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Household Energy Demand and the Impact of Energy Prices: Evidence from Senegal

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Household Energy Demand and the Impact of Energy Prices: Evidence from Senegal

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Abstract

This study analyzes household expenditure behavior at the quintile level, with a focus on energy expenditures. A Tobit Type I model is used for the estimation. Using the separability assumption of the AIDS model, expenditure elasticities and own-price elasticities are computed despite the lack of information on consumer prices. Results indicate that households behave according to their level of income. The poorest quintile has the highest budget share for kerosene, while the richest has the highest budget share for electricity, LPG, and fuel for transport. Results showed that firewood, charcoal, and kerosene are normal goods. But electricity, LPG, and fuel for transportation are superior goods for most of the quintiles. Own-price elasticities showed that the poorest quintiles are very sensitive to the price change of electricity, LPG, and charcoal. But the richest are very sensitive to fuel for transportation price variations. These results suggest that universal subsidies are not appropriate in such context. If the goal of a fuel subsidy is to reduce energy poverty, targeted fuel subsidies should be preferred to universal subsidies, especially for electricity, LPG and fuel for transportation.

Key words: energy demand, almost ideal demand system, Tobit, price elasticity, expenditure elasticity.

JEL Classifications: C13, C22, C82, O11

1 Introduction

Fossil fuel subsidies are often used by governments to promote economic development or alleviate poverty. But they have been proven as an inefficient means of achieving their primary goal of poverty reduction. Rather they have created market distortions and encouraged wasteful consumption. The recent energy crisis has contributed to make fossil fuel subsidies very costly and unsustainable for government budget and economic growth, especially for many African countries. This situation has called for urgent policy actions to reform these subsidies.

In Africa, many governments have direct or indirect subsidies. The electricity sector is particularly fossil fuel intensive. In 2010, about 80 percent of electricity supply in the continent was generated from thermal sources, and the projections indicate that this share will be reduced to about 62 percent by 2030 (NEPAD, African Union, and African Development Bank, 2011). This indicates that fossil fuels will continue to be the major source of electricity supply in the majority of African countries. But, this sector has benefited from important subsidies during the recent years following the rise in oil prices. Many governments have increased their subsidy to fossil fuels in order to smooth the international oil price shocks on consumers, especially the poor and most vulnerable.

Senegal, as many African countries, has been engaged for several decades in multiple energy policy reforms and subsidization programmes. For instance, to reduce charcoal consumption that accelerates deforestation, the government introduced tax exemptions for LPG equipment in the 1970s. But, by 1988, very few households had switched away from charcoal pushing the government to subsidize LPG itself. Prices were therefore set by the government for four sizes of gas cylinders: 2.7 kilograms, 9 kilograms, 12.5 kilograms, and more than 12.5 kg. Only the two smaller gas bottles benefited from direct subsidies. This policy resulted in a widespread adoption of LPG stoves with about 85% of all quintile of households using LPG. In addition, this policy contributed to reduce about 70 000 tons of wood-fuel and 90 000 tons of charcoal annually. In sum, the LPG subsidy program created strong incentive for households to switch from charcoal to LPG stoves, reduced household pollution and slowed down deforestation (Laan et al., 2010).

Yet this policy became a growing fiscal burden and the IMF recommended its removal in late 1990s. In addition, evidence emerged that wealthier citizens were benefiting more from these subsidies than poor households. In fact, the government had assumed that wealthy households would favor the larger LPG bottles (12.5 kg) and small bottles would be more used by the poor. Instead, poor households, especially in rural areas, were not able to afford LPG and continue to use wood and charcoal. The IMF found in 2008 that only 19% of the total improvement in welfare from LPG subsidy goes to the 40% poorest while 61% goes to the 40% richest of the population. LPG subsidies were then benefiting more the rich than the poorest. A law of phasing out these subsidies by 2002 was voted in March 1998 calling for a gradual removal of LPG subsidies (20% reduction annually). But this plan was put on hold due to negotiation within the West African Economic Union over the harmonization of economic policies (Laan et al., 2010).

In addition to LPG, the government has also subsidized electricity and other fossil fuel products. For instance, between 2005 and 2008, the national electricity utility received on average 34.5 billion

CFA of subsidies, and in 2011, they accounted for 18 billion CFA[1]. This indicates that there is indirect subsidization of electricity in Senegal. But, who really benefit from these subsidies? What would be the impacts of removing these subsidies on different groups of households?

There is a general consensus that the removal of fossil fuel subsidy is beneficial to the economy as it boosts growth and reduces the adverse environmental consequences. In that regards, during the recent years, many policymakers committed to rationalize and phase out inefficient fossil fuel subsidies. However, the social benefit is more challenging to achieve without redirecting part of the saved subsidy expenditures toward targeted social programs (Bacon and Kojima, 2006). Experiences around the world have shown that fossil fuel subsidy reforms are notoriously challenging as the impact on certain groups of the population can be very burdensome.

This study assesses the impacts of fuel price changes on household demand. Since the removal of fuel subsidies is equivalent to price increase, we tried to assess own-prices and cross-price elasticities of all types of energy consumed by the Senegalese households. This is done in a context where price data are not available. Household survey data of 2005 from Senegal ("Enquête de Suivi de la Pauvreté au Sénégal") is used. Because we are interested in the impact of fuel subsidy removal on the poorest, the analysis has been conducted at the quintile level. In fact, we assume there is heterogeneity among rich and poor households.

The paper uses an almost Ideal Demand System (AIDS) to analyze household consumption, with an emphasis on energy and energy-related consumption. Since household demand for many items are zeros, we used a censured model - Tobit type I model - to estimate the AIDS model. Own-price, cross-price, and income elasticities are then computed for all consumption items and for each quintile. This study constitutes a crucial step to design and implement successful accompanying measures to minimize the adverse impacts on poor and most vulnerable groups of population. The next section presents the AIDS model as well as the estimation methodology. The following gives a descriptive analysis of the data used. Section 4 discusses the results and we conclude in section 5 with some policy recommendations.

2 The AIDS Model and estimation methodology

2.1 The Almost Ideal Demand System model

To assess the impacts of fuel prices changes on household demand, this paper used an almost Ideal Demand System (AIDS) model. Deaton and Muellbauer (1980a, 1980b) developed a flexible demand system called the "almost ideal demand system". This model is extremely useful as it allows the demand system to have many desirable properties such as additivity, separability, and the capacity to classify goods by category (necessary, inferior, and luxury good). The basic AIDS model, or the Engel curve, is defined as follows:

$$w_{iqn} = \alpha_{iq} + \beta_{iq} Log(Y_{qn}) + \sum_j \gamma_{ijq} P_{ij} + \sum_n \delta_{iq} Z_{qni} + u_{iqn} \quad (1)$$

[1] CFA is the local currency which is also the common currency used in francophone African countries. This currency has a fixed rate with the euro: 1 euro = 655 CFA.

with $i = 1, ...K$, and K being the number of consumption items under consideration,
$n = 1, ...N$, represents the household and N is the number of households in the sample
q is quintile $q = 1, 2, 3, 4, 5$ with 1 for the poorest quintile households and 5 for the richest quintile households.
w_{iqn} is the budget/expenditure share of household n for the i^{th} good,and quintile q
P_i is the price of good i^{th},
Y_{nq} is the household nq total per capita expenditure as a proxy to her/his total income,
Z is a vector of household's characteristics which includes household size, age, sex, region of residence, schooling, homeowners, number of rooms in the house, worker status, and marital status,
δ_{iqn} is a parameter related to household n characteristics, and
u_{iqn} is an error term included in the model for estimation purpose.

