Universidad del País Vasco Euskal Herriko Unibertsitatea

EKONOMIA ETA ENPRESA FAKULTATEA
FACULTAD DE ECONOMÍA Y EMPRESA

MASTER IN ECONOMICS
Empirical Applications and Policies

MASTER IN ECONOMICS: EMPIRICAL APLICATIONS AND POLICIES

Grade 2018/2019

ANALYSING ENERGY POVERTY IN SPAIN

Autor: Endika Delgado Rubio

Directors: Oihana Aristondo Casilda and Lasso de la Vega

Bilbao, Spain

July 25, 2019

Index of content

Table Index

Graph Index

Abstract

In this thesis we study energy poverty in Spain both at the level of concept and reality, using the Spanish family budgets survey for the year 2010. First we introduce the phenomenon of energy poverty analysing lightly its underlying complexity. Then, based on a counting approach, we propose an overall indicator able to measure the energy poverty aggregating four simple indicators of a different nature, two of them based on expenditure or another two consensual based ones. Once we have defined our new indicator, we show the results on three phases. In the first one, we present a descriptive analysis on the four base indicators, followed by an analysis of the Counting Approach. And ending with a regressive analysis of both binomial outcome where we determine if the household is poor or not and the Counting Approach score. With the idea of showing the covariates that are relevant when determining whether or not a household is energy poor, and an analysis of the determinants for checking the determinants of being at one level and another of deprivation within the counting approach, respectively.

As a final point we explain the Spanish social bonus, jointly with its application criteria and its amount, as well as a small critique of its application criteria.

Objectives

The main objective of this thesis is to illustrate a more complex and precise method to study the energy poverty, using different types of indicators, namely, expenditure based and consensual based ones. Using this method to study the phenomenon of the energy poverty for a specific year, 2010, for Spain, to show what are the conclusions that we can obtain and if they are in line with previous studies. This evaluation of energy poverty for Spain is also a tool to understand the dimensions of the phenomenon and how it can affect families and individuals. In addition to being able to help policy makers to evaluate what is the amount of help needed to combat energy poverty and which are the population groups more vulnerable.

Methodology

In this thesis we use first a descriptive analysis of the energy poverty in Spain using data from the Family Budget Survey (EPF) for 2010. For this we have first to construct some of the indicators of the study. Then we base on a counting approach to aggregate the

different indicators to be able to analyse them altogether, and show the results of that counting when the population is classified according to different household variables and main breadwinners characteristics. Then we carry out a final statistical analysis with two regressions a Logistic Regression, where the determinants are evaluated to be poor or not, and an Ordered Logistic Regression, with the same idea but for evaluating its effect in the different levels of deprivation.

1. Introduction

In recent years, energy poverty is one of the issues on the agenda of all the countries of the European Union. In fact the European Union Itself under the *Directives 2009/72/EC and 2009/73/EC*, obliges the member countries to implement policies in this way. And this includes, of course, Spain.

In this sense in Spain there exists the social bonus, that is a public aid offered by the Ministry of Ecological Transition. This bonus is regulated by the "*real decreto-ley 7/2016, 23 de Diciembre*". The social bonus is a discount for the electric bill, with a different amount of money depending on the degree of vulnerability of the family unit.

Energy poverty is recognized as a different phenomenon but related to income poverty. Although there is no generally accepted definition of energy poverty, there is generally an awareness that such a phenomenon exists. In addition, there are a series of indicators that allow measuring different aspects of energy poverty. This indicators are divided in two categories Expenditure-based and consensual-based. (see, for instance, Rademaekers et al (2016))

The expenditure based indicators, are three, 2M, LIHC (Low Income High Cost) and HEP (Hidden Energy Poverty). In this work we only use two of these indicators the 2M and HEP. We have discarded LIHC because its information is already captured by the other two indicators.

The consensual based indicators are also three: the ability to keep the home adequately warm, the arrears with energy bills (electricity, water and gas), and housing conditions. In this thesis only two of them are used, the one that refers to the Invoices and the one referring to the Temperature. The Humidity variable has been ruled out since it has been considered unnecessary and with an excessive subjectivity factor, since the humidity in a house can come for many reasons many of them not related to energy poverty. As it could be the case of some humidity for living in a house near the coast or specific problems for raining in excess or simply for a breakdown in the pipes of the house.

The goal is to use a combination of the four Indicators, for this we use a counting method introduced by Atkinson (2003) to add the variables and in this way to be able to measure poverty in a multidimensional way. This method allows us to create a new variable that allows detecting energy poor household, taking into account several aspects of it.

With this new dimension the idea is, first, make a descriptive analysis of the main variables in terms of the dimensions of deprivation, then an analysis of these variables with

the counting method, with the idea to see the relation of them with the deprivation. And finally a regression analysis, one for seeing the effect of the different covariates in the fact of being energy poor and another to see the effect of the covariates to stay in one of other degree of deprivation of the counting.

In the final part we explain without going into too much detail the Spanish social bonus. With its relevant criticisms about the criteria for granting such aid. To finally give way to the conclusions of the thesis.

The work is organized as follows. First we review the previous literature, in the second section we introduce the definitions of energetic poverty, and the four indicators used and the database used in the analysis. Then in Section 4 we show the methodology with the explanation of the counting approach, the weights and the regressions, followed by Section 5 where the results obtained from the descriptive analysis of the counting approach and the regressions are shown. As a final part in Section 7 we discuss about the Spanish social bonus and Section 8 concludes.

1.1. Review of the literature

Energy poverty has been a problem, for decades, intimately related with income poverty until the crisis of 1973, also known as the oil crisis. From that moment on, energy poverty has been considered by many authors as a separate phenomenon. From this moment many authors has studied the problem, most of them for the UK, like *Bradshaw and Hutton (1983)*.

J*amasb and Meier (2011)* study energy poverty in England using a panel data for the years 1991-2008 and they measure the energy poverty as a ratio of spending in terms of income. *Hills (2012)* uses the dimensions LIHC (low income high cost) to measure the poverty in England. *Roberts et al (2015)* analyse the fuel poverty in the UK for the years 1997-2008 taking in to account the difference between the rural areas and the urban areas. Also in the UK, but only for Scotland *Morrison and Short (2008)* and *Roberts (2008)* study the relationship between the energy poverty and a higher incidence of being affected by some diseases and health problems.

With this health approach, Pronczuk-*Garbino (2005)*, *Howieson (2005)* and *Liddell and Morris (2010)* show that the main affected by the problems in health related with the energy poverty are the elder people and the children.

For France *Charlier and Legendre (2016)* and *Legendre and Ricci (2015)* show the proportion of fuel poor and their characteristics depend on the indicators used to measure

their energy poverty.

Papada and Kaliompacos (2016) use and objective expenditure-based method to analyse the fuel poverty in Greece.

Lis et al (2016a, 2016b) analyse the energy poverty for Poland, in the first "heterogeneity of the fuel poor in Poland quantification and policy implications" study the heterogeneity related with energy efficiency and income and in the second "What accounts for regional variation of fuel poverty in Poland" they study the regional differences and try to find the causes.

For Spain *Tirado-Herrero et al (2012, 2014) and Romero et al (2014)* study the impact of fuel poverty of different persons and households characteristics. Also for Spain *Aristondo and Onaindia (2018.a, 2018.b)* make a review in the energy poverty. In the first paper, they study the energy poverty for the years 2005, 2008, 2012 and 2016 using consensual based dimensions, and in the second one they use the counting method to make a poverty review for Spain, by regions, using consensual dimensions.

In Germany *Bierman (2016)* makes a research for the years 1994-2013 where it is analysed the life satisfaction of the individuals and different measures of energy poverty.

Welsch and Bierman (2017) makes a multinational study for fuel poverty and affordability of electricity, heating oil and natural gas in twenty one European countries for the years 2002-2011.

Churchill et al. (2018) makes for Australia a study that examines the relationship between energy poverty and well-being.

2. Definition of Energy Poverty

One of the main points for approaching to our study is to give a clear and simple definition for energy poverty. Already in the ends of the seventies *Isherwood and Hancock (1979)* pointed out that spending more than the median of spending on energy expenditure was a disproportionate expense.

One of the first attempts to give a definition of energy poverty is of *Boardman (1991)* that states that *"A household is energy poor if its expending in energy to maintain an adequate level of temperature requires an expending greater than 10% of the total income of the same*". This definition has several problems, one of them is that it does not propose dimensions to define an adequate temperature. Some years later, in the United Kingdom, this definition was completed by the DEEC (2010) with the introduction of a definition of adequate temperature: "*21ºC in the living room and 19ºC in the rest of the house*". Other of the main problem of this definition is the fact that it does not take into account other dimensions than monetary ones.

In *Moore (2012)* the author uses the concept of Minimum Income Standard (MIS) that is the minimum income that permits the household members to opt on choices which allow an active integration in the society that includes the necessary expenses for an adequate warm on their house.

But those first approximations are not enough, for finding better definitions of energy poverty we use two definitions used by the Environmental Science Association (ACA by its initials in Spanish), for the year 2018. The first definition is taken from *Tirado Herrero et al. (2012)* and is the following:

Definition 1: A household is energy poor if is unable to pay an amount of money enough to satisfy its domestic needs or/and if it's forced to allocate an excessive part of it's income to pay the energy bill of the household.

In the ACA's report of the year 2018 this first definition has been change for another one. The reasons for this change are some problems derived from the previous definition.

Firstly, the first definition is very linked with the payment of the bills, ignoring many other factors that could be important for a more adequate identification of the energy poor people, such as the ability to keep the house warm.

A second drawback of Definition 1 is that it is only adequate to analyse energy poverty

in the developed countries. A better definition should have a universal vocation, taking into account the affordability, the characteristics of the house, the family unit and the needs of the household.

To overcome these two failures of the first definition in a new and better concept the ACA decide to use the definition introduced by *Bouzorovsy and Petrova (2015).*

Definition 2: Energy poverty refers to: “the inability of a household to reach to a social and material necessary level of domestic energy services”.

This second definition can be explained by the decomposition in the different factors, these factors are summarized in Table 1:

Factor	Driving Force
Access	Low availability of adequate energetic vectors to cover the needs of the household
Affordability	Disproportion between the cost if energy and the household income including the taxes, assistance mechanism, inability to invest in the building of new energy infrastructures
Flexibility	Incapability to change from a form of energy provision to another that is better for the needs of the household
Energy efficiency	The disproportionate loss of useful energy in the energy conservation or services of the household
Needs	Disarrangement between the household needs and the services available for social, cultural, economic or health reasons

Table 1: Energy vulnerability factors and their constituent elements. Buzarovsky and Petrova (2015)

This last definition is the one that this work consider as the most correct and the one that we use as the first pillar of our analysis.

3. Indicators and Database

3.1. The indicators

For this work we choose four indicators to measure energy poverty. As in the case of the definitions we have a problem: there is not a single indicator that can fully and completely capture energy poverty. But unlike the definitions here there is no solution, instead, it has been chosen a series of indicators that are intimately related to energy poverty and that in some way reflect different aspects of energy poverty.

A total of four indicators have been chosen for this study, two of them can be classified as Expenditure based indicators and the other two as Consensual based Indicators.

3.1.1. Expenditure based Indicators

Expenditure based: European Commission (2016) "*Metrics that capture affordability of (adequate) energy services or inadequate consumption by using financial information*". We have chosen two expenditure based indicators:

-**(2M) Two times the median**: Percentage of population with disproportionate energy expenditure: measures the percentage of the population for which the energy expenditure, in terms of the total income of the household, are the double or more of the median of the nation.

-**(HEP) Hidden energy poverty**: measures the percentage of the population for which the domestic energy expenditure is below the half of the national median.

3.1.2. Consensual based Indicators

Consensual Indicators: *Healy (2004)* and *Healy and Clinch (2004)*, "*Self-reported indicators provide an effective way of understanding perceived energy poverty and more explicit insights than quantitative metrics. This family of indicators could be a 'backstop' or complementary to other indicators*". We have chosen two variables of this method those that are obtained by answering the following questions:

-**Temperature**: Have you had problems keeping your home at an adequate temperature during the last year?

-**Invoices**: Have you had any problem when paying the energy for your principal house?

With this four aspects of energy poverty we try to illustrate or approximate which household is energy poor and which is not.

3.2. The Database

For the analytical part of this work we use the Family Budget Survey (EPF) of the year 2010, provided by the National Institute of Statistics (INE). We use this specific year because it has an added module with data on welfare for the same individuals (households) as the EPF, the Welfare Module. This Module allows us to extract necessary information for the analysis that is going to be carried out. Particularly, we have the data for obtaining the indicators Invoices and Temperature, data not found in the EPF of other years.

This survey has Microdata for a total of 22,203 raw households, but after a series of small purges, eliminating those households for which there are no observations of the variables used to construct the indicators, the database remains with a total of 21,481 households that represents a total of 44,590,826 individuals.

3.3. Variables

3.3.1. Regions

For this work we analyse the regional distribution of the energy poverty, for the regional distribution there are two options, the first is to use the NUTs of order one and the other option is to use the NUTs of order two, that corresponds in Spain with the Autonomous communities plus the Autonomous Cities of Ceuta and Melilla. Since the use of data in autonomous cities can have significant distorting effects, it has been decided to exclude them from the analysis.

