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Fuel Demand Elasticity in Pakistan: An Analysis Based on Household Integrated Economic Survey (HIES)

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Abstract

The study aims to estimate fuel demand elasticities for domestic sector in Pakistan. The study applies the Linear Approximate Almost Ideal Demand System (LA-AIDS) using micro data of Household Integrated Economic Survey (HIES) for the year 2007-08. The LA-AIDS model is also expanded by making intercept as linear function of different household characteristic. The price and expenditure elasticities of demand for five major fuel items (electricity, gas, firewood, kerosene & dung cake) are estimated. The analysis has been carried out for rural and urban areas of Pakistan. The results of expenditure elasticities imply that all energy sources are necessity for all rural and urban households. It is also found that own price elasticities are greater than one which indicates energy items are price elastic. It is evident that education has positive impact on electricity budget share and negative impact on dung cake and firewood in most of the cases.

Keywords: LA-AIDS, Energy Demand, Own and Cross Price Fuel Elasticity, Expenditure Elasticity,

Introduction

The use of energy is important for the welfare of households in developed as well as in developing countries. The importance of energy can be traced by the share of expenditures on energy by the households. Transition from use of one form of energy to the use of modern forms of energy such as from wood to Liquefied Petroleum Gas (LPG) for cooking purposes can be an indicator of increased welfare. The share of household energy expenditures is likely to vary due to household personal income, energy prices, household size, and other household characteristics. The nature of household demand for energy and its determinants have crucial importance for forecasting its current and future needs. So, it is necessary to examine the sensitivities of household energy demand with respect to energy prices and expenditures.

During last five years, Pakistan's energy policy focused on installation of new energy projects. Moreover, along with the installation of new projects, government also continues to diversify energy supply to meet energy needs. With shortage of energy inputs, there is also continues increase in energy demand. So it is highly desirable to conduct the sensitivity of households' energy demand to income and prices. This is because households constitute the largest group of energy demand. According to Economic Survey of Pakistan (2017-18), household sector account for more than 50% of total electricity consumption. Moreover, along with industry and agriculture sectors, household sector is one of the largest sectors of Pakistan in overall energy consumption. The energy budget share of household is an important question.

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Country's energy policies can be extracted from the empirical research on household energy consumption patterns which provide evidence on consumer responses to income and price changes. These estimates of price and expenditure elasticities of various energy items can help policy makers in setting up of energy prices, taxes and subsidies. These elasticities can also help in assessing the impact of energy policies on different segments of the society. Guta (2011) have empirically analyzed the energy demand by applying LA-AIDS model for rural households in Ethiopia. The empirical results of the study imply that demand for inferior fuel is inelastic and is elastic for advanced fuel.

Chambwera (2004) used AIDS (Almost Ideal Demand System) to analyze urban household fuel demand in Harare, Zimbabwe, in an energy mix context, has found a strong substitution effect between different fuels. Campbell *et al*. (2003) in their study of energy transition indicated that with a rise in income a household switch from wood through kerosene to electricity. Baker *et al.* (1989) analyzed household energy expenditures for United Kingdom using micro data for the years 1972-83. The study employed two stage budgeting model of energy demand. The study concludes that income elasticities for the fuel are positive and small while price elasticities are large specifically for electricity. There are many other studies which try to estimate demand elasticity for fuels based on household survey data (Heltberg, 2003; Gupta & Konlin, Köhlin; Gundimeda & Köhlin, 2006; Jamasb & Meier, 2010; Hössinger *et al*. 2017).

In case of Pakistan, a small number of studies such as Iqbal (1983) estimated residential demand for electricity and natural gas in Pakistan using annual data from 1960 to 1981. Later Burney and Akhtar (1990) have estimated fuel demand elasticities using micro data. The study reported that consumption of oil, natural gas, coal and electricity are highly price inelastic, so these are necessities for Pakistani households. Likewise Chaudhary *et al*. (1999) estimated energy elasticities for industrial, agriculture and energy products. Their estimates suggest that the demand for all type of petroleum products is price inelastic. Bacon *et al*. (2009, 2010) have estimated fuel demand elasticities for Pakistan using quintile groups. But quintile groups do not provide the individual responses that are needed for policy purposes. There is no study found in literature that estimated fuel demand elasticities at provincial level.

