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Income and Energy Consumption in Mexican Households

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Abstract

The analysis of household energy consumption patterns is critical for evaluating public mechanisms, such as subsidies and social tariffs that aim to provide lower income earners with better access to energy sources. This paper focuses on Mexican households to analyze the relations between their levels of income, consumption of different forms of energy, and the role played by different household characteristics. Using microdata from the Mexican Income Expenditure Surveys, the paper first relate income and energy expenditure to determine the shape of this relation. It then applies OLS and Tobit models to determine how income levels affect energy consumption in relation to other covariates. The results show a positive relation for income deciles and energy consumption and some household characteristics—pointing to differentiated mechanisms for improving energy use.

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INCOME AND ENERGY CONSUMPTION IN MEXICAN HOUSEHOLDS

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1. Introduction

As noted by the World Economic Council (1999), and in Pachauri et al (2004), in the past, energy was not usually considered as a part of basic human needs. However, in recent years there has been a consensus that access to modern energy forms is an important mechanism for the provision of healthcare, sanitation, water, and so forth, and at the same time it benefits development through more efficient provision of lighting, cooking, power, and transport, etc. (IEA, 2010).

There has been an increasing focus in research on analyzing the importance of energy access and use and their links with income and poverty. For example, in some countries, such as Mexico, the availability of some forms of energy at the household level has been taken into account when measuring poverty from a multidimensional perspective; one such measure is "access to basic services in the household" (this involves mixing items together in the same indicator, for example, electricity, fuel for cooking, water, sewage, garbage collection, etc.).

Access to and use of energy are also related to inequality, since the share of payments for energy at different income levels differs substantially. Moreover, to the extent that energy subsidies are provided by public sources to all households, or that a social tariff may be designed for improving access to energy for certain social groups, the structure of the correlations between energy and income levels has to be studied to better target such public mechanisms, and to avoid regressive subsidies.

The effect of energy use on household poverty may run through several mechanisms. Kanagawa and Nakata (2007) aggregated four main lines where energy affects welfare: health, education, income, and environment. Barnes et al (2011) and Khandker et al (2012) analyzed the relation between income poverty and energy poverty in India and Bangladesh. Using different surveys the authors estimate a demand for energy at the household level, including income deciles, to determine at which decile there is an increase in the demand for energy. They find that households below the 5th decile are considered to be energy poor. Other authors, such as Pereira et al (2010), have focused on more aggregated effects, and analyze the effects of rural electrification at the local level on the decrease in energy poverty in Brazil.

Although Mexico is a middle income country, it still has high levels of poverty and inequality. In the past decade, moderate income poverty rates fell from 53.6% in 2000 to 42.7% in 2006, then increased again due to the economic crisis to 51.3% in 2010. Despite such figures, provisions for general access to some forms of energy have increased; for example, households with electricity constitute 98.2% of the total according to the 2010 Census. Even though some energy subsidies are provided to consumers (i.e. gasoline subsidy), some of the subsidies have regressive effects, which benefit the richer groups more than the poor (UNDP, 2011). Others have pointed at the regressivity of the subsidy for electricity (i.e. Yepez-Garcia et al, 2010). Therefore, there is room to analyze to what extent households along the income distribution demand some forms of energy, and to suggest better targeting policies.

The National Development Plans of Mexico, which are the general guiding planes for each government term, have not addressed energy issues from a social point of view. At most, the 2006–2012 Plan mentioned in a general manner a possible link between energy, hunger reduction, and food security, but did not investigate this further. In spite of this, in 2007 the anti-poverty program Oportunidades included in the cash transfer an extra amount of Mex$50 (about US$3.8) for poor households to spend on electricity, gas, and coal, among other things. For rural households receiving this extra amount from the anti-poverty program, energy represents about 13% of total monthly spending, second only to food (Gertler et al, 2009), a share that is common for all poor Latin American households (CEPAL, 2009).

However, there are no empirical studies that link energy use to income levels or to household characteristics for Mexico at the household level. Thus, this paper aims to fill this gap. The objective of the paper is to calculate the determinants of different sources of energy consumption at the household level for urban and rural Mexico, focusing on the effects of income levels. Our empirical hypothesis is that energy consumption increases with income but that the starting point differs for rural and urban households. In addition, we want to test whether household characteristics play a role in determining energy consumption, and when they do, they can be taken into account when designing a more targeted subsidy scheme.

To test our hypotheses, we first compare income with energy expenditure, and then apply both OLS with log of consumption and a Tobit model to calculate significant factors affecting energy expenditure and to separate the models for urban and rural households. Here, we are using microdata at the household level from the National Income Expenditure Surveys (ENIGH), which include sociodemographic characteristics of the households, as well as data for all energy consumption, including those for different energy sources (electricity, gas, LPG, gasoline, etc.). These surveys also includes income that is used for the official measures of poverty in Mexico.

The main contribution of the paper is to shed light on a topic that has been overlooked by Mexican public policies: the relation between income levels, some other characteristics, and the different forms of energy consumption. The paper addresses issues such as inequality in the use of energy and explores mechanisms that would allow better access to energy and determine optimal prices—a discussion that starts with the identification of characteristics at different income levels of the energy consumption in both urban and rural areas.

The paper will, first, review the corresponding literature relating household characteristics to demand for energy level; second, it will explain the data and the models for the analysis; third, it will present the results, and finally, it will offer conclusions and the implications of the results.

2. Literature review

The academic literature has addressed in several ways access to and use of energy in relation to household income and some specific outcomes. Access to several forms of energy and household development are linked in that higher use of energy fosters the generation of jobs while improving living conditions. Energy consumption may have an effect not only on living standards (World Bank, 2002) but also on aggregate welfare indicators such as those included in the Millenium Development Goals (i.e. CEPAL, 2009), making energy provision one of the core mechanisms for public policy analysis of poverty reduction and income generation.

According to Kanagawa and Nakata (2007), the use of energy, measured as that used for cooking, such as LPG, reduces the exposure of households to hazardous contaminants, increases the consumption of different types of foods and medicines, improves the distribution of time between household members, enables studying with more light, reduces the digital division, and moderates the use of wood as fuel, preventing deforestation. They argue that local electrification fosters households' entrepreneurship, increases the mechanization of local industry, which results in higher productivity, and generates local industry in rural areas. However, the authors do not establish a clear link between energy and household income, nor do they address the extent to which energy consumption results in a higher income or vice versa.[1]

[1] Causality between energy consumption and development indicators is also a matter of interest for policy derivation. At the national level, several studies have tried to discern such a relation, with mixed results since the work of Kraft and Kraft (1978) suggested that causality only runs from GNP to energy consumption. But the evidence has been more mixed than conclusive following Kraft and Kraft (1978), and just examining some of them finds a likely problem of causality (as in Jumbe, 2004), that energy consumption causes growth (i.e. Narayan and Smyth, 2008), or that there is no relation between either variable (i.e. Akarka and Long, 1980). Several others, for example Mahadevan and Asafu-Adjaye (2007), find that energy consumption may affect growth during a short period, while causality going in both directions is mostly found in developed countries. Soytas and Sari (2003), when analyzing countries in the G-7, also find different results according to what set of countries are included in the data. Perhaps the level of aggregation could be an explanation for the mixed results, as shown in the study by Abid and Sebri (2012). At the household level, the challenge is higher due to the difficulty of finding exclusion variables. But as the IEA (2010) points out, causality runs mainly from income to energy use.

At the household level, other sets of analyses have been carried out. Joyeux and Ripple (2007) aggregated the residential demand for electricity worldwide. Rejecting co-integration tests between consumption of energy and GDP, the authors suggest that standards of living that are based on income usually omit some data regarding the use of residential energy.

The determinants of energy demand at the household level, as well as the variation of such determinants across income groups, are analyzed by Jamash and Meier (2010) for Britain. These authors use a panel of data for households over a period of 17 years. They calculate Engel curves, finding an s-curve relationship between household income and energy spending. They also apply a model for energy consumption given a set of characteristics of the household, finding significant variations according to income levels, while low income households are less responsive to electricity prices but more responsive to gas price changes.

Other studies have focused on the importance of income and household characteristics for improving tariff schemes in gas and electricity sectors. Navajas (2007) conducted an analysis for Argentina using microdata concerning to what extent household energy consumption (natural gas and LPG), when prices are low, is less responsive to income than to household characteristics. The author applies log regressions to the household´s energy consumption, finding that household characteristics are the main determinants of consumption, and then suggests that the social tariff could be based on those factors. He also finds that there is a marginal improvement in welfare for low user tariff schemes.

