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Article

Impact of Ageing and Generational Effects on Household Energy Consumption Behavior: Evidence from Pakistan

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Keywords: ageing effects; cohort effects; generational effects; household energy consumption; energy demand; Pakistan

1. Introduction

Developing countries have been going through the process of ageing for the past few decades. Today is the age of communication and globalization and underdeveloped countries, like Pakistan, are not lagging behind in knowledge and access to modern technology in the health sector. Therefore, like in many other countries, life expectancy in Pakistan is also increasing along but with comparatively slower rate. According to WHO statistics, the current annual average growth rate of life expectancy at birth in Pakistan is 0.23% (Country statistics and global health estimates by WHO and UN partner). The population ageing trend spanning over the several past decades in Pakistan means that the proportion of elderly people in population is increasing, as shown in Figure 1, and this trend is expected to continue in near future as well (Source: United Nations Population Division, Department of Economic and Social Affairs. World Population Prospects: The 2015 Revision. (Medium variant)). The effects of the populations aging on economy have been extensively studied in literature. In this regard, life cycle models of Ramsey [1] and Modigliani [2] were pioneering contributions; households adopt different consumption attitudes as they age in order to satisfy their needs at different phases of life cycle. Thus, at the aggregate level, the age structure of populations can affect savings and aggregate consumption. Hence, it becomes quite significant to study how changes in the distribution of age affect consumption decisions of households.

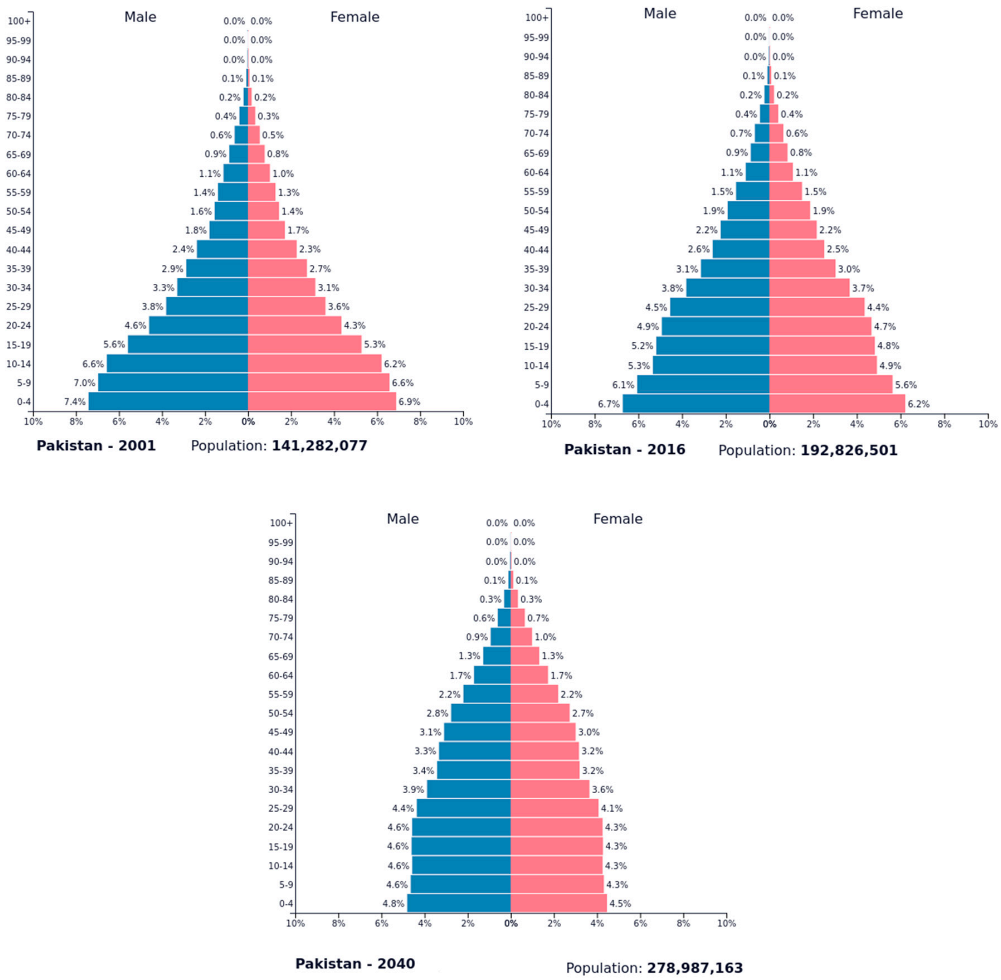

Figure 1. Population Pyramid. Source: United Nations Population Division, Department of Economic and Social Affairs. World Population Prospects: The 2015 Revision (Medium variant).

The study of energy consumption behavior of different age groups has been recently acknowledged as being of paramount importance among economists, especially in the context of climate changes. In this regard, relevant literature concludes that an aging of population can compel policy makers to slow down efforts towards reduction in the energy intensity and emission of greenhouse gases [3]. This conclusion is related to the observation that increasing energy demands for heating and cooling is interlinked with less active or inactive lifestyles of elderly populations. However, this scenario is more complicated than expected, as it involves numerous factors, including consumer preferences, trends in aggregate income, and societal transformation. Several contradictory effects may arise through the interplay of such factors. This paper puts aside these counteracting forces and their macroeconomic aggregate results and it focuses on the microeconomic perspective of energy demand by exploring household heterogeneity in terms of age and generation. In order to analyze the impacts of the age and generational specific effects on the structure of energy consumption, the cohort analysis is considered to be an appropriate tool because it facilitate and allows for the separation of the age (A), the period (P), and the cohort (C) effects. The age effect depicts the impact of the age category on energy consumption. Period effects characterize the impact of macro-economic and historical events on energy consumption, e.g., business fluctuations or epidemics (Deaton, 1997), whereas the cohort effect helps to determine generational differences in energy demand.

The paper makes two major contributions. To the best of our knowledge, no empirical work in Pakistan has utilized detailed and extensive information available through the study of household surveys spanning over a number of years. In this regard, the first contribution of this study is the exploitation of detailed and extensive information available in the household survey data sets. The second contribution is the estimation of age and cohort effects on household energy expenditure by Pakistani households. Although there are some studies (Burney and Akhtar [4]; Chaudhry [5]; Hussain and Asad [6]; Idrees, et al. [7]; and, Tehseen and Khan [8]) that have investigated the connection between the energy expenditure and various economic and demographic characteristics, none of these studies has attempted to measure generational effects on energy consumption. Our data has been drawn from Household Income Expenditure Survey (HIES) for eight years over the period 2001–2002 to 2015–2016, as collected by the Pakistan Bureau of Statistics (PBS).

The study uses the method of Deaton and Paxson [9] and applies decomposition among age, year, and cohort effects to analyze the relevance of interplay between cohort and age effects. Other factors that were linked to household energy demand include personal and dwelling characteristics. Our pooled analysis confirms that age is a key factor in determining household energy demand, showing rising trends in expenditure with age. These findings are also supported by international literature [10]. The results also provide strong empirical evidence of significant differences in the shape of cohort and age effects. The pure age effect could also be entangled with various cultural factors that may differ across generations. Resemblance in cultural influences and social experiences shape the patterns of energy consumption through generations. Thus, the differences in electricity expenditures across generations are greater than those in gas, and are smaller than those in firewood expenditures.

Rest of the paper is organized in the following manner. Section 2 includes an overview of the relevant literature and a survey of the aging and its relationship to energy consumption. Section 3 contains datasets and their descriptive analysis. Sections 4 and 5 describe methodology and data management. Section 6 presents and discusses the empirical results of the decomposition of changes in energy consumption across data points into age, period, and cohort effects. Finally, Section 7 concludes the study.

