Analyzing household energy demand and the impact of fossil fuel subsidy reform: Evidence from Senegal *

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Abstract

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. Several studies have demonstrated that fossil fuel subsidies do not reach the poor; instead, much of the welfare goes to the better off of the society. As many developing country, Senegal was engaged for several decades in multiple energy policy reforms and subsidization programmes. Yet, these policies became a growing fiscal burden. To assess quantitatively the impact of fuel price variation on consumers, and hence the impact of these subsidies removal on households, we used a 2005 survey dataset on Senegalese households.

An almost ideal demand system was used to analyze household demand system which includes all type of energy consumed, food, education, and health expenditure. because of the presence of many zero in households consumption regarding all these items, a Tobit type I model was used in order to better assess own-price, cross-price, and income elasticities. The marginal effects of several household characteristics were also estimated. These include: the household size, whether or not the head of the household holds a degree, he/she is a female, he/she owns a house, he/she is a farmer, a worker, if for the household transparency is a concern for policymakers, if consumer price reduction should be a priority for the government, or if youth unemployment is the first priority for their community. We also include regional dummies to take into account the presence of fixed effects in the model. Price and income elasticities were also estimated adjusting for the presence of zero in several consumption items.

The Tobit regression results indicated that except for kerosene, the marginal effects of household total expenditure on all the other type of energy demand are positive. Kerosene should be subsidized as evidence showed it is an inferior good. But, fuel for transport becomes a luxury good for richer households. The remaining energy items are shown to be necessary goods. The results of this study confirmed that, to reach the poor, fuel subsidies need to be reformed in Senegal in a well-targeted manner instead of being universal as this has been the case for several years.

Key words: consumer demand, almost ideal demand system (AIDS), Tobit model, own-price, cross-price, income elasticities, marginal effects.
JEL codes: C13, C22, C82, O11

1 Background

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 erduction. 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 (AfDB, 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 and 12.5 kilograms. 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 quintiles 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 benefited more the rich than the poorest in rural areas. 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 CFA bil-

lion of subsidies, and in 2011, they accounted for 18 billion CFA[1]. Then, 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(World Bank, 2008). Experiences around the world have showed that fossil fuel subsidy reforms are notoriously challenging as the impact on certain groups of the population can be very burdensome.

This study tries to understand 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. In particular, the study used microeconomic data to analyze Senegalese households energy demand and therefore the impact of changes in fuel prices. A distributional analysis of different types of energy consumed by households using the 2005 household survey ("Enquête de Suivi de la Pauvreté au Sénégal") is undertaken. The concentration curses are used to classify energy and other consumption items as necessary, inferior, or luxury goods.The paper used an almost Ideal Demand System (AIDS) model to analyze household consumption, especially 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. 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. The following gives a descriptive analysis of the data used. Then, the Tobit regression results are reported in section xx.

2 The 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:

$$w_{in} = \alpha_i + \beta_i Log(Y_n) + \sum_j \gamma_{ij} P_{ij} + \sum_n \delta_{in} Z_n + u_{in} \quad (1)$$

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,

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

w_{in} is the budget/expenditure share of household n for the i^{th} good,
P_j is the price of good j^{th}, Y_n is the household n total per capita expenditure as a proxy to her/his total income,
Z is a vector of household's characteristics which includes household size, region of residence, level of education, literacy, and household poverty status, what the household considers as the first government priority, if consumer price adjustment should (or should not) be the first government concern, if youth unemployment is (or not) the household community first concern,
δ_{ih} is a parameter related to household h characteristics, and
u_{in} 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 term $\sum_j \gamma_{ij} P_{ij}$ excluded from equation (1). Therefore, the reduced form of the AIDS model is given as:

$$w_{in} = \alpha_i + \beta_i Log(Y_n) + \sum_n \delta_{in} Z_h + u_{in} \tag{2}$$

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:

$$\sum_{i=1}^{K} \alpha_i = 1$$

$$\sum_{i=1}^{K} \beta_i = 0$$

- The capacity to classify all categories of goods as normal goods: 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, for many goods, a substantial proportion of households has zero expenditures. In this kind of situation, a censured regression model is appropriate in order to accurately estimates the demand parameters. A Tobit type I model is then used to estimate the AIDS model.

