Indian Journal of Economics and Business
Vol. 21 No. 2 (April, 2022)

http://www.ashwinanokha.com/IJEB.php

Household energy demand in Pakistan: An application of the Extended Linear Expenditure System

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Received date: 06 February 2022
Revised date: 26 April 2022
Accepted: 25th May 2022
Published: 29th June 2022

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Abstract: Pakistan has been facing a consistent rise in residential energy consumption. Providing affordable energy for household consumption has become an inevitable challenge. To analyze how the household expenditure patters have changed over time in response to the unstable oil prices and rising prices of energy, this study focuses on three energy sources (electricity, natural gas and petrol) by using household expenditure data (PSLM) for the years 2005-06, 2010-11 and 2015-16. The income and price elasticities of these sources have been calculated taking aid of Extended Linear Expenditure System. The energy expenditures analysis shows that the urban and rural households spending on electricity has increased overtime despite the rise in tariffs. Moreover, outlays on diesel as well as petrol have soared substantially for urban as well as the rural households. However, the low magnitude of the income and price elasticities indicates that households consume these energy sources according to their needs.

1. Introduction

Energy consumption plays an imperative role in the welfare of households (HHs) both for the developed as well as the developing countries. Its significance can be traced through the share of expenditure HHs spend on energy usage. The expenditure share of HHs on energy consumption varies with prices, household income, household size and other household characteristics. Along with the increasing population, the energy demand of the domestic sector of Pakistan is rapidly increasing.

Over the last decades, the Pakistan has been facing severe crisis due to insufficient energy production to fulfill the escalating demand. The energy supply has increased by more than 40 times during the past 25 years (National Bank of Pakistan, 2008), yet the demand outweighs the supply. The phenomenal growth of energy consumption is caused by the increased economic activities and growth of industrial, agriculture and service sectors along with the increasing population. The demand supply gap has further

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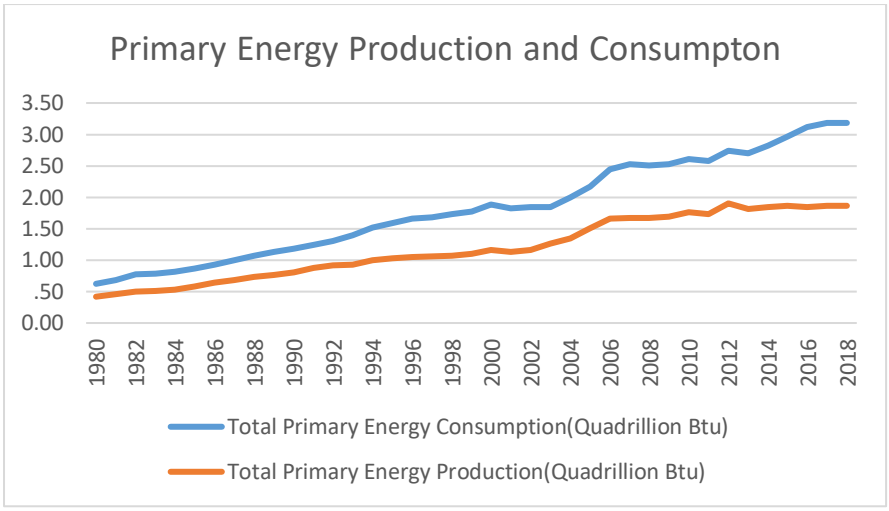
widened by the inefficient use and wastage of energy resources (Fig 1).During 1980's, 86% of the demand was fulfilled by internal supply while the remaining 14% was met through imported energy sources. Since then the supply shortfalls have been increasing reaching around 50% at the end of 2013 (Annual Report SBP, 2014).

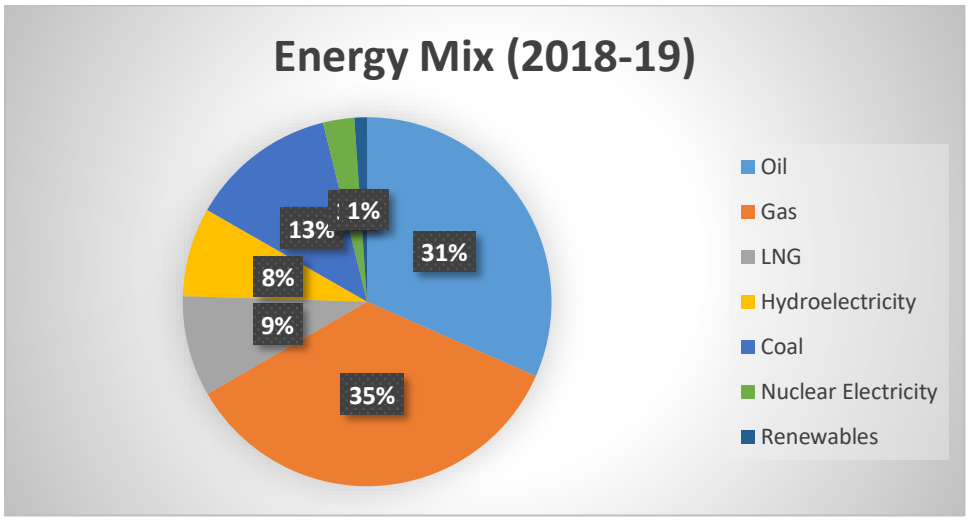
Figure 1: Supply and Demand gap of primary energy of Pakistan



Source: IEA, 2019
Note: quad=10^{15} BTU (British Thermal Unit)

In 2017, primary energy (coal, natural gas, nuclear, hydro, bio fuels and waste, oil, wind and solar energy) consumption for Pakistan was 3.18 quadrillion btu. Primary energy consumption of Pakistan increased from 1.73 quadrillion btu in 1998 to 3.18 quadrillion btu in 2018 growing at an average annual rate of 4.19% (International Energy Agency, 2019). While, the production of primary energy was 1.86 quadrillion btu. Primary energy production of Pakistan increased from 1.07 quadrillion btu in 1998 to 1.86 quadrillion btu in 2018 growing at an average annual rate of 3.69%.