Other studies have focused on how rural households increase their energy consumption according to the available income. In Barnes et al (2011) and in Khadker et al (2012), the authors analyze for rural India and Bangladesh the relation between income deciles and energy consumption, finding those households below the 5th deciles as energy poor. Pachauri et al (2004) also determined energy poverty according to calculations for the required energy use of households in India, and found a general reduction in the numbers of energy poor over time. Others, such as Pereira et al (2010), analyzed the effects at the local level of rural electrification on the decrease in energy poverty in Brazil.

Gertler et al (2009) focused on how cash transfers to poor households in rural Mexico may increase their demand for energy. These authors, using data only for the extremely poor households receiving Oportunidades anti-poverty cash transfers, find that cash transfers increase the assets that demand more energy, increasing consumption.

In general, research has focused on relating different energy consumption to income and other characteristics, either at household or at aggregate levels. This is the approach we follow for Mexico, since this issue has not been addressed and it may be relevant to know how to target possible subsidies in a highly unequal country. On the basis of the previous literature, our hypothesis is that there is an increasing relation between income and energy consumption, which may differ in urban and rural areas and according to the energy source. We standardize the measures of energy so we can compare where the effects from income or other characteristics could have a larger incidence. We also differentiate between the energy sources that a household can consume. In doing so, we outline some possible directions for better targeting of public subsidies.

3. Data, methodology, and preliminary relations

3.1 Data

We use microdata from the National Income Expenditure Surveys (ENIGH) 2010. A survey is carried out every two years, and includes detailed questions regarding expenditures (monetary and nonmonetary) on different energy sources, other expenditures, and income. Energy expenditure is included as the total amount paid during the period, but quantities of energy are not reported (i.e. kilowatts, liters of gasoline, etc.). The data also includes the sociodemographic characteristics of the members of the household, the characteristics of the house, and the level of access to different services. These surveys are used for the official measures of poverty in Mexico, and they are representative of both urban and rural areas.[2]

Our sample consists of 27,544 households, of which we exclude those not reporting energy consumption in the aggregate. We keep those with consumption of at least one of the energy sources. We also exclude those observations with no positive total income, and those with energy consumption above the total income of the household, which leaves 25,714 households in the sample for the analysis.

The ENIGH surveys record all energy consumption, but we exclude batteries, candles (all households with this expense have electricity too), diesel, and other energy sources such as paper, coal, and oil, since their expenditure share is too low for estimations. We do not consider wood either because quantities and prices are not available, only an amount if households paid for it, and the survey does not include collected wood. In addition, the share of expenditure is about 15% for the rural low income deciles, but is not relevant for other deciles or urban households.

We focus on LPG, natural gas, gasoline, and electricity. However, natural gas is only available in some urban municipalities where there is an authorized distributor. Therefore, we restrict our analysis to households in urban areas with a distributor. Confirmation on the locations of distributors was taken from the Commission for Energy Regulation (Comision Reguladora de Energia, CRE).

[2] At the state level, in 2010 only five states have a sampling that it is representative at the state level.

For our survey, we measure the income level of a household and the different sources of energy consumption. We follow the aggregation of different sources of income for the household members to determine the aggregated total income, and categorize it by income deciles for urban and rural households separately. We also calculate the expenditure for each of the energy sources for households reporting expenditure on at least one source of energy, leaving out of the sample households without energy consumption.[3]

With regard to energy consumption, it may be difficult to derive conclusions on the comparable effects of income and household characteristics since each energy item has a different measure. In order to make a comparison between these different sources of energy consumption, we transform the expenditure to a measure of energy intensity, Kilograms of Oil Equivalent (KgOE), which is a standardized measure of energy that can be extracted from one kilogram of crude oil. This measure allows all data for energy consumption to be presented as comparable between sources of consumption. Also, the conversion to KgOE requires quantities of each type of energy used, and ENIGH only record the expenditure, so we extract prices from the Commission for Energy Regulation, calculate an approximated quantity for each energy type, and then convert it to KgOE.

We also have several characteristics of the household head, and of the household, in our estimations. All of the basic statistics are presented in the next table.

[3] Households not reporting any energy consumption account for 6% of the sample.

Table 1: Basic Statistics and Variables Definition

Variable	Definition	Urban			Rural		
		N	Mean	Std. Dev.	N	Mean	Std. Dev.
North	=1 for Northern States[a]	20407	0.183	0.386	5307	0.151	0.358
Center	=1 for Center States[b]	20407	0.552	0.497	5307	0.513	0.500
South	=1 for Southern States[c]	20407	0.265	0.442	5307	0.336	0.472
Vehicles	Number of household vehicles	20407	0.653	0.881	5307	0.436	0.733
Appliances	Number of household appliances	20407	6.977	4.042	5307	4.117	2.613
Refrigerator	=1 if the house has refrigerator	20407	0.879	0.326	5307	0.665	0.472
Stove	=1 if the house has a stove	20407	0.939	0.240	5307	0.651	0.477
Washing machine	=1 if the house has a washing machine	20407	0.693	0.461	5307	0.457	0.498
Fan	=1 if the house has a fan	20407	0.524	0.499	5307	0.361	0.480
Air conditioning	=1 if the house has air conditioning	20407	0.135	0.341	5307	0.043	0.202
Heating	=1 if the house has heating	20407	0.018	0.133	5307	0.005	0.067
Owners of housing	=1 if the house is owned (even if they are still paying for it)	20407	0.677	0.468	5307	0.860	0.347
Log (dormitories)	Log of the number of rooms used for sleeping	20407	0.628	0.459	5307	0.517	0.457
Housing quality	This is the sum of three dummy variables: floor, ceiling and wall quality[d]	20407	2.635	0.731	5307	1.976	0.954
Employment type	=1 if the household head is self-employed or an employer	20407	0.193	0.394	5307	0.386	0.487
Male	=1 if the household head is male	20407	0.736	0.441	5307	0.822	0.383
Formal	=1 if the household head has access to social security for his job	20407	0.321	0.467	5307	0.116	0.320
Indigenous language	=1 if the household head speaks an indigenous language	20407	0.082	0.275	5307	0.247	0.431
Log(Household size)	Log of the number of household members	20407	1.203	0.552	5307	1.326	0.552
Skilled	=1 if the household head has 12 or more years of schooling	20407	0.286	0.452	5307	0.062	0.241
Decile 1-10	=1 for the correspondent decile	20407	0.099	0.299	5307	0.099	0.298
Dependant variable for OLS							
Log(LPG)	Log of the monthly LPG household consumption	11279	3.398	0.480	1980	3.307	0.447
Log (electricity)	Log of the monthly electricity household consumption	18892	3.048	0.905	4979	2.493	0.878
Log(gasoline)	Log of the monthly gasoline household consumption	8477	4.313	0.836	1513	3.897	0.870
Log(natural gas)	Log of the monthly natural gas household consumption[e]	1008	3.796	0.669	6	3.816	0.923
Log(energy)	Log of the monthly energy household consumption	20407	3.997	1.123	5307	3.166	1.251
Dependant variable for Tobit							
LGP	Monthly LPG household consumption	20407	18.651	22.415	5307	11.207	16.828
Electricity	Monthly electricity household consumption	20407	30.732	47.926	5307	17.257	24.091
Gasoline	Monthly gasoline household consumption	20407	42.910	78.697	5307	20.163	48.407
Natural Gas	Monthly natural gas household consumption [e]	7683	7.284	24.446	681	0.509	6.042
Energy	Monthly energy household consumption	20407	95.036	112.598	5307	48.693	67.458

[a] Northern States: Baja California, Baja California Sur, Sinaloa, Sonora, Chihuahua, Coahuila, Durango, Nuevo Leon, Tamaulipas

[b] Center States: Aguascalientes, Colima, Distrito Federal, Guanajuato, Guerrero, Hidalgo, Jalisco, Mexico, Michoacan, Morelos, Nayarit, Puebla, Queretaro, San Luis Potosi, Tlaxcala, Veracruz, Zacatecas

[c] Southern States: Oaxaca, Chiapas, Tabasco, Campeche, Yucatan, Quintana Roo

[d] Floor quality =1 if the floor is made of concrete, wood, tile, or other coating; wall quality =1 if the wall is made of partition, brick, block, stone, or concrete; ceiling quality =1 if the roof is made of concrete slabs or joists with a vault

[e] Restricted to municipalities with natural gas distribution infrastructure

The basic statistics are split for urban and rural areas. In general, urban households have more domestic appliances (vehicles, refrigerators, stoves, washing machines, other appliances, fans, air conditioning, and heating), more dormitories, and better-quality houses than those in rural areas. Rural households have a larger share in regard to ownership, self-employment, male heads, indigenous individuals, and number of members. Energy consumption is always higher for urban households, and the total energy consumption for urban households (95 KgOE) is double that of rural households (48.6 KgOE).