Rama *et al*. (2015) while analyzing the effects of energy subsidies concluded that these subsidies disproportionately affected households in Pakistan. The richest 20 percent households got around 40 percent of the subsidies while poorest 40 percent households received less than 30 percent of the total electricity subsidy. Khan *et al*. (2015) tried to estimate income and price elasticities for different categories of fuels using the Extended Linear Expenditure System, for the periods 2001-02 and 2010-11. The study conclude that electricity followed by natural gas been the dominant fuel for urban households while firewood and electricity have been the main fuels for rural households. The study also found that urban households spent proportionately less on fuels compared to rural counterparts.

Kojima (20016) analyzed the consumption of various energy components using micro data for the years 1994, 1997, 1999 and 2001. The study concludes that household energy mix have changed from kerosene-biomass-electricity in 1994 to biomass-electricity in 2001. Further study also highlighted that consumers did not cut back on their consumption of natural gas and electricity but they did cut back consumption of kerosene and LPG. Tehseen and Khan (2017) using the survey of 16,341 households covering the period 2010-11, analyzed the electricity demand. According to their finding income have no effect while price play a significant role in the determination of electricity demand. In another study, Omer (2018) suggest that fuel demands in Pakistan are generally (own & cross) price inelastic in the short run, but are relatively elastic in the long run. One percent increase in the price of petrol, CNG, or diesel leads to 0.28, 0.66 and 0.21 percent decrease in their demands, respectively. Moreover, income elasticity estimates suggest that petrol is a normal good while diesel and CNG are inferior goods.

Given the importance of demand elasticities, the present study aims to estimates fuel demand elasticities for Pakistan. The existing literature for fuel demand elasticities is either too old or they have just estimated elasticity for one type of fuel. The present study estimates the elasticities for various types of fuels by employing comprehensive econometric technique. The present study used two stage budgeting process to estimate elasticities of different types of fuels. Among these, in the first stage, household decides that how much they spend on fuel and non-fuel commodities. In the second stage, they decide how much on each of the category of fuel should be spent out of their fuel expenditures. Haq *et al*. (2011) has used two stage budgeting process to estimate demand for food, however no study used this approach to estimate fuel demand elasticities. The present study aims to bridge the gap by conducting own price elasticities of different fuels and addresses the scope of energy substitution by estimating cross price elasticities of different fuels.

Methodology

LA-AIDS Model and Estimations

In literature, choice of appropriate functional form of the demand model remained in question. Mainly the demand model is selected on the basis of relative exploratory power, theoretical consistency and simplicity and easy to estimate. There are many demand systems such as: Indirect Translog System, Generalized Linear Expenditure system, and Quadratic Expenditure System. Another type of demand system is Almost Ideal Demand System (AIDS), a demand system proposed by Deaton and Muellbauer (1980). The AIDS model can be seen as the most appropriate and major breakthrough in demand system generations.

Deaton and Muellbauer (1980) developed a flexible demand system called Almost Ideal Demand System (AIDS) having properties which are consistent with theory of demand. In testing the maintained hypothesis of demand theory such as zero homogeneity of demand functions, the AIDS Model has major advantage over other flexible functional form models. According to them, the AIDS parameters, for national levels correspond better to observed household demand behavior than parameters obtained through any other flexible functional form model.

Derivation of AIDS model

The Cobb Douglas utility function, reflecting additive preferences between subsistence and above subsistence or bliss level of consumption, is at the root of AIDS. Following the notations of Deaton and Muellbauer (1980), if for a given commodity, consumption is divided between subsistence level a and bliss level b then the Cobb Douglas utility function takes the following form:

$$V(q) = a^{1-u} b^{u} \qquad \text{............... (1)}$$

Where, "$1 - u$" indicates the proportion of subsistence and "u" indicates the proportion of "bliss" level consumption. The direct expenditure function, containing the utility level derived from consumption may be written as follows:

$$C(U,P) = (p.a)^{1-u} (p.b)^{u} \qquad \text{............... (2)}$$

Where, P is the price vector. In estimating expenditure levels, "*a.p" and "b.p"* may be replaced with general function:

$$C(U,P) = a(p)^{1-u} b(p)^{u} \qquad \text{............... (3)}$$

If expenditure function remains linearly homogenous in "a" and "b" which in turn remain linearly homogenous in prices, the demand equations derived from it will be homogeous of degree zero in prices. Since Cobb- Douglas utility function is closely tied to linear expenditure system. Expenditure function, based on it are called " general linear expenditure function". Since this type of expenditure function are independent of prices. It may be called "Price Independent General Linear Expenditure Function (PIGL)".