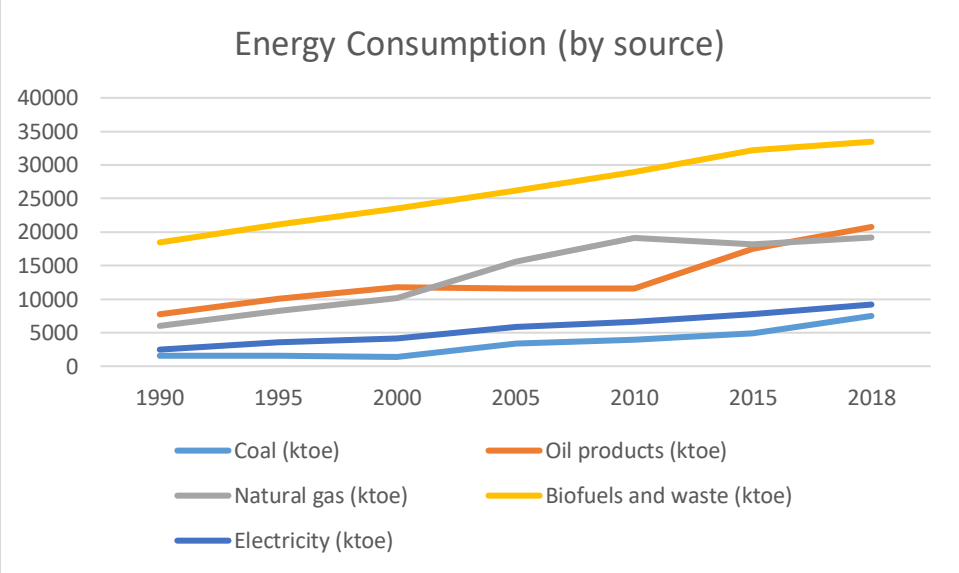
Figure 2: Energy Mix of Pakistan 2018-19



Source: Pakistan Economic Survey 2018-19

The energy generation of Pakistan relies greatly upon oil and gas that attributes to 77% of total energy produced. In terms of energy mix, the dependence on oil has declined to 31.2% in the FY2018, which was recorded as 43.5% in the period 1998-2001 (Fig 2). The share of hydroelectricity has reduced to 7.7% in 2017-18 which was 13.1% in 1998. Although the declining share of oil has reduced the fiscal burden, as a result of shortsightedness of policy makers, the successive administrations have failed to increase the hydro power generation. The dependence upon natural gas which was the highest in FY2006 (50.4%) has now reduced to 34.6% in the FY2018. This decline in the energy mix s due to the exhausting reserves of natural gas in addition to the restricted consumption by the transport sector (shown in Fig 3) and the usage of Liquid Natural Gas (LNG) since 2015 which has increased to 8.7% in 2018 (Pakistan Economic Survey 2018-19). The share of coal has increased to 12.7 percent and that of nuclear electricity gradually improved to 2.7% which was 0.2% in 1997.

Figure 3: Energy consumption by Source



Source: IEA, 2019

The energy needs are expected to increase three folds by 2050 while the supplies are not very inspiring. The commercial energy shared by household sector has been rising since 1990's, as revealed by pattern of commercial energy consumption. Nevertheless, during the same time span, the prices of energy products used by household sector have also witnessed an increase. The reduction in government's commercial fuels subsidies has proved to be a fuel to the injury in the current uncertain scenario. These changes in pricing policies of energy sources are likely to have both price and income elasticities. These elasticities provide vital information for policy makers to design appropriate pricing and income policies.

However, there are insufficient demand elasticities estimated recently at the household level of country for various energy sources. This study seeks to examine in detail the intertemporal patterns of household expenditure on three main energy sources i.e., electricity, natural gas and petrol and diesel using Pakistan Social and Living Standards Measurement Survey (PSLM) data for the years 2005-06, 2010-11 and 2015-16 for urban and rural HHs. The price and income elasticities are computed with the Extended Linear Expenditure System which was also used by Burney and Akhtar (1990). Estimating price and income elasticities over three different periods of high (2005-06), low (2010-11) followed by

fluctuating oil price (2015-16) will provide useful information regarding the effect of international oil prices on our energy prices and energy consumption. For example, during the end of 2014 following the international trend the decline in oil prices within Pakistan resulted in oil crisis[4]. As a result there were long ques on the petrol pumps for a few days followed by the emergency response by the government. However, Pakistan stays vulnerable to such kind of incidents as there is very little effort made to study and analyze the impact of such shocks. Previous studies on energy demand by the household sector have not analyzed the demand for petrol and diesel along with the other fuels consumed by the HHs. In order to analyze the impact of changing energy prices in response to the international oil price shocks it is necessary to consider the consumption of petrol and diesel by HHs as the petroleum products are directly influenced by such changes.