2. Literature Survey: Ageing Population and Residential Energy Demand

Majority of the literature on the study and analysis of household energy consumption recognize that the demand of residential energy is affected by both non-human and human factors concerning households. Climate and dwelling conditions come under non-human characteristics, whereas psychological, demographic, and cultural elements fall under human characteristics, as mentioned by Bardazzi and Pazienza [11]. Models of household energy demand are widely based on control variables, such as meteorological temperature levels and weather conditions. To study global warming in terms of quantifying its impact on cooling and heating expenditures, a growing number of articles can be found in the literature that is focusing on the elasticity of energy demand in relation to variations in climate and temperature. As expected, a negative relationship is established between temperature levels and energy demand related to heating. Conversely, expenditures that are related to cooling show a positive relationship of energy demand with temperature levels. However, cultural components and threshold effects have introduced non-linearity in these relationships between temperature level and energy demands. A study that is based on Dutch micro data by Brounen, et al. [12] unveiled that the dwelling characteristics are more applicable in terms of studying heating and gas consumption. On the other hand, demographic characteristics have greater effect on consumption of electricity than on consumption of other energy types. In addition to that, electricity is found to be more sensitive to income fluctuations when it is compared to natural gas.

From the perspective of socio-economic characteristics, a number of studies have shown relevance of economies of scale in relation to household energy usage. In this context, household size evidently becomes a key variable. Moreover the economies of scale implies that small households consume, more energy in per capita terms in order to maintain their energy related functions within certain limits such as appropriate supply of hot water, home cooking, and heating. Significant economies of scale were observed by Ironmonger, et al. [13] in household energy usage and expenditure in Australia.

In this study, small differences are found among household types. However, the study found strong evidence of diseconomies of scale in the case of elderly households.

According to Torgler, et al. [14], well educated households are inclined to adopt a friendly attitude towards environment, and, hence, towards energy saving and cost reduction. They also like to take advantage of energy efficient house construction styles and manage to install energy storage and generation devices, such as batteries, UPSs, and solar panels. Longhi [15] reported that households in the United Kingdom (UK), having at least one person with a university degree tend to have two percent less per capita expenditures on energy than rest of the households. Such findings suggest that educated people may have more environmental awareness and are more willing to accommodate pro-environmental ways of life. Moreover, income level of household may also have some importance, but it has been found to be less relevant than expected while predicting consumption heterogeneity. This study also shows wide variations in income elasticity estimates. However such variations seem to be reduced when micro data sets are used. In addition to that, these findings show that elasticities are, in general, higher for heating related electricity expenditures than for the overall energy expenditure. It is also observed that socio-economic circumstances of household have very small impact on energy consumption in comparison to their dwelling characteristics (related to gas expenditure) and household size [15].

Regarding the role of household's age structures, most of the literature for advanced countries indicates an inverted U shaped relationship of household energy expenditure with age of household head [16]. This pattern emerges because of the changing composition and size of the household along with age of the household head. The highest probability of finding the house with overlapping generations is when the age of head lies between 40 and 60 years. Obviously, energy consumption during this age brackets will be at peak. At individual level aging is often associated with higher energy expenditure. Elderly households have more energy expenditures because they spend a larger portion of their days in houses, and hence, require more cooling and heating comforts [10]. Decline in household size can create relationship of energy consumption with aging. This impact, at the household level, appears in the form of a loss of economies of scale in energy usage, as observed by Schröder, et al. [17] for Japan.

Wide variations in energy consumption patterns are observed among similar types of households, which may be better explained by studying the characteristics of the relevant energy culture. Energy choices can be understood, according to Stephenson, et al. [18], by exploring the interactions between "material culture (e.g., technologies, building form), cognitive norms (e.g., beliefs, understandings), and energy practices (e.g., activities, processes)". For example, newly retired people, with greater wealth and better health than their parents are probably more able to satisfy their ambitions of recreational and traveling activities by adopting a lifestyle that is filled with modern stuff of leisure and comfort [19].

Literature on household energy demand in Pakistan is quite limited. Burney and Akhtar [4] employed cross section data to estimate income elasticities of household energy demands. The study also computed price elasticities by imposing Linear Expenditure System on estimated linear Engle equations. Chaudhry [5] estimated household electricity demand in the Punjab province by applying an endogenous switching regression model while using data from Multiple Indicator Cluster Survey carried out by Punjab Bureau of Statistics from September 2003 to December 2003. This study reveals that the electricity demand has positive relationship with income and ownership of appliances. Khattak, et al. [20] collected data from 200 households in November and December 2009 from Peshawar district and examined the role of economic and non-economic factors that are involved in determining household electricity demand. The study revealed that the income, electricity price, number of rooms in house, weather conditions, and education level of household head are important determinants of household energy demand in the Peshawar district. The study also found that electricity price matters for the consumers with the comparatively low consumption of electricity.

Using data for the years 2004–2006, Hussain and Asad [6] performed a detailed analysis of residential electricity demand in Pakistan. The study observed that urban households spend more on electricity than rural households. Households in the province of Punjab have greater electricity expenditure than households in other provinces. Also the household possessions in the form of electric equipment and appliances, especially air conditions and refrigerators, positively affect electricity expenditure. Idrees, et al. [7] employed the pooled data of household survey of Pakistan covering the years 2004–2005 and 2007–2008 and estimated electricity demand in the forms of log linear, translog, and linear functional. The study observed that increase in total expenditure, household size, house size, temperature, and the number of heating degree days results in increased electricity demand, while an increase in electricity price reduces its demand. In a recent study, Tehseen and Khan [8] estimate the household electricity demand function in Pakistan while using household data for the year 2010–2011. The study found that in all regions of the country electricity demand is price elastic and income inelastic, while household size shows a positive impact on electricity demand.

The above review of literature shows that most of the studies in Pakistan are based on cross section data that contain limited information on price variation. Although one study attempted to extract price variation from a set of cross sectional data, yet it was unable to identify the variations in energy demand that can be attributed to period, age, and cohort effects. With this background, the present study makes a major contribution to literature by exploring the generational effects on energy expenditure in Pakistan.

3. Demographic Transition and Energy Consumption in Pakistan: Data and Descriptive Analysis

We employ and analyze the data from eight rounds of Household Income Expenditure Survey (HIES) collected by Pakistan Bureau of Statistics (PBS) during the period 2001–2002 to 2015–2016. Data on energy prices are taken from the Monthly Review on Price Indices conducted by PBS. Table 1 describes sample size for all of the selected survey years, the average total expenditure per household by year adjusted for energy price inflation, the household head's average age and average family size. We observe a slight increase in the average age of household heads from 45.389 in 2001–2002 to 46.335 in 2015–2016 and continuous decrease in average family size.

Table 1. Summary Statistics.

Year	Sample Size	Average Total Annual Expenditure (Rupees)	Average Age of Household Head (Years)	Average Household Size
2001–2002	16,061	6853.58	45.389	7.22
2004–2005	14,686	8841.46	45.620	6.93
2005–2006	15,453	10,046.57	45.632	7.17
2007–2008	15,512	12,125.04	45.837	6.9
2010–2011	16,340	18,509.85	46.112	6.66
2011–2012	15,803	21,796.14	46.164	6.73
2013–2014	17,989	25,156.93	46.204	6.61
2015–2016	24,238	37,696.11	46.335	6.5

Note: Authors' calculations from HIES datasets.

As the surveys are based on repeated cross sectional data from an independent sample, we cannot extract any exact information of individuals' behavior over time. However, it contains all of the necessary information in the form of different ages in different household groups. In order to make comparison among households with different characteristics, it is useful to perform a cross-sectional analysis on energy expenditures. The HIES data are registered with reference to the person who is considered as household head. We use five-year age classes of household heads to distinguish energy demand by age and present the data of household demographic characteristics in Table 2. It shows the relative frequencies of household head's age classes of selected survey years. The table shows a changing population structure in Pakistan. In particular, the share of younger household heads aged

18–34 years decreased from 21.9% in the year 2001–2002 to 19.2% in 2015–2016, while the share of older household heads aged 35–59 increased from 58.5% to 62.8 during the same time period. The most prominent increase can be seen in proportion of population in the age group 40–49 years from 44% to 49%. This result is in line with population pyramids of the years 2001 and 2016, as presented in Figure 1.