$$ln\ C(U,P) = (1-u)\ ln\ a(p) + u\ ln\ b(p) \qquad \text{............... (4)}$$

Where $a(p)$ and $b(p)$ are the function of prices, p is the price vector and u denotes the utility. Hence, a PIGL expenditure function may take a logarithmic form as shown in the equation. Functions like above equation are called "price independent, general linear log functions" or (PIGLOG). Deaton and Muellbauer (1980) began their derivation of AIDS by specifying "$a(p)$" and "$b(P)$". They specified following two functions:

$$ln\ a(p) = \alpha_0 + \sum_i \alpha_i\ ln\ P_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij}^{*}\ ln\ P_i\ ln\ P_j \qquad \text{............... (5)}$$

$$ln\ b(p) = ln\ a(p) + \pi_k\ p_i^{\beta k} \qquad \text{............... (6)}$$

These equations were selected, because they lead to a system of demand functions with desirable properties. Combining the two equations yields the AIDS expenditures:

$$ln\ C(U,P) = \alpha_0 + \sum_i \alpha_i\ ln\ P_i + ½ \sum i \sum j\ \gamma_{ij}^{*} lnP_i\ lnP_j + \bar{U}\beta_0\pi_i p_i^{\beta i} \qquad \text{.............. (7)}$$

Where, α_i, β_i and γ_{ij}^{*} are the parameters and γ_{ij}^{*} = ½ (γ_{ij} + γ_{ji}), P_j are the prices and $\bar{U}$ is the utility level. From this expenditure function, we can derive the demand functions. By applying Sheppard's Lemma, the first derivative of the expenditure function with respect to commodity's price yields demand equation for the same commodity.

$$\frac{\partial C(U,p)}{\partial P_i} = q_i \qquad \text{............... (8)}$$

The demand function approximates are "first order" because they are based on first derivatives. AIDS demand functions can be defined in terms of budget share. Multiplying both sides of equation (8) by $\frac{p_i}{C(U,p)}$ yields:

$$\frac{\partial C(U,\ P)}{\partial P_i}\ \frac{p_i}{C(U,p)} = \frac{q_i p_i}{C(U,p)} = \ w_i \ ....\ (9)$$

The logarithmic differentiation of the expenditure function gives market shares:

$$w_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij}\ ln\ p_j + \beta_i\, U \beta_0 \pi\ p_i^{\beta_i} + e_i\ \ ....\ (10)$$

Utility maximization means spending at the level of the budget constraint, setting the share equation equal to total expenditure (X), expressing total utility. Equation (10) will be AIDS demand function in share form:

$$w_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij}\ ln\ p_j + \beta_i\ ln\left[\frac{X}{P}\right]\ ....\ (11)$$

Where, w_i indicates budget share of good i, P_j indicates the price of good j, X indicates the total expenditure, n indicates the number of goods, P indicates the price index, and $\propto_i$, γ_{ij}, and β_i are the parameters. Approximated by Stone's price index $ln(\mathrm{P}) = \sum_j w_j\, ln(p_j)$.

The Stone's price index developed by Stone (1954) is used to deflate the expenditure of the i^{th} household. The price index is constructed for each household by multiplying the log of price of j^{th} commodity faced by the household with the average budget share of j^{th} commodity for all households. The price index (P^*) is obtained by the summing the product over all commodities. This version is called Linear Approximate Almost Ideal Demand System, or LA-AIDS. The interpretation of LA-AIDS is simple: market shares change with respect to relative prices and real expenditure. The theoretical restrictions on demand function are as follows:

Adding-up: $\sum_1^n \alpha_i = 1$, $\sum_1^n \gamma_{ij} = 0$, $\sum_i \beta_i = 0$

Homogeneity: $\sum_j \gamma_{ij} = 0$

Symmetry: $\gamma_{ij} = \gamma_{ji}$

By using the following relationship proposed by Pollock and Wales (1978), equation (11) is augmented with household specific, demographic and socio economic characteristics:

$$\alpha_i \ = \ \alpha_i^* \ + \sum_j \delta_{ij} z_j \qquad ....\ (12)$$

Where, z_j indicates the socio economic variables and δ_{ij} indicates the parameters of socio economic variables. The socio economic variables includes: binary variables for employment of the household head (self-employed, farming, public/private sector employee) and a binary variable for literacy of the head of the household. Substituting equation (12) into equation (11):