Because w_{in} is observable only if $w_{in} > 0$, the Tobit model is defined as follows:

$$\begin{cases} w_{in} = w_{in}^* & if \quad w_{in}^* > 0 \\ w_{in} = 0 & if \quad w_{in}^* < 0. \end{cases}$$

where w_{in}^* is a latent variable while w_{in} is the observable variable. Let's assume that the vector of the error term in equation (2) u_{in} has an normal distribution: $u_{in} \sim N(0, \sigma_i^2)$. 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 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. But after estimating the $(K-1)$ equations, the parameters of the excluded equation can be recovered using the constraints mentioned above. According to Berten (1969), it does not make any difference which equation is dropped.

In this study, we put all consumption items into ten (10) separate groups: wood, electricity, charcoal, fuel for transportation, gas (LPG), kerosene, food, education, health, and miscellaneous. The last group consisted of all remaining consumption items which are not included in the other nine (9) items. As mentioned previously, one of these items are excluding during the regression. The excluded items is the miscellaneous group. In the regression, we also assumed that the error term is grouped-heteroscedastic meaning that the variance of the error term varies with each type of consumption items.

2.2.2 Elasticity estimation

From the Tobit model estimation, we estimate income and price elasticities. For notation convenience, let us define $z_{in} = \frac{X_{in}\theta_i}{\sigma_i}$, with $X_{in}\theta_i$ the deterministic part of equation (2). Since we have:

$$\begin{aligned} E(w_{in}) &= P(w_{in} > 0) E[w_{in} \mid w_{in} > 0] + P(w_{in} = 0) E[w_{in} \mid w_{in} = 0] \\ &= \Phi_{in} \times \left(X_{in}\theta_i + \sigma_i \frac{\phi_{in}}{\Phi_{in}} \right) + (1 - \Phi_{in}) \times 0 \\ &= \Phi_{in} \times X_{in}\theta_i + \sigma_i \phi_{in} \end{aligned} \tag{3}$$

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

$$\eta_{in}^u = 1 + \left[\frac{\Phi_{in} X_{in} \alpha_i}{\Phi_{in}\theta_i + \sigma_i \phi_{in}} \right] \tag{4}$$

The conditional expenditure elasticity is given by:

$$\eta_{in}^c = 1 + \frac{\alpha_i \left[1 - z_{in} \frac{\phi_{in}}{\Phi_{in}} - \left(\frac{\phi_{in}}{\Phi_{in}} \right)^2 \right]}{X_{in}\theta_i + \sigma_i \frac{\phi_{in}}{\Phi_{in}}} \tag{5}$$

Regarding price elasticities, there is no data available on consumer price for this cross-sectional data. 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, the 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 (De Janvry and Sadoute, 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 money). In the literature, De Janvry and Sadoulet (1995) for instance used this property to disaggregate groups of goods to estimate the Engel curves, the direct and cross-price elasticities for Morocco's rural households. According to Deaton and Muellbauer (1980), 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:

$$\varepsilon_{iin} = \frac{1}{\omega}\eta_{in}\left(1 - w_i\eta_{in}\right) - w_{in}\eta_{in}$$

Cross-price elasticities are defined as:

$$\varepsilon_{ijn} = -\frac{w_{jn}}{\omega}\eta_{in}\eta_{jn} - w_{jn}\eta_{in}$$

Where η_i is the expenditure elasticity of good i^{th} and ω is the flexibility of the currency. Yet, the AIDS model implies a monetary flexibility of -1 and this simplifies the two formulas as follows:

$$\varepsilon_{iin} = -\eta_{in}\left(1 - w_{in}\eta_{in}\right) - w_{in}\eta_{in} \tag{6}$$

$$\varepsilon_{ijn} = w_{jn}\eta_{in}\eta_{jn} - w_{jn}\eta_{in} \tag{7}$$

Assuming that η_{in} is known, one can obtain price elasticities by simply replacing η_{in} by its estimate. unconditional and conditional price elasticities are obtained by replacing η_{in} by or η^c_{in} respectively.