The remaining article is structured as follows. Section 2 discusses the literature review, Section 3 analyzes the theoretical framework, Section 4 explains data, Section 5 explains the trends in household consumption, and Section 6 delves into the results while Section 7 concludes the study.

2. Literature Review

The literature on household energy demand is limited in case of developing countries like Pakistan (Ngui,*et al.* 2011). Several studies for example Filippini and Pachauri (2004), Atakhanova and Howie (2007), Athukorala and Wilson (2010), Shi,*et al.*(2012) and Lin, Rizov and Wong (2014) have focused on the demand for just one energy source i.e., electricity. Other studies have focused on a group of fuels used by HHs as firewood, charcoal, electricity, natural gas etc. Shittu,*et al.*(2004) computed income elasticities of fuels for poor, average, and wealthy HHs of Nigeria. By applying logit model they found that among different fuels, only firewood had negative income elasticity in case of poor, average and wealthy HHs with values of -5.02, -4.94, and -4.31 respectively. Later in 2008, Gundimeda and Köhlin estimated expenditure and price elasticities for various income groups in urban and rural areas of India using LA-AIDS model. They found that estimates of price elasticity for fuelwood, electricity, LPG and kerosene oil were same in case of urban and rural HHs. While for Fuelwood and LPG the price elasticities were close to one.

Maria, Bond and Willson (2012) investigated the income and elasticities of energy consumption in Mozambique. Their results suggested that fuelwood (-0.41) and charcoal (-0.28) were more price inelastic in comparison to candles (-0.88) and electricity (-0.60). The income elasticity of kerosene, candles and electricity was greater as compared to that of charcoal and firewood. In the same way Akpalu, Aglobitse and Dasmani (2011) found charcoal, firewood and LPG to be price inelastic as compared to kerosene among different fuels.

Ngui,*et al.*(2011) computed the price and expenditure elasticities for urban and rural HHs in Kenya. They found that electricity was more price elastic with a value of -0.88 as compared to fuelwood, kerosene oil, charcoal and LPG. Kerosene oil had the highest expenditure elasticity with a numerical value of 1.06. Other studies have also focused on fuels used in vehicles such as petrol and diesel (Ajanovic,*et al.*(2012), Akinboade,*et al.*(2008), Baranzini and Weber (2013), Dahl, Ajanovic andSchipper (2012), Lin and Zeng (2013) and Winebrake,*et al.*(2015)). These studies have used country level data and estimated price and income elasticities for gasoline (petrol) and diesel. The price

[4] Muhammad Omer, SBP report (2018).

elasticities were found to be very low ranging from -0.3 to -0.85. However the income elasticities varied widely ranging from 0.3 to 1.4.

In case of Pakistan there are very few studies that have estimated price and income elasticities for energy demand using household micro data. Iqbal (1983) computed the price and income elasticities for 4 energy sources i.e., electricity, natural gas, LPG, coal and kerosene oil using annual data for the time period 1960-1981. He formed two fuel groups by adding electricity, natural gas and LPG in the first group and coal and kerosene oil in the other group. The results suggested that both of the energy groups were very less responsive to income and price changes.

Later Burney and Akhtar (1990), estimated price, income and expenditure elasticities for fuel demand using the Household Income and Expenditure Survey 1984-85. The urban and rural HHs were analyzed separately with the help of extended linear expenditure system for the five fuel categories. The own price elasticities were found to be very low whereas firewood had positive price elasticity. The expenditure elasticities were positive for all the fuel types except for firewood. The study reported that the price elasticities for electricity, natural gas, coal and oil are very low. According to Burney and Akhtar, these low price elasticities showed that only the minimum fuel requirement of the HHs is being met.

Later in 2015, Khan,*et al.* estimated income and price elasticities using Extended Linear Expenditure System for different fuels. Their results suggest electricity followed by natural gas have been the dominant fuels used by urban HHs while firewood and electricity were the main fuels used by rural HHs in both periods i.e., 2001-02 and 2010-11. However, all fuel types had low income and price elasticities indicating that energy consumption is less likely to change with income and price changes for urban as well as rural HHs. The study also found that the proportion spent by urban HHs on fuels was less as compared to the rural HHs. Irfan, Cameron and Hassan (2017) used the Linear Approximate Almost Ideal Demand System (LA-AIDS) model to investigate the expenditure and price elasticities at urban, rural, and national levels by pooling three data sets (2007-08, 2010-11 and 2013-14) of PSLM surveys. They found that all fuels excluding natural gas had very low price elasticities at the country level and for the urban HHs. In case of rural HHs, LPG and natural gas had higher estimates of price elasticity than the urban HHs. The expenditure elasticities were all positive ranging between zero and one.

Omer (2018), investigated the price and income elasticities for petrol, CNG and diesel using monthly data over the period of 2004-2015 for the transport sector. Their estimates of price elasticities show very small numerical values of own price and cross price elasticities in the short run. However, in the long run, the demand elasticities are comparatively higher.

3. Theoretical framework

This study estimates income and price elasticities for the three energy items i.e. electricity, gas and petrol using an Extended Linear Expenditure System (ELES) formulated by Lluch (1973). The ELES is based on household utility maximization behavior. The household expenditure decision is assumed to be made on per capita basis and is independent of other socio-economic factors as gender, age, education etc. it is expressed as

$$e_i = p_i x_i = p_i \gamma_i + \beta_i (y - \sum p_j \gamma_j) \qquad (1)$$

where, i = 1, 2, ..., n goods, $e_i$is the per capita expenditure of household on good i, $p_i$is the price of good i, $x_i$is per capita consumption of household on good i, y is per capita income of household, while $\gamma_i\beta_i$are the parameters which will be estimated.