The Engel curve tracks the relationship between the demand of a good and the income of the consumer assuming all prices are kept unchanged. But since the dataset used in this study does not contain any information on prices, the terms $\sum_j \gamma_{ijq} P_{ij}$ are excluded from equation (1). Therefore, the reduced form of the AIDS model is given as:

$$w_{iqn} = \alpha_{iq} + \beta_{iq} Log(Y_{qn}) + \sum_n \delta_{iq} Z_{iqn} + u_{iqn} \tag{2}$$

Based on the properties of the AIDS model, expenditure shares must satisfy a certain number of properties which are:

- The adding-up restriction or the budgetary constraint which implies that:

$$\sum_{i=1}^{K} \alpha_{iq} = 1 \tag{3}$$

$$\sum_{i=1}^{K} \beta_{iq} = 0 \tag{4}$$

- The capacity to classify all categories of goods as: normal, luxury, necessary or inferior goods. To be more precise, a good is categorized as normal good if its demand increase as income increases. Normal goods can also be classified into two categories: necessary good or luxury good. With a necessary good, demand increases least proportionately than an increase in income while for a luxury good, demand increases more proportionately than an increase in income. If the slope of the Engle curve is negative, then the good is an inferior good.

- The saturation constraint which means that: when the income elasticity increases, the goods with high consumption tends toward a saturation point.

2.2 Estimation Methodology

2.2.1 The Tobit-Type I model

Very often, data based on household expenditure survey are censured. For many households, it usually happens that they do not consume many of the consumption items under consideration. Therefore, a substantial proportion of households has zero expenditures for certain goods. In this kind of situation,

demand equations can be estimated using a censured regression model, especially the Tobit model. This paper used a Tobit type I model to estimate the AIDS model defined previously.

Because the expenditure share of good i, w_{iqn}, is observable only if $w_{iqn} > 0$, the Tobit model is defined as follows:

$$\begin{cases} w_{iqn} = w^*_{iqn} & if \quad w^*_{iqn} > 0 \\ w_{iqn} = 0 & if \quad w^*_{iqn} \leq 0. \end{cases}$$

where w^*_{iqn} is a latent variable while w_{iqn} is the observable variable. Let's assume that the vector of the error term in equation (2) u_{iqn}, has an normal distribution: $u_{iqn} \sim N(0, \sigma^2_{iq})$. But, because of the adding-up restriction, this implies that the covariance matrix of U is singular. To address this problem, one of the K demand equations should be excluded from the system and the estimation should be done for only the $(K-1)$ equations. Assuming the errors terms are independently distributed, the Tobit regression can be run for each of the $(K-1)$ demand equations separately, and for each of the five quintile. But after estimating the $(K-1)$ equations, the parameters of the excluded equation can be recovered using the constraints mentioned above (equations (3) and (4)). According to Blanciforti and Green (1983), and Barten (1969), it does not make any difference which equation is dropped.

In this study, we classify all the consumption items into ten (10) separate groups: firewood, electricity, charcoal, fuel for transportation, liquefied propane gas (or LPG), kerosene, food, education, healthcare, and others. We excluded the last item (others) during the estimation. We also assumed that the error terms are grouped-heteroscedastic meaning that the variance of the error term varies with each of the ten categories of consumption items.

2.2.2 Elasticity estimation

The final goal of this type of study is to come up with demand elasticities which are income and price elasticities. These elasticities measure household behavior following changes in income or in prices. With the knowledge of these elasticities, we can then analyze the impact of government policies through fuel price changes, either it removes fossil fuel subsidies or it changes them. In this regards, from the Tobit model estimation, we derived the income and price elasticities. For notation convenience, let us define $z_{iqn} = \frac{X_{iqn}\theta_{iq}}{\sigma_{iq}}$, with $X_{iqn}\theta_{iq}$ the deterministic part of equation (2). Since we have:

$$\begin{aligned} E\left(w_{iqn}\right) &= P\left(w_{iqn} > 0\right) E\left[w_{iqn} \mid w_{iqn} > 0\right] + P\left(w_{iqn} = 0\right) E\left[w_{iqn} \mid w_{iqn} = 0\right] \\ &= \Phi_{iqn} \times \left(X_{iqn}\theta_{iq} + \sigma_{iq}\frac{\phi_{iqn}}{\Phi_{iqn}}\right) + \left(1 - \Phi_{iqn}\right) \times 0 \\ &= \Phi_{iqn} \times X_{iqn}\theta_{iq} + \sigma_{iq}\phi_{iqn} \end{aligned} \tag{5}$$

with $\Phi_{iqn} = \Phi_{iqn}\left(z_{iqn}\right)$. The unconditional expenditure elasticity can be derived as following:

$$\eta^u_{iqn} = 1 + \left[\frac{\Phi_{iqn}X_{iqn}\alpha_{iq}}{\Phi_{iqn}\theta_{iq} + \sigma_{iq}\phi_{iqn}}\right] \tag{6}$$

The conditional expenditure elasticity is given by:

$$\eta^c_{iqn} = 1 + \frac{\alpha_{iq}\left[1 - z_{iqn}\frac{\phi_{iqn}}{\Phi_{iqn}} - \left(\frac{\phi_{iqn}}{\Phi_{iqn}}\right)^2\right]}{X_{iqn}\theta_{iq} + \sigma_{iq}\frac{\phi_{iqn}}{\Phi_{iqn}}} \tag{7}$$

Let's recall that we have no data available on consumer prices for the cross-sectional dataset used in this study. Yet, the goal of using the Engel curve is to derive elasticities, and since prices data are not observable in our dataset, a solution is to use the utility separability assumption (Frisch, 1959). According to this assumption, goods that are included in the utility function can be gathered together, and those which intervene only in one general direction through the budgetary constraint can also be put together (Sadoulet and De Janvry, 1995).

There are several types of separability[2], but the most restrictive one was introduced by Frisch (1959). According to this author, there is a strong separability if each good belongs to a given group. Therefore, price elasticities can be generated from the knowledge of budget proportions and Engel elasticities. The strong separability of consumer preferences has this advantage of estimating price elasticities (with unobservable price data) with the only knowledge of the income elasticity and the currency flexibility (or the flexibility of the marginal utility of the money). In the literature, Sadoulet and De Janvry and (1995) for instance, used this property to disaggregate groups of goods to estimate the Engel curves, the direct as well as the cross-price elasticities for Morocco's rural households. According to Deaton and Muellbauer (1980a), there is no more need to have price data to be able to estimate price elasticities. With the separability assumption, own price elasticities are defined as follows:

$$\varepsilon_{iiqn} = \frac{1}{\omega}\eta_{iqn}\left(1 - w_{iq}\eta_{iqn}\right) - w_{iqn}\eta_{iqn}$$

Cross-price elasticities are defined as:

$$\varepsilon_{ijqn} = -\frac{w_{jqn}}{\omega}\eta_{iqn}\eta_{jn} - w_{jqn}\eta_{iqn}$$

Where η_i is the expenditure elasticity of good i^{th} and ω is the money flexibility also called the Frisch parameter. Yet, the AIDS model does implies a monetary flexibility of -1 (Blanciforti and Green, 1983)[3]. This simplifies the two formulas as follows:

$$\varepsilon_{iin} = -\eta_{in}\left(1 - w_{in}\eta_{in}\right) - w_{in}\eta_{in} \tag{8}$$

$$\varepsilon_{ijn} = w_{jn}\eta_{in}\eta_{jn} - w_{jn}\eta_{in} \tag{9}$$

Because of the nonlinearity in the Tobit model, demand elasticities are derived following Maddala (1983), McDonald and Moffitt (1980), and Taniguchi and Chern (2000). Assuming that η_{iqn} is known, one can obtain price elasticities by simply replacing η_{iqn} by its estimate. Unconditional and conditional price elasticities are obtained by replacing η_{iqn} by or η^c_{iqn} respectively. Hence, unconditional price elasticities are obtained as follows:

$$\varepsilon^u_{iiqn} = -\eta^u_{iqn}\left(1 - E\left(w_{iqn}\right)\eta_{iqn}\right) - E\left(w_{iqn}\right)\eta^u_{iqn}$$

Using expression (3), the unconditional own-price elasticities are derived as follows:

[2] The additivity of consumer's preferences is a particular case of strong separability.