Table 2. Age Composition of Households Head in Relative Term.

Age Classes	2001–2002	2004–2005	2005–2006	2007–2008	2010–2011	2011–2012	2013–2014	2015–2016
18–24	0.039	0.03	0.024	0.028	0.036	0.026	0.033	0.026
25–29	0.076	0.07	0.064	0.068	0.081	0.067	0.074	0.064
30–34	0.104	0.097	0.099	0.102	0.113	0.099	0.098	0.096
35–39	0.141	0.144	0.136	0.13	0.133	0.134	0.137	0.139
40–44	0.131	0.144	0.143	0.136	0.132	0.135	0.142	0.149
45–49	0.121	0.139	0.143	0.137	0.134	0.145	0.13	0.133
50–54	0.11	0.114	0.119	0.11	0.104	0.122	0.108	0.116
55–59	0.083	0.085	0.089	0.1	0.095	0.093	0.091	0.093
60–64	0.08	0.071	0.076	0.078	0.069	0.078	0.075	0.081
65–69	0.048	0.043	0.045	0.051	0.048	0.05	0.047	0.044
70–74	0.036	0.033	0.033	0.032	0.03	0.028	0.036	0.032
≥75	0.032	0.031	0.027	0.028	0.025	0.023	0.03	0.027
Total	1	1	1	1	1	1	1	1

Source: Authors' calculations on HIES data.

Table 3 shows the proportion of the residential energy expenditure in the total consumption expenditure. This share is observed to increase in the first three surveys from 7.51% to 7.88%. But thereafter, the energy share showed a declining trend with some fluctuations. One of the reasons has been the easy availability and the adoption of more energy efficient household appliances, such as air conditioners, refrigerators, fans, kitchen gadgets, light bulbs, and vehicles. It may also be noted that the declining trend in share of energy consumption is more prominent among the households with middle aged and older heads, whereas for the younger household heads, the trend seems to be opposite. The table also shows trends in the residential energy expenditure by householder's age groups. We observe somewhat U-shaped relationship of share of energy expenditure with age. That is, the share of energy in consumption basket appears to be higher among the households with young and old heads as compared to ones that are headed by middle-aged persons, and this trend is more prominent in the recent years.

Table 3. Residential Energy Expenditure Share by Household Head's Age Class.

Age Classes	2001–2002	2004–2005	2005–2006	2007–2008	2010–2011	2011–2012	2013–2014	2015–2016
18–24	7.63%	7.73%	7.75%	7.63%	7.39%	7.65%	7.08%	7.68%
25–29	7.42%	7.97%	8.15%	7.85%	7.39%	7.76%	6.92%	7.61%
30–34	7.63%	8.03%	8.02%	7.72%	7.46%	7.81%	7.04%	7.17%
35–39	7.53%	7.79%	7.95%	7.80%	7.40%	7.66%	7.16%	7.17%
40–44	7.52%	7.82%	7.79%	7.84%	7.01%	7.64%	6.76%	6.78%
45–49	7.51%	8.06%	7.81%	7.61%	7.17%	7.44%	6.76%	6.82%
50–54	7.44%	7.79%	7.72%	7.74%	7.20%	7.50%	6.78%	6.88%
55–59	7.21%	7.72%	7.80%	7.65%	7.08%	7.50%	6.96%	7.01%
60–64	7.36%	7.73%	7.86%	7.82%	7.40%	7.92%	6.89%	7.09%
65–69	7.76%	7.72%	8.09%	7.92%	7.25%	7.66%	7.13%	7.14%
70–74	7.80%	7.81%	7.70%	7.70%	7.58%	7.44%	7.03%	7.21%
≥75	7.62%	8.34%	7.97%	7.51%	7.95%	8.20%	7.29%	7.54%
Total	7.51%	7.87%	7.88%	7.75%	7.28%	7.64%	6.94%	7.06%

Source: Authors' calculations on HIES data.

The above observations are further confirmed from Table 4, which shows a decreasing trend in the proportion of households that spend more than 10% of their total expenditure on energy. These decreasing trends can also be seen in the number of people among the households with middle-aged and older heads. We also observe a U-shaped relationship between the percentage of households allocating more that 10% of expenditure to energy and the age of household head, especially in the last four survey years.

Table 4. Percentage of Energy Consumption Share (>10%) by Household Head's Age Class.

Age Classes	2001–2002	2004–2005	2005–2006	2007–2008	2010–2011	2011–2012	2013–2014	2015–2016
18–24	25.28%	23.52%	27.91%	24.81%	24.23%	22.65%	20.90%	24.14%
25–29	21.42%	25.63%	26.21%	26.43%	21.96%	25.63%	18.21%	22.78%
30–34	24.83%	26.93%	25.08%	24.39%	20.28%	25.84%	19.13%	19.97%
35–39	22.46%	24.17%	25.46%	25.68%	20.47%	24.21%	19.21%	18.77%
40–44	22.63%	23.73%	25.07%	25.38%	16.10%	24.33%	17.55%	16.14%
45–49	22.95%	24.96%	23.94%	22.92%	19.14%	23.04%	17.38%	16.38%
50–54	22.38%	23.28%	24.05%	24.02%	18.52%	23.17%	16.79%	16.85%
55–59	21.41%	22.47%	24.38%	22.94%	18.54%	23.01%	17.50%	18.27%
60–64	22.31%	22.41%	23.47%	26.07%	21.24%	26.62%	17.64%	19.22%
65–69	23.92%	25.72%	26.10%	26.09%	20.49%	23.47%	18.44%	19.30%
70–74	25.52%	24.43%	21.82%	23.46%	22.96%	24.36%	18.60%	20.74%
≥75	23.27%	30.51%	27.16%	22.06%	25.45%	29.40%	22.27%	22.05%
Total	22.92%	24.47%	24.86%	24.61%	19.69%	24.35%	18.22%	18.51%

Source: Authors' calculations on HIES data.

To gain further insight, we present the relationship between the age of household head and household's expenditure per capita at constant prices in Figure 2. We can see an almost consistent rising trend in energy consumption both with respect to age and time. Obviously, one of the reasons for increase in energy consumption over time is the growth in real per capita incomes. Similarly, positive correlation between energy consumption and the age of household head could be explained by an increase in the income of household head with age, as suggested by life cycle theory at the micro level. It may also be noted that the statistics in the figure do not control for variations in energy consumption due to different tastes and preferences across different generations/cohorts.

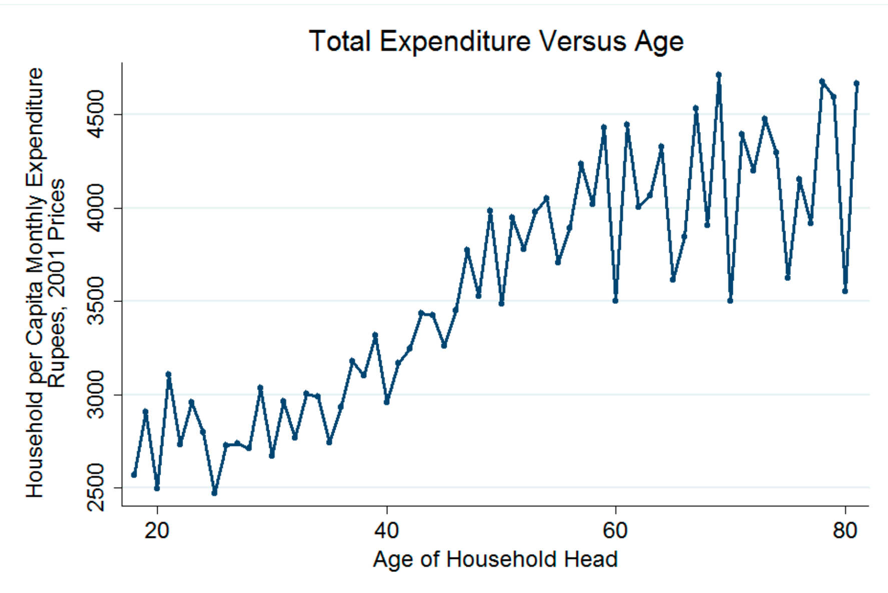

Figure 2. Age of Household Head.

