM 2007-2008 is the most latest version

[4] www.pakmet.com.pk

Following Zarnikau (2003) and Xiao *et. al*. (2007), we use quantity of electricity consumption by the household on the dependent side of the electricity demand regressions. However, the direct information on quantity of electricity consumed by a household is not available in our data sources. The only available information is total expenditures made by a household on electricity. This includes pure electricity cost, general sales tax, and electricity line meter rent and television fee. Therefore, we calculated the electricity consumption from this information in two stages. In the first stage we deducted the general sales tax, meter rent and television fee from the total spending and in second stage the units of electricity consumed were worked out by using the rate brackets for the surveyed years.

The expenditure shares of each energy source in total expenditures on energy made by each household is another important variable which is helpful in determining the relation between different energy sources. These energy sources are divided into three groups; electricity, gas and other energy sources. Other energy sources include firewood and kerosene oil. The expenditure on each energy source is reported in the PSLM. The share of expenditure on each energy source is calculated by dividing expenditure on each source by household total expenditures.

In most of the regions of Pakistan the climate does not remain the same throughout the year. Even in tropical regions winters are cold. Since the consumption of electricity varies with climate it may be an important predictor of residential demand for electricity. The literature suggests that temperature is the fundamental unit for measuring climate. Consequently, the present study takes temperature as a proxy for climate. The data on the temperature of major cities is taken from the Pakistan Meteorological department. We have measured it in two ways; heating degree days (HDD) and temperature above the threshold level (TAT).The temperature of 34.90c is taken as threshold level. Heating degree days indicates the number of days in a month when temperature gets above 34.90c. The temperature above the threshold level means the number of degrees centigrade above 34.90c.

Ownership of electric appliances is another factor that affects the demand for electricity. Air-conditioners, refrigerators, electric irons, electric heaters and other high voltage appliances are the primary users of electricity.

5. Empirical Results

We utilize different functional forms to get an idea of the statistical magnitude of electricity demand in the residential sector of Pakistan. For this purpose, we estimate both single equation and system based models. As mentioned above, the single equation based models are proposed in the linear and log linear specifications. Linear and Log linear models are estimated following Xiao *et. al*. (2007). In linear and log linear models, we use the alternative measures (HDD and TAT) for capturing the impact of temperature. These are Heating Degree Days and Temperature above Threshold level (see Table 2).

Table 2: Parameters of Single Equation Models

	Linear Model		Log-Linear Model	
	With HDD	**With TAT**	**With HDD**	**With TAT**
	Model: 1	**Model: 2**	**Model: 3**	**Model: 4**
Intercept	210.92***	197.34***	1.96**	4.69**
Price of electricity (PE)	-142.13**	-125.58**	-0.462**	-0.31***
Total expenditure (TE)	0.0061**	0.0061**	0.0002***	0.0002***
Heating degree days (HDD)	0.694**	NA	0.003**	NA
Temperature above threshold level (TAT)	NA	0.077*	NA	0.0002*
House size (HS)	4.784**	4.51**	0.049***	0.045*
Household size (HHS)	0.105***	0.105***	0.009***	0.011**
Dummy variable for ownership of AC (D)	90.35**	91.02***	0.219**	0.319**
Diagnostic check				
$\mathbf{R^2}$	0.4769	0.4744	0.2927	0.2878
Adjusted $\mathbf{R^2}$	0.4768	0.4742	0.2923	0.2877

Note: *, **, *** implies that the coefficients are significant at 10 percent 5 percent and 1 percent respectively. The standard errors are White's heteroscidascity consistent.

The signs of the coefficients for price of electricity, total expenditures, house size and households' sizes match our expectations. The negative sign for price of electricity in all four models implies that the demand for electricity will decrease as the price of electricity increases. Similarly, the demand for electricity may rise as household size or house size increases. Importantly, all these coefficients are statistically significant in the regression equations. The R^2 shows that almost 48 percent of the variation in the dependent variable is explained by the independent regressor of the equation.

The difference between Model 1 and Model 2 is that we replace TAT with HDD. The second column of Table 2 gives the linear model estimates with TAT (see Model 2). The replacement of HDD by TAT has no effect on the signs of the other coefficients and its coefficient is also positive. This indicates that high temperature causes an increase in electricity demand whether measured by TAT or number of HDD. However both variables have different interpretations. The coefficient of HDD shows an average increase in electricity consumption due to increase in HDD in a month. The coefficient of TAT gives the increase in electricity consumption due to one unit increase in temperature above 34.90c. The coefficient of TAT is 0.077 indicating that on average during a month if temperature on any day gets above 34.9c, then a 0.1c increase in temperature increases consumption of electricity by 0.077 units. The coefficient of HDD is 0.694. It indicates that on average during a month each additional heating day causes a 0.694 unit increase in consumption of electricity.