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \sum ln\ P_j + \beta_i ln\left(\frac{X}{P}\right) + \sum_j \delta_{ij}\, z_j + e_i \quad ....\ (13)$$

Price and Expenditure Elasticities of Demand

The own price, cross price and expenditure elasticities can be estimated as follows:

Own price elasticity of good I:

$$\varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{w_i} - \beta_i \quad \text{............... (14)}$$

Cross price elasticity for good i with respect to good *j*:

$$\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \left(\frac{w_j}{w_i}\right) \quad \text{............... (15)}$$

Where δ_{ij} is kronecker delta and is equal to one for own price and zero for cross price elasticities. The Expenditure elasticity is:

$$\eta_i = 1 + \frac{\beta i}{w_i} \quad \text{............... (16)}$$

Econometric Formation of LA-AIDS Model

The final equation is estimated for rural and urban areas and for entire Pakistan. The budget shares and prices included in the equation are for five energy commodities: Electricity (e), Natural Gas (g), Firewood (d), Dung cake (f) and Kerosene (k).

$$w_e = \alpha_e + \gamma_{ee} \ln p_e + \gamma_{eg} \ln p_g + \gamma_{ek} \ln p_k + \gamma_{ef} \ln p_f + \gamma_{ed} \ln p_d + \beta_e \ln(X/P^*) + \delta Z + \varepsilon_e$$

$$w_g = \alpha_g + \gamma_{gg} \ln p_g + \gamma_{ge} \ln p_e + \gamma_{gk} \ln p_k + \gamma_{gf} \ln p_f + \gamma_{gd} \ln p_d + \beta_g \ln(X/P^*) + \delta Z + \varepsilon_g$$

$$w_d = \alpha_d + \gamma_{dd} \ln p_d + \gamma_{de} \ln p_e + \gamma_{dk} \ln p_k + \gamma_{df} \ln p_f + \gamma_{dg} \ln p_g + \beta_d \ln(X/P^*) + \delta Z + \varepsilon_d$$

$$w_f = \alpha_f + \gamma_{ff} \ln p_f + \gamma_{fe} \ln p_e + \gamma_{fk} \ln p_k + \gamma_{fd} \ln p_d + \gamma_{fg} \ln p_g + \beta_f \ln(X/P^*) + \delta Z + \varepsilon_f$$

$$w_k = \alpha_k + \gamma_{kk} \ln p_k + \gamma_{ke} \ln p_e + \gamma_{kf} \ln p_f + \gamma_{kd} \ln p_d + \gamma_{kg} \ln p_g + \beta_k \ln(X/P^*) + \delta Z + \varepsilon_k \quad \text{............... (17)}$$

This system of share equations has 55 parameters. The subscripts w_e, w_g, w_d, w_f and w_k represent the expenditure share on electricity, natural gas, dung cake, firewood, and kerosene, respectively[4]. In the view of fact that disturbance terms are not linearly independent and that one of the equations can be deleted. This means estimators of one of the equation can be obtained through the homogeneity property. Here we delete the last equation in the estimation process and use the following restrictions based on homogeneity property:

$$\gamma_{ee} + \gamma_{eg} + \gamma_{ek} + \gamma_{ef} + \gamma_{ed} = 0 \quad \text{............. (18)}$$

This implies that:

$$\gamma_{ee} + \gamma_{eg} + \gamma_{ef} + \gamma_{ed} = -\gamma_{ek}$$
$$\gamma_{gg} + \gamma_{ge} + \gamma_{gk} + \gamma_{gf} + \gamma_{gd} = 0$$

[4] For detailed description of variables see Appendix C.

$$\gamma_{kk} + \gamma_{ke} + \gamma_{kg} + \gamma_{kf} + \gamma_{kd} = 0$$
$$\gamma_{dd} + \gamma_{de} + \gamma_{df} + \gamma_{dg} + \gamma_{dk} = 0 \text{ .... } (19)$$

Moreover, symmetry implies that $\gamma_{eg} = \gamma_{ge}$, $\gamma_{ek} = \gamma_{ke}$, $\gamma_{ed} = \gamma_{de}$, $\gamma_{gk} = \gamma_{kg}$, $\gamma_{gd} = \gamma_{dg}$, and $\gamma_{kd} = \gamma_{dk}$. These restrictions are used to recover the deleted equation.