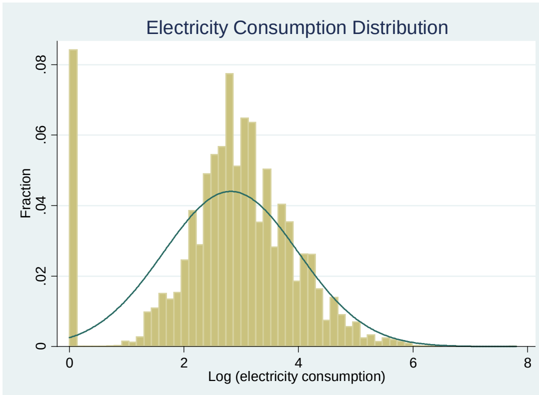
As noted in Table 1, dependent variables for energy consumption are presented in logs and as the normal reported continuous variables (including zeros in reported energy consumption). This may be relevant for defining our model in the next sections. In Figure 1 we analyze the distribution of zeros in reported energy consumption; if the weight of zeros is relevant, then our model should take this into account.

The graphic analysis shows that there is a spike in zero consumption, suggesting a censoring at zero when we divide by energy source, while for the total energy consumption all the responses are above zero consumption. The only distributions resembling a normal distribution are for electricity and the total energy consumption. Therefore, in the section that discusses our model we address these issues in order to avoid possible biases or inconsistencies in the estimations derived from zero consumption of some energy types.

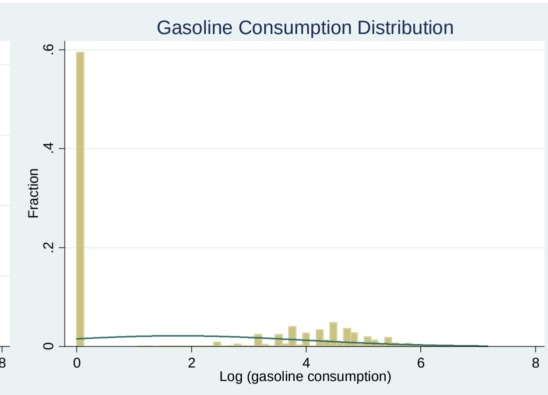
3.2 Preliminary relations

We calculate preliminary correlations between income deciles and the shares of expenditures in energy for households and total energy consumption in KgOE. In Figures 2 and 3, we display the share of the households' energy expenditure to total expenditure, and also the percentage for each energy type, as a share of total energy expenditure in KgOE.

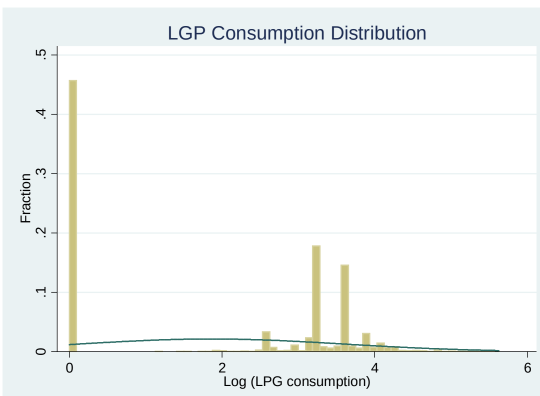
Figure 1: Energy consumption distribution of continuous responses



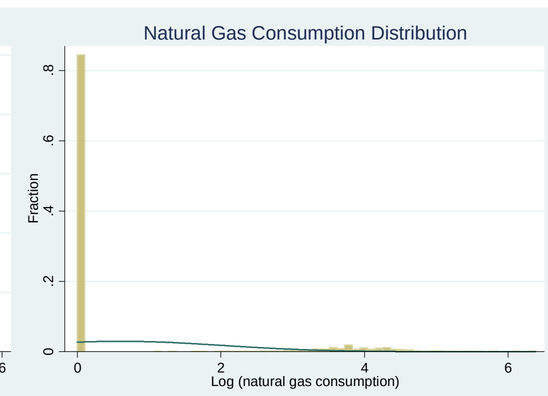
Total observations	25714
Lower bound	0
Number of observations lower bound	1843
Percentage	7.2%



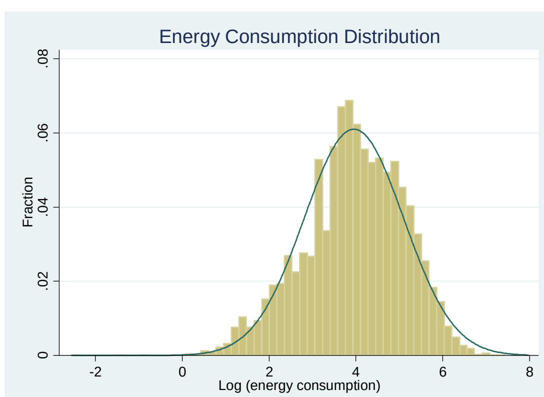
Total observations	25714
Lower bound	0
Number of observations lower bound	15724
Percentage	61.1%



Total observations	25714
Lower bound	0
Number of observations lower bound	12455
Percentage	48.4%



Total observations	8364
Lower bound	0
Number of observations lower bound	7350
Percentage	87.9%

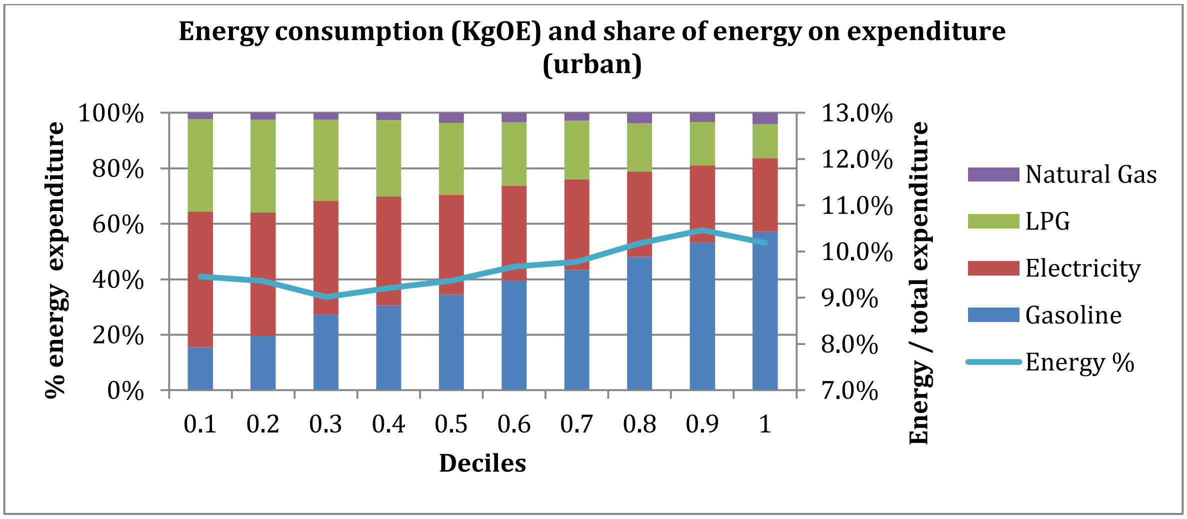


Total observations	25714

Notes: For the distribution calculation, a logarithmic transformation is applied in order to reduce the dispersion of the data. However, to prevent the observations reporting no consumption becoming missing values, we add 1 to all observations in the corresponding variable and then the logarithmic transformation is applied.

For urban areas, energy consumption as a share of total expenditure, represented by the line in the graph, accounts for about 9% in the lower deciles but above 10% for the three higher deciles. For rural households, it is about 8% in the lower deciles, and reaches about 12% in the top decile.