[3] The AIDS model does implies a money flexibility parameter of minus one. Blanciforti (1982) provided a proof of this proposition. This is an advantage but also a limitation of the applicability of the parameters in economic policy analysis, especially when the money flexibility is not minus one, for instance across different countries and income groups (Blanciforti and Green, 1983).

$$\varepsilon^u_{iiqn} = -\eta^u_{iqn}\left[1 - \eta^u_{iqn}\left(\Phi_{iqn}X_{in}\theta_{iq} + \sigma_{iq}\phi_{iqn}\right)\right] - \eta^u_{iqn}\left[\Phi_{iqn}X_{in}\theta_{iq} + \sigma_{iq}\phi_{iqn}\right] \tag{10}$$

The unconditional cross-price elasticities are given by:

$$\varepsilon^u_{ijqn} = \left[\Phi_{iqn}X_{in}\theta_{iq} + \sigma_{iq}\phi_{iqn}\right]\left[\eta^u_{iqn}\eta^u_{jqn} - \eta^u_{iqn}\right] \tag{11}$$

The conditional own-price elasticities are obtained as follows:

$$\varepsilon^c_{iiqn} = -\eta^c_{iqn}\left[1 - \eta^c_{iqn}\left(X_{iqn}\theta_{iq} + \sigma_{iq}\frac{\phi_{iqn}}{\Phi_{iqn}}\right)\right] - \eta^c_{iqn}\left[X_{iqn}\theta_{iq} + \sigma_{iq}\frac{\phi_{iqn}}{\Phi_{iqn}}\right] \tag{12}$$

The conditional cross-price elasticities are given by:

$$\varepsilon^c_{ijqn} = \left[X_{iqn}\theta_{iq} + \sigma_{iq}\frac{\phi_{iqn}}{\Phi_{iqn}}\right]\left[\eta^c_{iqn}\eta^c_{jqn} - \eta^c_{iqn}\right] \tag{13}$$

These price elasticities derived from the demand equations are also called the Hicksian demand (or compensated) price elasticities which can be connected to the Marshallian (uncompensated) demand elasticities using the Slutsky equation.

3 Data and descriptive analysis

The dataset used in this study is a survey on household poverty in Senegal (Enquête de Suivi de la Pauvreté au Senegal) for 2005-2006, conducted by the Senegalese National Statistical and Demographic Agency (ANSD). Designed to be conducted every other year, this survey is part of a general framework of monitoring living conditions of the population, with particular emphasis on poverty. The main objective of this survey was to provide to government and development partners, relevant information on the country's economic and social situation (ANSD, 2007). The survey also highlights government priorities regarding its economic and social development policies, and its international commitments.

We use a sample of 12,718 individual households. Descriptive statistics for the household expenditure shares are reported in Table (1). We split the sample into quintile. As mentioned previously, ten different expenditure categories are considered.

As we can observe from Table (1), households in Senegal spend a high share of their budget on food. On average, they spend 65% of their budget in food and this share decreases as the household belongs to the higher quintile. On the opposite, a very small share of the budget is allocated to education. On average, households spend 0.1% of their budget on education. The share of education increase as we move towards the highest quintile. For healthcare expenditures, there is no clear pattern in household behavior: households allocate on average about 2.5% of their budget on health expenditures.

Regarding energy expenditures, on average, households allocate about 5% of their budget for this item. The energy share increases as we move towards higher quintiles: the poorest quintile allocates on average less than 4.4% of their budget while the richest allocate more than 6.4% for this item.

When we split energy expenditures by energy types and by quintile, it appears that the poorest households allocate much more of their budget especially to kerosene (2.3%) and less than 0.1% to electricity or LGP. On the reverse, the richest households allocate less than 0.1% of their budget to

Table 1: Mean of Expenditure Shares by Quintile

	Quintile-1	Quintile-2	Quintile-3	Quintile-4	Quintile-5	All
Firewood	0.00395	0.00731	.01000	0.00873	0.00675	0.00735
	(0.01315)	(0.01448)	(0.01549)	(0.01376)	(0.01211)	(0.01399)
Charcoal	0.00373	0.00499	0.00641	0.00765	0.00707	0.00597
	(0.01079)	(0.00915)	(0.00899)	(0.00892)	(0.00713)	(0.00918)
Kerosene	0.02307	0.01504	0.01061	0.00702	0.003945	0.01193
	(0.02721)	(0.01415)	(0.01246)	(0.01031)	(0.00764)	(0.01722)
LPG	0.00747	0.00952	0.01415	0.01885	0.0195	0.01390
	(0.01844)	(0.01611)	(0.01692)	(0.01573)	(0.01192)	(0.01668)
Electricity	0.00396	0.00437	0.00780	0.01196	0.01774	0.00917
	(0.01176)	(0.01022)	(0.01304)	(0.01438)	(0.01404)	(0.01378)
Fuel Transport	0.00171	0.00249	0.00266	0.00345	0.00941	0.00394
	(0.01121)	(0.01296)	(0.01300)	(0.01396)	(0.02520)	(0.01632)
Energy	0.04390	0.04373	0.05164	0.05765	0.06442	0.05227
	(0.03819)	(0.03095)	(0.02933)	(0.02893)	(0.03227)	(0.03308)
Food	0.65309	0.69833	0.68205	0.64975	0.59291	0.65522
	(0.17359)	(0.11015)	(0.09419)	(0.09330)	(0.10878)	(0.12500)
Education	0.00095	0.00075	0.00086	0.00108	0.00157	0.00104
	(0.00204)	(0.00104)	(0.00108)	(0.00129)	(0.00202)	(0.00158)
Health	0.02496	0.02337	0.02231	0.02507	0.03113	0.02537
	(0.03733)	(0.02878)	(0.02652)	(0.02666)	(0.03140)	(0.03055)
Others	0.27710	0.23380	0.24314	0.26645	0.30997	0.26609
	(0.15897)	(0.09865)	(0.08711)	(0.08958)	(0.10428)	(0.11408)

Note: Standard deviations are in parentheses.

Source: Author, using the survey data.

kerosene, but 1.9% and 1.8% to LPG and electricity, respectively. In summary, Figure (2) to Figure(7) illustrate energy consumption patterns by energy type and by quintile.

Now, let's analyze who use the energy and how they use it? Table (2) reports energy use distribution by quintile. On average, 33% of households use firewood for cooking, 57% use charcoal for cooking, 87% use kerosene, 47% use electricity, 58% use LPG and only 10% spend money on fuel for transportation. It can also be noticed that least than 17% and 25% of the poorest spend their money on electricity and LPG, respectively. On the other side, 84% and 91% of the richest households use electricity, and LPG respectively. We can observe that the rates of electricity, LPG, and charcoal users increase as we move towards the highest quintile.

Table (3) reports the average annual total expenditures per capita by quintile. We use total expenditures as a proxy for the household total income. We made this approximation since the database available does not have any information on the households income. On average, a senegalese households spends about 356,929 CFA francs per adult equivalent annually for all kinds of consumption.

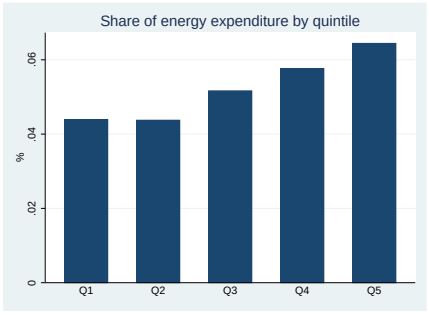

Figure 1: Energy expenditure share by quintile
Source: Author, using the survey data.