Problem of Missing Prices

When information on prices is not available then the problem of missing prices arises. Cox and Wohlgenant (1986) proposed the solution of this phenomenon. The authors recommended that at first step discard the incomplete observations and estimate the parameters by using remaining observations. At second step, use the sample means for missing values. In the present study to retain sample observations, missing values are replaced by sample mean value at *District* level.

Estimation Procedure of LA-AIDS Model

For estimation of LA-AIDS model while imposing theoretical restrictions of symmetry and homogeneity, Zellner's Iterative Seemingly Unrelated Regression (ITSUR) will be used Zellner (1962). The SUR model may improve the efficiency of estimated parameters when there is correlation across equations. The set of restrictions led to singularity. We have dropped one share equation of kerosene form the system of equations. Using the other estimated parameters of remaining four equation and the restrictions applied above, we then obtain the parameters of dropped equation.

In the analyses, we shall perform complete demand system for energy for entire Pakistan, Rural and Urban Pakistan separately. The second part of our analysis aims to present the cross price, own price, and expenditure elasticities of energy demand to determine how demand for various sources of energy is affected by its prices, household expenditure and household characteristics.

Data

This study has used cross sectional data of household expenditure micro data from Household Income and Expenditure Survey (HIES) for the year (2007-08). A smililar study based on household electricity expenditure data is carried out by Fell *et al*. (2010). These kind of household surveys are without the information regarding quantity and price. In the present study, HIES is used to estimate a demand system for five energy components. These components are electricity, natural gas, firewood, dung cake and kerosene. The information on household's monthly fuel expenditure, consumption of fuel components and household characteristics such as literacy of household head, and employment of household head, agriculture as employment, self-employed and paid employee are taken from HIES. The data on prices of kerosene, dung cake and firewood are taken from HIES by dividing total quantity consumed to total value of the particular fuel. The data on prices of electricity we took the tariff brackets which are taken from Economic Survey of Pakistan (2011-12), published by Finance Division Government of

Pakistan and data on prices of natural gas we took tariff brackets which are published by Oil and Gas Regulatory Authority (OGRA)[5].

Results Based on LA-AIDS Model

The restrictions of homogeneity and symmetry condition are imposed on unrestricted SUR model and test for restriction is applied by using *Wald Coefficient Test*. The results of Wald Coefficient Test hold the homogeneity and symmetry conditions which imply that the restriction can be enforced, and the estimated results are consistent with theory. The adding up restriction will automatically impose. Tables in appendix display the parameter estimates.

In the tables presented in Appendix-C and D, price of related commodities, household expenditure and other household characteristics are the explanatory variables. Among the household characteristics we have considered education of household head and employment or occupation to see whether or not it makes a difference being self-employed, paid employed or agriculture as employment. In the table, coefficients of each parameter along with statistical significance as indicated by t-values are presented. Further own and cross price elasticities for Pakistan are presented in Table 1.

Table 1: *Own and Cross Price Elasticities of LA-AIDS Model for Pakistan*

Cross and Own price elasticities	Electricity	Gas	Dung cake	Firewood	Kerosene
Pakistan					
Electricity	-.30	-.07***	-.11***	-.23	-.49
Gas	-.07***	-1.21***	.18	.07**	.53
Dung cake	-.11***	.18	-1.26	.01***	.44
Firewood	-.23	.07**	.01***	-.76	-.27
Kerosene	-.49	.53	.44	-.27	-2.07
Rural Pakistan					
Electricity	-.22	-.11	-.17	-.18	-.74
Gas	-.11	-1.40	.22	.04***	1.39
Dung cake	-.17	.22	-1.22	.01***	.55
Firewood	-.18	.04***	.01***	-.74	-.65
Kerosene	-.74	1.39	.55	-.65	-.25
Urban Pakistan					
Electricity	-.40	-.06	-.05*	-.30	-.18
Gas	-.06	-.72	.06***	.04***	-1.05
Dung cake	-.05*	.06***	-1.23	.04***	.19
Firewood	-.30	.04***	.04***	-.76	.18
Kerosene	-.18	-1.05	.19	.18	-2.24

****, **, * indicate significance at 99%, 95%, and 90% level of confidence, respectively*

In part (a) all own price elasticities have expected negative signs. Only own price elasticity of natural gas has significant effect. The estimates show that own price of electricity is highly inelastic, price of firewood are relatively inelastic while price of dung cake, kerosene and natural gas are elastic, having sign greater than one. The cross price complementary effects are found between electricity and dung cake is statistically significant and natural gas and electricity which implies that a fall in the price of

[5] For detail see Appendix-A and Appendix-B.

electricity will increase the demand for natural gas. While cross price substitution effects are found between natural gas and firewood, and between dung cake and firewood, which implies that an increase in the price of firewood the demand for natural gas will increase.