3.3.2. Variables of the Main Breadwinner

Civil Status

In the Database there is information for the civil status of the breadwinner, this variable can take five values, married, single, separate, widowed or divorced.

Level of Studies

In the level of studies of the breadwinner we choose the variable that gives the levels of study in its reduced version of the variable. This leaves us with four values which are, up to primary, lower secondary, upper secondary and higher.

Sex

As in the case of income poverty a study by sex is probably an interesting approach, Nowadays, one of the points, which are usually more studied and found in public debates, are the differences between men and women. In this Database, we can difference only the sex of the main breadwinner, not the sex of the rest of the members of the household.

Type of contract

The type of contract is one variable that can affect the energy poverty by the side of the income, households with greater wage stability of their main breadwinner are less susceptible to poverty than other households with less stability.

3.3.3. Variables of the Type of House

Antiquity

This variable refers to the years that have passed since the construction of the house, this variable may have interest for regulatory issues on construction.

Size of the locality, population density, type of locality

These three variables define the characteristics of the locality in which the home is located in three different dimensions. The first refers if the locality is big, small... the second say if the population density of the locality is high medium or low. And the third defines if the locality is high urban, low urban or rural.

Heating and hot water

These dummy variables define whether the home has or not heating and hot water.

Tenure regime

This variable can take 4 values, property, mortgage, rent or cession. The assignment is a type of contract that in exchange for a remuneration, or no one cedes the use of a property to another individual.

Province Capital

It is a dummy variable that specifies whether the locality is a provincial capital or not.

Type of Housing

This variable defines if the house is a multi-familiar, uni-familiar or other type.

Number of rooms and surface

This two variables express the number of rooms in the housing and the surface of the housing expressed in square meter, respectively.

Number of children under sixteen

The children's in a household could be one of the main factors that affect the energy poverty, mainly on the side of the expenditure variables, since they do not contribute income but they do generate expenses.

Number of children with disabilities

The inclusion of this variable is, in my opinion, very relevant, since raising and caring for a child with a certain degree of disability can be a considerable cost and can influence income poverty as well as energy poverty. The nature of the offspring's disability is, in my opinion, irrelevant for the study that we have in hand, since it is not mainly interested in the over-exertion involved in raising them.

4. Methodology

4.1. The Counting Approach

The counting is a method of aggregation, developed by Atkinson (2003), that consists in aggregating the different variables of deprivation by adding them, prioritizing its importance with the use of different weights, giving greater weight to the variables that are considered more relevant and a lower weight to those that are considered less important. This is the method used in this thesis because it is the only method that can aggregate qualitative variables.

4.2. The Weights

One of the main issues that must be taken into account when doing a multivariate analysis is to determine which weights are going to be given to each of the different variables of the analysis. There are several procedures to assign weights. According to *Decancq and Lugo (2013)* the weights are divided in three main categories: Data-driven, Normative and Hybrid. At the same time these categories are subdivided into more specific ones.

Data-driven: are a function of the distribution of the achievements of the society.

Frequency-Based Weights: Is determined as a function of the distribution of the achievement levels in that dimension.

Statistical Weights: *Krishnakumar and Nadar (2008)* differentiate two types of statistical weights:

Descriptive weights: this weights are used to describe and summarize data.

Explanatory weights: this approach assumes that the observed variables are dependent on some unobserved underlying variable.

Most Favourable Weights: This weights are individually and endogenously determined, with the intention of maximizing its well-being. The Highest relative weight are assigned to the variables with the best individual performance.

Normative: only depend on the value judgements about the trade-offs and are not based on the actual distribution of the achievements in the society under analysis.

Equal or Arbitrary Weights: The weights are equal for all the variables or arbitrary

but not equal.

Expert Opinion Weights: This weights are the result of consulting different experts in the field to study.

Price-Based Weights: this approach uses the marginal rates of substitution of the different variables, to use this method is necessary to make some assumptions on the transformation functions and the degree of substitutability.

Hybrid: is a mixture of normative and Data-Driven and depend on some form of valuation of these achievements.

Stated Preference Weights: Based on the opinion of a representative proportion of the total population, generally obtained with a survey.

Hedonic Weights: This method returns the Implicit valuation of the self-perceived well-being of the individual using the self-reported happiness of the individual.

In this thesis we use the Expert opinion weights. The consulted experts are Oihana Aristondo, Casilda Lasso and myself. The decided weights are represented in Table 2.

We (me and the experts) have decided to put the weights shown on Table 2 with the following criteria. We have decided that the variables Invoices and Temperature that are Consensual indicators should have a lower weight than the Expenditure Based Indicators. It has been considered that the consensual indicators are the product of the own proprioception of the interviewed person and that therefore they are endowed with the inherent bias of expressing an opinion.

For the two consensual indicators we have weighted the Invoices variable with a higher value, since we have considered that the fact of not being able to pay an invoice or having difficulties to do it penalizes much more when a subject or not is energy poor, that the fact of not having an adequate temperature in the home.

For the Expenditure Based Indicators we have decide to weight them with the same value. In our opinion both indicators are equally important when measuring poverty, and after a first approximation the two variables seem to be talking about two nuances of the different energy poverty with little overlap between them.

	Invoices (fact)	**Temperature (Temp)**	**2M**	**HEP**
Invoices (fact)	1	3/2	1/2	1/2
Temperature (Temp)	2/3	1	1/4	1/4
2M	2	4	1	1
HEP	2	4	1	1

Table 2: Origin of the weights

With this table of preferences we have used the Saaty's Method (Saaty (1987)) to generate the appropriate weights for the priorities that we have decided for the variables. After that we have rounded up the obtained of the Saaty process, multiplying it by ten, with the idea of simplifying the calculations and showing it in a most intuitive way. All this process is reflected in Table 3.

	Invoices (fact)	Temperature (Temp)	2M	HEP
Saaty's Weights	0.17	0.098	0.366	0.366
Rounded Weights	0.2	0.1	0.4	0.4
Final Weight	2	1	4	4

Table 3: Saaty's method results and final weights.

With these weights now it is time to build our Counting scores as follows:

$$C_i = w_1 * d_{1i} + w_2 * d_{2i} + w_3 * d_{3i} + w_4 * d_{4i}$$

where C_i is the value of the counting score for the individual i, w_1=2 is the weight for Invoices, d_{1i} is the value of the variable Invoices for the individual i, w_2=1 is the weight for Temperature, d_{2i} value of the variable Temperature for the individual i, w_3=4 is the weight for 2M, d_{3i} value of the variable 2M for the individual i and w_4=4 is the weight for HEP, d_{4i} value of the variable HEP for the individual i.

In our case the counting scores can take eleven degrees of energy deprivation, from the degree zero with no deprivation to a value of eleven that aggregate all the four variables of deprivation (2M, HEP, Invoices and Temperature). All the other values of the counting are different combinations of the different deprivations.

4.3. Regressions: Logistic and Ordered Logistic

For the regression analysis that we do in this thesis we have chosen to run two regression, a Logistic Regression to see the effect of the covariates for determine who is energy poor and who is not (binary outcome), and an Ordered Logistic regression to see this effect into the different levels of deprivation of the counting (ordinal outcome).

4.3.1. Logistic Regression

In this regression, the aim at to determining the effects of covariates on being energy poor or not. That is, we have a dependent variable that is binary. To determine the

probabilities or at least the sense of the effect of those covariates we have to run a Logistic regression.

The observed answer Y_i by individual i, is defined for N individuals in our logistic model by the measurement equation:

$$Y_i = 1 \quad \text{if} \quad \tau_{m-1} \leq Y_i^* \quad \text{for} \quad i = 1,2,\ldots,N$$

where the τ's are dimensions to be estimated, and Y_i^* is a latent variable representing the propensity of being or not energy poor. The structural model for this variable is defined as:

$$Y_i^* = x'_i\beta + \varepsilon_i \quad \text{for} \quad i = 1,2,\ldots,N$$

where x_i' is a row vector with the ith observation of the explanatory variables, β is a column vector of structural coefficients and ε_i is an error term with a *Logistic distribution*. Under simple identification conditions, this model can be estimated by the maximum likelihood method (Long 1997).

4.3.2. Ordered Logistic Regression

The dependent variable with which we work is the result of our aggregation of the different variables of deprivation in the counting approach. This variable is a variable that can be considered as ordinal, due to the very nature of counting approach. In order to be able to rank the values of this variable, the way to analyze the effect of the covariates on the dependent variable is through the use of an Ordered Logistic regression.

The observed answer Y_i by individual i, is defined for N individuals in our ordered logistic model by the measurement equation:

$$Y_i = m \quad \text{if} \quad \tau_{m-1} \leq Y_i^* \quad \text{for} \quad i = 1,2,\ldots,N \quad \text{and} \quad m = 0,1,\ldots,11$$

where the τ's are dimensions to be estimated, and Y_i^* is a latent variable representing the propensity of being in one of the degrees of deprivation of the counting. The structural model for this variable is defined as:

$$Y_i^* = x'_i\beta + \varepsilon_i \quad \text{for} \quad i = 1,2,\ldots,N$$

where x_i' is a row vector with the ith observation of the explanatory variables, β is a column vector of structural coefficients and ε_i is an error term with a *Logistic distribution*. Under simple identification conditions, this model can be estimated by the maximum likelihood method (Long (1997)).

In order to evaluate the effect of explanatory variables on the level of deprivation of the counting, we use the estimated coefficients for the ordered logistic model to calculate the predicted probabilities.

The predicted probability that Yi = m (m = 0,1,…, 11) given specific values of our explanatory variables x_i^v is:

$$\widehat{Pr}(Y_i=1|x_i^v)=F(\widehat{\tau}_1-x_i^{v\prime}\hat{\beta})$$

$$\widehat{Pr}(Y_i=m|x_i^v)=F(\widehat{\tau}_m-x_i^{v\prime}\hat{\beta})-F(\widehat{\tau}_{m-1}-x_i^{v\prime}\hat{\beta}) \quad \text{for m=1, 2,…,10}$$

$$\widehat{Pr}(Y_i=11|x_i^v)=1-F(\widehat{\tau}_{10}-x_i^{v\prime}\hat{\beta})$$

where F is the cumulative distribution function of the logistic distribution and τ, β are estimated dimensions.

5. Empirical Application

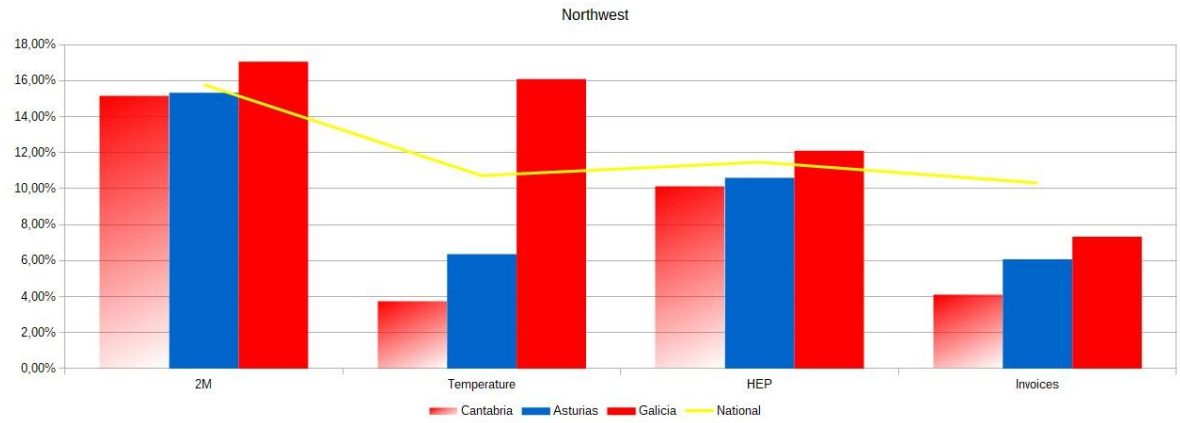
5.1. Descriptive Results

5.1.1. Descriptive Results by General Variables

By Regions

In this section we give a purely descriptive vision of the different dimensions used to measure energy deprivation with respect to the regions of Spain. With the idea of simplify the exposition we will present the different regions in groups, as if it were the NUTS of order one with some modifications, Madrid is included in the Center and Canary Island in the South.

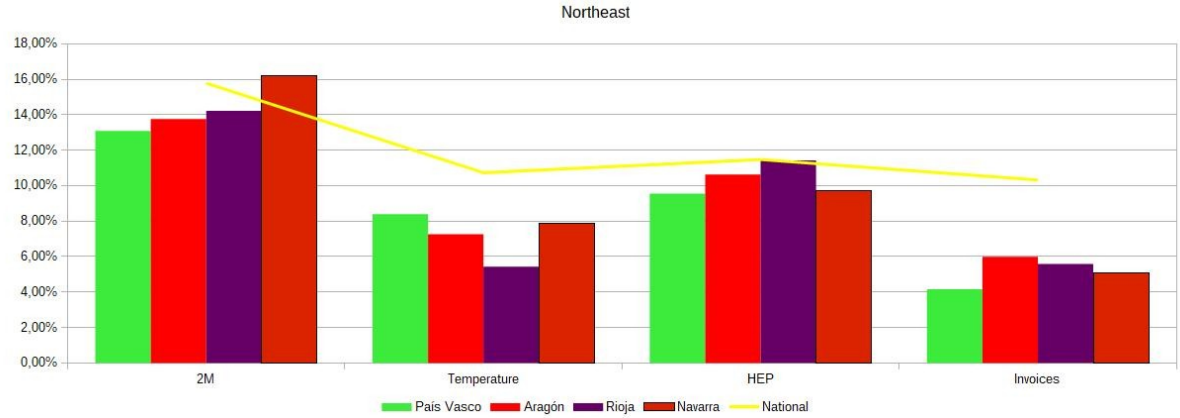
Northwest



Graph 1: Comparative of energy poverty dimensions for Northwest.