The βi's show the MPC (marginal propensity to consume of good i), with ∑ βi = μ is the overall MPC. While the parameter $\gamma_i$represents the basic needs or subsistence quantity of good i, while $\sum p_j\gamma_j$indicates total subsistence expenditure. The expression $(y - \sum p_j\gamma_j)$denotes supernumerary income. The relationship shown by Equation 1 is referred to as the ELES.

The aggregate expenditure system is obtained by adding up the expenditure equations for all the goods as

$$E = (1 - \mu)\sum p_i\gamma_i + \mu y \qquad (2)$$

The system of equations given by equation 1 need to be estimated simultaneously as $\gamma_i$is present in all the equations. This generally requires maximum likelihood function as it imposes cross equation restriction. However the term $p_i\gamma_i$is independent of the unit of observations since the commodity prices are identical for each household in cross section data. Hence, it can be replaced with γ_i^*. The stochastic specification of the ELES is given as

$$e_{ih} = \alpha_i + \beta_i y_h + \epsilon_{ih} \qquad (3)$$

where, h = 1, 2, ..., H HHs, $\alpha_i = \gamma_i^* - \beta_i\sum\gamma_i^*$and ϵ_{ih} is the error term.

The estimation of eq. 3 for each energy commodity by the Ordinary Least Squares (OLS) method is equivalent to the estimation of the system by maximum likelihood method. The OLS estimates of $\alpha_i$and β_i can be used to estimate the maximum likelihood estimates of μ,$\gamma_i^*$and $\sum\gamma_i^*$ with the help of the following relationships

a) $\mu = \sum\beta_i$
b) $\sum\gamma_i^* = \sum\frac{\alpha_i}{1-\mu}$
c) $\gamma_i^* = \alpha_i + \beta_i\sum\gamma_i^*$

The demand elasticities are computed as

(i) Income Elasticity : $\eta_{iy} = \beta_i(\frac{y}{e_i})$

(ii) Own-price Elasticity: $\eta_{ii} = (1 - \beta_i)\left(\frac{\gamma_i^*}{e_i}\right) - 1$

(iii) Cross-price Elasticity: $\eta_{ij} = -\beta_i(\frac{\gamma_j^*}{e_i})$

From (iii) it can be seen that for a positive cross price elasticity either $\beta_i$has to be negative (good i be inferior) or γ_j^*has to be negative (good j be a luxury good). Otherwise the uncompensated cross price elasticities under the ELES can take up only negative values. Hence, these negative elasticities are inconclusive under normal circumstances. The ELES has a disadvantage over the other demand systems as it assumes that the marginal utility of a product is not influenced by the consumption of any other product. This assumption of additive preferences assumption as it is not very credible in case of consumption items (Alderrman,1988). However, the ELES has the benefit of providing estimation of price and income in absence of data for prices.

4. Data

This study is based on the micro level data of the Pakistan Social and Living Standards Measurement (PSLM) Survey 2005-06, 2010-11 and 2015-16, compiled by the Pakistan Bureau of Statistics. The PSLM 2005-06 data are based on a nationally representative sample of 15417 HHs, with 5997 HHs (39%) living in urban areas and 8818 (57%) residing in rural areas. For 2010-11 the data are also based on a nationally representative sample of 16,313 HHs, with 6,572 HHs (40%) living in urban areas and 9,741 (59.7%) residing in rural areas. While for 2015-16 the data are also based on a nationally representative sample of 24239 HHs, with 16,155 HHs (66%) living in urban areas and 8,083 (34%) residing in rural areas[5].

5.Household Energy Expenditure and Energy Prices

The trend of rural and urban household energy consumption have been depicted in figure 4 and 5. It can be seen that there has been a significant inter fuel substitution during the phase of 2001-16. The consumption of kerosene oil has reduced immensely while, there has been a persistent rise in the electricity consumption.

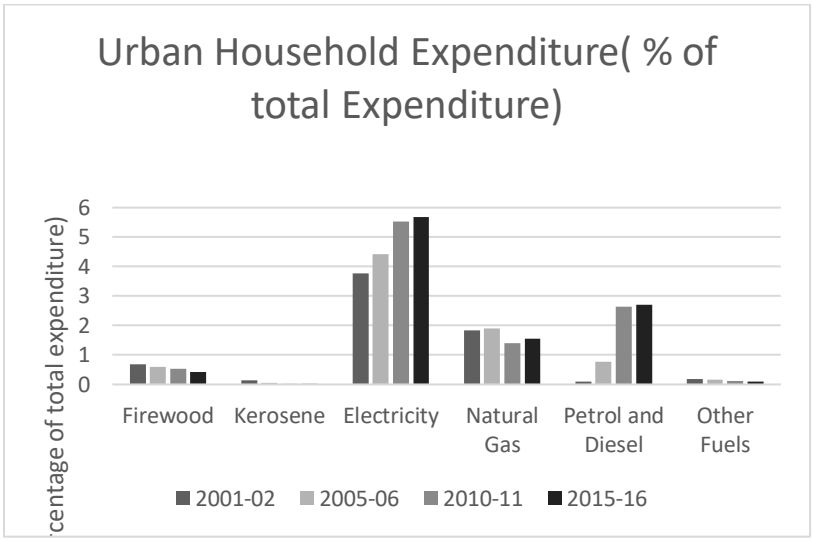


Figure 4. Urban Household Expenditure on Energy Sources
Source: PSLM survey (2001-02, 2005-06, 2010-11, 2015-16)

[5]The sample from all the survey rounds excludes households for which the reported total consumption expenditure was zero or missing.