Hence, unconditional price elasticities are obtained as follows:

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

Using expression (3), we get the unconditional own-price elasticity as follows:

$$\varepsilon^u_{iin} = -\eta^u_{in}\left[1 - \eta^u_{in}\left(\Phi_{in}X_{in}\theta_i + \sigma_i\phi_{in}\right)\right] - \eta^u_{in}\left[\Phi_{in}X_{in}\theta_i + \sigma_i\phi_{in}\right] \tag{8}$$

The unconditional cross-price elasticity is given by:

$$\varepsilon^u_{ijn} = \left[\Phi_{in}X_{in}\theta_i + \sigma_i\phi_{in}\right]\left[\eta^u_{in}\eta^u_{jn} - \eta^u_{in}\right] \tag{9}$$

Condition own-price elasticities are obtained as follows:

$$\varepsilon^c_{iin} = -\eta^c_{in}\left[1 - \eta^c_{in}\left(X_{in}\theta_i + \sigma_i\frac{\phi_{in}}{\Phi_{in}}\right)\right] - \eta^c_{in}\left[X_{in}\theta_i + \sigma_i\frac{\phi_{in}}{\Phi_{in}}\right] \tag{10}$$

The conditional cross-price elasticities are given by:

$$\varepsilon^c_{ijn} = \left[X_{in}\theta_i + \sigma_i\frac{\phi_{in}}{\Phi_{in}}\right]\left[\eta^c_{in}\eta^c_{jn} - \eta^c_{in}\right] \tag{11}$$

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.

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

3 Data and descriptive analysis

This study used a 2005 survey dataset on "Enquête de suivi de la pauvreté" from Senegal. A sample of 12,717 households was used for the energy demand analysis. Table 1 some descriptive statistics of some variables used in the analysis. On average, a senegalese household spend 18,756,731 CFA annually. The richest household spend four time more than the poorest households. The size of the household tend to increase with the level of income. An average household accounts for about nine members, and this size increases as the income increases. On average, the head of the household aged 51 years and this age increases as the household is richer.

Table 1: **Descriptive statistics**

Total expenditure (in CFA)				
Quintile	Mean	Standard Deviation	Min	Max
Lowest	5,154,240	1,996,336	28,731	8,036,188
Second	10,405,638	1,367,928	8,037,801	12,800,526
third	15,456,658	1,605,861	12,801,515	18,308,470
Fourth	22,105,228	2,379,664	18,312,950	26,732,938
Highest	40,631,905	16,672,487	26,734,004	200,656,144
total	18,756,731	14,475,354	28,731	200,656,144
Household size				
Lowest	5.8	3.91	1	31
Second	7.6	4.03	1	36
third	8.66	4.4	1	40
Fourth	9.98	5.05	1	43
Highest	13.09	7.56	1	68
total	9.03	5.72	1	68
Age of the head of the house				
Lowest	48.19	15.75	16	99
Second	48.84	14.37	16	99
third	50.38	14.030	17	99
Fourth	51.78	14.17	19	99
Highest	54.34	14.06	19	99
total	50.71	14.65	16	99

Source: Survey data.

Poor household have higher a illiteracy rate. It also comes out that rate of the heads of household who hold a degree increases as the household spend more money. The rate of the head of household who is a farmer increases as the household is poor and richer households live much more in urban area than poor household. During the survey, additional information were asked regarding government transparency, youth unemployment and government policies related to consumer price adjustment. About 42% of households expect the government to focus first on the issue of transparency. For only 18%, youth unemployment is a concern for their community. For 15% of households, government efforts

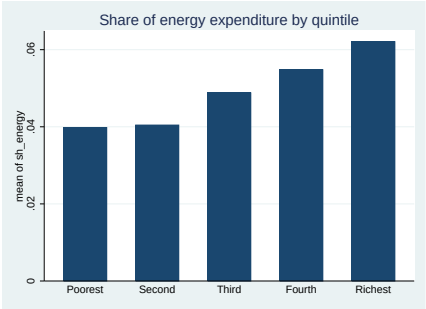
should target in consumer price reduction as a sectoral priority.

Table 2: **Descriptive statistics: % of the population**

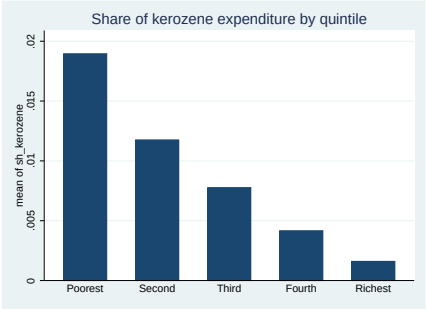
Quintile	Illiteracy	Hold a degree	Female	homeowner	Farmer	Urban
Poorest	.702	.035	.179	.786	.375	.393
Second	.678	.032	.212	.830	.297	.507
Third	.610	.064	.224	.804	.181	.651
Fourth	.525	.106	.230	.788	.130	.762
Richest	.431	.210	.214	.793	.077	.847
Total	.589	.089	.212	.800	.212	.632

Source: Survey data.