As Graph 1 shows, Asturias and Cantabria are bellow the rest of nation in all the dimensions, but for Galicia the results are not so laudatory, Galicia is only under the national energy deprivation when we look at the Invoices dimension, in all the others is above. In addition to the fact that in the four dimensions the three regions maintain the same order, it can be ascertained with relative certainty that Cantabria is less energy deprived than Asturias and that it is less energy deprived than Galicia.

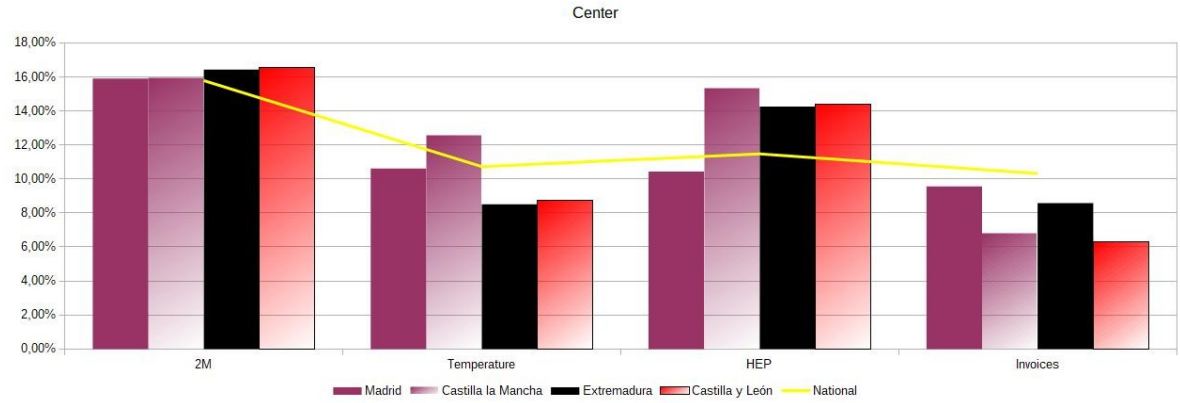
North-east



Graph 2: Comparative of energy poverty dimensions for North-East

When we observe Graph 2 for the Northeast of Spain, we can see that, with the exception of Navarra for the 2M dimension all the regions of the north east of Spain are below the national value for all the dimensions. We cannot order the regions in a way that allows us to see which is the least energy efficient but we can get some other information. the Basque Country is the least energy poor region according to Invoices, HEP and 2M, on the other hand looking at the variable Temperature is La Rioja who is the least deprived.

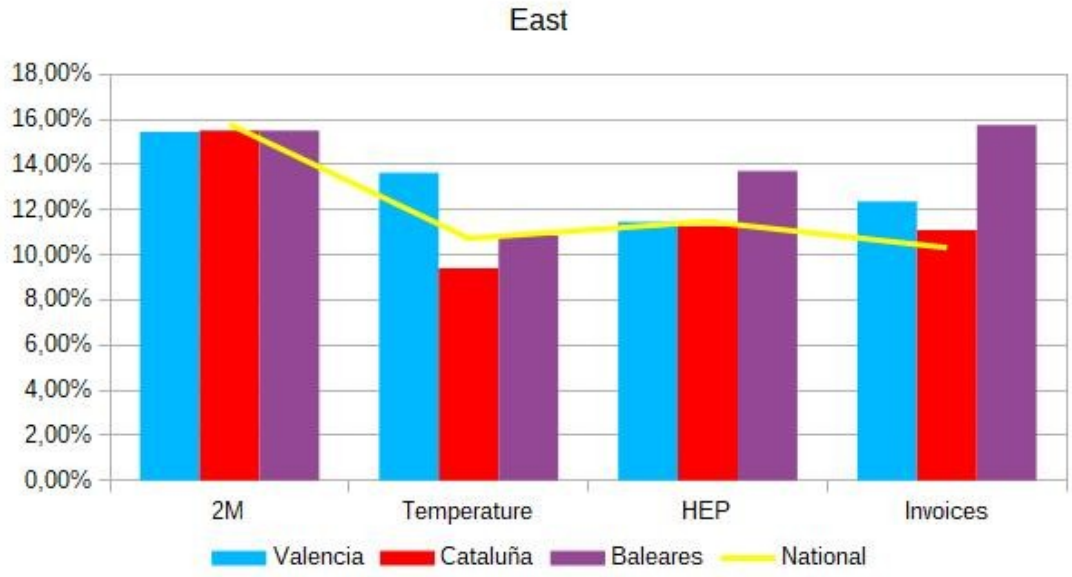
Center



Graph 3: Comparative of energy poverty dimensions for Center.

In the Centre of Spain, the percentage of energy deprived people with respect to the national total varies according to the dimensions in which we look during the comparison. For 2M we can assure that all regions are more energy deprived than it is the whole of the nation. When we focus on Temperature we have all the regions with the exception of Castilla la Mancha. For HEP only Madrid is under the rest of the nation and in Invoices variable all the regions of the Centre of Spain are under the total of the nation.

East

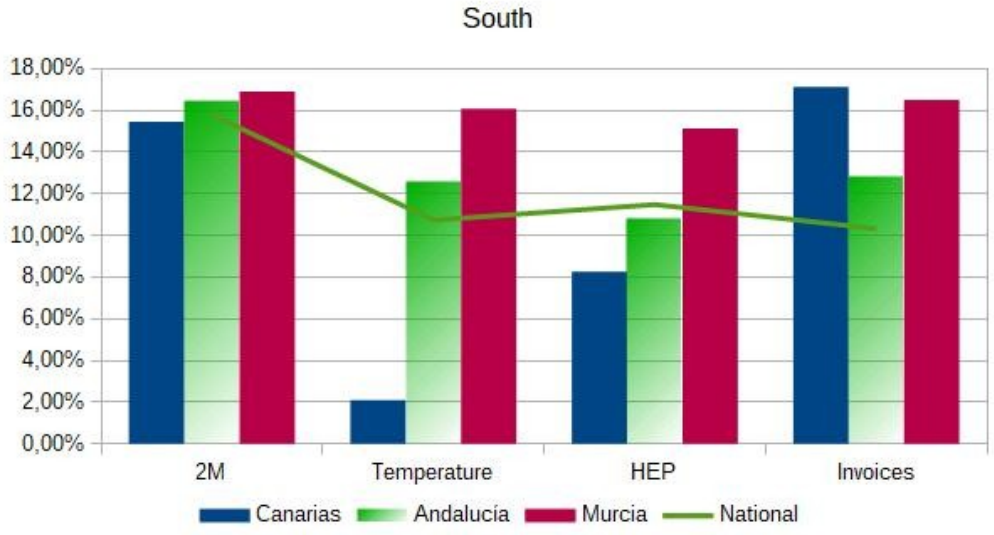


Graph 4: Comparative of energy poverty dimensions for East.

For the Spanish Levante, the situation is as follow, for the 2M dimension all the regions are under the nation, but on the contrary for the Invoices variable all of them are above. For Temperature only Catalonia is under the nation and for HEP Catalonia is under the nation but Baleares and Valencia are above, but Valencia is very close to the national energy deprived people.

With the exception of the 2M Catalonia is the Region Catalonia is the least energy deprived region of them all.

South



Graph 5: Comparative of energy poverty dimensions for South.

In the South of Spain and for 2M and Temperature only the Canary Islands has less percentage of deprived individuals then the national ones. For HEP Andalusia and Canarias have a smaller proportion of their population poor according to this variable than there is at national level. The value of two percent of poor people according to the Temperature dimension for Canarias is easily explained by the fact that the subtropical climate has warm and stable temperatures throughout the year with hardly any variations. With the exception of Invoice variable we can say that Canary Islands it is the least deprived region of the three.

By Income Poverty

In this section we show the percentage of people deprived, taking into account whether they are considered poor or not, according to the poverty criterion of 60% of the median expenditure.

		2M	HEP	INVOICES	TEMPERATURE
Income Poverty	No poor	13,84%	9,65%	7,34%	8,64%
	Poor	25,30%	20,53%	12,80%	21,36%

Table 4: Percentage of Deprived People by Income Poverty

As we can see in the table 4 there is a higher percentage of people deprived in the four areas when the person is considered poor than when it is not, as expected. It is noteworthy that this difference is smaller when it comes to the variable invoices, where the difference is only 5% and is maximum in temperature where the difference is 12.72%.

5.1.2. Descriptive Results by characteristics of Main Breadwinner

Table 5 shows the results of the descriptive analysis of the variables referring to the characteristics of the main breadwinner of households, and their relationship with the different types of deprivation used in the analysis.

		2M	HEP	INVOICES	TEMPERATURE
Sex	Female	19,22%	12,27%	11,26%	13,46%
	Male	14,71%	11,26%	7,32%	9,96%
Level of studies	Low	23,03%	16,49%	9,61%	15,53%
	Medium-Low	18,03%	12,09%	10,22%	12,09%
	Medium-High	13,97%	9,13%	10,03%	10,69%
	High	8,09%	8,05%	3,65%	5,24%
Marital Status	Single	14,16%	13,73%	11,50%	13,75%
	Married	14,49%	11,25%	7,14%	9,61%
	Widow	25,45%	11,20%	6,30%	12,13%
	Separate	25,02%	11,41%	19,70%	18,55%
	Divorced	20,22%	8,99%	15,05%	15,23%

Table 5: Percentage of Deprived People by Sex, Level of Studies and Marital Status of Main Breadwinner

By Sex

When we observe the sex of the main breadwinner we can see a clear but no so big difference of deprived people in all the four dimensions. When the sex is male we observe lower ratios of poor people, from less than 1% for HEP to almost a 5% for the 2M. For Invoices and Temperature is very close, of a 4% approximately.

By Level of Studies

For the level of studies the difference is larger, we can see a clear positive relation for all the dimensions, with the exception of Invoices, this difference is specially pronounced for 2M where we go from 23.03% of deprived people in low studies to 8.09% for people with high studies. The case of Invoices is different, the percentage of deprived people with low, medium-low and medium-high studies is almost the same, but as for the other dimensions, the deprived percentage of people for High studies is not only lower that for the other level of studies, is the lower for all the category.

For the marital status we see substantial difference depending the dimension we are observing. For 2M the category with a lower percentage of deprived people, is to be single followed very close by to be married, the other categories are higher, 5% for divorced and 10% for the separated and the widowed.

By Marital Status

In HEP the differences are not so big, divorced is the category with lower percentage of poor people and single with the higher with only a 4% of difference, the other categories are very close, practically represent the same percentage of individuals.

For Invoices, widow is the category with lower percentage, and separate the one with higher, this difference is about a 12%, the other categories has also a high difference.

In Temperature comment that married is a category with lower percentage of people

deprived and that separated is the category with the highest percentage. The other categories, although they have differences between them, are relatively close.

The results obtained when we have observed the marital status have a certain degree of uncertainty, since it could be thought that being married, with coexistence with another person and the advantages, among others, that suppose the economy of scale of life as a couple, would be the category with the least deprivation, and this only occurs in the case of Temperature.

5.1.3. Descriptive Results by Variables of Type of House

		2M	HEP	INVOICES	TEMPERATURE
Tenancy Regime	Property	16,94%	10,35%	3,45%	7,68%
	Mortgage	12,10%	8,12%	10,43%	8,84%
	Rental	19,64%	22,31%	17,29%	24,35%
	Cession	37,45%	13,49%	37,45%	11,96%
Antiquity	Old	16,38%	14,05%	9,27%	12,65%
	New	14,80%	7,29%	6,61%	7,73%
Type of Locality	High Urban	10,38%	5,10%	4,53%	3,78%
	Low Urban	14,96%	11,77%	9,27%	11,31%
	Rural	22,79%	13,40%	5,02%	11,72%
Capital	No Capital	18,06%	11,51%	8,12%	11,43%
	Capital	11,11%	11,46%	8,56%	9,47%
Population density	High	12,30%	11,16%	9,18%	9,90%
	Medium	15,87%	11,06%	8,60%	11,81%
	Low	22,49%	12,53%	6,18%	11,62%
Hot Water	NO	20,18%	56,31%	23,40%	50,10%
	Yes	16,79%	11,56%	8,28%	10,70%
Heating	NO	17,08%	17,20%	12,74%	17,11%
	Yes	16,62%	8,06%	5,42%	6,65%
Number of Disable Children	0	17,09%	11,19%	5,36%	10,29%
	1	14,62%	11,03%	9,66%	11,62%
	2	16,30%	11,66%	9,84%	8,73%
	3	22,32%	17,14%	20,18%	18,21%
	4	32,47%	22,10%	23,40%	20,55%
	5	24,41%	44,10%	30,93%	66,08%
	6	6,71%	62,98%	69,69%	30,58%
	7	91,18%	8,82%	23,36%	23,36%
	8 or more	0,00%	0,00%	100,00%	0,00%
Number of Rooms	0	37,51%	33,68%	0,00%	0,00%
	1	22,74%	37,66%	10,37%	24,56%
	2	18,62%	18,96%	11,73%	14,33%
	3	18,14%	19,39%	10,47%	12,67%
	4	16,35%	14,40%	9,85%	13,05%
	5	16,37%	11,68%	9,36%	10,64%
	6	15,91%	9,03%	6,75%	9,42%
	7	18,94%	8,62%	4,05%	9,48%
	8	20,17%	6,63%	4,54%	8,38%
Size of Locality	Very large	13,08%	11,84%	9,02%	9,91%
	Large	14,71%	11,14%	9,71%	12,48%
	Medium	15,78%	11,50%	9,47%	11,03%
	Small	18,54%	11,63%	7,21%	10,61%
	Very Small	25,02%	11,96%	5,87%	11,52%

Table 6: Percentage of Deprived People by Tenancy Regime, Antiquity, Type of Locality, Capital, Population Density, Hot Water, Heating, Number of Disable Child, Number of Rooms and Size of Locality.