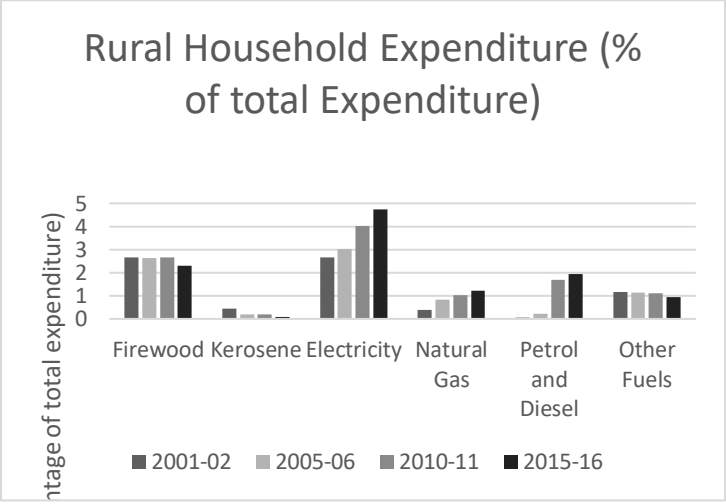


Figure 5. Rural Household Expenditure on Energy Sources
Source: PSLM survey (2001-02, 2005-06, 2010-11, 2015-16)

Table 1 shows the average monthly expenditures of the three energy goods under discussion of HHs using constant prices of 2001-02. The annual increase in real expenditures on the three energy sources is approximately 16 percent for the urban HHs for the period 2006-11 while for the rural HHs it is 6.2 percent. Whereas during the period 2011-16 it is 5.2 percent for the urban HHs and 10.4 percent for the rural HHs. It can be seen that the real expenditure of rural HHs have increased at a faster pace. The increase of household budget share on energy sources (mainly electricity and natural gas) may be due to both rise in energy prices and greater utilization of energy on household appliances due to higher levels of income over the years. The higher utilization of household appliances over time is supported by Khan and Khalid (2010) who found that both urban and rural HHs increased the expenditure share on durable goods (the increase being higher for rural HHs (2.5 times)) with the passage of time[6].

Table 1. Average household expenditure on fuels

Average household Expenditure(Rs. Per month)						
	2005-06		2010-11		2015-16	
	Urban	Rural	urban	Rural	urban	Rural
Electricity	256.45	143.03	465.85	216.89	565.57	253.58
Natural Gas	168.27	87.79	146.18	128.91	156.73	186.70
Petrol and Diesel	169.72	101.14	320.20	134.52	411.68	157.17
Total	523.8194	298.54	932.80	391.55	1176.98	597.45
Other	16072.58	14917.33	19003.91	17207.27	96145.37	62101.46

[6]The durable goods category includes expenditures on household appliances, such as refrigerators, freezers, electric fans, air coolers, air conditioners, etc.

Table 2shows that within the three energy sources, both urban and rural HHs had highest expenditure shares on electricity followed by petrol during the three years under review. The expenditure share of natural gas of the urban sector reduced during 2002-11, which may be driven by the fall in average household size[7]. Due to the fall in average household size the usage of natural gas for cooking and heating purposes declines. Another reason might be the increase in efficiency of appliances using natural gas overtime. On the other hand the rural HHs have increased the usage of natural gas over the phase of 2006-2016 due to its easy availability and the fuel switching behavior form firewood to natural gas of rural HHs. The fuels switching behavior of the rural HHs is also supported by Khan, *et al.*(2015) who found that over the years with the increase in gas connections in the rural areas the use of firewood has declined along with the increased use of natural gas. Comparison of these results with the earlier estimates by Burney and Akhtar (1990) and Khan, *et al.*(2015) shows that increase in the average expenditure share on energy sources is mainly driven by higher budgetary outlays on electricity caused by the greater use of household appliances by both urban and rural HHs across the country.

Table 2. Average household expenditure (% of total household expenditure)

Average household expenditure (% of total household expenditure)						
	2005-06		2010-11		2015-16	
	urban	Rural	Urban	rural	Urban	Rural
Electricity	3.77	2.02	5.53	4.02	5.67	4.74
Natural Gas	1.89	0.82	1.41	1.04	1.55	1.23
Petrol and Diesel	0.10	0.06	2.64	1.69	2.71	1.94
Total	7.06	3.89	9.58	6.26	9.93	7.91
Others	92.91	96.09	90.42	93.73	90.07	92.09

The average real household expenditure in per capita given in Table 3 shows that per capita expenditure of electricity on case of urban HHs increased at a higher rate than the rural areas during the period 2006-16. For the period 2006-2011 it raised by 16% for the urban areas while 8.5% for rural areas. Whereas for the period 2011-16 it raised by 5.6% for urban HHs and 4% for rural HHs. On the other hand in case of natural gas the rise for urban HHs in the period 2005-11 was by 10% and that of rural HHs was 11.6%. During the phase 2010-16 the increase of per capita expenditure in case of urban HHs for gas was 3.5% and that of rural HHs was 4%. In case of petrol the rise in expenditure was 18% for the urban HHs in the period 2006-11 and 3.6% for rural areas. During the phase 2010-16 the increase of per capita expenditure in case of urban HHs for petrol was 1.5% and that of rural HHs was 3.5%. This shows that the rise in per capita expenditures on energy sources is higher in the period of 2005-10 than that of 2011-16.