Figure 2



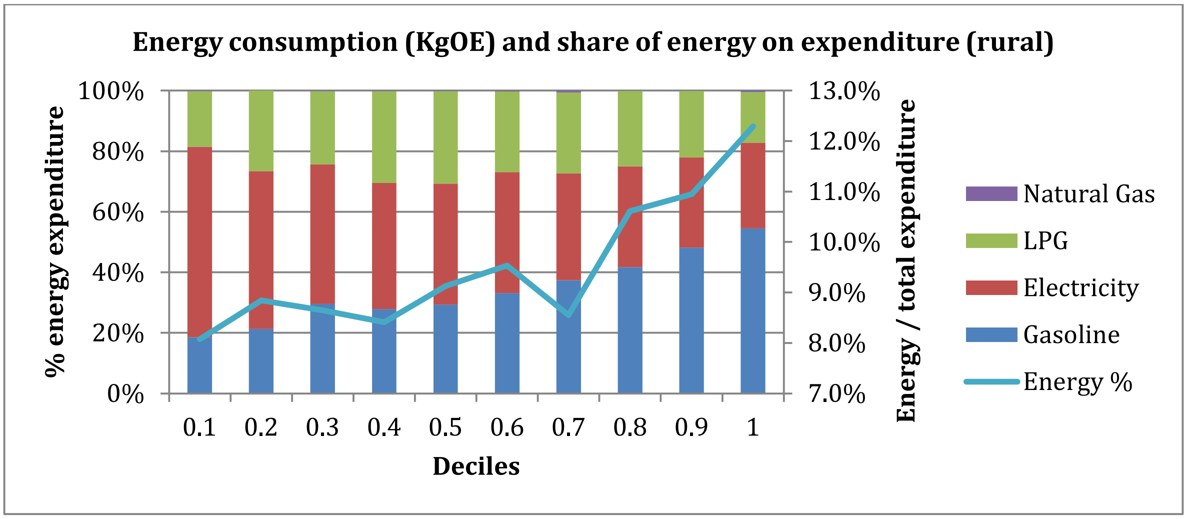
Source: own calculations using ENIGH 2010

In urban areas, the lower deciles consume more units of electricity, followed by LPG, gasoline, and natural gas, while the upper income levels consume more units of gasoline, followed by electricity, LPG, and natural gas. In rural areas, households in lower deciles consume more units of electricity, LPG, and gasoline, while upper income households use more units of gasoline, electricity, and LPG, in that order.[4]

Since the KgOE measure allows for comparison of the same unit but for different energy consumption, Figures 4 and 5 show the units that average households in each decile consume in urban and rural areas.

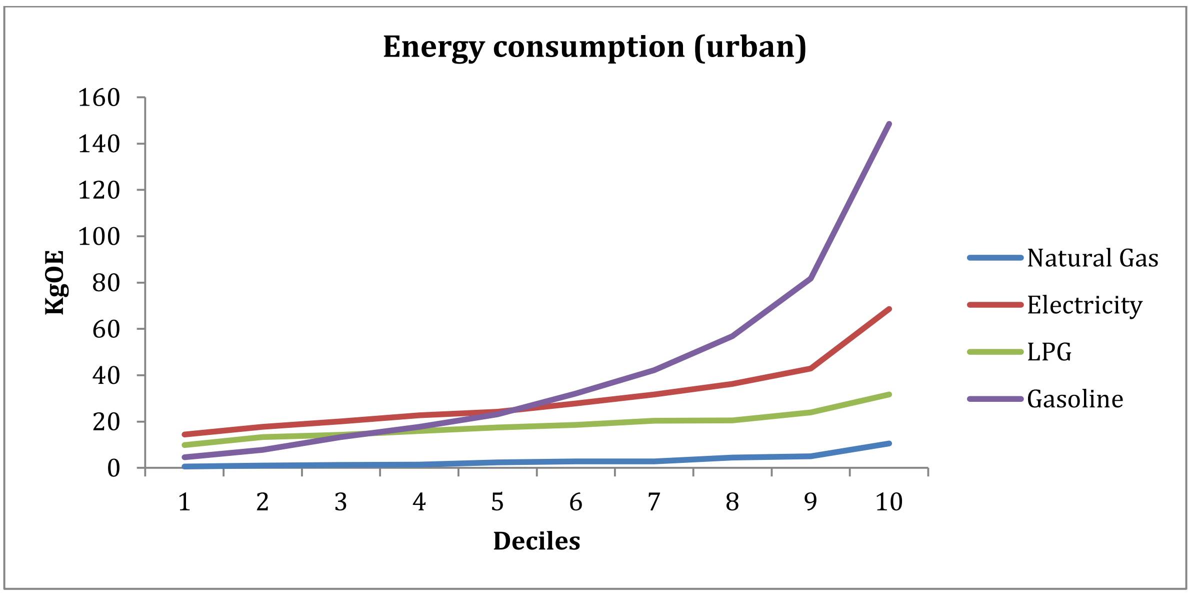
[4] Indirect consumption of gasoline or diesel through public services is not addressed here, since the payment is for the service (transportation, for example) and not for the raw material (gasoline).

Figure 3



Source: own calculations using ENIGH 2010

Figure 4

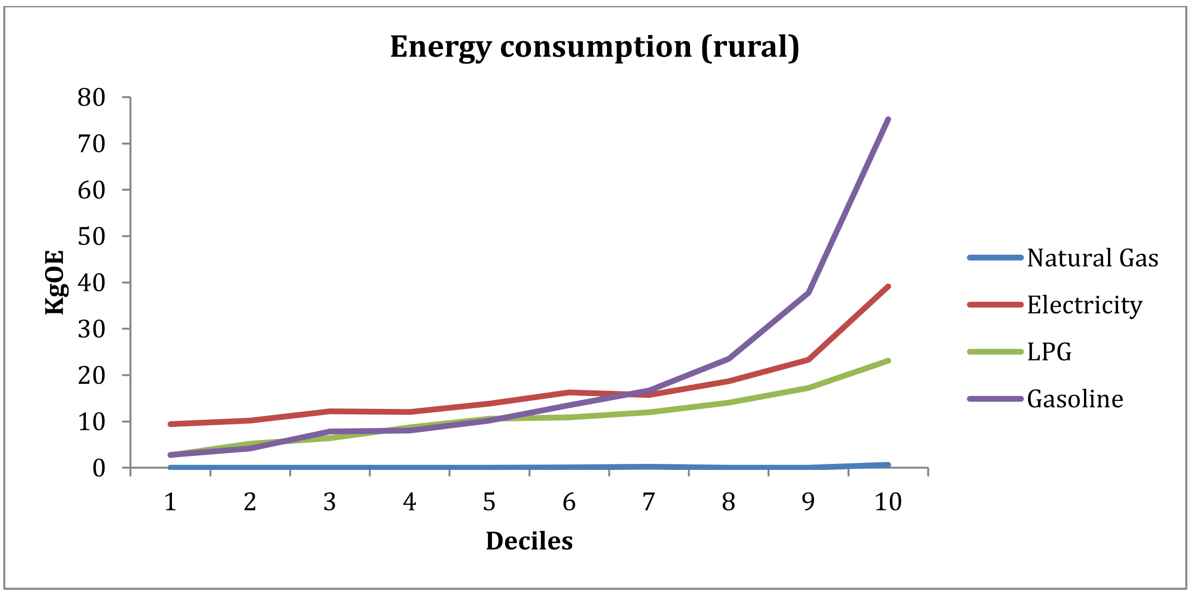


Source: own calculations using ENIGH 2010

According to Figure 4, urban households have a steep increase in their use of gasoline when income increases, while for the lower deciles there is an increase of up to 20 KgOE in the consumption of electricity and LPG. While the lower income households can consume half of the energy units of gasoline that they consume of LPG or electricity, the upper decile consumes more than double the energy units of gasoline that they consume of electricity, which can be up to 160 KgOE, as is the case for gasoline.

Figure 5 does not show a different picture for rural households than the previous figure, although the energy units are much lower than for urban households. From the lower to middle deciles, households consume more units of electricity, while gasoline consumption increases for the upper levels. Lower income households consume up to 10 KgOE of electricity, while upper income levels consume up to 80 KgOE of gasoline.