By Tenancy Regime

For the Tenancy Regimen we can see in table 6 a clear pattern, if we consider property and mortgage together, that in the end both represent having the property of the house, we can see they are the categories with the less percentage of deprived people in the four dimensions. On contrary, the categories of rent and cession are the most deprived in the four dimensions. No definitive conclusions can be drawn from looking at all the categories separately since there is none of them that has a prevalence over the others, beyond the relationships previously exposed.

By Antiquity

By Antiquity, we see in table 6 a clear pattern an older house is accompanied by a higher percentage of people deprived in all dimensions. This difference from Old house to new house varies from less than 2% for variable 2M to approximately 7% for HEP.

By Type of Locality, Size of Locality and Density of Population

When we analyse in table 6 the main characteristics of the locality where the house is located we can discover that being located in a high urban area is a guarantee of a lower percentage of people deprived in the four dimensions, but living in a low rural or urban area does not seem to mean an excessive difference, especially for Temperature where the percentages are very similar. The difference between living in a high urban area or doing it in the category with the highest percentage of deprives is substantial, for 2M, where the difference is twelve percentage points, while for Invoices, the smallest difference is five points.

For the population density, when we look to 2M we see that the difference from living in a high dense locality reduce the deprived people in four points with respect to live in a medium dense locality and in twelve points with respect to a little densely populated. For the Invoices dimension, the relationship is the inverse but the major difference does not exceed three points. For the rest of the dimensions the difference is completely negligible.

Depending on the size of the locality, we find that when studying 2M the difference between the percentage of deprives and the size of the city follows an inverse relationship, and that at the point of greatest difference, this is around twelve points. For HEP the difference is barely noticeable, and for Invoices and Temperature, although the difference is appreciable, it hardly exceeds four percentage points at the point of greatest separation.

By Capital

Living in the capital of a province it seems to have only relevance when you consider

2M, not living in it means that there are seven percentage points more people deprived, but in relation to the rest of variables, for HEP and Invoices is too small to be taken into account and for Temperature living in a capital only means 2 less points of deprived people.

By Hot Water and Heating

To have Hot Water and Heating has a, in general, positive effect for not being deprived in none of the dimensions, but its influence is quite different. As we can see in table 6, While heating has an effect, barely noticeable for 2M and nine, seven and eleven points respectively for HEP, Invoices and Temperature. The effect of hot water is more explosive, from a difference of four and fifteen points for 2M and Invoices to more than forty for HEP and Temperature, this means that more than 50% of people who do not have hot water in their homes are consider deprived for these dimensions.

By Number of Disable Children's

For analyse this the first thing that we do, is to ignore the data for the categories of more than five disable child’s, this is going to simplify the analysis. When comparing the four dimensions, in the table 6, together we can see a clear thing, when we consider from zero to two child's we see that that are consistently and together a factor to have less deprived population, compared to three, four and five children, this relationship to their internal distribution there is no clear prevalence of any of them. When we consider three, four and five children we see that clearly having three children is less deprivative than having four or five. in the latter, with the exception of 2M, where having four children is more deprivative than having five, for the rest of the dimensions four children is less deprivative than five children.

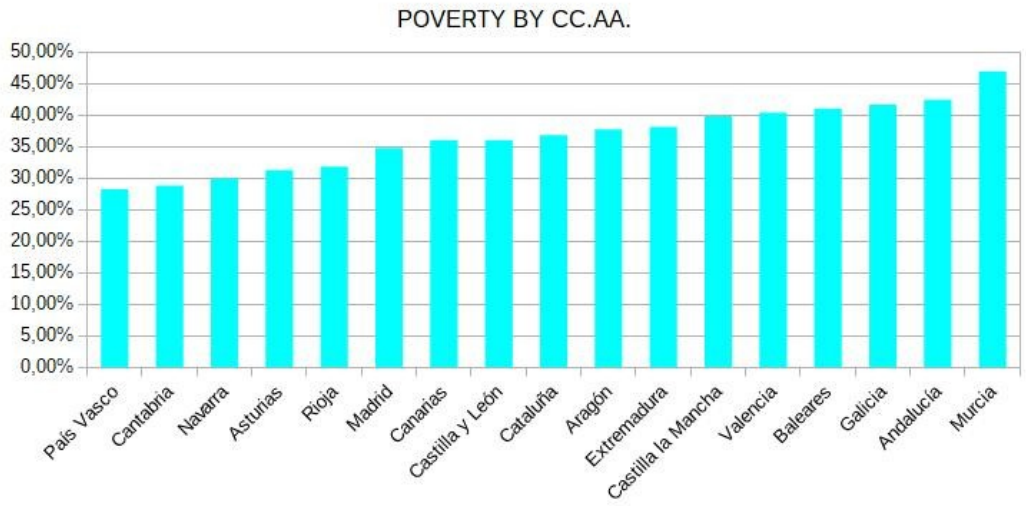
By Number of Rooms

For the number of rooms the analysis is complicated, to have few rooms, one or two, in the house is symptom of deprivation for all the dimensions, as shown in table 6, having seven or eight or more rooms is an aggravation for deprivation for 2M but not for the other categories, where in fact decreases. In general terms from three to six rooms the percentage of the deprived people with the number of rooms remains approximately stable. Except for HEP where passing from three to six deprivations is an increase of ten percentage points.

5.2. Counting Analysis Results

5.2.1. Counting Approach Results by General Variables

By Regions



Graph 6: Percentage of people with at least one degree of deprivation by Region.

One of the main goals of this work is to study the differences in the energy poverty between the regions of Spain. Graph 6 shows the percentage of population deprived in at least one dimension. The five communities with lower deprived percentage of its population are La Rioja, Principality of Asturias, Chartered Community Navarre, Cantabria and Basque Autonomous Community. All these regions have less than thirty-two percent of energy poor people to the extent possible criteria, in which all individuals who are poor in at least one of the dimensions are included. In the other side of the Graph 6, the five regions with the higher rate of poor people we can find the communities of Valencia, Balearic Islands, Galicia, Andalusia and Murcia, this regions has at least forty percent of its population with at least one degree of deprivation, The difference between the energy poorest communities and the communities with less energy deprivation is more or less of an 8.5% that is a huge difference.

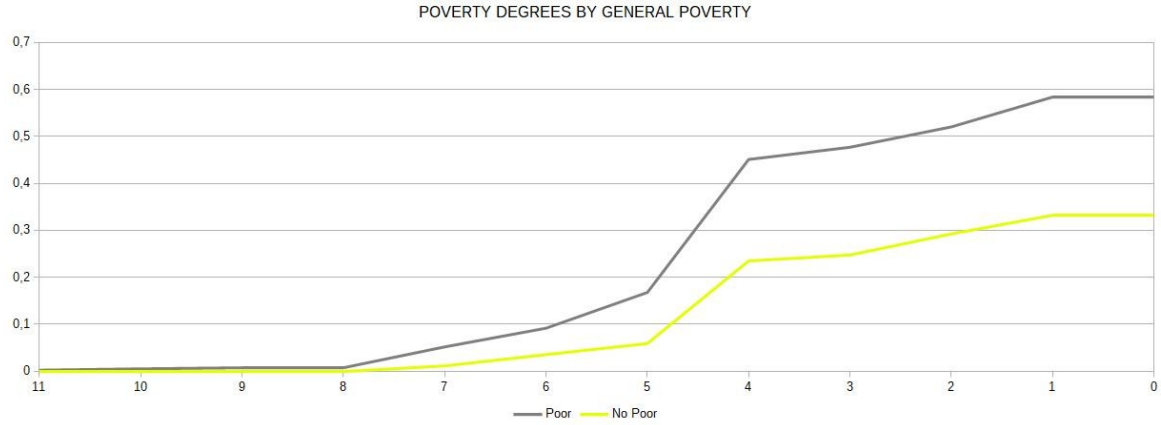
On the other hand, the results taken from this Graph 6 correspond to what was expected, as already indicated in the 2018 report of the ACA.

The Graphs from 7 to 20 show us the behavior of the different variables chosen with the counting. To do this, the Graphs show on ordinate axis the percentage of people who are deprived, while on the abscissa axis shows the degrees of accumulated deprivation, that is, eleven represents at least eleven degrees of deprivation, ten represents at least ten degrees of deprivation, that is, those individuals who are deprived in eleven and ten degrees of

deprivation.

These eleven Graphs have all two characteristics in common the first one is that from at least eight degrees of deprivation to at least eleven degrees of deprivation there are very few observations for all of them, and this prevents obtaining relevant conclusions of this section of the Graphs. In the other hand it is noted that when change from at least five degrees of deprivation to at least four degrees of deprivation, there is a considerable increase in the percentage of people who appear as deprived, this happens when we add those people who are only deprived in any of the two indicators based on the expenditure and the indicator Temperature.

By Income Poverty

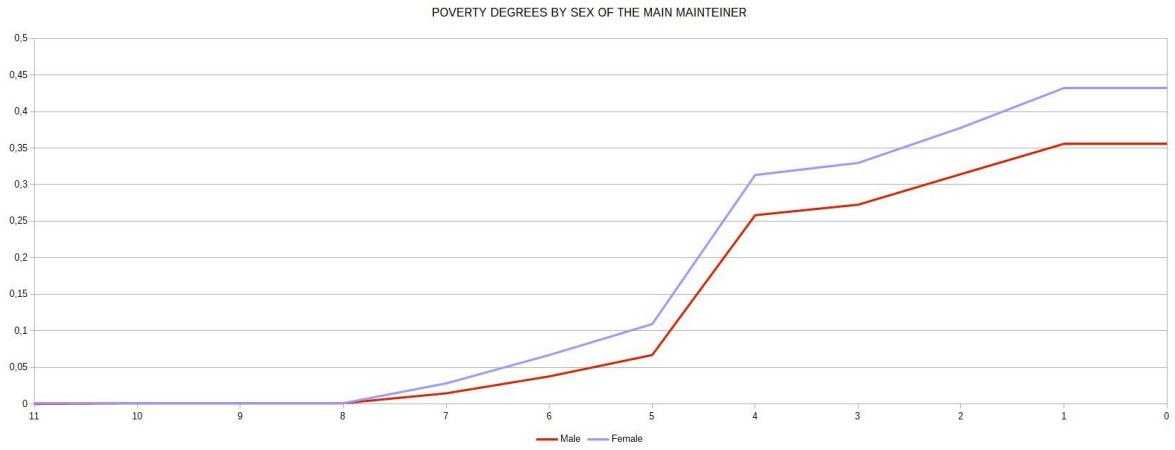


Graph 7: Deprivation degrees by Income Poverty.

When looking the distribution of the energy poor people with respect the people that is considered poor, shown in Graph 7, we can see that the relationship is, as expected, negative. There are less energy poor between those that are not poor than in those that are poor. This results are expected, the correlation between the income poverty and the energy deprivation, but the point that is remarkable is that there is no observation for those who are not income poor until it is exceeded up to eight degrees of energy deprivation.

5.2.2. Counting Approach Results by characteristics of Main Breadwinner

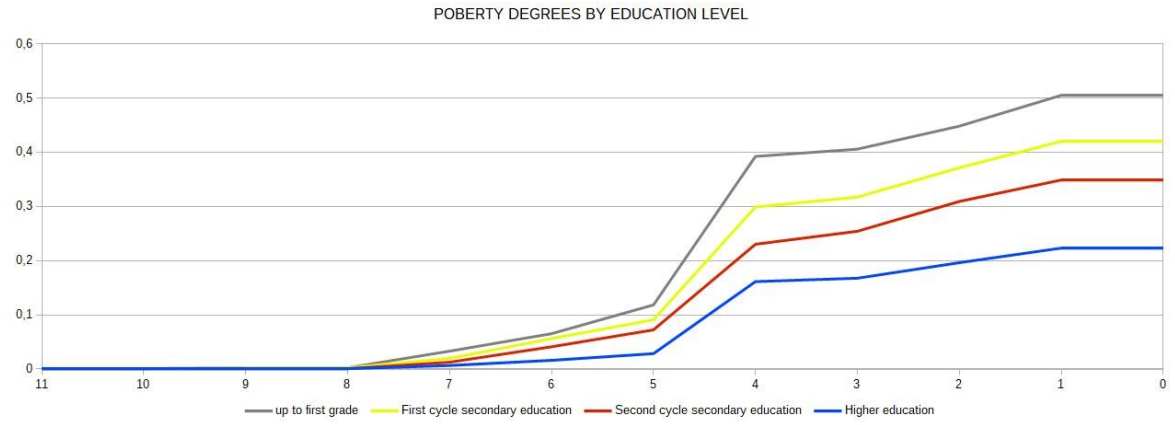
By Sex



Graph 8: Deprivation degrees by Sex of the Main Breadwinner.