Table 3. Average household expenditure (% of total household expenditure)

[7]The average household size fell from 6.9 in 2005-06 to 6.2 in 2010-11.

Average household expenditure per capita (Rs. Per month)						
	2005-06		2010-11		2015-16	
	Urban	Rural	Urban	Rural	Urban	Rural
Electricity	46.26	24.70	83.31	36.60	106.69	44.04
Natural Gas	17.37	12.51	26.05	19.83	30.56	23.7
Petrol and Diesel	30.82	17.66	58.71	20.70	63.33	24.41
Total	94.47	51.52	168.0956	64.25	727.62	340.98
Others	4448.57	3842.36	5149.479	3976.99	21287	12094.55

The average real monthly household income and expenditure (total and energy) in per capita terms for urban and rural HHs dividing the HHs in quintiles is given in Table 4. The per capita real expenditure on energy sources i.e., electricity, natural gas and petrol is seen to rise with income across all quintiles for urban and rural HHs while being highest for HHs in the fifth quintile.

Growth in real per capita expenditure on fuels is seen to be higher for rural HHs across all quintiles in comparison to urban HHs. This growth is most likely to be driven by the higher demand of household appliances and vehicles in response to the rising income levels of rural HHs. According to Khan and Khalid (2010), this rise in income is due to the rising farm support prices in addition to the increasing flows of domestic and foreign remittances.

Table 4. Average per Capita Real Household Expenditure and Income by Expenditure Quintiles

Expenditure quintiles	**Average per capita total household monthly expenditure (Rs.)**		**Average per capita total household monthly income(Rs.)**		**Average per capita total household monthly expenditure on fuel (Rs.)**	
2005-06	urban	rural	urban	rural	urban	Rural
First	418.32	167.38	511.29	270.67	28.12	26.31
Second	551.52	347.77	600.58	478.92	54.16	52.58
Third	779.44	529.69	839.30	699.91	87.27	86.31
Fourth	1137.22	816.64	1396.55	1048.41	158.57	142.41
Fifth	2084.28	1087	2179.59	1669.81	363.53	340.23
2010-11	urban	rural	urban	rural	urban	Rural
First	594.05	143.56	601.6072	455.4932	27.05	28.53
Second	852.21	620.25	859.43	691.8005	59.74	56.09
Third	1096.01	771.05	1546.29	869.4424	97.56	89.82
Fourth	1478.20	879.99	1807.03	1358.8211	168.53	195.32
Fifth	3216.43	939.39	3965.76	2127.677	485.92	486.78

2015-16	urban	Rural	urban	rural	urban	Rural
First	627.91	187.43	647.59	514.60	32.24	39.61
Second	1067.41	689.03	1169.45	823.34	76.31	72.45
Third	1505.16	866.76	1609.13	1029.95	122.07	115.76
Fourth	2710.66	1125.43	2909.1	1609.1	191.49	193.07
Fifth	4062.21	2013.41	4265.32	2467.86	501.24	492.34
Average annual growth rate (%)						
First	5.01	1.197	2.66	9.01	1.46	5.05
Second	9.35	9.81	9.47	7.19	3.78	3.77
Third	9.31	6.36	9.17	4.71	3.88	3.41
Fourth	13.83	8.67	10.83	5.34	2.07	3.55
Fifth	9.48	8.52	9.56	4.77	3.98	4.47

The real per capita expenditure on individual energy sources by quintiles is given in Table 5. It can be seen that the per capita expenditure on electricity, natural gas and petrol has by and large, increased for each quintile for both urban and rural HHs. In terms of annual growth during the period, it can be seen that the growth in real per capita expenditure on these energy sources is higher for rural HHs in most of the quintiles. The highest growth is seen in case of electricity with HHs in the fifth quintile showing an average annual growth of approximately 13 percent. Real per capita expenditures on natural gas is seen to fall for urban HHs while it has increase for rural HHs.

Table 5. Average per Capita Real Household Expenditure by Fuel Type and Expenditure

Expenditure quintiles	**Electricity**		**Natural gas**		**Petrol**	
2005-06	urban	rural	urban	rural	Urban	Rural
First	17.5	9.24	12.91	9.08	4.38	2.76
Second	36.21	20.66	21.08	14.81	48.30	24.77
Third	55.86	31.90	31.23	21.97	59.41	54.82
Fourth	87.13	48.80	46.37	33.59	195.51	101.25
Fifth	157.15	110.05	112.72	86.89	223.45	152.46
2010-11	urban	rural	urban	rural	Urban	Rural
First	23.40	10.42	10.97	8.33	6.26	3.40
Second	47.03	22.20	16.91	14.93	50.57	43.57
Third	71.67	35.97	23.14	22.43	91.67	56.49
Fourth	110.16	60.01	34.24	37.45	263.17	126.43
Fifth	297.57	148.59	85.55	104.62	358.90	171.30
2015-16	urban	Rural	urban	rural	Urban	Rural
First	29.25	18.02	10.29	13.97	6.22	4.52
Second	55.33	34.21	16.31	21.94	51.52	44.12
Third	82.38	52.35	22.87	31.07	77.19	59.58
Fourth	180.90	84.43	35.53	45.41	295.00	185.09
Fifth	324.41	252.94	99.30	125.62	392.69	182.57