In part (b) of table own and cross price elasticities are presented for rural Pakistan. All own price elasticities have expected negative signs. But none of the elasticities is statistically significant. Price elasticity of electricity and firewood are inelastic while price of natural gas and dung cake are elastic having signs greater than one. Electricity with all other fuel has complementary effect but not statistically significant. Significant substitution effect is found between natural gas and firewood, firewood and dung cake.

In part (c) of the table own and cross price elasticities are presented for urban Pakistan. All own price elasticities have negative signs. Own Price elasticities of electricity, natural gas and firewood is inelastic while price elasticity of dung cake is elastic. The signs of cross price elasticities show substitution effects between natural gas and firewood, natural gas and dung cake and between dung cake and firewood. While complementary effect is found between electricity with all other fuels.

Comparison of estimates between entire Pakistan, rural and urban Pakistan show that own price elasticity of electricity is highly inelastic in all regions of Pakistan. Cross price elasticity of electricity with all other fuels show complementary effects. Gas and firewood; and firewood and dung cake are substitutes with each other. Kerosene also has substitution effect with dung cake.

Table 2 presents expenditure elasticities for all fuel items for overall Pakistan, rural Pakistan and urban Pakistan. All positive expenditure elasticities indicate that all fuels are normal goods. In case of overall Pakistan expenditure elasticities for gas, kerosene and firewood are greater than one indicating that these are more responsive to expenditure changes. Expenditure elasticities for electricity and dung cake are relatively inelastic but high in magnitude. Expenditure elasticities are higher in rural areas of Pakistan as compared to urban areas for all fuels expect for dung cake that is more expenditure elastic in urban areas. Expenditure elasticity for firewood is highest for overall Pakistan and for rural and urban Pakistan. The expenditure elasticity for electricity is relatively inelastic for overall and for both rural and urban areas, one reason for this is lack of availability, and this will restrict the responsiveness of demand to higher income. Expenditure elasticity of kerosene in rural Pakistan have negative signs implies that it is an inferior good.

Table 2: *Expenditure elasticities for overall, rural and urban Pakist*an

Fuel Items	Pakistan	Rural Pakistan	Urban Pakistan
Electricity	.88*	.90*	.88
Gas	1.03*	1.09	.96*
Dung cake	.91*	.86	1.03*
Firewood	1.34*	1.37	1.26
Kerosene	2.53	-.78	.35

****, **, * indicate significance at 99%, 95%, and 90% level of confidence, respectively*.

The comparison with previous studies as Burney and Akhtar (1990) showed that own and cross price elasticities were found extremely low, implying that demand for fuel is extremely price inelastic, and all cross price elasticities have negative signs which means that all fuel goods are complement. Expenditure elasticities are also very low implying that demand for fuels in Pakistan is expenditure inelastic. But as our results show this is not the case today. Mostly own price elasticities have signs greater than one or near to one implying that all own price elasticities are price elastic, and cross price effects both have substitution and complementary effects. Especially cross price elasticities of natural gas and firewood and dung cake have substitution effects implying that natural gas can be substituted for low quality inefficient fuels. Expenditure elasticities are greater than one or higher in magnitude implying that all fuel items are expenditure elastic. Kerosene showed negative signs in some cases implying that it is inferior good.

Conclusion

The results show that price of related fuel items, household expenditure and household characteristics are important variable in determining the demand for energy. Literacy variable have positive relation with electricity and negative relation with dung cake, which implies that educated households will use more of modern fuel and uneducated household will remain using traditional and insufficient fuels. The occupation type does not make a difference whether a household is self-employed or paid employed because most coefficients yield insignificant signs. Own price elasticities for LA-AIDS suggest that all fuel items except for electricity are price elastic. All own price elasticities have negative signs in case of Pakistan and rural and urban Pakistan. The cross prices elasticities of different fuels show that demand for fuel items is responsive to the relative prices. However, the response is weak. The own price elasticities are greater than cross price elasticities. So we can say that demand for a particular energy source is more sensitive to change in own price than change in other prices.