Figure 5

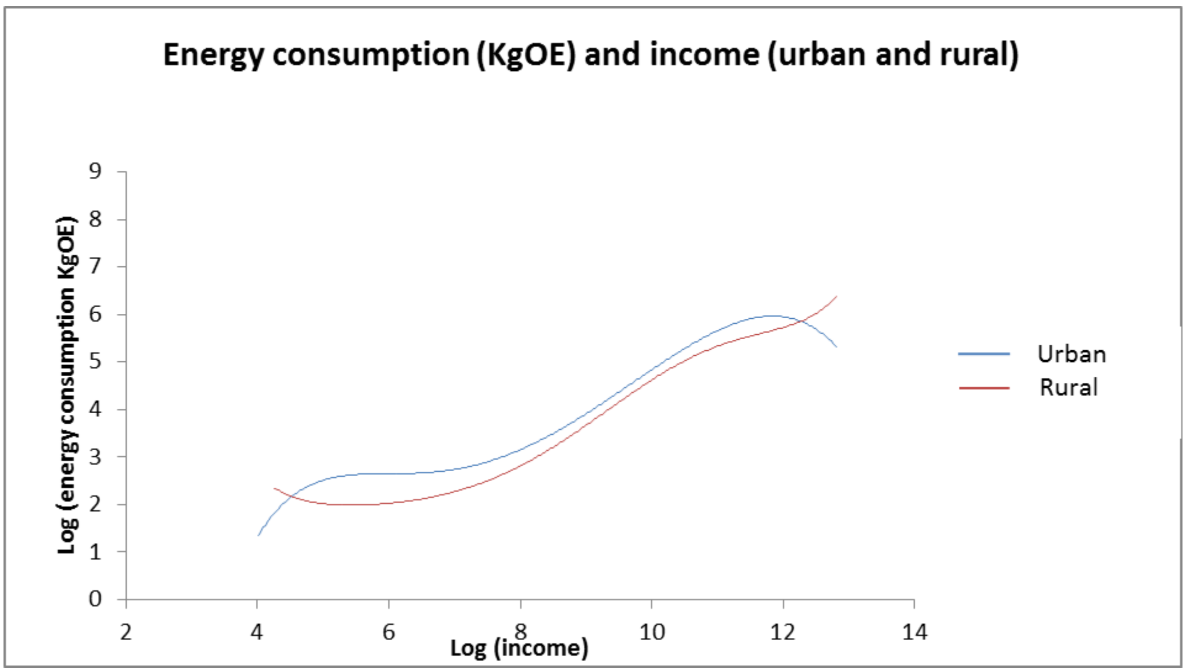


Source: own calculations using ENIGH 2010

Next we determine to what extent the aggregated energy expenditure is related to the level of income in the Mexican households using the Engel curves. These curves are expected to be close to linear in logs. In previous studies, such as those of Bradshaw et al (1987) and Jamasb and Meier (2010) an s-shaped curve has been found, suggesting that there are inflection points in the household's expenditure on energy; in other words, as income increases the expenditure on energy increases as well, then the relation flattens or decreases slightly, then increases again, indicating the changes in relations.

Figure 6 presents the relations between logs of income and energy consumption in both urban and rural households. The relation resembles an elongated s-shaped curve where energy expenditure increases with income, then there is an inflection point where it increases again only to slightly decrease at the upper levels. For rural households, the relation presents a wider s-shaped form, where it first experiences an almost flat relation, but then increases from about the middle of the curve. There is a slight change in upper levels but this continues to increase, though at a slow rate.

Figure 6



Source: own calculations using ENIGH 2010

Inflection points are different for rural and urban households. This suggests that relations between income and energy consumption are different in each area; energy is a necessary good in rural households, and policies helping to reach the inflection point would cover most of the households, while for urban households it would mostly be those in the lower income groups that were covered. For urban households, at the upper levels, the decreasing relation shows that energy can be seen as an inferior good.

To what extent are such relations significant? In the next section we apply our model to determine the demand for energy consumption at the household level, controlling for income levels but also for different geographical and socioeconomic characteristics of the households.

3.3 Model

Here we want to know the determinants of energy consumption (in KgOE) in households and, especially, the variation in consumption according to the income level. Following Barnes et al (2011) and other authors (i.e. Jamasb and Meier, 2010; Navajas, 2007 among several others), we set our model as:

$$E_{ij}=\alpha+\beta_1 X_j+\beta_2 H_j+\beta_3 I_j+\varepsilon_{ij}$$

where:

E is consumption units in KgOE of energy type i for household j
X is a vector of sociodemographic characteristics of the household and its head
H is the physical characteristics of the house.
I is income decile of the household j

This model could be implemented in logs with OLS; however, in all cases for different energy consumption, there are several households that do not consume such specific energy sources, and therefore having zeros in the variables and positive values for those that spend on the energy source is appropriate.

In this case, using OLS does not give consistent parameters as it is a censored sample and not representative of the population. For this reason, we implement the model using a Tobit specification, censored from below with zeros in the dependent variable (Cameron and Trivedi, 2005), where, simplifying all dependent variables into x:

$E^*=x'\beta+\varepsilon$

with error term:

$\varepsilon \sim N(0,\sigma^2)$

Here the variance is constant across observations. There is a latent variable E^* $N(x'\beta, \sigma^2)$, where the observed E is given by:

$$E = \begin{cases} E^* & \text{if } E^*>0 \\ - & \text{if } E^*<=0 \end{cases}$$

In our case, as we have expenditure in energy, when $E^*<=0$ then we have $E=0$. That is, we are censored on the left because of the zeros.

If income is not significant in explaining energy consumption, there is room to increase consumption in such households. In addition, as we control for other covariates, they can also be taken into account in more focused actions for subsidy provision, i.e. indigenous households, differentiation in regions, etc.

All variables included in the model were explained in the previous section about data. The results are presented in the next section for the Tobit with log data as in the studies of Khandker et al (2012) and Barnes et al (2011), and we also present the comparison results using OLS with logs in energy expenditure as in the studies of Navajas (2007) and Jamasb and Meier (2010).

4. Results

In this section, we present the results for different energy sources, and the aggregated energy consumption, using both OLS and Tobit models, as explained in the previous section, for comparison. The sample is for households with a positive income as well as a positive total energy consumption, if it is lower than the income. The dependent variable is the normalized measure of KgOE, which allows for comparison of the same energy units for the different sources.

The sample for the OLS models is restricted to households with positive consumption in the total energy source, since we have to convert in logs. Results are presented for urban and rural areas separately, and using clustered standard errors at the state level with the sample weights. LPG and natural gas are separated in the regressions since natural gas is available in only a few urban areas.

Table 2 displays results for the household consumption of LPG. The variables for geographical variation seem to be positive and significant, that is, northern and central states consume more LPG than households in the south, but only in the rural areas, and in the urban areas that only happens with households in central areas. The number of appliances and house owners is significant in terms of increasing LPG consumption in both urban and rural households. Male heads with formal jobs decrease the consumption in urban households. Households in which the heads are indigenous have a lower consumption of LPG in rural areas only when the Tobit model is applied.[5]

Regarding income deciles, for urban areas and when interpreting the Tobit model, there is an increasing effect of income and LPG consumption in KgOE, with an inflexion point between the 5th and 6th deciles, and again between the 7th and 8th deciles. For rural areas, there is also a positive relation, with an inflexion between the 6th and 7th deciles in the Tobit models. In this last case, significant relations start from the 3rd quantile, showing a significant difference from the OLS, where significance is only in the last upper decile.

[5] Of the total sample of 5307 rural households, 1309 are reported as indigenous; of those, 1153 report zero consumption of LPG, which explains why the coefficient becomes not significant when using the OLS regression.

Table 3 shows the results for natural gas consumption. In this case we only present results for urban areas where there is an authorized distributor. In the Tobit estimation, the geographical areas are significant in the north, compared to the center/south, suggesting that households in northern states consume more natural gas than households in other areas. Also, there are significant and positive effects from having heating and other machines, being owners of the house, the quality of the house, being self-employed, the larger number of household members, and the number of dormitories in the house, i.e. larger and better-quality houses consume more natural gas.