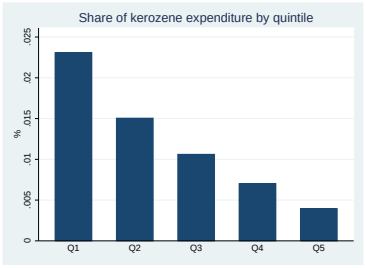

Figure 2: Share of kerosene expenditure by quintile
Source: Author, using the survey data.

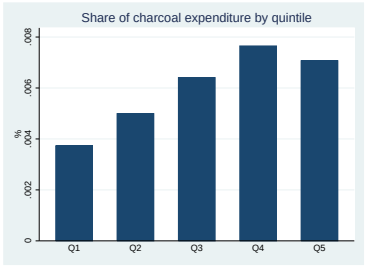

Figure 3: share of charcoal expenditure by quintile
Source: Author, using the survey data.

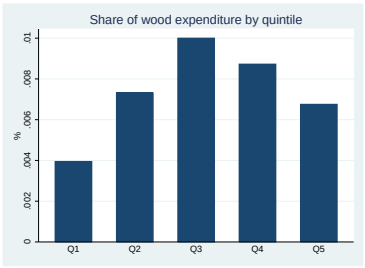

Figure 4: Share of firewood expenditure by quintile
Source: Author, using the survey data.

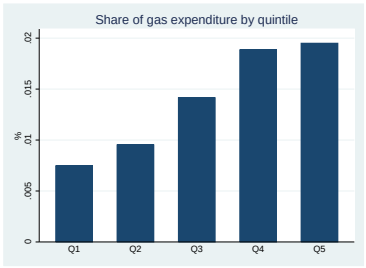

Figure 5: Share of LPG expenditure by quintile
Source: Author, using the survey data.

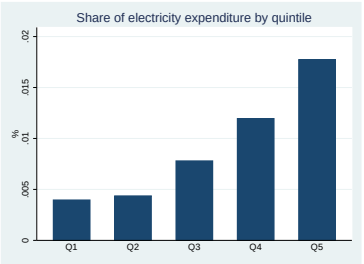

Figure 6: Share of electricity expenditure by quintile
Source: Author, using the survey data.

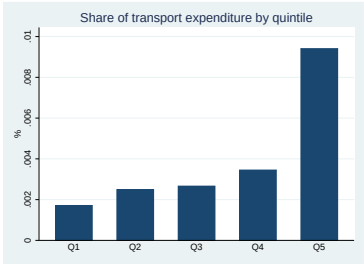

Figure 7: Share of transport fuel expenditure by quintile
Source: Author, using the survey data.

Table 2: **Energy use distribution by quintile**

Energy	All	Poorest	Second	Third	Fourth	Richest
Wood	33.05	14.88	30.66	42.17767	41.31	36.19
Charcoal	57.30	22.865	44.10	61.63	74.41	83.42
Kerosene	87.11	85.83	88.84	87.93	85.26	87.70
Electricity	46.75	16.65	25.31	44.06	63.88	83.81
LPG	57.89	24.56	39.82	58.76	75.63	90.61
Fuel for transport	10.20	05.75	08.25	08.14	09.98	18.86

Source: Author, using the survey data.

The richest household spend more than twice the amount spent by the poorest households.

Table 3: **Total Expenditure per capita (in CFA francs) by quintile**

Quintile	Mean	Standard Deviation	Min	Max
Lowest	219,022	249,541	2,389	3,650,381
Second	269,479	290,088	51,869	7,663,780
third	321,523	251,750	51,582	4,126,189
Fourth	399,216	310,247	84,840	606,9557
Highest	575,157	476,500	119,560	7,110,904
total	356,929	349,395	2,389	7,663,780

Source: Author, using the survey data.

Table (4) reports means and standard deviation of the explanatory variables used in the analysis. An average household accounts for about nine members, equal to about 7 adults equivalent. Female heads of household represents 21% of the sample. On average, the head of the household aged 51 years old and this age increases as the household is richer. About 56% of households are monogamous. Those who are homeowners account for 80%. Housing accounts about four rooms. The head of households who are workers represent about 63% of the sample.

From Table (5), we can observed that rich household have higher rates of schooling, and this rate decreases as the household belongs to the lower quintiles. It also appears that the proportion of households who are monogamous is the highest for the third quintile. The proportion of the heads of household who are farmers decreases when we move from the second quintile to the highest quintile. In addition, the proportion of urban households living in urban area increases when we move toward the highest quintiles.

Table 4: **Summary Statistics: Independent Variables**

VARAIABLES	MEAN	STANDARD DEVIATION
Household Finance (in CFA franc)		
HH Consumption Expenditure (Annual)	18,756,731	14,475,354
Per Capita Expenditure (Annual)	2,584,285	2,423,711
Demographics		
HH size (Adult equivalence)	7.11	4.42
HH Head's Age	50.71	14.65
Proportion of HH Head Female	0.21	0.41
Proportion of HH Monogamous	0.56	0.50
Proportion of Homeowners	0.80	0.40
Number of rooms	4.18	2.64
Proportion of Poor	0.43	0.49
Education		
Proportion of HH head attended school	0.32	0.47
Employment		
Proportion of Farmers	0.21	0.41
Proportion of Worker	0.69	0.46
Location		
Proportion of urban	0.63	0.48
Proportion of region Dakar	0.12	0.32
Proportion of region Diourbel	0.09	0.28
Proportion of region Fatick	0.09	0.28
Proportion of region Kaolack	0.09	0.28
Proportion of region Kolda	0.09	0.28
Proportion of region Louga	0.09	0.28
Proportion of region Matam	0.09	0.28
Proportion of region Saint Louis	0.09	0.28
Proportion of region Tamba	0.09	0.28
Proportion of region Thies	0.09	0.28
Proportion of region Ziguinchor	0.09	0.28

Source: Author, using the survey data.

Table 5: **Descriptive statistics: % of the population by Quintile**

Quintile	Schooling	Monogamous	Female	homeowner	Farmer	Urban
Poorest	0.2443919717	0.5875639512	0.179	0.786	0.375	0.393
Second	0.227	0.588	0.212	0.830	0.297	0.507
Third	0.292	0.596	0.224	0.804	0.181	0.651
Fourth	0.367	0.544	0.230	0.788	0.130	0.762
Richest	0.476	0.501	0.214	0.793	0.077	0.847
Total	0.321	0.563	0.212	0.800	0.212	0.632

Source: Author, using the survey data.

4 Empirical Results and Discussion

What is the real impact of price changes in consumer behavior, especially regarding fuel price changes through a removal or an introduction of fuel subsidy? The results of the Tobit type I model bring some answers. Tables (8) to (12) report the estimation results. The following discussion is based on statistically significant estimates of the Tobit regression. For each of the five quintiles, Table (6) reports expenditure elasticities while Table (7) provides cross-price and own-price elasticities[4].

Table 6: **Income elasticities by quintile**

Goods	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Wood	1.005	.721	.632	.597	.803
Charcoal	1.224	.896	.794	.661	.740
Kerosene	.8114	.791	.660	.550	.755
Electricity	1.651	1.936	2.201	2.521	1.301
LPG	1.540	1.340	1.503	1.398	.890
Fuel transport	1.942	2.299	1.670	1.533	2.449
Food	.977	.778	.843	.858	.860
Education	.563	.461	.711	.996	1.210
Health	1.082	1.286	1.319	1.089	1.137

Source: Author, using the survey data.