When looking to the distribution of the different degrees of energy deprivation of the individuals taking into account the sex of the head of family, man or a woman, we can see a clear evidence that if the main breadwinner is a woman is unmistakably an aggravating factor when it comes to being energy deprived. This trend to be maintained at all times men below the women in Graph 8 has a small exception. When it is observed more closely, when there are at least nine degrees of energy deprivation, it can be observed that poor individuals with a male head of family are poorer than those with a female head of family. Although this difference is very small since it barely reaches 0.02%. Those are enough evidence to say that the sex of the main breadwinner is relevant when determining the energy deprivation level.

By Level of Studies



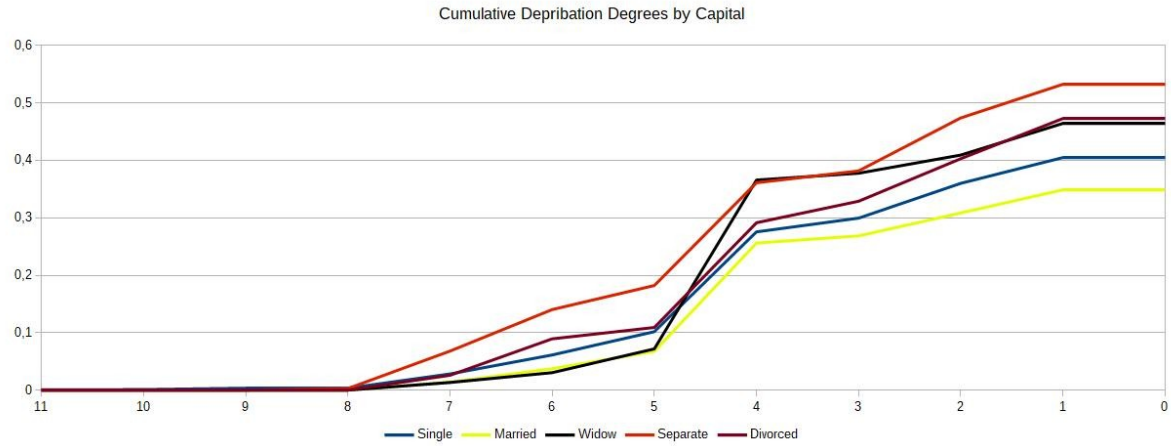
Graph 9: Deprivation degrees by Level of Studies of Main Breadwinner.

Level of Studies is one of the main factors to take into account when talking about Income Poverty and with energy poverty can not be otherwise. As in the other Graphs it is not relevant to look up to the four first cumulative energy deprivation degrees, eleven to

eight, from this point we can see that there is a negative correlation between the level education and the energy deprivation, and this seems to be consistent, because the curves of the Graph 9 do not intersect at any time.

The difference between the energy deprivation levels in the final step, when there is at least a degree of energy deprivation is considerably high. The difference between the population with the highest level of education and the population with the lowest level of education is more than two times, in the first group there is something more than 20% of the energy deprived, while in the last group, the least educated, exceeds 50%.

By Marital Status

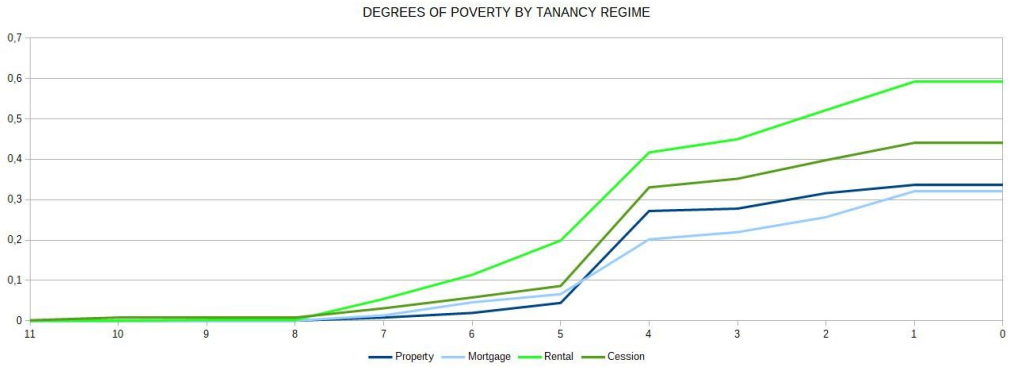


Graph 10: Deprivation degrees by Marital Status of Main Breadwinner.

When we look at Graph 10 we see that there is not a clear category that is the poorest or the least poor. Married, which is usually below the rest of the categories could be a good candidate but crosses widower at least in one occasion. And the same occurs with the candidate to be the poorest, separate. But, if we ignore widow, the things change a bit. We can consider that now and from the sixth degree of deprivation onwards married is the least poor, followed by to be single, the divorced and finally separate. But this has also a problem, from the seventh degree to the sixth degree divorced and single cross each other. We can only conclude that very likely, and after the sixth degree of deprivation, that married is the category with a lower correlation with being poor energetic and separated the one that possesses a greater correlation.

5.2.3. Counting Approach Results by Variables of Type of House

By Tenancy Regime



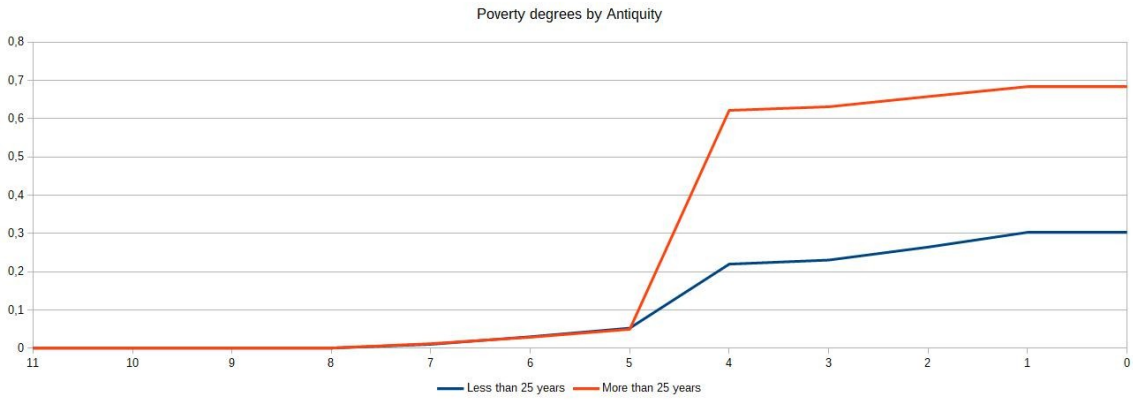
Graph 11: Deprivation degrees by Tenancy Regime.

One of the main interest of analysing this variable, the Tenancy Regime of housing, is that if the house is in property or in property with mortgage, the family has a greater freedom to implement improvements in the insulation and the energy efficiency of their home. This could mean less energy deprived in all the degrees of those households that own their own homes.

And this is what Graph 11 is telling us. If we consider the Graph lines by pairs, those who has property of their home (Property and Mortgage) in blue and those who no (Rental and Cession) in green, we can see a clear pattern. Those individuals whose family owns the home are in all the levels of deprivation below those individuals whose family has no the property of their home.

But when we study the four possibilities separately we see something much less clear, Property and Mortgage cross several times between them, we have no clear vision of what group is energetically poorer. If we consider now the other two groups, Rental and Cession, we see that until the eighth degree of energy deprivation the Rental individuals are below the Cession one, but from that point forward rental individuals are above, preventing in this way to draw definitive conclusions.

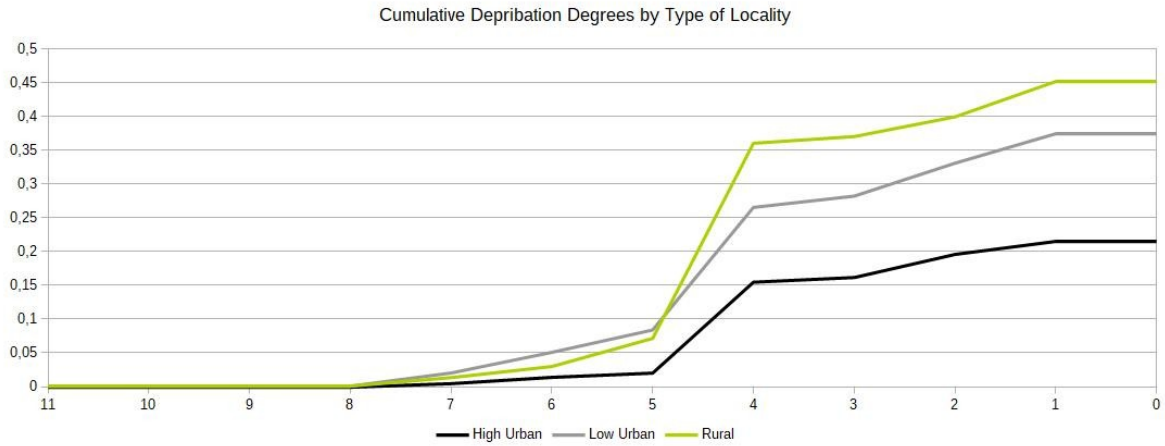
By Antiquity



Graph 12: Deprivation degrees by Antiquity.

This variable could affect energy deprivation not only because new homes are less susceptible to failures, less wear and tear due to time and use, but can also allow to be used as proxy for successive energy efficiency regulations have been made with the years. A newer house will be more prepared, by regulation, to maintain the temperature than in an older one. And this is reflected in the Graph 12, with at least four degrees of deprivation we can see that clearly the oldest homes are energetically poorer than the new ones, but from the sixth to the seventh energy deprivation degree the lines cross and the line of the oldest homes is positioned below of the newest line. But as the difference between the two lines is so small, approximately a 0.1%, that probably at the time of making the regression the age of the house will be relevant.

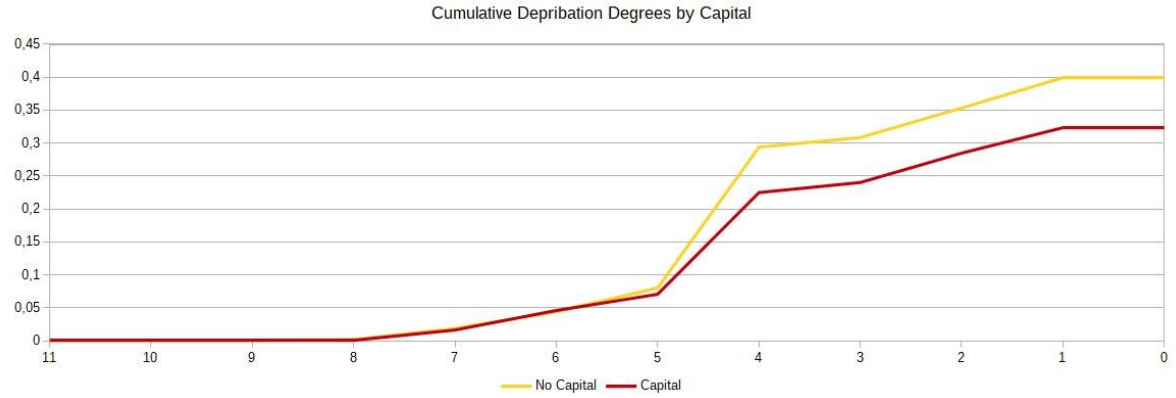
By Type of Locality



Graph 13: Deprivation degrees by Type of Locality

When looking at Graph 13 it can be seen a clear correlation between living in a high urban area and being less energy deprived, since the line that represents the cumulative degree of deprivation is from the eighth grade of deprivation onwards always below the other two categories. On the other hand, a definitive conclusion of rural and urban low can not be drawn since both lines intersect when passing from the fifth to the fourth degree of accumulated deprivation. These results, in particular, the conspicuous relationship between energy deprivation between rural areas and urban areas is consistent with the conclusions of the 2018 ACA report.