Figure 1 to 6 show the share of energy expenditures by energy type and by quintile. As we can see, poor households consume on average much less energy than rich households. The share of energy expenditure increases as we move from lower quintile to higher quintile. Regarding kerosene consumption, the poorest households are those who spend much high of their income for this good why the well-off households do spend very low share of their income for it. On the other side, the two highest quintile allocate much more their income to electricity and fuel for transportation. The share of expenditure allocated to LPG is higher for the last three quintile.

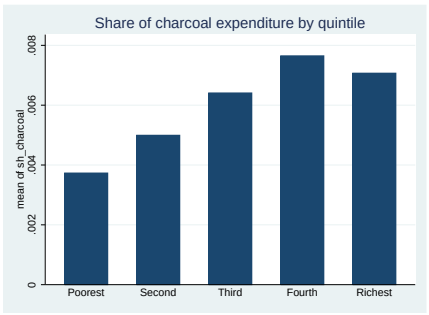


Source: Computation done by the author using the survey data



Source: Computation done by the author using the survey data

As a preliminary conclusion, poor households tend to allocate much higher share of the income to kerosene which rich households allocate much high of the income to fuel for transportation, electricity and LPG. If the goal of a fuel subsidy is to support energy consumption for the poor, it should target the type of energy consumed by the poor, instead of being universal, as this has always been the case.



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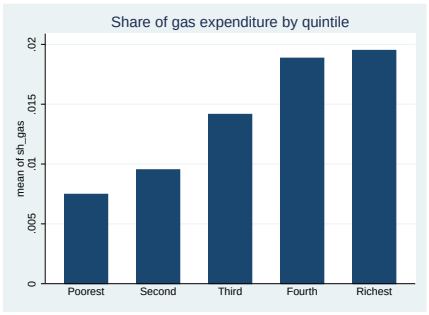

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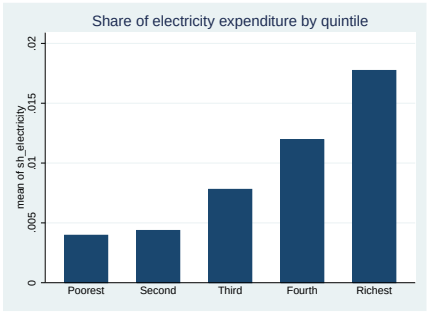

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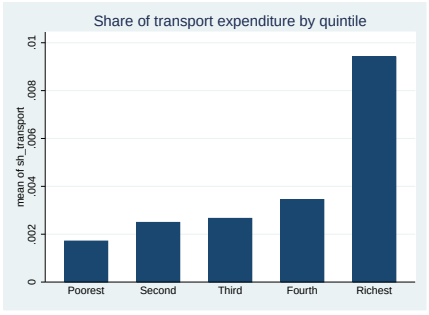

Source: Computation done by the author using the survey data

It is clear that subsidization policies should take into consideration household consumption pattern which varies considerably with the level of the income of the household.

4 Empirical results

What is the real impact of price changes in consumer behavior, especially regarding fuel price changes through the removal of the introduction of subsidy? We used the Tobit type I model to estimate the Engel curves as defined in the previous sections. Table 3 reports the estimation results. For all the consumption items, except healthcare expenditure model, the tobit regression gives significant estimates.

The marginal effect of the log of household income has a positive and significant estimate except for kerosene (the only energy item), food and education. This means that for all the energy item (excluding kerosene), when the household income increase, she/he increases its energy expenditure share. The household size has also a positive and significant effect on his energy expenditure share, excluding kerosene. Poor households tend to allocate much more of their income to wood, charcoal, and kerosene. On the opposite, rich household allocate much more of their budget to electricity, LPG, and fuel for transportation. Farmers tend to allocate much more of their budget to kerosene, fuel for transportation. Household heads who hold a degree tend to allocate much more of their budget to electricity, LPG, and fuel for transportation. Household heads who are illiterates allocate much more of their budget to electricity, LPG, and fuel for transportation.

The variable related to government transparency as the first priority has a positive impact on charcoal, fuel for transportation, and kerosene expenditure. For households who think that transparency should by the first priority for government, they tend to allocate relatively much more of their budget to these items. For households who think government need to first target consumer price reduction, they tend to allocate relatively much least of their income to electricity and fuel for transportation. The variable related to youth unemployment as the first issue of the community has a negative impact on kerosene and fuel for transportation expenditure share.