[4] These elasticities are unconditional elasticities. We also computed the conditional elasticities, but only results of the unconditional elasticities are reported and discussed

Table 7: Uncompensated elasticities by quintile

Category	Firewood	Electricity	LPG	Charcoal	Kerosene	Transport	Food	Education	Health
					Quintile 1				
Firewood	-1.378								
Electricity	0.00128	-5.223							
LPG	0.00104	0.00958	-3.560						
Charcoal	0.000929	0.00889	0.0136	-2.706					
Kerosene	0.000376	0.00368	0.00562	0.00133	-0.448				
Transport	0.000985	0.0102	0.0152	0.00368	-0.0102	-3.028			
Food	0.000556	0.00561	0.00842	0.00198	-0.00564	0.00193	-0.953		
Education	0.000288	0.00286	0.00444	0.00102	-0.00294	0.00111	-0.0108	-0.271	
Health	0.000581	0.00590	0.00884	0.00208	-0.00590	0.00202	-0.0220	-0.000401	-1.020
					Quintile 2				
Firewood	-0.348								
Electricity	-0.00289	-5.654							
LPG	-0.00172	0.00729	-2.073						
Charcoal	-0.00139	0.00625	0.00411	-1.394					
Kerosene	-0.000922	0.00406	0.00270	0.000429	-0.605				
Transport	-0.00169	0.00776	0.00507	0.000809	-0.00459	-2.030			
Food	-0.000956	0.00416	0.00278	0.000442	-0.00259	0.000856	-0.735		
Education	-0.000250	0.00143**	0.000995	0.000161	-0.000829	0.000342	-0.0311	-0.111	
Health	-0.00170	0.00749	0.00499	0.000798	-0.00459	0.00152	-0.175	-0.000586	-1.991
					Quintile 3				
Firewood	-0.0787								
Electricity	-0.00856	-3.944							
LPG	-0.00548	0.00523	-1.697						
Charcoal	-0.00296	0.00321	0.00220	-0.532					
Kerosene	-0.00279	0.00248	0.00181	-0.000654	-0.424				
Transport	-0.00586	0.00603	0.00421	-0.00151	-0.00572	-2.002			
Food	-0.00352	0.00350	0.00247	-0.000885	-0.00343	0.000921	-0.795		

Continuous on the next page

Table 7: Uncompensated elasticities by quintile

Category	Firewood	Electricity	LPG	Charcoal	Kerosene	Transport	Food	Education	Health
Education	-0.00243	0.00267	0.00183	-0.000653	-0.00246	0.000692	-0.0635	-0.377	
Health	-0.00619	0.00604	0.00427	-0.00155	-0.00594	0.00156	-0.152	-0.000428	-2.113
Quintile 4									
Firewood	-0.126								
Electricity	-0.0109	-5.135							
LPG	-0.00416	0.00554	-0.869						
Charcoal	-0.00267	0.00363	-0.000543	-0.386					
Kerosene	-0.00396	0.00502	-0.000758	-0.00203	-0.758				
Transport	-0.00794	0.0102	-0.00155	-0.00417	-0.00199	-3.098			
Food	-0.00396	0.00508	-0.000765	-0.00205	-0.000997	0.00175	-0.836		
Education	-0.00385	0.00519	-0.000766	-0.00204	-0.000987	0.00177	-0.0729	-0.755	
Health	-0.00485	0.00632	-0.000944	-0.00253	-0.00123	0.00216	-0.0903	-0.000134	-1.156
Quintile 5									
Firewood	-0.357								
Electricity	-0.00277	-1.365							
LPG	-0.00164	0.00109	-0.541						
Charcoal	-0.00175	0.00115	-0.00336	-0.603					
Kerosene	-0.00200	0.00122	-0.00367	-0.00111	-0.723				
Transport	-0.00687	0.00417	-0.0126	-0.00384	-0.00288	-8.484			
Food	-0.00202	0.00125	-0.00372	-0.00113	-0.000857	0.00484	-0.816		
Education	-0.00369	0.00220	-0.00667	-0.00203	-0.00155	0.00840	-0.141	-2.394	
Health	-0.00290	0.00180	-0.00536	-0.00163	-0.00123	0.00702	-0.113	0.000657	-1.527

Source: Estimation done by the Author

Quintile 1

For the poorest households, the expenditure elasticities is less than one for kerosene only (0.81); this means that when income increases by 1%, these households increase their expenditures for kerosene by 0.8%. Kerosene is normal goods. But, for firewood, charcoal, electricity, LPG, and fuel for transportation, when income increases by 1%, households increase their expenditures by more than 1% indicating that these goods are superior goods.

When we look at price elasticities, it comes out that the most important impact of price changes on household behavior is the electricity price with a own-price elasticity of -5.22, followed by LPG (-3.56), fuel for transportation (-3.03), charcoal (-2.71). We can say that demand for these goods are very elastic. But demand is inelastic for kerosene, food, and education. Cross-price elasticities are very marginal, but their signs indicate that energy items are substitute goods, excluding fuel for transportation and kerosene which are complementary goods. Finally, for this quintile, the expenditure elasticities of food, education are less than one (0.98; 0.56 respectively) indicating that these goods are normal goods. Healthcare has an expenditure elasticity close to one (1.1), showing that healthcare is almost a superior good for these households.

Table 8: Tobit estimation results: Quintile 1

Variables	Firewood	Charcoal	Kerosene	Electricity	Lpg	Transport	Food	Education	Health
Log Income	0.000279	0.000936***	0.000831***	0.000333**	0.00285***	-0.00701***	-0.0217*	-0.000375***	0.000292
	(0.000262)	(0.000238)	(0.000220)	(0.000170)	(0.000547)	(0.00153)	(0.0122)	(8.32e-05)	(0.00199)
Schooling	-0.000153	0.000857***	0.000462*	0.000261	0.00277***	-0.00256*	-0.0307**	0.000712***	-0.00386*
	(0.000423)	(0.000188)	(0.000248)	(0.000195)	(0.000534)	(0.00147)	(0.0132)	(9.42e-05)	(0.00205)
HH Size	0.000191**	6.53e-05	0.000152***	9.44e-05**	0.000439***	-0.00145***	0.00252	7.71e-05***	0.00134***
	(7.70e-05)	(4.60e-05)	(5.60e-05)	(4.26e-05)	(0.000156)	(0.000408)	(0.00230)	(1.87e-05)	(0.000501)
Age	1.36e-05	-3.73e-06	6.66e-06	-7.32e-06	1.86e-05	7.33e-05	0.000934***	9.59e-07	-3.80e-07
	(1.04e-05)	(5.99e-06)	(7.00e-06)	(5.09e-06)	(1.71e-05)	(4.49e-05)	(0.000266)	(2.39e-06)	(5.81e-05)
Female	0.00128***	0.000142	0.00133***	-0.000675**	0.000244	-0.000769	0.0614***	0.000263***	-0.00110
	(0.000437)	(0.000225)	(0.000282)	(0.000286)	(0.000671)	(0.00219)	(0.0147)	(9.69e-05)	(0.00288)
Homeowner	0.000146	-0.000739***	-0.000774***	0.000298	-0.00152**	0.00293	0.161***	0.000619***	-0.00244
	(0.000524)	(0.000214)	(0.000285)	(0.000220)	(0.000653)	(0.00200)	(0.0208)	(0.000130)	(0.00291)
Nb rooms	-0.000120	-7.13e-06	-0.000230***	4.03e-05	-0.000445***	0.00144***	0.00227	5.30e-05***	-0.000761
	(0.000109)	(4.61e-05)	(6.89e-05)	(2.54e-05)	(0.000158)	(0.000362)	(0.00215)	(2.02e-05)	(0.000563)
Farmer	-0.00117***	-0.000995***	-0.000861***	-0.000258*	-0.00273***	0.00357***	0.0271***	4.09e-05	-0.000619
	(0.000337)	(0.000169)	(0.000226)	(0.000146)	(0.000535)	(0.00129)	(0.00786)	(6.21e-05)	(0.00164)
Monogamous	0.000509	-0.000420***	0.000105	0.000167	-0.000347	-0.000673	0.0524***	0.000140*	0.000230
	(0.000377)	(0.000163)	(0.000242)	(0.000136)	(0.000482)	(0.00139)	(0.00955)	(7.41e-05)	(0.00181)