Table 2: OLS and Tobit for household consumption on LPG

	Urban				Rural			
	OLS		Tobit		OLS		Tobit	
Log (LPG)	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
North	-0.075	(0.061)	2.446	(1.714)	-0.076	(0.077)	3.049	(1.243) **
Center	0.110	(0.053) **	5.495	(0.978) ***	-0.042	(0.074)	2.631	(1.028) **
Vehicles	0.046	(0.011) ***	0.283	(0.345)	0.022	(0.028)	0.484	(0.285) *
Appliances	0.016	(0.002) ***	0.310	(0.060) ***	0.019	(0.006) ***	0.097	(0.101)
Refrigerator	0.029	(0.017) *	-0.270	(0.511)	0.074	(0.049)	0.730	(0.496)
Stove	0.056	(0.038)	7.995	(1.029) ***	-0.036	(0.062)	10.841	(0.614) ***
Washing machine	0.048	(0.012) ***	0.539	(0.390)	0.051	(0.051)	0.620	(0.434)
Fan	-0.020	(0.016)	-2.848	(0.486) ***	-0.059	(0.048)	-1.627	(0.517) ***
Air conditioning	-0.041	(0.042)	-2.201	(0.850) ***	-0.052	(0.073)	-1.049	(0.742)
Heating	0.071	(0.061)	-4.654	(2.107) **	0.143	(0.215)	0.009	(2.571)
Owners of housing	0.089	(0.016) ***	0.775	(0.297) ***	0.079	(0.041) *	0.507	(0.572)
Log (dormitories)	0.091	(0.017) ***	0.732	(0.658)	0.042	(0.042)	0.580	(0.657)
Housing quality	0.010	(0.010)	-0.214	(0.280)	-0.025	(0.020)	0.639	(0.294) **
Employment type	-0.007	(0.015)	-0.119	(0.314)	0.024	(0.035)	-0.439	(0.466)
Male	-0.027	(0.011) **	-0.543	(0.282) *	0.030	(0.051)	0.402	(0.768)
Formal	-0.056	(0.011) ***	-0.707	(0.340) **	-0.040	(0.038)	0.344	(0.665)
Indigenous language	-0.032	(0.031)	-0.145	(1.239)	-0.050	(0.060)	-1.649	(0.824) **
Log (household size)	-0.044	(0.029)	1.973	(0.378) ***	-0.071	(0.038) *	-0.122	(0.580)
Skilled	0.025	(0.012) *	-0.370	(0.524)	-0.047	(0.036)	-0.276	(0.721)
Decile 2	0.042	(0.026)	1.890	(0.730) ***	0.105	(0.096)	2.036	(1.307)
Decile 3	0.039	(0.033)	2.085	(0.618) ***	0.043	(0.095)	2.260	(1.308) *
Decile 4	0.081	(0.030) **	3.403	(0.862) ***	0.133	(0.083)	4.759	(1.599) ***
Decile 5	0.129	(0.039) ***	4.215	(0.881) ***	0.129	(0.120)	5.147	(1.350) ***
Decile 6	0.137	(0.047) ***	4.126	(0.896) ***	0.146	(0.113)	6.098	(1.474) ***
Decile 7	0.179	(0.045) ***	4.955	(0.995) ***	0.119	(0.126)	5.064	(1.426) ***
Decile 8	0.213	(0.045) ***	3.630	(1.011) ***	0.165	(0.121)	6.310	(1.459) ***
Decile 9	0.289	(0.056) ***	5.652	(1.180) ***	0.204	(0.122)	8.160	(1.789) ***
Decile 10	0.386	(0.053) ***	8.092	(2.490) ***	0.350	(0.121) ***	9.796	(1.859) ***
Constant	2.867	(0.080) ***	-38.764	(4.658) ***	3.071	(0.135) ***	-59.917	(7.174) ***
Sigma			33.197	(1.197)			27.821	(2.203)
N	11279		20407		1980		5307	
F/LR χ^2	295.88	(0.000) ***	832.65	(0.000) ***	112.34	(0.000) ***	319.22	(0.000) ***
R^2 / Likelihood	0.2423		0.0167		0.1131		0.0678	

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

Sample restricted to households consuming LPG for OLS

Table 3: OLS and Tobit for household consumption on natural gas

	Urban					
	OLS			Tobit		
Log (natural gas)	**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**	
North	-0.261	(0.162)		9.513	(5.382)	*
Center	-	-		-	-	
Vehicles	0.059	(0.041)		-0.362	(0.643)	
Appliances	-0.005	(0.008)		0.106	(0.202)	
Refrigerator	0.172	(0.072)	**	2.357	(2.509)	
Stove	-0.199	(0.146)		-3.142	(1.998)	
Washing machine	0.159	(0.069)	**	4.341	(1.144)	***
Fan	-0.069	(0.065)		0.895	(1.101)	
Air conditioning	-0.075	(0.051)		0.882	(2.085)	
Heating	0.393	(0.094)	***	11.120	(2.798)	***
Owners of housing	0.086	(0.036)	**	2.072	(0.812)	**
Log (dormitories)	0.123	(0.071)		4.671	(1.713)	***
Housing quality	0.096	(0.042)	**	3.250	(1.956)	*
Employment type	0.176	(0.090)	*	0.191	(1.275)	
Male	0.025	(0.042)		0.143	(0.960)	
Formal	0.022	(0.044)		0.443	(0.817)	
Indigenous language	0.524	(0.299)		-2.892	(3.131)	
Log (household size)	0.078	(0.076)		-5.468	(1.727)	***
Skilled	-0.040	(0.070)		0.843	(1.714)	
Decile 2	0.234	(0.155)		1.265	(2.358)	
Decile 3	-0.112	(0.168)		2.600	(2.363)	
Decile 4	0.115	(0.102)		0.602	(1.431)	
Decile 5	0.252	(0.143)	*	6.149	(3.842)	
Decile 6	0.176	(0.177)		6.214	(3.412)	*
Decile 7	0.268	(0.124)	**	7.555	(2.550)	***
Decile 8	0.358	(0.108)	***	8.673	(2.700)	***
Decile 9	0.263	(0.107)	**	8.606	(2.977)	***
Decile 10	0.497	(0.109)	***	15.845	(5.605)	***
Constant	2.993	(0.147)	***	-205.035	(48.298)	***
Sigma				90.573	(17.283)	
N	1008			7683		
F/LR χ^2	-	-	-	-	-	-
R^2 / Likelihood	0.2548			0.0521		

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

Sample restricted to households consuming natural gas for OLS

Sample restricted to municipalities with an infrastructure to distribute natural gas for Tobit

Here, for income deciles, there is an increasing effect starting in the 6th decile and continuing to the upper deciles, with a slight reduction between the 8^{th} and 9^{th} deciles, and then it almost doubles from the 9^{th} to the 10^{th} decile. That is, natural gas is mostly an urban middle- and high-income energy good. It must be noted, though, that selection may be present in this case, since, when it is available, gas distribution is mainly found in middle- and high-income neighborhoods.

Table 4 shows the results for the consumption of electricity in KgOE units. Here, a number of appliances and other household machines, as well as the quality of the houses, are correlated to electricity consumption. For example, according to the Tobit, having air conditioning increases consumption of electricity by 20.6 KgOE in urban households, or 19 KgOE in rural households. The better the house structure, the higher the consumption of electricity. Having a male household head seems to mean that less electricity is consumed in urban areas, but no significant relation is found in rural areas. Having more dormitories in houses in urban areas leads to more electricity consumption, but it is not significant in rural areas.

For electricity, there are substantial variations between OLS and Tobit models (although as mentioned here OLS may give inconsistent parameters) for rural households. In the OLS there is a significant increasing effect of income deciles on electricity demand. For Tobit this is only true in the upper decile. For the rural households, the Tobit shows a negative effect of income deciles on electricity demand, although it is not significant except at the upper decile where it is positive and significant. For the OLS, with a sample restricted to only those having a positive spend on electricity, the deciles are positive and significant at the upper levels.

Table 4: OLS and Tobit for household consumption on electricity

	Urban				Rural			
	OLS		Tobit		OLS		Tobit	
Log (electricity)	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
North	0.275	(0.117) **	2.528	(1.662)	0.321	(0.151) **	3.159	(2.051)
Center	0.020	(0.115)	-2.223	(1.323) *	0.197	(0.147)	1.698	(1.034) *
Vehicles	0.069	(0.013) ***	1.545	(0.403) ***	0.068	(0.020) ***	0.877	(0.677)
Appliances	0.013	(0.002) ***	0.529	(0.120) ***	0.018	(0.008) **	0.518	(0.192) ***
Refrigerator	0.227	(0.043) ***	1.536	(0.598) ***	0.293	(0.043) ***	1.698	(0.582) ***
Stove	0.057	(0.041)	-1.500	(0.914)	0.143	(0.034) ***	-0.314	(0.666)
Washing machine	0.055	(0.020) ***	-0.233	(0.479)	0.070	(0.034) **	0.694	(0.642)
Fan	0.122	(0.030) ***	2.021	(0.823) **	0.147	(0.037) ***	2.121	(1.106) *
Air conditioning	0.646	(0.063) ***	20.625	(3.579) ***	0.707	(0.092) ***	19.719	(6.291) ***
Heating	0.009	(0.102)	7.170	(5.671)	0.266	(0.119) **	40.623	(8.332) ***
Owners of housing	0.117	(0.019) ***	2.684	(0.405) ***	-0.017	(0.039)	1.775	(0.519) ***
Log (dormitories)	0.128	(0.019) ***	1.662	(0.633) ***	0.079	(0.047)	0.200	(0.644)
Housing quality	0.039	(0.010) ***	0.638	(0.297) **	0.080	(0.019) ***	1.043	(0.311) ***
Employment type	0.092	(0.021) ***	1.766	(0.556) ***	0.036	(0.032)	0.893	(0.685)
Male	-0.060	(0.018) ***	-0.893	(0.453) **	0.010	(0.028)	-0.248	(0.728)
Formal	-0.062	(0.013) ***	-1.625	(0.389) ***	-0.089	(0.033) **	-1.069	(1.231)
Indigenous language	-0.067	(0.036) *	-0.676	(0.775)	-0.027	(0.043)	-0.291	(0.759)
Log (household size)	0.212	(0.020) ***	2.501	(0.863) ***	0.067	(0.038) *	0.661	(0.667)
Skilled	0.001	(0.017)	-0.318	(0.529)	0.130	(0.050) **	2.506	(2.005)
Decile 2	0.129	(0.032) ***	0.945	(0.661)	-0.005	(0.074)	-1.501	(1.494)
Decile 3	0.175	(0.034) ***	0.783	(0.716)	0.066	(0.083)	-0.740	(1.457)
Decile 4	0.205	(0.039) ***	1.559	(0.613) **	0.069	(0.068)	-1.567	(1.592)
Decile 5	0.195	(0.039) ***	1.130	(0.842)	0.097	(0.088)	-1.854	(1.535)
Decile 6	0.221	(0.037) ***	2.109	(0.755) ***	0.195	(0.098) *	-1.387	(1.795)
Decile 7	0.264	(0.035) ***	2.130	(0.532) ***	0.136	(0.098)	-3.066	(1.595) *
Decile 8	0.308	(0.043) ***	3.011	(0.819) ***	0.212	(0.083) **	-1.440	(1.721)
Decile 9	0.370	(0.044) ***	4.408	(1.430) ***	0.302	(0.090) ***	-0.421	(1.734)
Decile 10	0.578	(0.040) ***	16.125	(2.026) ***	0.536	(0.089) ***	6.538	(2.100) ***
Constant	1.697	(0.148) ***	-2.771	(2.627)	1.428	(0.147) ***	-2.775	(2.552)
Sigma			41.266	(3.103)			24.916	(2.191)
N	18892		20407		4979		5307	
F/LR χ^2	284.590	(0.000) ***	281.030	(0.000) ***	1466.940	(0.000) ***	491.010	(0.000) ***
R^2 / Likelihood	0.3811		0.0265		0.4168		0.0328	