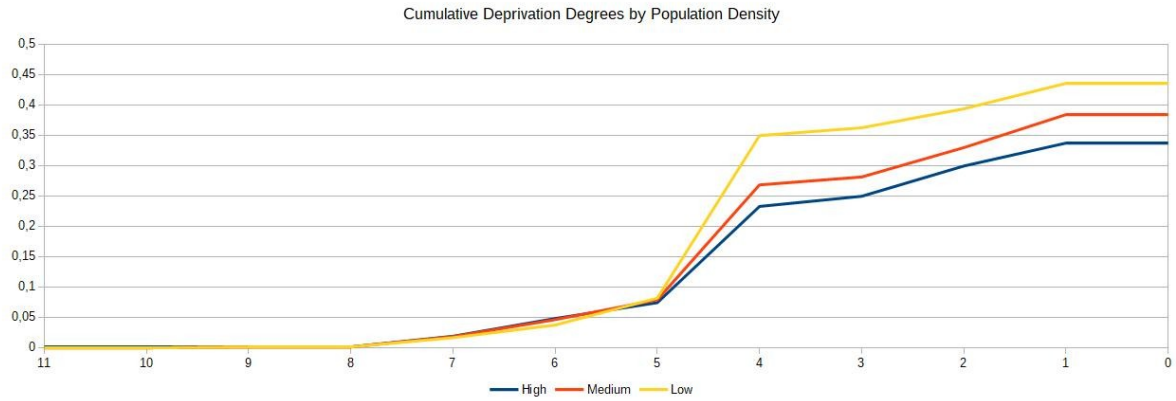
By Capital



Graph 14: Deprivation degrees by Capital.

For the relationship between the deprivation degrees and to live or not in a province capital we see that from at least six degrees of deprivation to at least one degree of deprivation to live in a capital is clearly below to live in another kind of locality. But form the eighth to the sixth this relation is not clear at all, because are to close to be relevant if one is above the other.

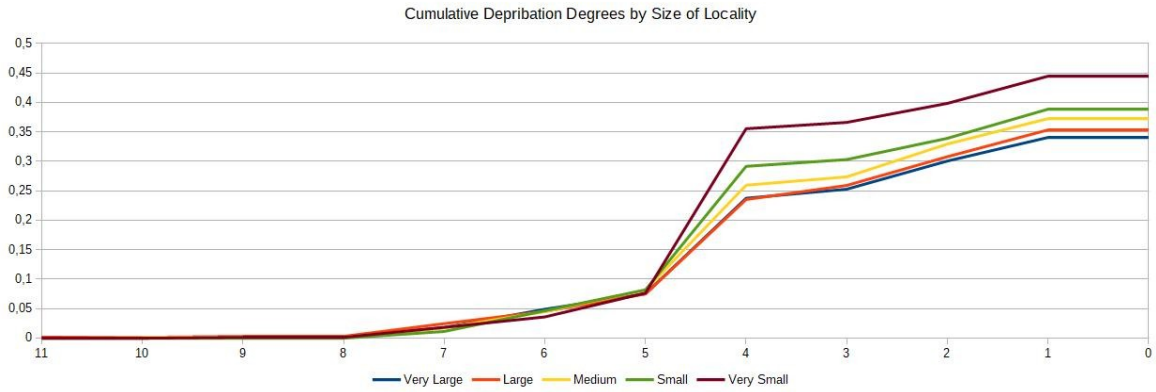
By Population Density



Graph 15: Deprivation degrees by Population Density.

For population density we can observe that no definitive conclusion can be drawn at first sight since from the eighth grade of deprivation to the fifth degree the cumulative curves intersect several times. But from the fifth cumulative degree of deprivation the pattern is clear, the degree of correlation to be energetically deprived decreases to the extent that the density of the increase increases among the three categories. Also clarify that although the difference observed is consistent, the degree to which the three lines are separated is not excessively large.

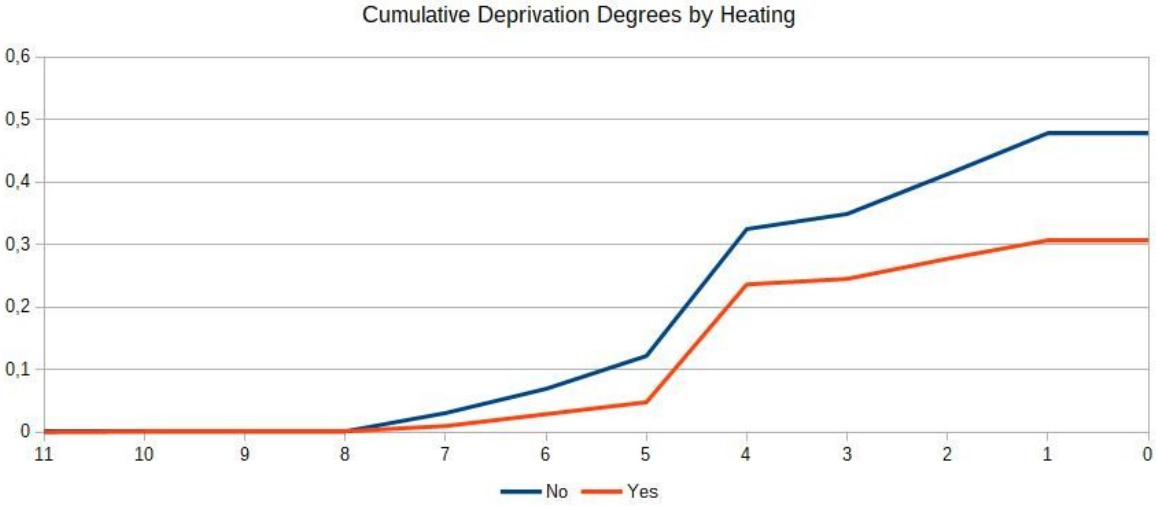
By Size of Locality



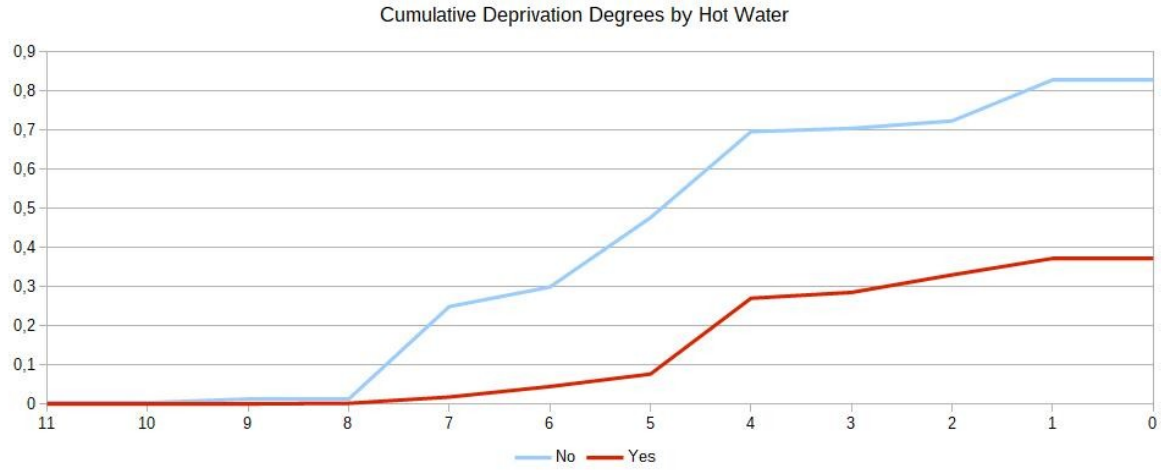
Graph 16: Deprivation degrees by Size of Locality

Of this Graph 16 we can not conclude anything definitive, since different categories intersect several times as they accumulate more and more degrees of deprivation. From the fifth degree of deprivation you can already guess a certain pattern. Very small localities, small and medium ones are in that order over large and very large. On the other hand, the very large and very large intersect when passing up to four to three deprivations and when they do not cross again, keeping very large below, the difference that separates them is extremely small. We can't obtain definitive conclusions on the impact on energy deprivation of the Size of Locality.

By Heating and Hot Water



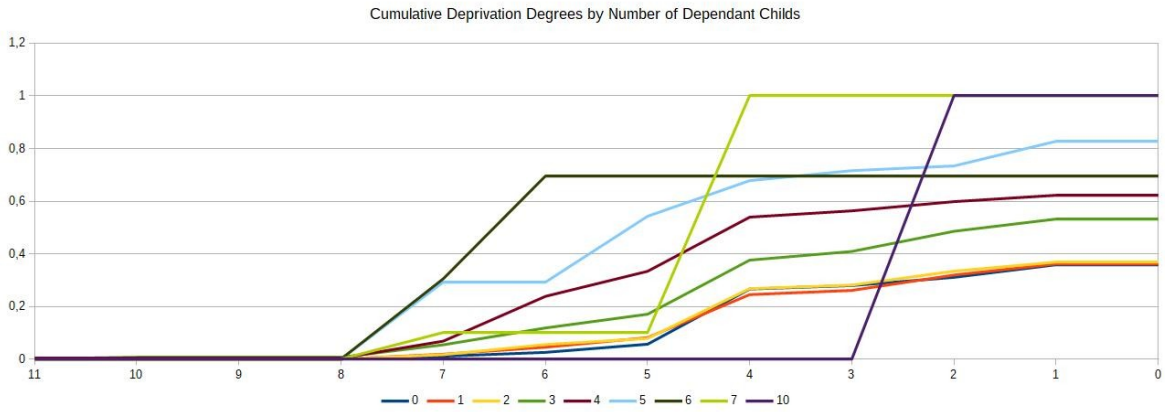
Graph 17: Deprivation degrees by Heating



Graph 18: Deprivation degrees by Hot Water

As we can see in the Graphs 19 and 18, the behaviour of the percentage of deprived people as a function of the cumulative increase of the degrees of deprivation is very similar, from the eighth degree of accumulated deprivation, or even before for hot water, there is a clear and pronounced divergence between the percentages of deprived with and without hot water and heating. Although this divergence is exaggeratedly more pronounced for hot water. We can conclude that the lack of a service directly related to the reason for study will necessarily have a very large relationship.

By Number of Dependent Children



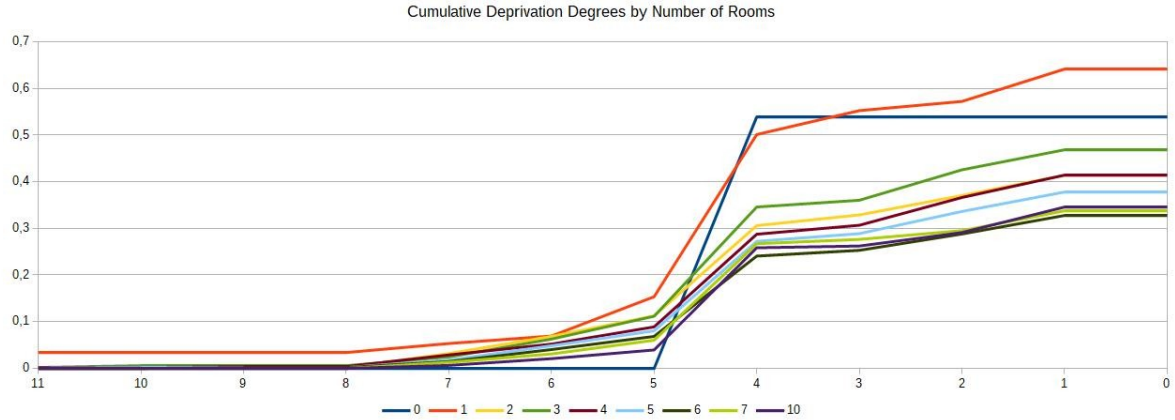
Graph 19: Deprivation degrees by Number of Dependent Children

In the Graph 19 it can be seen the percentage of people that is consider deprived in relation with the cumulative degrees of deprivation in terms of the number of dependent children in the household. For obtain some information from this Graph the first thing that we have to do is to ignore the lines of ten, seven and six dependent children, because for these numbers of children the sample has few individuals and this can distort what can be learned

from this Graph. Without this we can see for zero, one and two children the percentage of people deprived in any of the cumulative deprivation levels are no significantly different, but when we look to three children onwards we can see a clear increment of the percentage of deprived people in all the degrees of deprivation.

We can conclude that there is no a clear relationship for the number of children when talking of zero, one or two, but there are clear evidences when the number of children increases to three or more of an increase in the number of deprived in all degrees.

By Number of Rooms



Graph 20: Deprivation degrees by Number of Rooms

Graph 20 it can be seen the percentage of people that is consider deprived in relation with the cumulative degrees of deprivation in terms of the number of rooms in the house. In this Graph we have to ignore, since it does not provide any relevant information the individuals that live in a house with 0 rooms are a strange and extreme case. For the other types we can not say nothing definitive. But for six, seven and ten room we see that there is no a great difference in the percentage of deprived people. From five rooms we can see an inverse relationship between the number of rooms and the deprived ones, as the number of rooms decreases there is an increase in the percentage of deprived persons. This trend is only interrupted by individuals who live in households with three rooms that are a lower percentage than those who live in two-bedroom homes for all accumulated levels of deprivation

5.3. The Regressions

For the econometric study the idea is to make two kind of regressions, one Ordered Logistic Regression that captures the different degrees of energy deprivation of the counting

approach, allowing us to determine the effect of the different covariates when determining the degree of energy deprivation, by using and ordered logistic regression. The other idea for regression is to use a binomial variable of energy poverty and make a Logistic Regression, with the idea to study the effect of the covariates in being or not being energy poor.

5.3.1. Logistic Regression and Results

Who is energy poor?