Note:

Robust standard errors in parentheses

Number of observation: 2,541

*** p<0.01, ** p<0.05, * p<0.1

Source: Estimation done by the author using the survey data

Regarding household characteristics, results show that female heads of households tend to spend more in firewood, kerosene, food, and eduction, but less in electricity compared to male heads of household. Being a homeowner impacts negatively on charcoal, kerosene, LPG but spend more in food and education. Households with big houses (number of rooms) tend to spend less in kerosene, and LPG expenditures, but but affects positively food and education expenditures. Being a farmer impacts negatively on firewood, charcoal, kerosene, electricity, LPG but positively on fuel for transport. Regarding the heads of the household who are monogamous, they tend to spend less in charcoal, but more in food and education. Results also show that for the poorest households, those that have many members spend more in firewood, kerosene, electricity, LPG, but they have relatively negative impacts on fuel for transport compared to those with few members. Being an educated head affects positively charcoal, kerosene, LPG expenditure, but but negatively on fuel for transport.

Quintile 2:

Results indicate that, regarding energy expenditures, firewood, charcoal, kerosene are normal goods while electricity, LPG, and fuel for transportation are superior goods. As with the poorest quintile, food and education are normal goods but healthcare is a superior good. Like quintile 1, the own-price elasticity of electricity is the highest (-5.65) but firewood is inelastic for this group, in addition to kerosene, food, and education. Most of the cross-price elasticities are very marginal. But they indicate that food, education, and healthcare are complementary goods.

The heads of the households who are educated have a negative impacts on firewood and fuel for transportation expenditures. But they positively impact expenditures on charcoal, kerosene, LPG, and education. Households with a head who is aged tends to spend more for kerosene and education compared to those that are relatively younger. Being a female head of household increases spending on firewood, charcoal, kerosene, LPG, and education. Homeowners tend to spend more on firewood, electricity, fuel for transportation, food, and education. The size of the household has a positive impact on electricity, charcoal, and healthcare expenditures. The impact of farmers on firewood, charcoal, kerosene, and LPG expenditures is negative. Monogamous households have a positive effect on firewood, kerosene, and food expenditures, but a negative effect on education. Schooling impacts positively on charcoal, kerosene, LPG, and education expenditures; but has a negative effect on firewood, fuel for transport, and food expenditures. The size of the household has a positive effect on charcoal, electricity, and healthcare expenditures.

Table 9: Tobit model estimation results: Quintile 2

Variables	Firewood	Charcoal	Kerosene	Electricity	Lpg	Transport	Food	Education	Health
Log Income	-0.00124	0.00167***	0.000414	0.000480	0.00259**	-0.00346**	-0.124***	-0.000417***	0.0124***
	(0.000815)	(0.000424)	(0.000520)	(0.000420)	(0.00104)	(0.00156)	(0.0138)	(9.12e-05)	(0.00409)
Schooling	-0.00173***	0.00177***	0.00116***	7.04e-05	0.00438***	-0.00340***	-0.0226***	0.000578***	0.00200
	(0.000645)	(0.000246)	(0.000317)	(0.000394)	(0.000766)	(0.00108)	(0.00853)	(7.39e-05)	(0.00207)
HH Size	-6.92e-05	0.000164**	2.94e-05	0.000108*	0.000118	-0.000251	-0.0173***	3.65e-07	0.00236***
	(0.000154)	(7.79e-05)	(9.65e-05)	(6.20e-05)	(0.000215)	(0.000305)	(0.00226)	(1.49e-05)	(0.000598)
Age	1.28e-05	7.47e-06	2.35e-05***	-1.06e-05	1.06e-05	1.69e-05	0.000316	5.12e-06***	3.60e-05
	(1.56e-05)	(6.82e-06)	(8.98e-06)	(9.10e-06)	(2.23e-05)	(2.69e-05)	(0.000216)	(1.66e-06)	(5.52e-05)
Female	0.00102*	0.000695***	0.00204***	-0.00115***	0.00263***	-0.00160	0.0124	0.000309***	0.000419
	(0.000590)	(0.000240)	(0.000345)	(0.000438)	(0.000909)	(0.00103)	(0.00838)	(7.08e-05)	(0.00213)
Homeowner	0.00126*	-0.000408	-0.000744*	0.00138**	-0.00200**	0.00341***	0.0634***	0.000178**	0.000772
	(0.000710)	(0.000252)	(0.000414)	(0.000680)	(0.000949)	(0.00131)	(0.0116)	(8.92e-05)	(0.00262)
Nb rooms	-0.000390***	-4.39e-05	-0.000185**	8.63e-05*	-7.70e-05	0.000494**	0.00284**	2.37e-05**	-0.00104***
	(0.000138)	(4.29e-05)	(9.22e-05)	(4.89e-05)	(0.000171)	(0.000226)	(0.00111)	(9.26e-06)	(0.000367)
Farmer	-0.00220***	-0.00162***	-0.00181***	-0.000450	-0.00237***	0.00126	0.0123**	3.68e-05	0.00185
	(0.000496)	(0.000238)	(0.000291)	(0.000284)	(0.000725)	(0.000869)	(0.00522)	(4.43e-05)	(0.00173)
Monogamous	0.00141***	8.78e-05	0.000860***	0.000416	-7.32e-05	-0.000367	0.0133**	-9.01e-05*	-0.000215
	(0.000507)	(0.000220)	(0.000304)	(0.000278)	(0.000723)	(0.000894)	(0.00652)	(5.02e-05)	(0.00171)

Note:

Robust standard errors in parentheses

Observations: 2,544

*** p<0.01, ** p<0.05, * p<0.1

Source: Estimation done by the author using the survey data

Quintile 3:

For the third quintile, firewood, charcoal, and kerosene are normal goods, but electricity, LPG, and fuel for transportation are superior goods. Food and education are also normal good, but healthcare is a superior good. The price elasticity of electricity has also the highest magnitude (-3.94) but relatively smaller than those of the first and second quintiles. Firewood, charcoal, and kerosene are inelastic while LPG and fuel for transportation are elastic. All the cross-price elasticities are very marginal except those of food, education, and healthcare. Electricity, LPG, charcoal, and fuel for transport are complementary goods for households in this quintile.

The Tobit results indicate that households with educated heads spend relatively more in charcoal, kerosene, electricity, LPG, and education. But these households spend relatively less in firewood, fuel for transport, and food. The size of the household has a positive impact only on healthcare spending but negative impact on firewood and food. Female heads has a negative impact on electricity, but a positive impact on charcoal, kerosene, LPG, and education. Homeowner affects negatively spending in charcoal and kerosene, but a positive impact on firewood, fuel for transportation, food, and education. The number of rooms affect negatively spending in kerosene but have a positive impact on electricity and food expenditures. Farmer heads impact positively on only food expenditures but negatively on firewood, kerosene, charcoal, LPG, and education. Monogamous households have a positive impact on firewood, kerosene, and food expenditures.