Estimation of consumer demand elasticities is important in making policies about imposition of taxes and in giving incentives to consumers and producers. Policy maker can use own price elasticity to predict the effects of an increase in price by the seller or effects of imposition of taxes on household demand. In contrast with earlier studies, we find demand for electricity is inelastic while demand for other fuels is relatively price elastic. The inelastic nature of electricity suggests that government can generate more revenues by imposing taxes. On the other hand, policies in this direction should also focus on welfare of consumers. Another effect of such policies is predicted by estimation of cross price elasticities of household demand. As our results show that if price of electricity has been increased, households cannot substitute with something else because there is no close substitute of electricity.

All expenditure elasticities are positive indicating that all energy sources are normal goods. Although, expenditure elasticities for some items are less than one but they are higher in magnitude. These results suggest that income generating policies will increase the level of consumption, and thus, a steady growth will occur in production by enhancing effective demand. Comparison of rural and urban expenditure elasticities showed that rural and urban households have different patterns of consumption.

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APPENDIX

Appendix A: *Electricity Tariff Brackets for 2007-08*

Electricity Tariff Brackets	Electricity tariff rates(2007-08)
For 50 units	Rs. 1.40 per unit
Next 100 units	Rs. 2.65 per unit
Next 200 units	Rs. 3.64 per unit
Next 700 units	Rs. 6.53 per unit
Above 1000 units	Rs. 7.79 per unit

Source: Economic Survey of Pakistan, Government of Pakistan

Appendix B: *Natural gas Tariff Brackets for 2007-08*

Natural gas Tariff Brackets	Natural gas tariff rates (2007-08)
First slab (upto 50 cubic metres per month).	Rs. 2.90 per cubic meter
Second slab (over 50 upto 100 cubic metres per month).	Rs. 3.05 per cubic meter
Third slab (over 100 upto 200 cubic metres per month).	Rs. 5.55 per cubic meter
Fourth slab (over 200 upto 300 cubic metres per month).	Rs. 11.67 per cubic meter
Fifth slab (over 300 upto 400 cubic metres per month).	Rs. 15.18 per cubic meter
Sixth Slab(over 400 upto 500 cubic meters per month)	Rs. 19.73 per cubic meter
Seventh Slab(over 500 cubic meters oper month)	Rs. 25.67 per cubic meter

Source: Oil and Gas Regulatory Authority (OGRA)

Appendix C: *Description of Variables*

Abbreviation	Variable Description	Abbreviation	Variable Description
w_g	Budget share of natural gas	Z_4	Employee
w_k	Budget share of kerosene	β_i	Expenditure parameter
w_d	Budget share of dung cake	γ	Price parameter
w_f	Budget share of firewood	$\propto$	Intercept coefficient
Z_1	Dummy variable for literacy	δ	Coefficient of household characteristics
Z_2	Agriculture as profession	ε	Disturbance term
Z_3	Self employed		

Appendix D: *Parameter Estimates of LA-AIDS Model for Entire Pakistan*

Explanatory Variables	Budget share of Electricity	Budget Share of Dung cake	Budget Share of Firewood	Budget Share of Natural Gas	Budget share of kerosene
Constant	.60***	-.03	-0.889***	.42***	.89
	(9.41)	(-1.03)	(-12.72)	(8.58)	
Log price of electricity	.28***	-.04***	-0.090***	-.03***	.02
	(30.93)	(-12.09)	(-14.80)	(-3.90)	(1.39)
Log price of dung cake	-.04***	-.03***	0.016***	.04***	-.03***
	(-12.09)	(-10.73)	(6.21)	(12.80)	(-4.50)
Log price of firewood	-.09***	.02***	0.150***	.02***	-.11***
	(-14.80)	(6.21)	(20.68)	(3.95)	(-6.26)
Log price of natural gas	-.03***	.04***	0.020***	.01	.10***
	(-3.90)	(12.80)	(3.95)	(.57)	(8.55)
Log price of kerosene	.02	-.03***	-0.110***	.10***	.02
	(1.39)	(-4.50)	(-6.26)	(8.55)	
Log of fuel expenditure	-.04***	-0.01***	0.133***	.01***	.09
	(-12.37)	(-5.59)	(34.64)	(3.26)	
Literacy	.02***	-.001	-0.047***	.03***	.01
	(-12.37)	(-.77)	(-9.40)	(9.65)	
Self employed	.03***	.002	-0.032***	.01	.00
	(5.32)	(.70)	(-3.75)	(.99)	
Paid employed	-.01	.001	0.014***	-.01*	-.001
	(-1.15)	(.49)	(2.07)	(-1.66)	
Agriculture as profession	-.01	.02***	0.009	-.03***	-.01
	(-1.05)	(5.44)	(1.16)	(-5.33)	
S.E. of regression	.26	.11	.29	.19	
Sum of Square residual	1025.15	188.04	1276.70	572.54	