Table 3: Tobit model estimation results

Variables	Wood	Electricity	LPG	Charcoal	Kerosene	Fuel for Transport	Food	Education	Health
Log Income	.0071(.0007)	.0126(.0010)	.0103(.0005)	.0061(.0003)	-.0168(.0011)	.034(.0029)	-.0259(.004)	-.0006(.00012)	.00046(.00091)
Illiterates	.0085(.0007)	-.0097(.0006)	-.006(.0005)	-.0012(.0003)	.007(.0006)	-.008(.0023)	.029(.002)	-.0008(.00004)	-.0009(.0007)
Hold a degree	-.0112(.0012)	.004(.0008)	.0019(.0007)	-.0018(.0005)	-.0130(.0017)	.0230(.0033)	-.0369(.0033)	.0010(.0001)	.0004(.0012)
Household size	.0010(.0001)	.0009(.00005)	.0007(.00004)	.0003(.00002)	-.0012(.0001)	.003(.0002)	-.0008(.0002)	.00007(3.5e-06)	.0005(.0001)
Age	.0001(.00003)	.0001(.00001)	.00001(.00002)	.00004(7.4e-06)	-.00001(.00002)	-.0004(.0001)	.0002(.0001)	7.6e-06(1.5e-06)	.0001(.00002)
Female	.0028(.0008)	.0056(.0005)	.004(.0004)	.0025(.0003)	-.005(.0008)	-.0241(.0037)	.005 (.0018)	.0005(.00004)	-.00023(.0008)
Homeowner	.0079(.0012)	-.0005(.0006)	-.003(.0005)	-.002(.0003)	.0078(.0009)	.0215(.0037)	.0696.0027177)	.0003485(.00005)	.0006(.0009)
Farmer	-.0136(.001)	-.0182(.00084)	-.014(.0007)	-.0086(.0003)	.0104(.0006)	.0101(.003)	.015(.0025)	-.0003(.00005)	.0028(.0009)
Poor	.0026(.001)	-.0022(.0009)	-.0023(.0006)	.0015(.0003)	.0017(.0009)	-.0005(.0031)	.0084(.0038)	-.0005(.0001)	-.002(.0009)
Transparency	-.0004(.0007)	-.0003(.0005)	-.0008(.0004)	.0004(.0002945)	.002(.0006)	.0023(.0023)	-.0009(.0015)	-.00002(.00004)	-.0004(.0006)
Reduce consumer price	.0046(.0010)	-.0011(.0006)	.0004(.0005)	.0018(.00036)	.001(.001)	-.011(.003)	.006(.00223)	.000025(.00004)	.0016(.0008)
Youth unemployment	.0062(.0008)	.005(.0005)	.0034(.0005)	.0027(.0003)	-.006(.0009)	-.002(.0027)	-.004(.0026)	.0002(.00005)	-.0014(.0008)

Standard deviation are in parenthesis and are obtained using the Delta method

Source: Estimation done by the author using the survey data

The Tobit regression results clearly indicated that kerosene is kerosene has a negative marginal income effect on household expenditure while this effect this effect is positive for all the other items. This confirms that kerosene is an inferior good. We have performed a distributional analysis of different types of energy consumed by households (Figure 7). The concentration curves reveal that kerosene is an inferior good. Fuel for transportation tends to become a luxury good for highest quintile households. The concentration curve for wood tends to be closer to the equality line when we move toward the highest quintile. Electricity, charcoal and LPG are clearly necessary goods.

These results mean that kerosene is especially consumed by the poorest of the society, and subsidizing this type of energy will benefit directly the poor. In addition, subsidizing energy such as gas or charcoal would not contribute to increase poverty gap as their curve are close to the equality line. Electricity appeared to be a an normal good, but subsidizing it may contribute to increase poverty gap as the curve is far from the equality line but remains between this line and the Lorenz curve. Yet, subsidizing fuels for transportation, which include diesel and gasoline, will contribute to increase poverty gap, since these fuels are more consumed by the richest when their income increases.

In sum, universal subsidies will not be able to reach their first goal of reducing energy poverty. Poor households and rich households do not have the same behavior regarding energy price changes. For this reason, subsidies need to be well targeted to the group of population that are concerned. Subsidizing kerosene is a good way to reach the poorest households. But for the other types of energies, it is important for the government to redefine the subsidies so that they reach only the targeted population. Apart from kerosene, this means that universal subsidies should be avoided.

5 Conclusion and recommendations

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