Table 10: Tobit model estimation results: Quintile 3

Variables	Firewood	Charcoal	Kerosene	Electricity	Lpg	Transport	Food	Education	Health
Log Income	-0.00353***	0.00319***	-0.00108	0.000591	0.00321*	-0.00420***	-0.105***	-0.000288**	0.0119***
	(0.00121)	(0.000701)	(0.000891)	(0.000891)	(0.00183)	(0.00116)	(0.0151)	(0.000140)	(0.00384)
Schooling	-0.00162**	0.00411***	0.00142***	0.000781*	0.00422***	-0.00276***	-0.0353***	0.000576***	-0.00140
	(0.000644)	(0.000503)	(0.000380)	(0.000468)	(0.000983)	(0.000612)	(0.00679)	(8.13e-05)	(0.00194)
HH Size	-0.000445**	0.000137	-8.96e-05	3.91e-05	3.31e-05	-2.81e-05	-0.0118***	1.53e-05	0.00166***
	(0.000181)	(0.000127)	(0.000155)	(0.000113)	(0.000307)	(0.000231)	(0.00175)	(1.74e-05)	(0.000578)
Age	-6.54e-06	7.23e-05***	2.00e-05	-1.00e-05	5.13e-05*	-5.70e-05**	-0.000207	4.93e-06**	-2.89e-05
	(2.02e-05)	(1.54e-05)	(1.32e-05)	(1.47e-05)	(3.01e-05)	(2.28e-05)	(0.000177)	(2.40e-06)	(5.82e-05)
Female	0.00101	0.00199***	0.00185***	-0.00144**	0.00256**	-0.00120	0.00693	0.000163*	-0.00110
	(0.000748)	(0.000551)	(0.000499)	(0.000630)	(0.00116)	(0.000788)	(0.00713)	(9.23e-05)	(0.00195)
Homeowner	0.00235***	-0.00124**	-0.00104**	7.57e-05	-0.000197	0.00154**	0.0522***	0.000249**	0.000684
	(0.000762)	(0.000573)	(0.000515)	(0.000601)	(0.00123)	(0.000639)	(0.00870)	(0.000115)	(0.00248)
Nb rooms	-0.000237	0.000124	-0.000232**	0.000287***	-3.18e-05	0.000143	0.00363***	2.23e-05	0.000180
	(0.000171)	(0.000130)	(0.000116)	(0.000109)	(0.000269)	(0.000222)	(0.00134)	(1.65e-05)	(0.000503)
Farmer	-0.00176**	-0.00502***	-0.00256***	0.000430	-0.00876***	0.00136	0.0130**	-0.000151**	-0.00140
	(0.000754)	(0.000656)	(0.000559)	(0.000465)	(0.00120)	(0.000852)	(0.00531)	(6.24e-05)	(0.00172)
Monogamous	0.00139**	0.000624	0.000951**	-0.000102	0.00157	-0.000145	0.0139**	6.76e-05	-0.000532
	(0.000598)	(0.000457)	(0.000485)	(0.000411)	(0.00100)	(0.000729)	(0.00654)	(7.00e-05)	(0.00173)

Note:

Robust standard errors in parentheses

Observations: 2,544

*** p<0.01, ** p<0.05, * p<0.1

Source: Estimation done by the author using the survey data

Quintile 4:

As with quintile 2 and 3, the expenditure elasticities of firewood, charcoal, and kerosene are less than one, indicating that these goods are normal goods. LPG and fuel for transportation are superior goods. Food and education are also normal goods like for the previous quintiles. As with quintile 1 and 2, electricity has the largest own-price elasticity (-5.13). This means that quintile 4 households are very sensitive in the change of electricity price. They are also very sensitive in the change of fuel for transportation prices since its own-price elasticity is about -3.1. But these households are almost inelastic in the change of the price of firewood, LPG, charcoal, kerosene, food, and education. Cross-price elasticities are very marginal (close to zero) except for food and education.

Results of the Tobit estimation showed that schooling has a positive effect on charcoal, electricity, LPG, and education expenditures, but a negative impact on firewood, fuel for transportation, and food expenditures. Household size impacts negatively on kerosene, LPG and food expenditures but positively on charcoal expenditures. Age has a positive effect on charcoal, kerosene, LPG, and health-care expenditures. Being female head impacts positively on charcoal, kerosene, LPG, and education expenditures. Homeowners have positive impact only on firewood and food expenditures. The number of rooms has a positive impact on electricity, LPG, and education expenditures, but a negative impact on firewood, kerosene, and fuel for transportation expenditures. Being farmer has a negative impact on charcoal, kerosene, LPG, and education expenditures, but its effect is positive for only fuel for transport expenditures. Monogamous households impact positively on charcoal and kerosene expenditures.

Table 11: Tobit model estimation results: Quintile 4

Variables	Firewood	Charcoal	Kerosene	Electricity	Lpg	Transport	Food	Education	Health
Log Income	-0.00277***	0.00814***	-0.00242***	0.00101	-0.00104	-0.00110	-0.0840***	-0.000131	0.00219
	(0.000966)	(0.00157)	(0.000869)	(0.000744)	(0.00237)	(0.000944)	(0.0123)	(0.000225)	(0.00320)
Schooling	-0.00304***	0.00649***	0.000362	0.00118***	0.00581***	-0.00218***	-0.0240***	0.000893***	0.00107
	(0.000551)	(0.000772)	(0.000442)	(0.000419)	(0.00102)	(0.000451)	(0.00561)	(0.000104)	(0.00174)
HH Size	-0.000151	0.000629***	-0.000347***	-6.64e-05	-0.000551*	0.000193	-0.00582***	1.22e-05	0.000364
	(0.000143)	(0.000217)	(0.000132)	(8.80e-05)	(0.000296)	(0.000184)	(0.00163)	(2.42e-05)	(0.000430)
Age	4.44e-07	7.72e-05***	3.78e-05**	-1.83e-05	0.000133***	-9.93e-06	-0.000202	1.78e-06	0.000134**
	(1.65e-05)	(2.61e-05)	(1.60e-05)	(1.19e-05)	(3.94e-05)	(1.99e-05)	(0.000179)	(3.06e-06)	(6.18e-05)
Female	-0.000710	0.00401***	0.00151***	-0.000366	0.00424***	-0.000656	-0.0103*	0.000289**	0.00255
	(0.000588)	(0.000943)	(0.000501)	(0.000597)	(0.00115)	(0.000523)	(0.00617)	(0.000114)	(0.00244)
Homeowner	0.00116*	0.00119	-0.000517	0.000821	-0.00140	0.000157	0.0506***	9.62e-05	0.00211
	(0.000669)	(0.000876)	(0.000493)	(0.000618)	(0.00116)	(0.000481)	(0.00691)	(0.000119)	(0.00221)
Nb rooms	-0.000318***	0.000239	-0.000325***	0.000192**	0.000449*	-0.000322*	-3.87e-05	5.60e-05***	-0.000247
	(0.000117)	(0.000201)	(0.000119)	(7.89e-05)	(0.000273)	(0.000164)	(0.00152)	(2.05e-05)	(0.000457)
Farmer	-0.000804	-0.00845***	-0.00231**	0.000361	-0.00638***	0.00287***	-0.0105	-0.000258***	0.00193
	(0.000682)	(0.00137)	(0.000916)	(0.000379)	(0.00160)	(0.000935)	(0.00708)	(8.87e-05)	(0.00207)
Monogamous	-7.88e-06	0.00219***	0.000994**	3.32e-05	0.00145	-0.000378	-0.00493	6.70e-05	0.00229
	(0.000468)	(0.000797)	(0.000487)	(0.000405)	(0.00102)	(0.000550)	(0.00540)	(0.000107)	(0.00192)

Note:

Robust standard errors in parentheses

Observations: 2,544

*** p<0.01, ** p<0.05, * p<0.1

Source: Estimation done by the author using the survey data

Quintile 5:

For the richest quintile households, firewood, charcoal, and kerosene are normal goods with expenditure elasticities lower than one. But, contrary to the other quintiles, their expenditure elasticity is less than one for LPG (0.89). Fuel for transportation and electricity have expenditure elasticities of 2.45 and 1.3, respectively, indicating that these items are superior good. Food is a normal good, but education and healthcare are superior goods for the richest quintile. Price elasticities show that these households are very sensitive to the change in fuel for transportation prices, with a own-price elasticity of -8.48, the highest across all quintiles. But, the richest households are not sensitive in the change of the prices of firewood, LPG, charcoal, kerosene, and food. These households are relatively less sensitive to the change of the price of electricity, compared to the rest of the quintiles. Surprisingly, these households are very sensitive to the change of the cost of education (price elasticity of -2.39), contrary to the other quintiles.