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

Sample restricted to households consuming electricity for OLS

Although not significant, results for the Tobit may be due to two possible factors that are not mutually exclusive. First, the electricity supply is not constant in rural areas. Second, the number of households not reporting electricity consumption increases with income. In order to check this last option, we use a probit model in which the dependent variable takes the value of one if the household does not report consumption of each of the energy sources. If the coefficients are significant, then there is a trend for not reporting consumption. The table in Annex 1 presents such results, where it can be noted that in most cases there is a significant negative effect between income and not reporting, except for electricity in rural areas, which presents a positive effect for income and not reporting electricity consumption. That is, in this case, the number of zeros for electricity consumption increases up to decile 6, as opposed to the trend for the other sources, possibly biasing the results in the Tobit for the rural areas.

Table 5 displays the results for gasoline. The number of vehicles and being a house owner are positive and significant for gasoline consumption. Each vehicle increases gasoline consumption by 25 KgOE in urban households and by 16 KgOE for those in rural areas, according to the Tobit estimates. Households in the northern states consume more gasoline than in other states. Households with male heads consume more gasoline. Larger households consume less gasoline in urban areas than those in rural areas.

For urban and rural households, the effect of deciles increases, except for a fall from the 4^{th} to the 5^{th} decile in rural households. For rural areas, the increasing effect of deciles becomes significant from the middle deciles to the upper levels. This is because, in rural areas, those in the lower deciles do not increase their consumption of gasoline in line with their income until they reach a middle decile level of income (the 4^{th}). In contrast, in urban households the relationship is significant for all the income deciles. For significant deciles, there are large differences between urban and rural households, for example the urban 10^{th} decile consumes three times more KgOE units of gasoline than a rural one, according to Tobit estimations, but there is a similar pattern for the other deciles.

Finally, we present the results for aggregated energy consumption in KgOE units. Here the model is OLS, since aggregating all energy sources gives no zero observations in consumption for any household. In this case, such aggregation is relevant for public policies if in general they want to foster energy consumption without differentiating between the different sources.

Table 5: OLS and Tobit for household consumption on gasoline

	Urban						Rural					
	OLS			Tobit			OLS			Tobit		
Log (gasoline)	**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**	
North	0.292	(0.055)	***	5.817	(2.510)	**	0.152	(0.102)		4.785	(2.808)	*
Center	0.092	(0.046)	*	0.793	(1.876)		0.066	(0.082)		1.992	(2.016)	
Vehicles	0.165	(0.018)	***	24.951	(1.188)	***	0.175	(0.038)	***	16.054	(1.993)	***
Appliances	0.013	(0.003)	***	0.283	(0.215)		0.011	(0.009)		-0.227	(0.303)	
Refrigerator	0.016	(0.095)		2.354	(1.711)		0.123	(0.121)		5.236	(1.608)	***
Stove	-0.089	(0.070)		-0.276	(2.430)		0.137	(0.100)		3.376	(1.911)	*
Washing machine	0.084	(0.044)	*	5.510	(1.163)	***	0.094	(0.072)		4.837	(1.289)	***
Fan	0.001	(0.035)		0.981	(0.948)		-0.043	(0.055)		0.380	(0.916)	
Air conditioning	0.086	(0.035)	**	3.877	(1.494)	***	0.022	(0.100)		3.205	(1.297)	**
Heating	-0.002	(0.056)		-1.037	(3.409)		0.237	(0.184)		-3.857	(7.464)	
Owners of housing	-0.003	(0.028)		1.901	(1.040)	*	0.026	(0.094)		2.911	(0.951)	***
Log (dormitories)	0.029	(0.021)		1.501	(0.965)		0.077	(0.062)		2.675	(1.182)	**
Housing quality	0.042	(0.026)		0.900	(0.760)		0.048	(0.033)		0.561	(0.609)	
Employment type	-0.001	(0.025)		-2.317	(1.159)	**	0.195	(0.064)	***	1.398	(0.925)	
Male	0.070	(0.026)	**	6.409	(0.848)	***	0.124	(0.100)		7.411	(0.878)	***
Formal	0.003	(0.028)		0.686	(0.855)		-0.008	(0.080)		3.223	(1.282)	**
Indigenous language	-0.007	(0.091)		-3.151	(2.253)		0.215	(0.143)		-1.541	(2.806)	
Log (household size)	-0.093	(0.024)	***	-4.542	(1.069)	***	-0.044	(0.073)		0.379	(1.266)	
Skilled	0.153	(0.017)	***	6.781	(0.984)	***	0.209	(0.102)	**	7.108	(2.158)	***
Decile 2	0.091	(0.082)		6.805	(2.643)	***	0.302	(0.172)	*	1.205	(2.116)	
Decile 3	0.277	(0.060)	***	13.056	(2.492)	***	0.443	(0.156)	***	2.796	(2.522)	
Decile 4	0.393	(0.066)	***	17.101	(3.195)	***	0.458	(0.133)	***	5.726	(2.700)	**
Decile 5	0.382	(0.068)	***	19.013	(2.851)	***	0.494	(0.152)	***	3.510	(2.027)	*
Decile 6	0.501	(0.077)	***	22.593	(3.514)	***	0.614	(0.155)	***	6.594	(2.393)	***
Decile 7	0.567	(0.063)	***	25.939	(2.724)	***	0.595	(0.133)	***	7.922	(2.861)	***
Decile 8	0.677	(0.069)	***	32.879	(3.623)	***	0.760	(0.137)	***	9.491	(3.382)	***
Decile 9	0.824	(0.071)	***	38.370	(3.741)	***	0.824	(0.156)	***	11.440	(2.974)	***
Decile 10	1.054	(0.062)	***	57.087	(4.921)	***	1.136	(0.133)	***	16.485	(4.187)	***
Constant	3.053	(0.140)	***	-204.613	(11.350)	***	2.223	(0.266)	***	-223.184	(25.147)	***
Sigma				100.843	(3.399)					83.025	(4.099)	
N	8477			20407			1513			5307		
F/LR χ^2	1055.820	(0.000)	***	751.330	(0.000)	***	393.200	(0.000)	***	672.560	(0.000)	***
R^2 / Likelihood	0.3132			0.1099			0.262			0.1191		