*Values in Parenthesis are t-values. ***, **, * indicate significance at 99%, 95%, and 90% level of confidence, respectively.*

Appendix E: *Parameter estimates for Rural and Urban Pakistan*

	Urban Pakistan					Rural Pakistan				
Explanatory Variables	Budget share of Electricity	Budget Share of Dung cake	Budget Share of Firewood	Budget Share of Natural Gas	Budget share of kerosene	Budget share of Electricity	Budget Share of Dung cake	Budget Share of Firewood	Budget Share of Natural Gas	Budget share of kerosene
Constant	.92*** (9.55)	-.20 *** (-5.11)	-1.23*** (-10.88)	1.15*** (13.67)	.36	.26*** (3.07)	.13*** (3.49)	-.44*** (-4.98)	-.18*** (-3.07)	1.235
Log price of electricity	.24*** (19.44)	-.02*** (-3.81)	-.13*** (-14.22)	-.04*** (-3.61)	-.07*** (2.89)	.30*** (24.29)	-.06*** (-12.95)	-.07*** (-8.64)	-.02*** (-2.11)	-.04* (-1.86)
Log price of dung cake	-.02*** (-3.81)	-.02*** (-5.76)	.03*** (6.70)	.02*** (3.30)	-.06*** (-5.71)	-.06*** (-12.95)	-.03*** (-7.76)	.02*** (4.18)	.05*** (11.59)	-.003 (-0.34)
Log price of firewood	-.13*** (-14.22)	.03*** (6.70)	.15*** (12.56)	-.004 (-0.44)	-.26*** (-9.25)	-.07*** (-8.64)	.02*** (4.18)	.16*** (16.89)	.03*** (4.21)	.03 (1.30)
Log price of natural gas	-.04*** (-3.61)	.02*** (3.30)	-.004 (-.44)	.10*** (5.21)	.28*** (13.49)	-.02*** (-2.11)	.05*** (11.59)	.03*** (4.21)	.01 (0.61)	-.04*** (-2.55)
Log price of kerosene	-.07*** (2.89)	-.06*** (-5.71)	-.26*** (-9.25)	.28*** (13.49)	.12	-.04* (-1.86)	-.003 (-.34)	.03 (1.30)	-.04*** (-2.55)	.05
Log of fuel expenditure	-.05*** (-8.61)	.003 (1.30)	.10*** (14.76)	-.01 (-1.71)	-.04	-.03*** (-7.96)	-.01*** (-7.13)	.15*** (30.73)	.02*** (6.22)	-.12
Literacy	.04*** (5.19)	-.01*** (-2.27)	-.05*** (-5.90)	.02*** (3.66)	-.003	.01*** (2.34)	.003 (1.13)	-0.05*** (-7.24)	.03*** (8.29)	-.003
Self employed	.03*** (3.07)	.00 (0.04)	-.03*** (-2.89)	.01 (.72)	-.003	.01 (1.24)	.01 (1.06)	-.02*** (-2.02)	-.01 (-.68)	-.01
Paid employed	-.001 (-0.20)	.001 (.40)	.003 (.39)	-.002 (-0.31)	.003	-.01 (-1.08)	-.01*** (-2.02)	.02 (1.62)	-.01 (-1.45)	-.01
Agriculture as profession	-.05*** (-3.99)	.02*** (3.53)	.02*** (2.11)	-.002 (-.18)	-.02	.02*** (2.28)	.01 (1.42)	-.02*** (-2.19)	-.01 (-1.28)	.003
S.E. of regression	.24	.09	.28	.20		.27	.12	.29	.18	
Sum of Square residual	350.48	57.58	490.79	251.54		644.84	128.21	746.70	297.03	

*Values in Parenthesis are t-values. ***, **, * indicate significance at 99%, 95%, and 90% level of confidence, respectively.*