Average annual growth rate (%)						
First	6.71	9.50	-2.02	3.50	4.20	6.37
Second	5.28	6.55	-2.26	3.24	0.66	7.81
Third	4.74	6.41	-2.67	2.92	2.99	0.86
Fourth	10.72	7.30	-2.33	2.60	5.08	8.28
Fifth	10.64	12.98	-1.19	2.97	7.57	1.97

Table 6 shows that the marginal propensity to consume for the three energy goods for both the urban and rural HHs in all the three years under examination are quite low. The urban HHs are observed to have relatively higher marginal shares as compared to the rural HHs. The marginal expenditure share on these three energy items is seen to be the highest in the year 2005-06 for both rural and urban HHs. According to the results if the HHs increase expenditure per capita by one rupee the urban HHs will spend additional 7.9, 7.8 and 7.1 percent in 2005-06, 2010-11 and 2015-16 respectively. In comparison their rural counterparts will spend an additional 5.9, 4.6 and 4.3 percent in 2005-06, 2010-11 and 2015-16 respectively. Among the three energy goods, both rural and urban HHs have a higher allocation on electricity during the three sample periods. In comparison to Burney and Akhtar (1990) the marginal budget shares of electricity and gas are higher. This increase can be attributed to the availability of electricity and gas, greater use of electric and gas appliances and village electrification program carries out by the government.

Table 6. Marginal Expenditure Shares and Minimum Required Expenditure for Different Fuels

2005-06				
	Marginal Expenditure Share (%)		**Minimum Required Expenditure (Rs.)**	
	urban	rural	urban	rural
Electricity	0.043	0.018	59.26	21.94
Natural gas	0.016	0.010	21.94	2.43
Petrol	0.032	0.011	56.29	22.34
Total	0.089	0.059	137.49	46.71
Others	0.90	0.98	1536.43	921.32

2010-11				
	Marginal Expenditure Share (%)		Minimum Required Expenditure (Rs.)	
	urban	rural	urban	rural
Electricity	0.041	0.021	127.21	56.43
Natural gas	0.016	0.012	47.92	5.02
Petrol	0.021	0.013	72.96	36.54
Total	0.078	0.046	248.09	97.99
Others	0.972318	0.970497	3631.44	1440.52

2015-16		
	Marginal Expenditure Share (%)	Minimum Required Expenditure (Rs.)

	urban	rural	urban	rural
Electricity	0.037	0.015	132.65	76.34
Natural gas	0.016	0.012	48.07	30.28
Petrol	0.018	0.010	76.26	39.86
Total	0.071	0.037	256.98	146.4
Others	0.972365	0.976295	4062	2013.47

6. RESULTS

The results for the OLS regression are presented in Table 7 for the periods 2005-06, 2010-11 and 2015-16. The coefficients are statistically significant during the three years under consideration having anticipated signs. The intercept term for all the three energy sources is positive with small numerical values indicating that all the sources are necessary with low consumption expenditure for the three years under discussion. This is also corroborated by the positive ri* shown in Table 7. The coefficients are highly significant statistically during the years under consideration.

Table 7. Result of OLS regression

Note: Figures in parentheses are t-statistics. * Denotes coefficient as statistically significant at the traditional level of significance, i.e., 5 percent

	2005-06				**2010-11**				**2015-16**			
	Urban		Rural		Urban		Rural		Urban		Rural	
	α	β	α	β	α	β	α	β	α	β	α	
Natural gas	34.84	0.008	23.63	0.002	77.37	0.005	33.36	0.003	86.91	0.012	39.31	0.0037
	(16.9)*	(10.02)*	(23.80)*	(2.24)*	(47.53)*	(7.01)*	(63.25)*	(12.62)*	(57.57)*	(23.55)*	(37.04)*	(8.52)*
Electricity	13.47	0.002	8.76	0.000	23.52	0.00	5.96	0.001	24.23	0.002	2.9449	0.0007
	(20.6)*	(10.7)*	(26.23)*	(2.44)*	(43.19)*	(8.93)*	(22.24)*	(7.52)*	(50.41)*	(16.17)*	(13.04)*	(8.03)*
Petrol	22.23	0.006	18.19	0.001	52.67	0.005	20.83	0.0001	542.70	0.031	280.00	0.0101
	(9.86)*	(6.88)*	(14.58)*	(10.02)*	(22.88)*	(5.05)*	(26.76)*	(10.02)*	(41.25)*	(6.78)*	(28.50)*	2.535322
Total	0.36	2.05	0.15	4.68	153.57	0.012	60.16	0.004	653.85	0.046	322.25	0.014627
	(21.83)*	(3.06)*	(22.66)*	(7.43)*	(42.56)*	(7.73)*	(22.66)*	(7.43)*	(46.53)*	(9.43)*	(22.66)*	(7.43)*
Others	4211.93	0.16	3716.0	0.23	4639.3	0.43	2633.4	0.15	18691.3	1.64	11323.43	0.60237
	(28.5078)*	(2.89)*	(48.36)*	(3.39)*	(42.54)*	(8.99)*	(49.20)*	(5.50)*	(42.54)*	(8.9)*	(10.02)*	(13.53)*

The income elasticities are reported in Table 8. The numerical value of the income elasticities for all the three years remains positive and below unity, which implies that these energy sources are

normal goods for urban as well as rural HHs. The income elasticities for electricity and natural gas is seen to increase over the years in rural HHs which reflects their changing patterns of energy consumption. The decline in income elasticity for electricity for urban HHs in the phase 2005-2011 could be due to the energy shortages resulting in hours of load shedding in the second half of 2000. In the early 2000, there were no supply constraints as electricity was in surplus. In case of petrol the income elasticity is observed to increase both for rural and urban HHs over the three periods under review. This increase may be attributed to the greater usage of vehicles as well as generators due to load shedding.