Figure 3 shows household energy expenditure for all of the selected survey years with respect to household head's age. Figure 4 presents energy expenditure among different cohorts of household heads as they age. The figure shows different cohorts overlapping at common ages. This enables us to observe some limited information about variations in consumption across cohorts. This plot presents a noticeable life pattern, which shows a rising trend with age. In the range of the older ages, with the exception of a few cases, the lines representing the younger cohorts are consistently (although not for every case) above the lines presenting the older cohorts. This is considered as the cohort effect. We can see that the each line segment represents the same span of 15 years showing the period of 2001 to 2016. Each cohort shows a dip in the year 2007–2008, and also in the year 2010–2011, which corresponds to economic instability and crisis. One more economic downfall was observed in the year 2013–2014, due to the energy crisis in Pakistan. This is an example of the period (year) effect. It is an accumulated effect that displaces all cohorts, temporarily and synchronously, away from their profiles. Under this scenario, a fall in the economic growth rate can be represented by this effect.

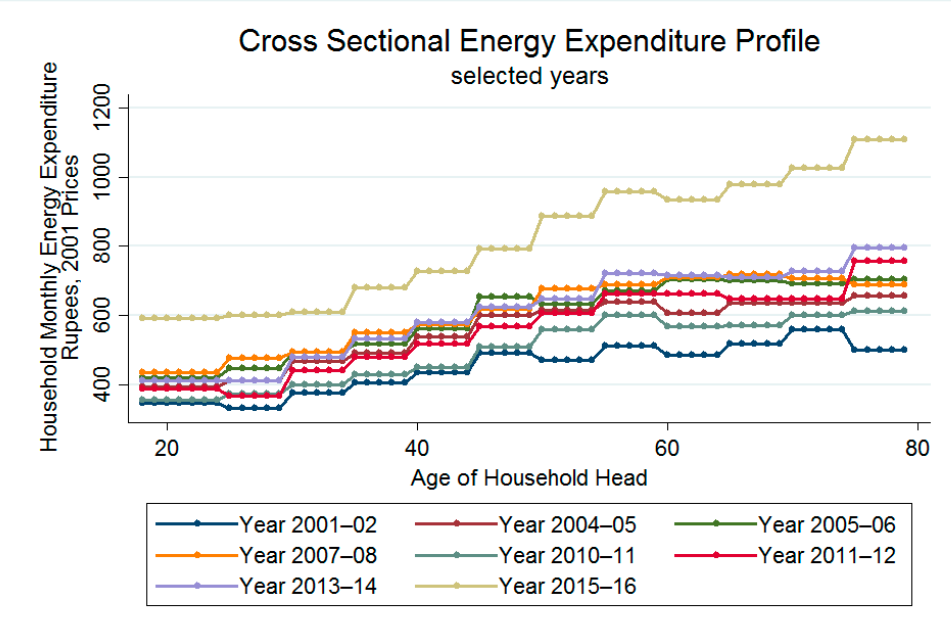

Figure 3. Cross Sectional Energy Expenditure Profile.

It follows from the above analysis that one has to formally decompose the variations in consumption pattern into a number of identifiable factors, including economic factors, like income and price effects, and demographic factors, such as age and cohort effects. In particular, a detailed analysis of these results requires these three effects, namely age, year, and cohort effects have to be separately distinguished from one another. To make these components separate from each other, we implement the decomposition procedure. In this context, survey data based economic analysis has its own benefits because of the presence of household characteristics spanned over a range of verities in the sample. But, it does have some limitations, as we do not observe the same cohort of household across ages, but we observe the experience of different generations at different ages. However, the use of time series of cross sections makes it possible to track down cohorts of families from one survey to the other survey. We can use successive surveys to track different cohorts. This procedure permits us to disentangle the life-cycle from generational components of consumption profiles.

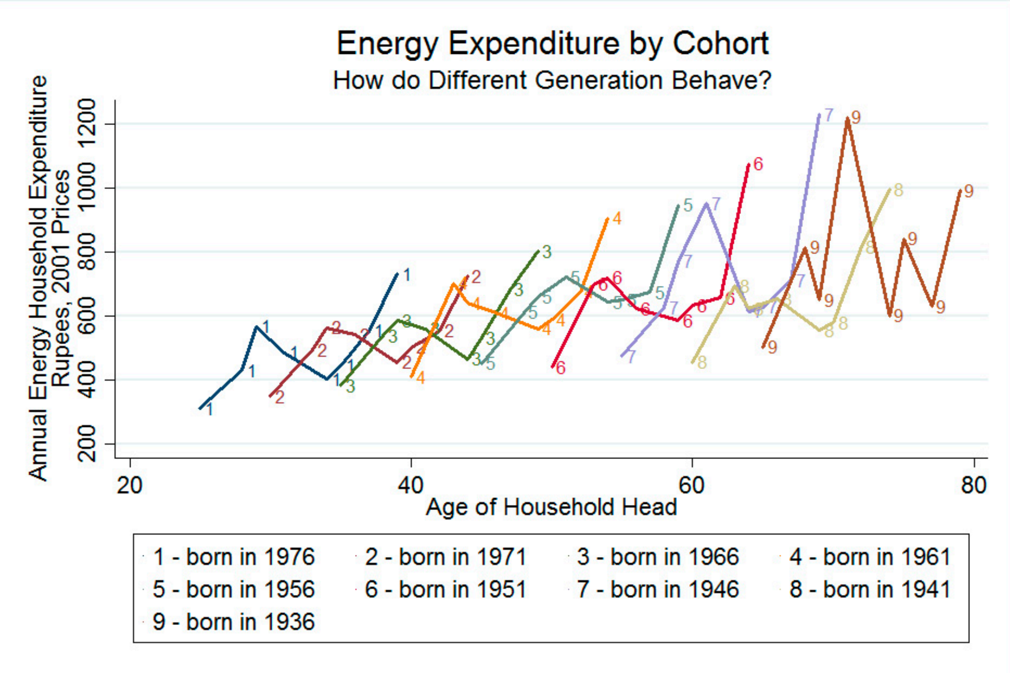

Figure 4. Age of Household Head.

4. Methodology

We aim to examine how consumers make their choices, which are not only affected by age but are also by generational preferences along with a number of other socioeconomic factors. The best way of examining cohort effects is to employ large enough panel data containing all information of individuals that were followed over an extended period of time. These types of extended data covering a long period of time are very rare. Therefore, to examine and track down groups of individuals over a certain period of time, Deaton (1985) proposed employing repeated cross-sections. In this scheme, within a cohort, the variables of interest are averaged over all individuals. Such empirical analysis, which is performed following the above scheme, has certain disadvantages and advantages over the panel data (Deaton, 1997). In this paper, we employ data from eight independent cross section data sets of HIES collected during the period 2001 to 2016. We choose to establish a model for household energy expenditure that not only accounts for age and cohort effects, but also considers the effects of a set of control variables. To achieve this objective, we use household instead of cohort as the unit of analysis. In this way, we can easily retain heterogeneity of characteristics related to individual observations. This approach is used by Bardazzi and Pazienza [11], while developing a model for fuel consumption in the Italian private transport sector and by Drescher and Roosen [21] to model the consumption of food away from home and food at home, by covering a German data spanned over 25 years long period.