5.1 Results of Translog Model

The four models estimated in the last section are single equation models and describe the demand for electricity in isolation. They do not show the impact of other energy sources on electricity demand. To avoid this problem we use a translog model to estimate the complete demand system of the consumer. In our analysis, we included three energy sources: electricity, gas and other. The ‘other’ category includes kerosene oil and firewood. Along with the three energy sources we treated all other commodities as a single commodity group. The system has four equations. In order to impose the cross-equation symmetry restrictions, we dropped the fourth equation. The parameters of the dropped equation were estimated through restrictions. The translog model was estimated in two ways. First, we took all prices and total consumer expenditures. Later on variables of household size, house size and climate are also incorporated.

Translog demand function basically explained through indirect utility function which is the function of expenditure and prices. Therefore in first part of our analysis we just took price and expenditure. The results of these analyses are given in Table 3.

All intercepts except the share of electricity are significant. Most of the price coefficients and all expenditure coefficients are significant. The intercept terms and coefficients of total expenditure are strictly positive, while the price coefficients have mixed signs. However, the important outcome of this analysis is the corresponding elasticities. The elasticities are reported in Table 4.

Table 3: **Translog Estimates with Prices and Total Expenditure**

	Share of electricity	**Share of gas**	**Share of other energy sources**	**Share of rest of commodities**
Intercept	0.003	0.026**	0.021**	0.95***
Price of electricity	0.041**	-0.002	-0.022***	-0.017**
Price of gas	-0.002	-0.002	0.018**	-0.014**
Price of other energy sources	-0.022**	0.018**	-0.00098	0.005
Price of rest of commodities	0.022*	-0.005***	-0.02*	0.003
Total expenditure	0.001***	0.001***	-0.007	0.0005***

Note: *, **, *** implies that the coefficients are significant at 10 percent 5 percent and 1 percent respectively. The standard errors are White's heteroscidascity consistent.

Table 4: **Own and Cross Price Elasticities (with only prices and expenditure)**

	Electricity	**Gas**	**Other energy resources**	**Rest of commodities**
Electricity	0.11	-0.23	-0.68	0.05
	(3.25)	(-6.35)	(-18.80)	(1.49)
Gas	-0.23	-1.16	1.04	-0.04
	(-6.35)	(-117.51)	(105.90)	(-4.94)
Other energy sources	-0.68	1.04	-1.00	0.002
	(-18.80)	(105.90)	(-37.40)	(0.20)
Rest of commodities	0.05	-0.04	0.002	**1.06**
	(1.49)	(-4.94)	(0.20)	(1.14)

Note: *, **, *** implies that the coefficients are significant at 10 percent 5 percent and 1 percent respectively. The standard errors are White's heteroscidascity consistent.

Own price elasticity of demand for gas and other energy sources is negative and that of electricity and rest of the commodities is positive. This indicates that when electricity demand is analyzed along with the demand for other energy sources, it has a positive relation with price. The cross price elasticity between most of the energy sources is negative. This indicates that energy sources are complementary which again is a strange finding.

Next we estimate a full model including climate, house size and household size. Climate is measured in two ways; through TAT and HDD. Among these, HDD is more simple and comprehensible. It simply gives the effect on energy consumption due to each additional heating degree day. Therefore in our final analysis we take HDD as our measure of climate. The results of the estimated Translog share equations are given in Table 5.

Table 5: Translog Estimates with All Considered Variables

Variables	Share of electricity	Share of gas	Share of other energy sources	Share of rest of commodities
Intercept	0.012	0.02**	0.009	0.959***
Price of electricity	0.04**	0.005*	-0.016**	-0.029*
Price of gas	0.005*	-0.004**	0.017***	0.018***
Price of other energy sources	-0.016*	0.017**	-0.017**	-0.016
Price of rest of commodities	-0.001	-0.029**	0.038**	-0.005
Total expenditure	0.01**	0.02**	-0.08***	0.05**
Heating degree days	0.00015**	-0.00007**	-0.0004**	0.0003**
House size	0.0006**	0.001**	0.0003**	-0.002***
Households' size	-0.0007***	-0.0004***	0.0006**	0.0005**