For households characteristics, the Tobit results indicate that schooling does not affect expenditures in the same way. It has a positive impact on charcoal, electricity, LPG, and education; but a negative effect on firewood, fuel for transportation, food, and education. Household size affects negatively charcoal, LPG, and food expenditure but affects positively electricity, education, and healthcare expenditures. The age of the head of the household has a positive impact on kerosene, education, and healthcare but has a negative effect on electricity and fuel for transportation. Being homeowner impacts positively on firewood, charcoal, electricity, LPG, food, and education expenditures. The number of rooms has a negative impact on kerosene but a positive impact on electricity expenditures. Females heads have a positive impact on charcoal and kerosene, but a negative impact on electricity expenditures. Being a farmer affects positively fuel for transport but for the rest (charcoal, kerosene, LPG, healthcare), it has a negative impact. Being monogamous does not affect significantly any of the energy expenditures, but affects positively education expenditures only.

Table 12: Tobit model estimation results: Quintile 5

Variables	Firewood	Charcoal	Kerosene	Electricity	Lpg	Transport	Food	Education	Health
Log Income	-0.000825***	0.00200*	-0.00139***	0.00965***	-0.00465***	-0.000858**	-0.0912***	0.000844***	0.00713***
	(0.000285)	(0.00104)	(0.000384)	(0.00156)	(0.000768)	(0.000386)	(0.00643)	(0.000260)	(0.00232)
Schooling	-0.00167***	0.00559***	0.000422	0.00470***	0.00183***	-0.00102***	-0.0244***	0.00125***	-0.00418**
	(0.000281)	(0.000968)	(0.000342)	(0.00140)	(0.000681)	(0.000357)	(0.00571)	(0.000152)	(0.00210)
HH Size	4.15e-05	-0.000293**	-4.24e-05	0.000420***	-0.000530***	2.27e-05	-0.00348***	8.19e-05***	0.000801**
	(3.25e-05)	(0.000135)	(5.49e-05)	(0.000157)	(0.000111)	(4.03e-05)	(0.000681)	(2.50e-05)	(0.000376)
Age	-4.48e-06	0.000121***	3.14e-05**	-0.000145***	2.78e-05	-3.38e-05***	0.000307	1.97e-05***	0.000219**
	(8.64e-06)	(3.39e-05)	(1.31e-05)	(4.79e-05)	(2.65e-05)	(1.28e-05)	(0.000189)	(5.62e-06)	(8.57e-05)
Female	-0.000403	0.00184*	0.000767*	-0.00473***	4.10e-05	-0.000470	-0.00129	0.000266	0.000119
	(0.000299)	(0.00105)	(0.000412)	(0.00173)	(0.000722)	(0.000327)	(0.00576)	(0.000194)	(0.00249)
Homeowner	0.00164***	0.00312***	0.000127	0.00288*	0.00273***	0.000167	0.0700***	0.000625***	0.00232
	(0.000374)	(0.00110)	(0.000428)	(0.00174)	(0.000739)	(0.000248)	(0.00639)	(0.000207)	(0.00230)
Nb rooms	-4.34e-05	0.000593**	-0.000225***	0.000966***	9.79e-05	4.21e-05	-0.000311	-1.27e-05	-0.000131
	(4.98e-05)	(0.000247)	(8.45e-05)	(0.000241)	(0.000181)	(6.83e-05)	(0.000988)	(3.03e-05)	(0.000662)
Farmer	7.55e-05	-0.0130***	-0.00368***	0.00251	-0.0102***	0.00236***	0.0139	0.000127	-0.00774***
	(0.000517)	(0.00197)	(0.000841)	(0.00194)	(0.00157)	(0.000836)	(0.0119)	(0.000174)	(0.00274)
Monogamous	-0.000194	0.00126	-0.000103	-0.000293	0.000279	-0.000344	-0.000467	0.000651***	0.000665
	(0.000239)	(0.000936)	(0.000358)	(0.00132)	(0.000716)	(0.000396)	(0.00540)	(0.000171)	(0.00213)

Note:

Robust standard errors in parentheses

Observations: 2,545

*** p<0.01, ** p<0.05, * p<0.1

Source: Estimation done by the author using the survey data

In conclusion, as the results showed, all the five quintiles do not have the same economic behavior. Households in different quintiles do not react necessarily in the same way. The Tobit results and estimates of expenditures and price elasticities demonstrated that we have heterogeneity among the quintiles. This implies that ignoring this heterogeneity may lead to biased estimates and therefore inadequate policy recommendations, especially regarding energy consumption and subsidization.

5 Conclusion and Policy recommendations

This study analyzed household expenditure behavior, with a special focus on energy expenditures. Five different quintiles have been analyzed separately. To our knowledge, this is the first time that such analysis has been conducted at the quintile level, accounting for group heterogeneity among households. The AIDS model has been used and defined at the quintile level. Using the the separability assumption, expenditure elasticities, as well as own-price and cross price elasticities are computed despite the lack of information on consumer prices.

The results showed that households behave according to their level of income. The poorest quintile has the highest budget share for kerosene, while the richest quintile has the highest budget share for electricity, LPG, and fuel for transport. In addition, for all quintiles, we found that firewood, charcoal, and kerosene are normal goods. But electricity, LPG, and fuel for transportation are superior goods for most the the quintiles.

Own-price elasticities showed that households in the poorest quintile are very sensitive to the price change of electricity, LPG, charcoal, and fuel for transportation. But they are less sensitive to the variation in the price of kerosene. On the opposite, the richest households are very sensitive in the change of fuel for transportation prices but are also those that have the highest budget share for this good. This implies that fuel for transportation is a luxury good and consumed mainly by the richest households. This implies that subsidies on fuel for transportation should be removed since it does not affect the poorest and is consumed more by the richest households. LPG is also a luxury good and those who spend much of their budget are not the poorest but the three richest quintiles. As a consequence, LPG also should not be universally subsidized since it is more consumed by the rich households. Electricity is also a luxury goods for all the five quintiles and is much consumed by the rich households. However, when its price increases, the richest households do not change much their consumption, while the poor households reduce drastically their consumption. Universal subsidies for electricity is not appropriate in such case. Instead, subsidies that target poor households may be much appropriate for energy poverty reduction.

On the other side, the poorest households have the highest share of expenditure on kerosene. In addition, the poorest quintile has the highest own-price elasticity for kerosene while those of the rest are close to zero. This means that kerosene is used by the poorest and increasing its price will be more harmful for them. In other words, kerosene should be subsidized in order to reduce energy-poverty among the poorest. The highest budget share on charcoal are those from the three richest quintiles. This is also the case for the firewood. But their expenditure elasticities are less than one for these quintiles. The highest own-price elasticities of firewood and charcoal are those of the poorest households. It implies that increasing the price of charcoal and firewood will affect more the poorest.

All these results imply that energy price variations do not have the same impact across all households. Removing fuel subsidy implies increasing that fuel price and introducing a fuel subsidy is equivalent to decreasing that fuel price. Consequently, with the above results, universal subsidies on energy consumption are not appropriate and fair for the entire society. If the goal of a subsidy is to reduce energy poverty in the society, it is then important that these subsidies go directly to those who are in need and do not have the financial capability to afford the energy. In conclusion, this study found that, in senegal, poor households do not react in the same manner as rich households regarding energy consumption, and targeted energy subsidies should be much preferred to universal subsidies.

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