For our thesis and after seeing some results of the counting we have decided to use the definition the weaker energetic poor. We consider poor those individuals with at least one point in the counting. With this definition of Energy Poor we make a regression for a binary outcome, for this we use a Logistic regression:

$$EnergyPoor_i = \alpha + \beta\, TypeOfHouse_1 + \gamma\, MainBreadWinner_i + \delta\, CCAA_i + \varepsilon_i$$

The variables included in this regression are the same than the named in the description in the database with the exception of the variables that make reference to the type of house. This variable has been eliminated since it generates problems and its exclusion from the model towards the variable Surface.

It should be noted that as we are using a logistic regression we can only interpret the sign of the coefficients but not the number, as much a hierarchical approximation of the values of the coefficients could be given.

Table 7 shows the results of the regression.

LOGISTIC REGRESSION

COVARIATES		Coef.	Std. Err.
Sex		-0.112**	0.045
Autonomous Community	Rioja	0.126	0.093
	Basque Country	0.121	0.077
	Navarre	0.108	0.083
	Murcia	0.411***	0.091
	Madrid	0.413***	0.082
	Galicia	0.19**	0.079
	Extremadura	-0.101	0.089
	Valencia	0.277***	0.073
	Catalonia	0.267***	0.072
	Castilla-La Mancha	0.144*	0.083
	Castile and León	0.311***	0.079
	Cantabria	0.044	0.100
	Canary Island	0.2**	0.086
	Balearic Island	0.263***	0.094
	Asturias	0.120	0.098
Capital		-0.179***	0.060
Tenure Regime	Property	0.359***	0.074
	Mortgage	-0.356***	0.077
	Rental	0.25***	0.084
Antiquity		-0.245***	0.038
Size of the Locality	Small	-0.137**	0.062
	Medium	-0.225***	0.062
	Large	-0.148**	0.075
	Very Large	-0.152*	0.089
Type of contract	Without contract	0.124	0.112
	Indefinite contract	-0.476***	0.040
	Eventual/ Temporary	0.168***	0.052
Marital Status	Single	-0.253***	0.089
	Married	-0.378***	0.083
	Widow	-0.321***	0.093
	Separated	-0.033	0.116
Level of Studies	Low Studies	0.95***	0.054
	Low-Medium Studies	0.724***	0.048
	High-Medium Studies	0.451***	0.054
Poor		0.493***	0.042
Heating		-0.159***	0.042
Hot Water		-0.344	0.270
Disabled Children		0.186***	0.035
Population Density	High density	-0.22***	0.068
	Medium density	-0.163***	0.053
Type of locality	Minor Urban	-0.067	0.053
	High Urban	-0.349***	0.088
Children under 16		0.067*	0.039
Surface		0.001***	0.000
Number of rooms		-0.05**	0.017
Constant		0.128	0.307
Number of observations	21.054		
Log Likelihood	-11790.702		
Pseudo R^2	0.0978		

Table 7: Logistic Regression results.

In red we can see all the coefficients that are relevant at a 5% significant level and have a negative sign. In blue we have the coefficients that are significant at a 5% and have a

positive sign. In our case we can say that most of the variables are significant.

As expected, being poor or not descends with as the educational level of the main breadwinner falls.

For its part, the effect of sex, not surprising, is negative, which indicates that if the main breadwinner is male, the household will be less likely to be among the poor energetic than in the base case, being a woman. The same result is obtained in the case of the antiquity of the home and the size of the town and the marital status. If these two are to be qualified, as for the size of the locality, with respect to a locality very small all the coefficients are negative, one of them, the very large is not significant at 5% although it is at 10%. The case of civil status is similar, all alternatives have a negative sign, with respect to being divorced, but being separated is not significant at 5%.

When we observe the variables of population density and type of locality we see that their sign is negative and they are significant with the exception of minor urban that is not significant. This is in line with the ACA 2018 report, which says that there is a lower tendency to energy poverty in rural areas than in smaller urban areas, although that difference is very small.

Fro the variables Heating and warm water we observe something curious, although the heating variable is negative and significant, as it must be, hot water is not significant, this is most likely caused by the small number of people who lack it in our sample.

When we look to the autonomous communities we have a surprise, our base is Andalusia, which is expected to be one of the poorest, but we observe that the communities of Madrid and Catalonia which are normally the richest communities of Spain has a positive sign, the regression says that is easier to find an energy poor household in Madrid or Catalonia than in Andalusia. The other communities or are with the expected sign or are not significant.

A final point to highlight is the apparent contradiction in which the variables surface and number of rooms have opposite signs, surface positive and number of rooms negative, since it would be better to think that they shared a sign. But the certain thing is that a greater number of rooms for the same surface, has result that the desired temperature can be maintained with greater ease in the zones that are convenient.

5.3.2. Ordered Logistic Regression and Results

$$Counting_i = \alpha + \beta\, TypeOfHouse_1 + \gamma\, MainBreadWinner_i + \delta\, CCAA_i + \varepsilon_i$$

Before beginning to interpret the results shown in the table 8, we have to clarify some

points about the Ordered Logistic regression. The first thing is that we can not, as in the case of the logistic regression, interpret the values of the coefficients, but also we can not interpret the sign of them, since as we will see in the table itself, the marginal and discrete changes of the different phases of the regression could have different signs than the coefficient. The only thing we can make clear of the regression is whether the coefficients are globally significant or not.

To have a clearer idea of how the regression works internally, we have chosen to obtain the marginal and discrete effects of the predicted probabilities. In such a way that in this case we can interpret the signs of the regression and for which values of the counting are significant the different covariates.

Another point to consider before analyzing the regression is that in the table shown below only appear from zero to seven degrees of deprivation, counting having a total of eleven degrees of deprivation. In our case we have chosen not to show them, because, they are counting values with very few observations and their results are not good enough to be taken into account.

			ORDERED LOGISTIC REGRESSION							
			No Poor	1 Degree	2 Degrees	3 Degrees	4 Degrees	5 Degrees	6 Degrees	7 Degrees
COVARIATES		Coef.	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Sex*		-0.134*** (0.0417)	0.03*** (0.009)	-0.002*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0002)	-0.019*** (0.006)	-0.003*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0004)
Autonomous Comunity	Rioja*	0.101 (0.087)	-0.023 (0.02)	0.002 (0.001)	0.002 (0.001)	0.001 (0.0005)	0.014 (0.013)	0.002 (0.002)	0.001 (0.001)	0.001 (0.001)
	Basque Country*	0.178** (0.0721)	-0.04** (0.017)	0.003*** (0.001)	0.003** (0.001)	0.001** (0.0004)	0.026** (0.011)	0.004** (0.002)	0.003** (0.001)	0.002** (0.001)
	Navarre*	0.165** (0.078)	-0.037** (0.018)	0.002** (0.001)	0.003** (0.001)	0.001** (0.0004)	0.024** (0.012)	0.004** (0.002)	0.002** (0.001)	0.001* (0.001)
	Murcia*	0.391*** (0.084)	-0.091*** (0.02)	0.005*** (0.001)	0.006*** (0.001)	0.002*** (0.0004)	0.058*** (0.013)	0.009*** (0.002)	0.006*** (0.001)	0.004*** (0.001)
	Madrid*	0.48*** (0.077)	-0.112*** (0.019)	0.006*** (0.001)	0.007*** (0.001)	0.003*** (0.0004)	0.072*** (0.012)	0.011*** (0.002)	0.008*** (0.002)	0.005*** (0.001)
	Galicia*	0.341*** (0.072)	-0.079*** (0.017)	0.005*** (0.001)	0.005*** (0.001)	0.002*** (0.0004)	0.051*** (0.011)	0.008*** (0.002)	0.005*** (0.001)	0.003*** (0.001)
	Extremadura*	-0.137 (0.084)	0.03* (0.018)	-0.002 (0.001)	-0.002 (0.001)	-0.001 (0.0005)	-0.0188* (0.0112)	-0.003* (0.0015)	-0.0017* (0.001)	-0.001* (0.0006)
	Valencia*	0.301*** (0.067)	-0.069*** (0.016)	0.004*** (0.001)	0.005*** (0.001)	0.002*** (0.0004)	0.044*** (0.01)	0.007*** (0.002)	0.005*** (0.001)	0.003*** (0.001)
	Catalonia*	0.257*** (0.068)	-0.059*** (0.016)	0.004*** (0.001)	0.004*** (0.001)	0.001*** (0.0004)	0.038*** (0.01)	0.006*** (0.002)	0.004*** (0.001)	0.002*** (0.001)
	Castilla-La Mancha*	0.207*** (0.077)	-0.047*** (0.018)	0.003*** (0.001)	0.003*** (0.001)	0.001*** (0.0004)	0.03*** (0.012)	0.004** (0.002)	0.003** (0.001)	0.002** (0.001)
	Castile and León*	0.371*** (0.074)	-0.086*** (0.018)	0.005*** (0.001)	0.005*** (0.001)	0.002*** (0.0004)	0.055*** (0.012)	0.008*** (0.002)	0.006*** (0.001)	0.004*** (0.001)
	Cantabria*	0.011 (0.096)	-0.002 (0.021)	0.0002 (0.002)	0.0002 (0.002)	0.00006 (0.0006)	0.001 (0.013)	0.0002 (0.002)	0.0001 (0.001)	0.0001 (0.001)
	Canary Island*	-0.021 (0.081)	0.005 (0.018)	-0.0003 (0.001)	-0.0003 (0.001)	-0.0001 (0.0005)	-0.003 (0.011)	-0.0004 (0.002)	-0.0003 (0.001)	-0.0002 (0.001)
	Balearic Island*	0.177** (0.088)	-0.04* (0.02)	0.003** (0.001)	0.003** (0.001)	0.001** (0.0005)	0.026* (0.013)	0.004* (0.002)	0.003* (0.001)	0.002* (0.001)
	Asturias*	0.168* (0.092)	-0.038* (0.02126)	0.0025** (0.001)	0.003* (0.001)	0.001* (0.0005)	0.024* (0.014)	0.004* (0.002)	0.002* (0.001)	0.001* (0.001)
Capital*		-0.18*** (0.056)	0.039*** (0.012)	-0.003*** (0.001)	-0.003*** (0.001)	-0.001*** (0.0003)	-0.025*** (0.008)	-0.003*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0004)
Tenure Regime	Property*	-0.35*** (0.069)	0.077*** (0.015)	-0.005*** (0.001)	-0.006*** (0.001)	-0.002*** (0.0004)	-0.049*** (0.01)	-0.007*** (0.001)	-0.005*** (0.001)	-0.003*** (0.001)
	Mortgage*	-0.349*** (0.072)	0.075*** (0.015)	-0.006*** (0.001)	-0.005*** (0.001)	-0.002*** (0.0005)	-0.048*** (0.01)	-0.007*** (0.001)	-0.004*** (0.001)	-0.003*** (0.001)
	Rental*	0.325*** (0.078)	-0.074*** (0.018)	0.005*** (0.001)	0.005*** (0.001)	0.002*** (0.0004)	0.048*** (0.012)	0.007*** (0.002)	0.005*** (0.001)	0.003*** (0.001)
Antiquity*		-0.242*** (0.035)	0.053*** (0.008)	-0.004*** (0.001)	-0.004*** (0.001)	-0.001*** (0.0002)	-0.034*** (0.005)	-0.005*** (0.001)	-0.003*** (0.0005)	-0.002*** (0.0003)
Size of the Locality	Small*	-0.124** (0.058)	0.027** (0.012)	-0.002** (0.001)	-0.002** (0.001)	-0.0007** (0.0003)	-0.017** (0.008)	-0.002** (0.001)	-0.002** (0.001)	-0.001** (0.0004)
	Medium*	-0.195*** (0.058)	0.042*** (0.012)	-0.003*** (0.001)	-0.003*** (0.001)	-0.001*** (0.0004)	-0.027*** (0.008)	-0.004*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0004)
	Large*	-0.135* (0.07)	0.029** (0.015)	-0.002* (0.0012)	-0.002* (0.0011)	-0.001* (0.0004)	-0.019** (0.009)	-0.003** (0.001)	-0.002** (0.001)	-0.001** (0.001)
	Very Large*	-0.115 (0.083)	0.025 (0.018)	-0.002 (0.001)	-0.002 (0.001)	-0.001 (0.0005)	-0.016 (0.012)	-0.002 (0.002)	-0.002 (0.001)	-0.001 (0.001)
Type of contract	Without contract*	0.173* (0.102)	-0.039 (0.0237)	0.002* (0.001)	0.003* (0.002)	0.001* (0.001)	0.025 (0.015)	0.004 (0.002)	0.003 (0.002)	0.002 (0.001)
	Indefinite contract*	-0.464*** (0.038)	0.104*** (0.008)	-0.007*** (0.001)	-0.007*** (0.001)	-0.003*** (0.0003)	-0.066*** (0.005)	-0.01*** (0.001)	-0.007*** (0.001)	-0.004*** (0.0004)
	Eventual/ Temporary*	0.205*** (0.048)	-0.046*** (0.011)	0.003*** (0.001)	0.003*** (0.001)	0.001*** (0.0003)	0.03*** (0.007)	0.004*** (0.001)	0.003*** (0.001)	0.002*** (0.0005)
Marital Status	Single*	-0.255*** (0.082)	0.054*** (0.017)	-0.004*** (0.001)	-0.004*** (0.001)	-0.002*** (0.0005)	-0.034*** (0.011)	-0.005*** (0.001)	-0.003*** (0.001)	-0.002*** (0.001)
	Married*	-0.363*** (0.077)	0.082*** (0.018)	-0.005*** (0.001)	-0.006*** (0.001)	-0.002*** (0.0005)	-0.052*** (0.011)	-0.008*** (0.002)	-0.005*** (0.001)	-0.003*** (0.001)
	Widow*	-0.342*** (0.086)	0.072*** (0.017)	-0.006*** (0.002)	-0.006*** (0.001)	-0.002*** (0.0005)	-0.045*** (0.011)	-0.006*** (0.001)	-0.004*** (0.001)	-0.002*** (0.001)
	Separated*	0.028 (0.108)	-0.006 (0.024)	0.0004 (0.002)	0.0005 (0.002)	0.0001 (0.0006)	0.004 (0.01529)	0.001 (0.002)	0.0004 (0.001)	0.0002 (0.001)
Level of Studies	Low Studies*	0.963*** (0.051)	-0.224*** (0.012)	0.011*** (0.0006)	0.013*** (0.001)	0.005*** (0.0004)	0.144*** (0.008)	0.024*** (0.002)	0.017*** (0.001)	0.01*** (0.001)
	Low-Medium Studies*	0.732*** (0.045)	-0.167*** (0.011)	0.01*** (0.001)	0.011*** (0.001)	0.004*** (0.0003)	0.107*** (0.007)	0.017*** (0.001)	0.011*** (0.001)	0.007*** (0.001)
	High-Medium Studies*	0.438*** (0.051)	-0.101*** (0.012)	0.006*** (0.001)	0.006*** (0.001)	0.002*** (0.0003)	0.065*** (0.008)	0.01*** (0.001)	0.007*** (0.001)	0.004*** (0.001)
Poor*		0.55*** (0.039)	-0.127*** (0.009)	0.007*** (0.0005)	0.008*** (0.001)	0.003*** (0.0003)	0.081*** (0.006)	0.013*** (0.001)	0.009*** (0.001)	0.005*** (0.001)
Heating*		-0.279*** (0.039)	0.062*** (0.009)	-0.004*** (0.001)	-0.004*** (0.001)	-0.002*** (0.0002)	-0.04*** (0.006)	-0.006*** (0.001)	-0.004*** (0.001)	-0.002*** (0.0004)
Hot Water*		-0.874*** (0.233)	0.211*** (0.058)	-0.007*** (0.0005)	-0.009*** (0.001)	-0.004*** (0.0005)	-0.136*** (0.036)	-0.025*** (0.009)	-0.018*** (0.007)	-0.011** (0.004)
Disabled Children		0.188*** (0.033)	-0.042*** (0.007)	0.003*** (0.0005)	0.003*** (0.001)	0.001*** (0.0002)	0.026*** (0.005)	0.004*** (0.001)	0.003*** (0.0005)	0.002*** (0.0003)
Population Density	High density*	-0.24*** (0.064)	0.053*** (0.014)	-0.004*** (0.001)	-0.004*** (0.001)	-0.001*** (0.0004)	-0.034*** (0.009)	-0.005*** (0.001)	-0.003*** (0.001)	-0.002*** (0.001)
	Medium density*	-0.137*** (0.05)	0.03*** (0.011)	-0.002*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0003)	-0.019*** (0.007)	-0.003*** (0.001)	-0.002*** (0.001)	-0.001*** (0.0004)
Type of locality	Minor Urban*	-0.032 (0.05)	0.007 (0.011)	-0.001 (0.001)	-0.001 (0.001)	-0.0002 (0.0003)	-0.005 (0.007)	-0.001 (0.001)	-0.0004 (0.001)	-0.0003 (0.0004)
	High Urban*	-0.359*** (0.083)	0.075*** (0.016)	-0.006*** (0.002)	-0.006*** (0.001)	-0.002*** (0.0005)	-0.047*** (0.01)	-0.006*** (0.001)	-0.004*** (0.001)	-0.003*** (0.0005)
Children under 16*		0.067* (0.037)	-0.014* (0.0081)	0.001* (0.001)	0.001* (0.001)	0.0004 (0.0002)	0.009* (0.005)	0.001* (0.0007)	0.001* (0.0005)	0.0005** (0.0003)
Surface		0.001*** (0.001)	-0.0003*** (0.0001)	0.00002*** (0.00001)	0.00002*** (0.00001)	7.45e-06*** (0.000)	0.0002*** (0.0001)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Number of rooms		-0.032** (0.016)	0.007** (0.003)	-0.0005** (0.0003)	-0.0005** (0.0003)	-0.0002** (0.0001)	-0.005** (0.002)	-0.001** (0.0003)	-0.0005** (0.0002)	-0.0003** (0.0001)
Number of observations	21.054									
Log Likelihood	-22070.063									
Pseudo R^2	0.0677									