Following Aristei, et al. [22], Drescher and Roosen [21], and Bardazzi and Pazienza [11], we employ an age-period-cohort (APC) decomposition model, including a vector of control variables in terms of Z. Consequently, we model energy expenditure as a function of explanatory variables and dummy variables representing age, cohort, and period effects. The resulting equation for the household energy expenditure is as follows:

$$\log(hh\ EX)_i = \alpha_0 + \beta\ D_{age} + \gamma\ D_{cohort} + \delta\ D_{year} + \theta\ Z_i + u_i \quad (1)$$

In this equation, $\log(hh\ EX)_i$ is a logarithm of the real energy expenditure of the household i, D_{age} is the vector representing age dummies (for 56 age year), D_{cohort} a vector of cohort dummies (for 71 cohorts), D_{year} a vector of year dummies (for eight years), Z_i is a vector of control variables that includes a set of non-human characteristics (housing and weather) and socio-economics factors for each observation point i, and the term u_i represents the unobserved error.

In order to avoid any singularity, one dummy must be dropped out from all three of the vectors representing dummies. However, the estimation of this regression still looks impossible because of the additional linear relationship across age, year, and cohort. We can refer to cohort's age with '*a*' if we choose to label cohort '*c*' with age of the household's head in the year $t = 0$, and here '*t*' represents the date. That is:

$$a = c + t \tag{2}$$

Therefore, to obtain normalization effects, we have to impose another restriction. Following the method of Deaton and Paxson [9], we implemented the constraint, according to which the year dummy coefficients are sum to zero and considered orthogonal to a time-trend (Consider dt to be the usual zero-one dummy. To enforce this restriction, we use a set of $T - 2$ year dummies, dt^*, defined as follows: from $t = 3, \ldots, T$. $dt^* = dt - [(t - 1)\, d2 - (t - 2)\, d1]$.). This is equivalent to characterizing all of the observable trends in the data to cohort and age effects, but not time. Moreover, it is equivalent to using the year effects in order to take cyclical fluctuations into account, which are averaged out to zero over the long enough period of time. (This identification problem is well-known in the literature and several alternative normalisation methods have been proposed (among others, by McKenzie [23], Schulhofer-Wohl [24] and Yang, et al. [25]. All these approaches have their short-comings with increased generality coming at the cost of increased technical complexity.).

The control variables in the vector Z include gender, education level, employment status of household head, household income (proxied by total consumption expenditure), household size, ownership and size of home (the latter proxied by number of rooms), consumer price index of energy type, climatic zone, and rural versus urban region of household's residence. More details on the construction of variables follow shortly.

5. Data and Construction of Variables

As shown in the pie chart in Figure 5, 85.1% the proportion of the total household energy expenditure consists of the combined expenditure of electricity, gas, and firewood. Therefore, we use the main energy types, electricity, gas, and firewood, in our analysis. Our model of household energy expenditure on electricity, gas, and firewood is based on Equation (1), along with explanatory variables. Table 5 includes all variables that are used in the model. Left hand side of the Equation (1) consists of dependent variable, which is the logarithm of the household's real energy expenditure (on electricity, gas, and firewood, alternatively). Data on energy expenditures are reported in terms of purchased values and receipts in kind in exchange for some good or service rendered. The in kind receipts are imputed at the prevailing market prices and are added to expenditures on purchased quantities to arrive at energy expenditures. The same procedure is adopted for total expenditure, which is used as a proxy of total income because households tend to under-report their actual incomes. In order to convert nominal variables, namely energy expenditures and total expenditure, into real values, we use commodity-specific price indexes taking 2001 as the base year.

Table 5. Variables Construction.

Variables	Description
EX*i*	Log of real energy expenditure per household (monthly) used as a measure for energy consumption. These variables are use as dependent variables separately for each equation.
D_{cohort}	Vector of cohort dummies: Cohort*i* where $i = 11, 12, \ldots, 81$ $i = 11$ if birth year = 1991; $i = 12$ if birth year = 1990; . . . ; $i = 81$ if birth year = 1920. Cohort*i* is set equal to one if the household head is born in given birth year and zero otherwise.

Table 5. *Cont.*

Variables	Description
D_{age}	Vector of age dummies: Age*i* where *i* = 25, . . . , 81. Age*i* is set equal to one if the household head age is *i* and zero otherwise.
D_{year}	Vector of year dummies: Year*i* where *i* = 2001–2002, 2004–2005, 2005–2006, 2007–2008, 2010–2011, 2011–2012, 2013–2014, 2015–2016. Year*i* is set equal to one if the survey year is *i* and zero otherwise.
Gender	Dummy variable for male household head. Gender is set equal to one if household head is male and zero otherwise.
Education level	Dummy variable for household head education. Variable is set equal to one if household head education is tertiary and zero otherwise.
Employment status	Dummy variable is set equal to one if household head is employed person and zero otherwise.
TE*xp*	Log of per capita real household expenditure
Climatic Zone	Dummy variables for climatic zones. Zone*i*; where *i* = A, B, C, D, E. Dummy for Zone*i* is set equal to one if the household lives in zone *i* and zero otherwise.
CPI*i*	Consumer price index (monthly) for electricity, gas and firewood with base year 2001 = 100
Property	Dummy variable for home ownership, set equal to one if household is owner of house and zero otherwise.
Region	Dummy variable, set equal to one if household is living in urban area and zero otherwise.
Room number	Integer
Household size	Integer

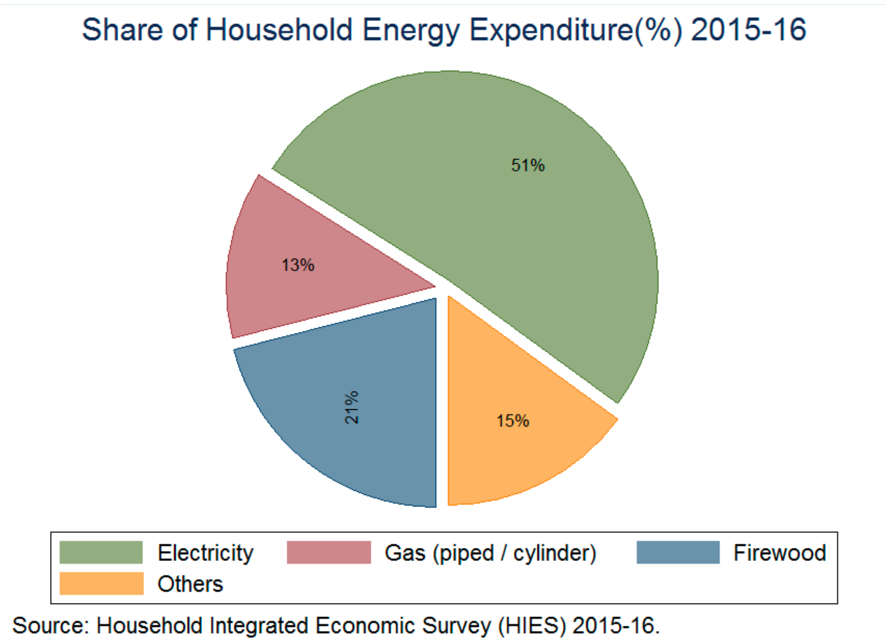

Figure 5. Share of Household Energy Expenditure (%) 2015–2016.

In order to control for household size, per capita household income is used to compare household expenditure with different demographic compositions. All of the expenditures are measured at constant prices of the year 2001. The age and cohort dummies are defined on the basis of household head's characteristics. For this purpose, we only consider household head's age 25 to 81 years. In order to eradicate any problem with selectivity, we trimmed out household heads below 25 and above 81.