Note: the t-statistics are presented in the parenthesis

The coefficient of HDD is positive for electricity and negative for the other two energy sources. This result matches our expectations. In the hot season demand for high voltage appliances like air-conditioner increases, so consumption and thus share of electricity in total expenditure also increases. Gas, kerosene oil and fire wood are mainly used for cooking and heating. Consequently, the negative sign on HDD for gas and firewood makes sense. The coefficient for house size is positive for all commodities. It indicates that as house size increases the demand for energy sources also increase which also is unsurprising. The coefficient for household's size is negative for electricity and gas, which indicates that as household size increases the share of these two energy sources decreases. The coefficient of total expenditure in all case is near to zero. It indicates that as total expenditure increases, the allocation of the expenditure remains almost unchanged. To be more accurate, the share of expenditure spent on electricity, gas and other commodities shows a minor increase and the expenditure share spent on other energy sources decreases.

We many now turn to the elasticities obtained through the share equations of the translog model. The elasticities are given in Table 6. All own price elasticities are negative except electricity. This indicates that demand for all energy sources, and the rest of commodities showed negative relation with price. However the system results show that price has a positive impact on the demand for electricity.

Table 6: Elasticities Based on the Estimates of Table 5

Cross and own elasticity	Electricity	Gas	Other energy resources	Rest of commodities
Electricity	0.12	0.63	-0.58	-5.86
	(4.50)	(17.03)	(-16.02)	(-161.01)
Gas	0.63	-1.46	0.64	-0.02
	(17.03)	(-147.92)	(65.48)	(-2.24)
Other energy sources	-0.58	0.64	-1.63	0.06
	(-16.02)	(65.48)	(-60.54)	(2.54)
Rest of commodities	-5.86	-0.02	0.06	-0.08
	(-161.01)	(-2.24)	(2.54)	(-0.08)

Note: the t-statistics are presented in the parenthesis

The resulting cross-price elasticities show that cross price elasticity between electricity and gas is positive. It indicates that with an increase in price of any one the demand for the other also increases. Although electricity and gas are not substitutes of each other in the context of a household, in other substantial cases they do serve as substitutes for each other. For example gas can also be used for lightning; electricity can be used for cooking. Due to these relations the positive coefficient of cross price elasticity of demand between these two is understandable.

The coefficient of cross price elasticity of demand between electricity and *other energy sources* is negative. This implies that when the price of electricity increases then consumers are forced to decrease their demand for minor energy sources as well as their demand for electricity. The cross price elasticity of demand between gas and other energy sources is positive. This indicates that other energy sources are substitutes for gas. This is not a surprise because in many areas of Pakistan firewood is being used as a substitute for natural gas in the residential sector.

The results of the single equation model show that household electricity demand has a negative relation with its own price and that all other variables including house size, household size, temperature, household income and ownership of air-conditioners have positive effect on household electricity demand. Results showed that house size and total expenditure have positive effect on consumption of all energy sources. Heating degree days leads to increase in the consumption of electricity and decrease in the consumption of gas. The own price elasticity for all energy sources is negative with the exception of electricity. This finding is contradictory with the results of the single equation models. The comprehensive version of the translog model showed that cross-price elasticity of demand between electricity and gas is positive and negative between electricity and other energy sources.

6. Concluding Remarks

This article is an attempt to investigate the determinants of electricity demand in the case of Pakistan by using household level data from 2004-05 and 2007-08. The other novelty of the paper is that we use three different functional forms in order to get a clear look at the patterns of the statistical parameters of electricity demand. These functional forms are linear, log linear and translog functional forms.

The linear and log linear models show that total expenditure, house size, household size, heating degree days, and temperature above threshold level may increase demand for electricity, and higher price of electricity may decrease the residential demand for electricity. The signs and significance of elasticities through translog parameters indicate gas is a close substitute for electricity in the case of Pakistan. The sign of all own price elasticities, except electricity, were negative.

The other important determinant is climate. Both TAT and HDD cause an increase in the demand for electricity and a decrease in the consumption of gas, kerosene oil and firewood. This finding is as per expectations that demand for air-conditioners increases in hot days and thus causes an increase in consumption of electricity. House size also leads to an increase in consumption of all energy sources and all other consumption goods, while household size has negative impact on the consumption of electricity and gas.

The results of the study show that energy prices, household income, household size, climate and house size all play an important role in determining the demand for electricity. Therefore, demand side policies can play a vital role in decreasing the gap between electricity demand and supply. Some determinants, like energy prices and household size, can be influenced by government policies. Energy prices, for example, can be influenced through the system of taxation, and household size through family planning programs. Recently, it has become standard practice in different European countries for government to educate households to decrease electricity consumption in order to conserve resources and avoid waste.

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