Table 8: Ordered Logistic regression results and discrete and marginal effects on deprivation level.

In this table, in the first column, we have the summary results of the regression, for this column we can say only if the covariates are or not significant. We can say that the significant variables for the Ordered Logistic are approximately the same as those of the logistic, with the exception of Basque Country, Navarre, Castilla la Mancha and hot water, Canary Island and Large (size of locality) used to be significant in the logistic but no longer.

Now we have to analyse the columns from no poor to seven degrees, this columns contains the results of run the marginal and discrete effects of the regression. The first thing that stands out is the first column “no poor”, this column has, for the significant variables, the opposite sign of the values of the other columns, this not only justifies the need to calculate the marginal and discrete effects, but this is also the case because for this column we are measuring the effects associated with not being poor, as opposed to the rest of the columns, this is true for all the studied covariates.

We can say that, according to the sign of marginal and discrete changes, we can say that with respect to live in Andalusia living in any Autonomous Community other than Rioja, Extremadura, Cantabria, the Canary Islands or Asturias, has the effect of increasing the probability of increasing your degree of deprivation in the counting, that is, increasing the severity of energy deprivation, or directly your probability of having one degree of energy deprivation. This result does not coincide with the specifics in the analysis of Counting, although it is also true that in counting there was no clear prevalence of any community as the least deprived or the most deprived.

When we look to the variables associated with the characteristics of the main breadwinner, we can see that sex is one of the variables that decrease the probabilities to be deprived, an increase the possibilities of not being energy poor, this variable changes from being woman, the base, to be male. For the variables that form the marital status we can see that all has a negative value in comparison to be divorced, with the exception of being separated that is not significant at any level.

For the different types of contract, were we consider to be unemployed as a basis, we can see that as expected be indefinite has a negative effect in the deprivation, but to have eventual/temporal contract has a negative effect something that is contra intuitive, the variable without contract is not significant.

The variables Poor and level of studies, has the expected effect, being its bases not poor and high level of studies, the expected is that they have a positive discrete effect for the deprivations and negative for not poor, which is what we can observe for our regression. The same happens for the number of disabled children.

Even though the variable number of children under sixteen is not globally significant at 5% significance if it is at 10%, what stands out here is that for seven degrees of deficit in

counting, the variable is significant at 5% and has the expected sign.

For the variables of the Type of House that includes the rest of the variables of the model, we analyse them in three groups. The first is surface, that is the only variable that has an effect that increase the probability of being deprived, the more surface the house has, the more likely it is to be deprived at any of the levels.

With the variables capital, antiquity, heating, hot water, the population density variables and number of rooms has negative effect in the predicted probabilities of being energy poor, that is, those factors diminish the probabilities of being poor for the seven levels of deprivation. This result for antiquity corresponds with the results of the counting analysis of the antiquity of the house. The behaviour of the other variables is as expected, with the exception of the variable number of rooms, the result of this variable should be in the same sense than the surface variable. One possible explication for this difference is that a more compartmentalized dwelling, with more rooms, is simpler to maintain at an adequate temperature than a less compartmentalized house, it is in general terms, more energetically efficient.

For the variables of the group of tenure regime, size of locality and type of locality, the results are not so clear. For the type of locality we have that high urban is significant and has a negative effect on energy deprivation, but minor urban is not significant at a 5% significance level. For tenure regime we find an expected result, for mortgage and property the effect is to diminish the expected energy deprivation, based on the cession regime, and for rental the effect is the opposite, those results are the expected with what was exposed during the analysis of the counting. For the size of locality, with respect to a very small city, small and medium are significant and has an effect that diminish the energy deprivation. Very large variable is not significant at a 5% level, and large variable although it is not significant globally, if it is in a concrete way for the degrees of energy deprivation from four to seven, with a diminishing effect of the energy deprivation.

6. The Social Bonus

The social bonus is a public aid offered by the ministry of ecological transition. This bonus is regulated by the “real decreto-ley 7/2016, 23 de Diciembre” this bonus introduce the concept of vulnerable energy consumer.

6.1. What is the Social Bonus?

The social bonus is a discount for the electric bill, with a different amount of money depending on the degree of vulnerability of the family unit.

If the family is considered to be vulnerable the bonus is of a 25% of the electricity bill.

If the family is considered to be severe vulnerable the bonus is of a 40% of the electricity bill.

6.2. Definition of Vulnerable Energy Consumer.

To be a vulnerable energy consumer, according with the “real decreto-ley 7/2016, 23 de Diciembre” there are four conditions to be consider as poor energy and another one to have the right to claim the bonus.

a.- Have an income lower or equal to 1.5 times the IPREM, in case there is no minor in the family unit.

b.- Have an income lower or equal to 2 times the IPREM, in case there is a minor in the family unit.

c.- Have an income lower or equal to 2.5 times the IPREM, in case there is two minors in the family unit.

d.- Be in possession of the title of large family.

e.- That all the members of the family unit that have income are pensioners of the social security for retirement or for permanent disability, perceive therefore the minimum amount in force at each moment for said kind of pension.

There are also some conditions that modify the previous conditions from a to c,

increasing by 0.5 the relationship between the family income and the IPREM.

-That any member of the family unit has a recognized disability of at least a 33%.

-Any member of the family unit has the condition of victim of G*ender Violence*.

-Any member of the family unit has the condition of victim of *Terrorism*.

A household will be considered severe vulnerable If according with the previous requirements has an annual income equal or lower than a 50% of it for households in sections a, b or c with the relevant modifications. Or receive an annual income less than or equal to one and two times the IPREM in the case of the groups included in the sections e and d respectively.

6.3. Criticism of the Social Bonus

The first thing to say about the social bonus is that in the possible modifiers applied when calculating the income with respect to the IPREM, to be considered worthy of the social bonus or not, there is a clear and demarcated agenda not strictly related to energy poverty at the time of granting it. We could say that the modifications, both the victim of terrorism and the gender violence, correspond more to political agendas of marked ideological tendencies than to purely economic or social criteria. On the contrary, the idea of a modification for a member of the family with at least a 33% of disability. Although it is a questionable criterion, its base closest to the economic sphere and generates less rejection. Although this criterion is quite ambiguous and could not be correct in all its aspects. For example, if the disability is an affection which does not prevent the development of a normal life, the inclusion of this help is clearly out of place. But in the opposite case, if this disability prevents the development of a normal life, and taking into account the excessive effort involved in a home caring for that person, the truth is that the amendment seems correct.

The only one of the criteria for granting the social bonus with which we are not in agreement is the bonus in which it is granted because it is a large family. This criterion perhaps more thought in sterile an attempt in promoting the birth rate that in fighting the energy poverty, it lacks sense in terms of energy poverty. This criterion has nothing to do with those used in previous stages of this work and in fact it can be the case that a family with many descendants, three children specifically, and with an incoming income or a capital income very much for the criterion of IPREM could be charging the aid without needing it.

7. Conclusions

In recent years, energy poverty has attained great importance at the level of social policy for the countries of the European Union, Spain among them.

In order to shed light and try to better understand the phenomenon of energy poverty, a multivariate study has been carried out in which an attempt was made to combine the study of consensual and expenditure indicators, in order to study them jointly and to try to reach the different aspects that can be taken by the energy poverty has been used a counting approach.

In the study using data for the year 2010 some important points have been revealed. In the analysis of the regions we can conclude, it is not certain reasonable doubts, that the communities of the Basque Country and Cantabria are the communities with the least problem of energy poverty, on the other hand Andalucia, Murcia and Galicia are the communities with greater energy poverty. This is reflected both in the analysis of the counting and the descriptive, on the other hand this intuition is not transferred to the regression analysis.

On the other hand, other interesting variables for the study, such as the sex of the head of the family or their level of studies, being income poor or not, the antiquity of the house, whether or not they have hot water, or to some extent the tenure regime, have been shown to be factors determinants and with clear effects in all aspects of the study.

Other promising variables such as heating, marital status or type of location, all of the ingredients are apparently in order to be unequivocal determinants, and in the end they are not completely relevant in the study of the regressions.

About the Social Bonus and as almost always happens in these issues, when applying a public policy to combat a real problem, purely political interests are mixed with the evidence and "objective" criteria on the problem.

One point that needs to be clarified before concluding the thesis is that many of the results of the analysis, not to say the great majority of them, depend largely on the weights assigned by the group of experts when building the counting approach. An analysis with other weights could lead, or not, to results different from those obtained here. It would be interesting, therefore, in the future to make variations of this work by changing the weights given to the different indicators, to verify the validity and robustness of the results obtained here.

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