Such problems that are related to selectivity can arise due to any extreme and unreliable values in relation to the variables of interest. We develop and deploy cohorts at each age. Therefore, we took 71 cohorts, which are developed according to household head's year of birth. The youngest one of all of these is 25 years old in 2015–2016 (born in 1990–1991). As we measure age in first survey year, the oldest one is 81 years old in 2001–2002 (born in 1920–1921). The rational of selecting the youngest cohort at age 25 is simply that the probability of a person less than 25 years of age to be the head of a household is very low in comparison to any older persons. Period dummies are described for each survey year. Other determinants are defined in terms of dwelling and socio-economic factors, which include gender, education level, employment status, household size, total expenditure per capita, climatic zones, room numbers, and region. Pakistani households that are located in residential areas use different types of energy sources, such as electricity, gas (piped/cylinder), firewood, kerosene oil, dung cakes, cotton sticks, agricultural wastes, etc.

The climate varies vastly throughout the year in most regions of Pakistan. So, it is impractical to consider the whole country under one climatic zone because different stations have different topography and complex microclimates. Based on geographical features, the Pakistan Metrology Department has divided the administrative districts into five different zones, as shown in Figure 6. Therefore, we use dummy variables to represent these five zones. The literature review explains the reasons of using other variables in our model for the estimation of household energy expenditure.

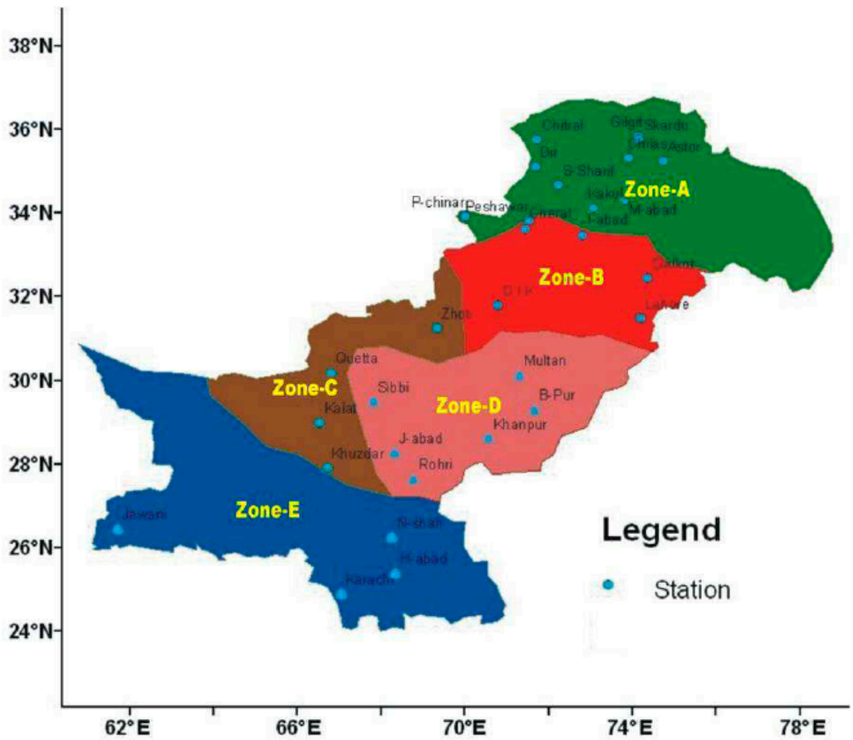

Figure 6. Map of Pakistan Showing different climate zones of Pakistan along with their latitude and longitude. Zone A: High mountains, cold weather; Zone B: Sub-mountains and mildly cold; Zone C: Cold winter and hot summer; Zone D: Hottest and dry zone, where highest max temp are recorded; and, Zone E: Warm humid sub-tropical climate mostly coastal cities.

6. Results and Discussions

We applied the above-mentioned APC model augmented with control variables for households' expenditure on three energy types: electricity, gas, and firewood. We decomposed the variations in energy expenditure into different effects, such as age and cohort, and then presented them in a table and graphs. Parameter estimates of statistics of all the variables other than age, cohort, and year dummies are presented in Table 6, while age, cohort, and period effects are shown in panels of figures named Figures 7–9. In these panels of the figures, the first plot at the top left side presents average of log expenditure for every fifth cohort combined with the energy expenditures. The rest of the three plots in these figures represent the age, cohort (plotted as a function of the household head's age in 2001), and year (period) effects. All of these effects have a combined statistical significance. In Figure 7, electricity expenditure is almost linearly increasing with age. The pattern of life can be verified by the age effect where the coefficient estimates of age dummies increase from 0.01 to 0.42 corresponding to the age-range from 25 to 80. The cohort effects are presented at the bottom left side of the figure. These effects have more or less the same magnitude as the age effects, and they show almost linearly decreasing trend towards older generations. We can infer from the estimates that electricity consumption per cohort-year increases by 0.85. The year effects are presented at the bottom right side of the panel. These effects are exhibiting somewhat linearly increasing trend against survey years with one bump against the year 2011. This bump in the curve arises because of the sudden rise in electricity price due to an increased demand of electricity on one hand and its severe shortage in supply on the other hand.

Next, Figure 8 shows that the age and cohort effects on expenditure on gas are relatively less prominent than on electricity expenditure. However, the year effect is significant, more or less in the same way, as in the case of electricity. It shows its lowest point in the year 2011–2012, because of the energy downfall, and consequently the restricted availability of gas. A steadily increasing linear trend can be observed in the age effect in relation to the gas expenditure. From the perspective of cohort effects, obviously the younger generations show increased gas expenditure.

Figure 9 presents the age effects of the firewood expenditures. In general, the average of log firewood expenditure seems to increase with age. Age effect shows an almost linearly increasing trend. However, the cohort effect shows a decreasing pattern. Both age and cohort effects, in this case, are substantial and are almost of the same magnitude as in the case of electricity.

To categorize the generations on the basis of energy expenditure, we divide approximately 71 cohorts into two groups: one group consists of younger generations who were born during the period 1955 to 1990 and the other group consists of older generations who were born during the period 1920 to 1956. The coefficients of cohort effects for the younger generations are between 0 and −0.2 in the case of electricity and 0 to −0.05 in the case of gas with a minor inter-cohort difference in the spending pattern of electricity and gas. Clearly, the younger cohort grew up in a technologically advanced era, in a time of economic prosperity. The presented cohort effects for the elderly generation clearly demonstrate the fact that earlier born cohorts spend less and the later born cohorts spend more (the coefficients drop down from −0.05 to −0.6, −0.0937, and −0.646, respectively, for electricity, gas, and firewood). Spending attitude of most of the cohorts seems to be largely influenced by experiences.

The results that are related to the other control variables are in line with literature. The own price elasticities are found to be statistically significant for all types of household energy. The negative sign for own price of energy in all three of the models means that, while holding other things constant, the demand for energy will decrease as the price of energy increases.

The gender variable has positive and statistically significant effect on electricity consumption. In the case of gas and firewood, on the other hand, the gender effects are statistically insignificant. Gender's role in household electricity consumption indicates that the households headed by male members, on average, tend to consume more energy than the households that are headed by female members. Due to the differences in social roles and socialization trends, the usage of electricity may be influenced by gender and it may show the tendency to change the consumption behavior. In general, females seem more inclined towards practicing the energy-saving habits and they exhibit more pro-environmental behavior than males [26–28].

Our regression results confirm that education level of household head is also directly linked to consumer's behavior of spending on energy educated people are more likely to maintain a high quality lifestyle and therefore they have higher electricity consumption than the less educated people. Therefore, such people have higher consumption of electricity and gas and relatively lower consumption of firewood. These findings are also supported by [29,30].

Table 6. Regressions Results (Dependent Variables are in Column Heading).