Table 8. Income Elasticities for Different Fuels

	2005-06		**2010-11**		**2015-16**	
	Urban	rural	urban	Rural	urban	rural
Electricity	0.63	0.24	0.41	0.35	0.38	0.40
Natural gas	0.32	0.42	0.27	0.74	0.25	0.83
Petrol and diesel	0.28	0.12	0.34	0.33	0.36	0.54

These results are similar to the findings of Khan,*et al.*(2015), Lin, C. Y. C., & Zeng, J. J. (2013) and Gundimeda and Kohlin, (2008) which show that electricity, natural gas and petrol behave as normal goods for rural and urban HHs with a positive income elasticity. However the magnitude of income elasticities varies for different fuels. In case of urban HHs, the income elasticity is highest for electricity in all the three periods indicating that electricity consumption of urban HHs is more responsive to income changes. Whereas in case of rural HHs the income effect is largest for natural gas.

Table 9. Uncompensated Price Elasticities for Different Fuels

2005-06	**Urban**			**Rural**		
	Electricity	Natural gas	Petrol	Electricity	Natural gas	Petrol
Electricity	-0.66	-0.0026	-0.0065	-0.364407	-0.00103	-0.00192
Natural gas	-0.0076	-0.310601	-0.00869	-0.00276	-0.28212	-0.0019
Petrol and diesel	-0.01541	-0.00557	-0.253655	-0.00195	-0.00072	0.115791

2010-11	Urban			Rural		
	Electricity	Natural gas	Petrol	Electricity	Natural gas	Petrol
Electricity	-0.444348	-0.0029	-0.0077	-0.616183	-0.0009	-0.00205
Natural gas	-0.0094	-0.211689	-0.00803	-0.00686	-0.24003	-0.00327

Petrol and diesel	-0.01062	-0.0037	-0.143938	-0.00032	-0.0068	-0.20772

2015-16	urban			Rural		
	Electricity	Natural gas	Petrol	Electri6ity	Natural gas	Petrol
Electricity	-0.505142	-0.0019	-0.0022	-0.557806	-0.00045	-0.02627
Natural gas	-0.0071	-0.371886	-0.07833	-0.00975	-0.41365	-0.05956
Petrol and diesel	-0.01039	-0.00255	-0.231104	-0.00178	-0.00019	-0.16178

The uncompensated own and cross price elasticities are given in Table 9. The price elasticities of all three energy sources have anticipated negative signs in all three years under discussion. However, the magnitude of these elasticities is observed to be small indicating that the consumption in both urban and rural HHs is not much responsive to the changes in prices. These estimates are similar to the findings in the literature (Athukorala and Wilson (2010), Gebreegziabher,*et al.*(2010) and Sene, S. O. (2012)). Although the magnitude of these price elasticities are small, it has been observed that electricity which has the highest budget share among the three energy sources has the highest own price elasticity. According to Ngui,*et al.*(2011) the category of fuel which has the largest budget share is more responsive to price changes as HHs respond more by increasing or decreasing the expenditure share on the respective fuel category.

7.Conclusion and Policy Implication

The aim of this study has been to analyze the household expenditure patterns on three main energy sources i.e., electricity, natural gas and petrol in response to the increasing energy prices by using three sets of micro data for the years 2005-06, 2010-11 and 2015-16. The income and price elasticities of these sources have been computed using Extended Linear Expenditure System. In addition the household expenditure patterns on these energy sources have been analyzed for different expenditure quintiles of urban and rural HHs. Quintile wise household per capita expenditure witnessed a rise in electricity natural gas and petrol for both urban and rural HHs during 2006-16, however the growth in per capita expenditure in these energy sources is observed to be higher in case of rural HHs.

The marginal budget shares of all the three sources have been found to be on lower side across the three periods for both urban and rural HHs. However, the marginal budget shares of the urban HHs are seen to be relatively higher than the urban counterparts. The income elasticities of all the three sources are found to be less than unity, indicating that all the three sources behave as normal goods. However, due to the small magnitude these results show that households do not increase their consumption of these energy sources significantly with the rise in their income. The price elasticities are found to have the expected negative signs with low magnitudes indicating they are less responsive to changes in price. The low price elasticities indicate that as the prices of these energy sources fall, there will not be a proportional increase in the demand of these sources.

The results of these demand elasticities indicate that both urban and rural households consume energy (electricity, gas and petrol) according to their needs. The prices of all the three sources have changed in the years under consideration with increasing prices of gas and electricity and fluctuating prices of petrol yet the demand elasticities have remained low for all the three periods. It has also been observed that the petrol prices in Pakistan do not necessarily fall with the decline in international oil prices. The prices of petrol were reduced at the end of 2014 in response to the falling international oil prices but were immediately increased due to the artificial shortage of fuel. Hence, targeting energy subsidies in order to reduce the fiscal burden may be a suitable policy by the government. However, such a decision should be carefully designed as it will adversely affect the poor.

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