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

Sample restricted to households consuming gasoline for OLS

Table 6: OLS for household total energy consumption

	Urban			Rural		
	OLS					
Log (energy)	**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**	
North	0.391	(0.070)	***	0.381	(0.117)	***
Center	0.254	(0.065)	***	0.292	(0.115)	**
Vehicles	0.395	(0.016)	***	0.455	(0.048)	***
Appliances	0.012	(0.004)	***	0.012	(0.008)	
Refrigerator	0.162	(0.060)	***	0.322	(0.046)	***
Stove	0.328	(0.050)	***	0.551	(0.059)	***
Washing machine	0.152	(0.023)	***	0.159	(0.038)	***
Fan	0.021	(0.021)		0.061	(0.044)	
Air conditioning	0.326	(0.037)	***	0.312	(0.053)	***
Heating	0.018	(0.085)		-0.169	(0.190)	
Owners of housing	0.106	(0.022)	***	0.054	(0.050)	
Log (dormitories)	0.127	(0.016)	***	0.082	(0.047)	*
Housing quality	0.055	(0.012)	***	0.079	(0.024)	***
Employment type	-0.010	(0.017)		0.013	(0.027)	
Male	0.024	(0.017)		0.124	(0.030)	***
Formal	-0.013	(0.012)		0.084	(0.041)	**
Indigenous language	-0.040	(0.061)		-0.093	(0.046)	*
Log (household size)	0.049	(0.020)	**	0.037	(0.043)	
Skilled	0.105	(0.018)	***	0.169	(0.056)	***
Decile 2	0.215	(0.043)	***	0.078	(0.060)	
Decile 3	0.295	(0.037)	***	0.108	(0.083)	
Decile 4	0.400	(0.058)	***	0.281	(0.066)	***
Decile 5	0.477	(0.074)	***	0.262	(0.075)	***
Decile 6	0.526	(0.075)	***	0.390	(0.071)	***
Decile 7	0.612	(0.060)	***	0.317	(0.078)	***
Decile 8	0.705	(0.049)	***	0.473	(0.068)	***
Decile 9	0.824	(0.065)	***	0.591	(0.084)	***
Decile 10	1.058	(0.075)	***	0.781	(0.079)	***
Constant	1.934	(0.121)	***	1.333	(0.147)	***
Sigma						
N	20407			5307		
F/LR χ^2	11346	(0.000)	***	1009.930	(0.000)	***
R^2 / Likelihood	0.5421			0.5841		

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

Households in northern and central areas consume more energy than households in southern states. Variables such as having fans and heating, and employment types are not significant in either urban or rural areas, while other variables are mostly significant. Indigenous households in rural areas consume significantly less energy. Larger households in urban areas with highly skilled heads consume more energy. For urban areas, there is a clear increasing effect of deciles on total energy demand. For rural areas, the significant effects start from the middle deciles and then there is a slight decrease between the 4th and 5th deciles, and between the 6th and 7th.

From these results, we can see that there is support for the hypotheses presented for analysis. According to whether we are looking at a rural or an urban area there is an increasing effect of income on energy consumption, and this includes variations according to household characteristics that can be considered for improving subsidies targeting. To some extent, the results for rural areas are similar to the results presented by Khandker, Barnes and Samad (2012) and Barnes, Khandker and Samad (2011) for rural India and Bangladesh, with elongated s-shaped curves between income deciles and total energy consumption. But for urban areas, the trend is different for Mexico as it is constantly increasing, while India still has a long s-shaped relation.

Moreover, as in the work of Navajas (2007) for Buenos Aires, we find for Mexico that not only is income important, but also household characteristics could be addressed for better targeting of those in need of different schemes of subsidies. In our results this is mostly derived from the geographical areas (the south and rural areas consuming less), and some characteristics are inherent to the household, such as being indigenous (less consumption) and the quality of the house (more consumption).

5. Conclusions

This paper has analyzed the relation between energy consumption and income levels, and other characteristics, in Mexican households. To the extent that subsidies are currently applied to energy sources for general consumption, or that a social tariff has to be designed, this issue becomes relevant for better targeting of public mechanisms. Previous studies linking energy consumption and income have only focused on the extreme poor who receive conditional cash transfer schemes (i.e. Gertler et al., 2009).

We used microdata at the household level from the Income-Expenditure Surveys (ENIGH) 2010 for Mexico. The surveys record energy expenditure, income, and socio-economic characteristics, among other things. We first calculated energy consumption standardized in KgOE, so that all results can be directly compared to each other. We then calculated relations between income and energy expenditure through Engel curves, then applied an econometric model to relate specific and total energy consumption to household characteristics and income levels through Tobit and OLS models. The preliminary relations show an s-shaped curve with slight variations for urban and rural households. For rural areas, the relation always increases.

The results from the econometric models show that, in general, there is an increasing relation between income levels and energy demand, with some exceptions, and that supports the hypothesis for this analysis. For total energy consumption, in urban areas there is a constant increasing and significant effect, while for rural areas the relation resembles an elongated s-shaped curve, with significant effects starting from the middle deciles and spreading to the upper ones. Rural electricity consumption shows a larger divergent trend from the other energy sources, since the model shows only the effects at the upper income levels. Gasoline consumption clearly increases with income, and urban households consume three times the amount of rural households. In addition, it should be noted that household characteristics are also relevant for targeting households that need to increase energy consumption but lack the means to do it on their own. The geographical area and indigenous status, as well as the size and quality of the houses are also relevant according to some of the energy data analyzed.

This may have some repercussions for policy design. In Mexico, gasoline is still highly subsidized and has regressive impacts (UNDP, 2011). In addition, designing a mechanism for fostering the use of different energy sources could take into account the variation in the income levels that was presented here and consider some of the relevant characteristics found in this analysis, such as the geographical location, indigenous status, and the quality of the house, etc.

Further studies could design other surveys for Mexico that include not only the amount spent on energy but also the specific quantities and quality, so the study could be improved with more specific surveys on the topic. In addition, the need to improve subsidies' mechanisms requires more research on what amounts can be subsidized for households based on the income decile as well as on their inherent characteristics, and, further, on how such policies to foster energy consumption fit into the protocols to reduce global warming.

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Annex 1: Probit for energy consumption

	LPG			Electricity			Natural Gas			Gasoline		
	Coef.	**Std. Err.**		**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**		**Coef.**	**Std. Err.**	
	Urban											
Decile 2	-0.060	(0.023)	***	0.003	(0.013)		-0.010	(0.015)		-0.114	(0.031)	***
Decile 3	-0.069	(0.023)	***	-0.002	(0.009)		-0.030	(0.016)	*	-0.185	(0.029)	***
Decile 4	-0.106	(0.030)	***	-0.004	(0.012)		-0.023	(0.014)		-0.231	(0.031)	***
Decile 5	-0.126	(0.031)	***	-0.007	(0.009)		-0.075	(0.029)	***	-0.290	(0.032)	***
Decile 6	-0.117	(0.031)	***	-0.010	(0.014)		-0.089	(0.026)	***	-0.355	(0.029)	***
Decile 7	-0.121	(0.031)	***	-0.016	(0.017)		-0.111	(0.025)	***	-0.402	(0.027)	***
Decile 8	-0.066	(0.044)		-0.021	(0.021)		-0.139	(0.034)	***	-0.468	(0.022)	***
Decile 9	-0.087	(0.043)	**	-0.023	(0.020)		-0.146	(0.030)	***	-0.519	(0.016)	***
Decile 10	-0.080	(0.060)		-0.028	(0.019)		-0.264	(0.056)	***	-0.603	(0.018)	***
N	20453			20453			20453			20453		
Wald	721.040	(0.000)	***	63.500	(0.000)	***	1781.990	(0.000)	***	16499.360	(0.000)	***
	Rural											
Decile 2	-0.188	(0.020)	***	0.079	(0.025)	***	-	-		-0.093	(0.028)	***
Decile 3	-0.201	(0.034)	***	0.101	(0.048)	**	-	-		-0.172	(0.043)	***
Decile 4	-0.231	(0.040)	***	0.147	(0.058)	**	-	-		-0.203	(0.051)	***
Decile 5	-0.273	(0.042)	***	0.102	(0.036)	***	-	-		-0.254	(0.059)	***
Decile 6	-0.319	(0.046)	***	0.100	(0.044)	**	-	-		-0.303	(0.051)	***
Decile 7	-0.351	(0.042)	***	0.066	(0.047)		-	-		-0.388	(0.058)	***
Decile 8	-0.329	(0.039)	***	0.085	(0.052)		-	-		-0.396	(0.063)	***
Decile 9	-0.306	(0.066)	***	0.101	(0.063)		-	-		-0.409	(0.067)	***
Decile 10	-0.363	(0.061)	***	0.022	(0.070)		-	-		-0.560	(0.047)	***
N	5359			5359						5359		
Wald	217.06	(0.000)	***	194.25	(0.000)	***				779.37	(0.000)	***

Notes: ***, **, * denote significance at 1%, 5% and 10 %

Clustered standard errors at state level

The control variables were North, Center, Employment type, Male, Formal, Indigenous language, Log (household size), Skilled

Dependent variable = 1 if the household does not report spending on that energy source