Variables	Electricity	Gas	Firewood
Log of Electricity Price	−0.690 *	−0.08	0.067
	(0.124)	(0.102)	(0.075)
Log of Gas Price	0.133 *	−1.026 *	0.032
	(0.050)	(0.021)	(0.083)
Log of Firewood Price	0.266 **	0.499 *	−0.238 *
	(0.102)	(0.066)	(0.060)
Gender	0.039 *	0.01	0.014
	(0.008)	(0.009)	(0.014)
Level of Education	0.084 *	0.057 *	−0.072 **
	(0.009)	(0.018)	(0.035)
Employment Status	−0.073 *	−0.025 *	−0.014
	(0.006)	(0.009)	(0.012)
Property	0.026 *	0.002	0.008
	(0.005)	(0.012)	(0.029)
Household Size	0.041 *	0.041 *	0.049 *
	(0.001)	(0.002)	(0.004)
Log of Total Household Expenditure	0.821 *	0.499 *	0.420 *
	(0.005)	(0.022)	(0.027)
Zone A	−0.118 *	−0.348 *	0.184
	(0.011)	(0.093)	(0.130)
Zone B	0.485 *	−0.347 *	−0.263 *
	(0.007)	(0.074)	(0.064)
Zone D	0.377 *	−0.399 *	−0.366 *
	(0.008)	(0.074)	(0.048)
Zone E	0.274 *	−0.550 *	−0.414 *
	(0.007)	(0.081)	(0.088)
No. of Rooms	0.034 *	0.024 *	0.006
	(0.002)	(0.003)	(0.006)
Region	0.299 *	−0.014	−0.028 *
	(0.004)	(0.05)	(0.007)
Constant	5.530 ***	4.581 ***	2.375 ***
	(0.377)	(0.018)	(0.459)
R-squared	0.462	0.337	0.257
Number of observations	118335	62645	66172

Note: All estimates are produced by Pooled OLS for data 2001–2016 with robust standard errors that are clustered by years. Standard errors are in parentheses. Age 25, Cohort 26, Female, Zone C, and rural is used as reference household head age, cohort, gender, climatic zone and region, respectively. Year 2001–2002 and Year 2004–2005 is due. The parameter estimates significant 1%, 5% and 10% levels of significance are indicated by *, ** and *** respectively.

Our results show that the employment status of the household head is significantly related to the consumption of electricity and gas, but not to the consumption of firewood. Thus, a person in fulltime employment will spend more time away from their home, and this will subsequently result in lower energy consumption. Our results confirm the findings of Ndiaye and Gabriel [31] and Gatersleben, et al. [32] that the number of individuals in a household size or the size of the household displays a positive relationship to energy consumption. Contrary to the other international studies and estimations, our results confirm that if the householder is also the owner of the house, then the residential electricity expenditure is also higher. This result is contrary to findings in Kaza [33] that house owners are compelled by some incentives to install more energy-efficient heating and cooling systems in their homes. Our results show that home owners feel more at ease in installing energy intensive appliances, like air conditioners, coolers, and fans that they otherwise would have to uninstall at the time leaving a rented house. Thus, they are more likely to own equipment/devices that consume more energy. This result is also an indicator of positive wealth effect on energy consumption. The result show that home ownership does not contribute significantly to the consumption of gas and firewood expenditure.

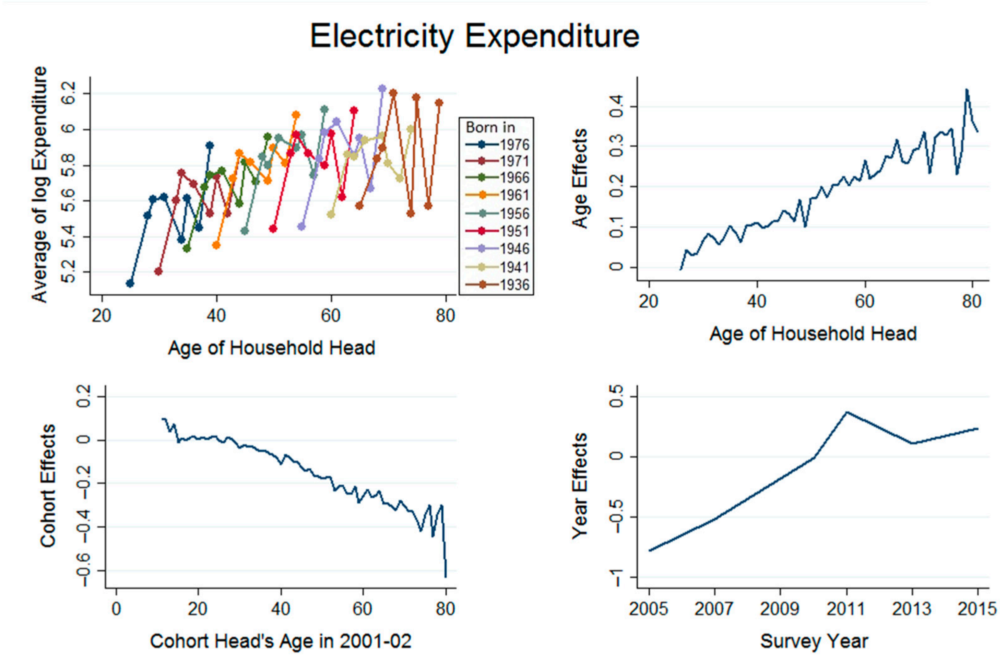

Figure 7. Electricity Expenditure.

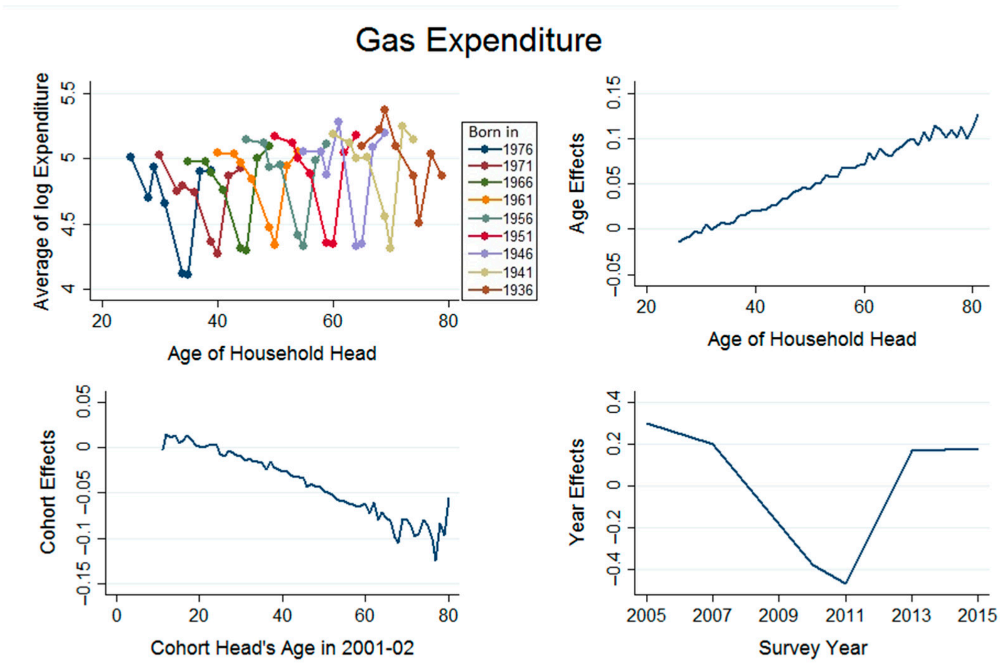

Figure 8. Gas Expenditure.

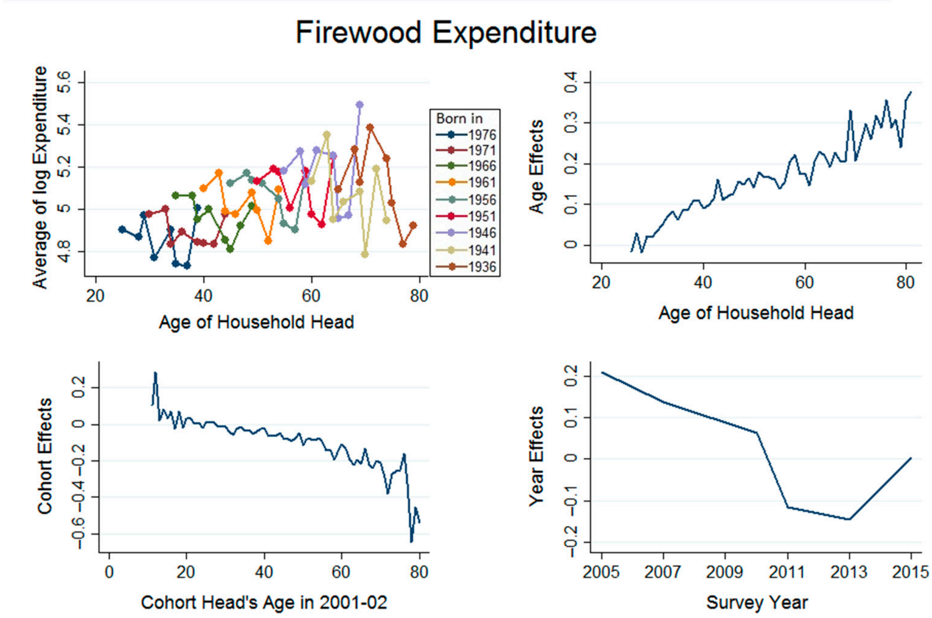

Figure 9. Firewood Expenditure.

As a proxy to household income level, the total household consumption level clearly shows a positive relationship with energy consumption. Higher income of household heads potentially allows for them to maintain a high quality lifestyle, which is based on buying modern energy consuming goods/products (i.e., thermal comfort), not easily affordable for lower income household heads (Haas [34] and Jensen [35]). The results show that expenditure (income) elasticity of energy consumption is low, especially for gas and firewood. The main reason for low-income elasticities for gas and firewood is that these two energy types are mainly used for cooking and heating, the demand for which is not much sensitive to changes in income level.

The effects of climatic zone variables on household electricity consumption are generally significant. Due to the atmospheric temperature differences in different zones, electricity expenditure is higher in Zone B and zone D, gas expenditures are higher in zone C, firewood expenditure are highest in Zone A and lowest in zone E. These results reveal/confirm that the household energy consumption varies across zones and that these variations can be based on their climatic characteristics. This can be explained, as follows: In zone B; most of the people have access to electricity and gas; in zone C, gas expenditure is high due to the cold climate, which demands the high use of heater and geysers; and, in zone C, the gas expenditure is also high because of common availability of gas.

Our results show, as expected, that the number of rooms in a household does have a significantly positive statistical effect on the household electricity usage and this usage increases with each additional room.

Our results show relatively higher expenditure on electricity in urban areas and relatively higher expenditure on firewood in rural areas. Therefore, the residential location is also a significant factor that plays a role in determining the consumption pattern of households. In this context, the process of urbanization in Pakistan is important. In the South Asian region, Pakistan is categorized among the most urbanized countries [36]. Urban population in Pakistan has increased from 25.3% in the year 1970–1971 to 40% in 2015–2016. This growth in population shows almost a rise of 47% in the urban population [37]. This trend in population growth indicates a structural transformation of Pakistani rural areas into urban centers. Such areal transformations significantly affect and redefine patterns of energy consumption via different channels. As influx of migrating people from rural to urban areas is increasing, better facilities that are related to public energy are being provided in the urban areas. Therefore, the electricity demand in urban areas is rising sharply. The impact of urbanization on the electricity usage is becoming vigorously forceful than ever before. This is particularly evident for electricity consuming users. The latter is linked to the fact that the urban households survive more on modern energy consuming equipment and increased usage of electricity, thereby maintaining additional household comfort. The ongoing process of urbanization is one of the reasons that explain why Pakistan has remained unable to meet its electricity demand despite substantial growth in electricity generation. If this process continues as expected, Pakistan will have to gear up its efforts to generate low cost energy, e.g., through hydro sources.

7. Conclusions and Policy Implications

We have made a significant contribution to the existing literature by thoroughly investigating the roles of age and cohort effects in determining Pakistani households' energy usage patterns. Although some researchers in Pakistan have examined and explored the links between energy demand and various economic and demographic characteristics, we endeavored to explore the generational effects on energy usage in this paper, which, to the best of our knowledge, has never been studied for Pakistan. Based on most studies in economics, it is becoming a universal observation that population aging increases household energy demand. This is also true for Pakistan because older people spend a large proportion of their time in homes and thus consume more energy by using fans, lights, air conditioners, and other domestic equipment for longer hours.

In addition to verifying the importance of demographic determinants of residential energy usage in Pakistani households, our analysis provides a clear evidence of age and generational patterns in energy expenditures. While exploring the pure age effect, we confirm the general findings, as reported in the literature, that energy consumption exhibits a steadily increasing trend with age, which means that it is highly likely to have an increase in total energy demand with population ageing.

We conclude our key findings, as, (1) households' per capita monthly energy expenditure increases almost steadily with the increase in household head's age, (2) estimated values of age effects show increasing trend with age, (3) estimated values of cohort effects show decreasing trend with age, which implies that newer generations are more prone to the use in their daily lives high energy consumption modern equipment and products, and (4) year effect for electricity expenditure exhibits an increasing trend and shows peak at year 2010–2011, due to the increased prices of electricity.

In Pakistan, the family structure is different from that found in the developed countries. In general, Pakistani culture supports the joint family system, as with increasing age of the household head the young members of the family tend to remain within the household. Inevitably, the size of the family is further increased by the birth of grandchildren. We found that younger cohorts have relatively elevated energy consumption trends because their expenditures on residential energy are much higher than the oldest cohorts' expenditure. In Pakistan, the numbers of technology adept people are increasing and this also includes elderly people. This part of the population seems to have an easy access to electrical appliances and modern household equipment that are linked to leisure and comfort. Modern Pakistani lifestyle is transforming into more active life style because of the digital connectivity and economical availability of electronic equipment, and such lifestyle develops a culture demanding more electricity in the country. Unfortunately, the new energy culture of modern Pakistani generations is not linked with concomitant energy-saving attitudes. Indeed, the new energy culture is clearly connected with household comforts, such as cooling and heating. Similarly, the aging population also implies increased residential energy demands. Across generations, in Pakistan, a change in economic culture has invariably produced a pattern of extensive energy consumption.

Government policies are aimed at building new power stations for non-renewable energy generation across the nation. In order to bridge the gap between government policies and modern research in economics, it has become enormously important for government office bearers and policy makers to understand the impact of different factors that are related to generational behavior and household characteristics on energy usage. In the perspective of changing age structure in Pakistan due to the ongoing demographic transition, the energy demand is expected to increase further in the future. Therefore, our study recommends policy makers to initiate projects to build more dams and hydroelectric power stations for the sustainable energy future of Pakistan. Our results predict time trends in energy consumption, which means that coming generations would rely more on energy. Such trends would have serious implications from the perspective of future energy needs of Pakistan. Therefore, it is important for Pakistan to explore new avenues for power generation through solar and renewable energies to meet the needs of more environmentally friendly low carbon pollution future. Pakistan also needs to start new gas exploration projects and gas distribution planning strategies on large scale in the country. Moreover, the increasing trends in energy usage can be mitigated by introducing and encouraging businesses of solar energy equipment and also by promoting a culture of energy efficient building constructions in Pakistan. Our study in this paper would play a complementary role in designing Pakistan's energy policy by putting stress on the significance of taking different lifestyles, age effects, and cohort effects into account. We argue that the government should design policies to develop a more sustainable behavior towards an energy consumption culture, according to the needs of different lifestyles of overlapping generations in Pakistan.

Author Contributions: In this work, M.A. conceived the research idea, managed and organized the data, built the research framework, analyzed the data, calculated all results, described and explained all findings, and wrote the manuscript. E.A. reviewed the manuscript, polished and refined the research idea and directed it in right direction. Moreover E.A. provided help in correctly implementing the methods, explaining and interpreting the major findings, and summarizing and concluding the research work while describing its policy implications.

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