AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

ESRI Working Paper No. 765

November 2023

Hidden fuel poverty in Spain and Ireland: a comparative study of measuring and targeting[1]

F. Javier Palencia González[b], Miguel A. Tovar Reaños[a], Jose Maria Labeaga Azcona[b]

a) Economic and Social Research Institute, Dublin, Ireland; Trinity College Dublin, Dublin, Ireland
b) Departamento de Teoría Económica y Economía Matemática, UNED, Madrid, Spain

[1] Corresponding author: miguel.angeltovar@esri.ie

Abstract

In this article, we use expenditure-based and self-reported data on fuel poverty for Spain and Ireland to analyse extreme levels of low energy consumption. Unlike most of the European countries, these two nations have recently launched official strategies to measure and tackle fuel poverty. We focus on measurement and targeting of measures to tackle fuel poverty. We find that low energy consumption is linked with low-income levels and that popular expenditure-based metrics fail to identify the most vulnerable. In addition, newly proposed metrics for hidden poverty are more effective in identifying vulnerable households. We also find differences across countries regarding the targeting of measures to tackle fuel poverty. In Ireland, a larger proportion of households that report being unable to afford suitable levels of heating are covered by government aid than in Spain.

Keywords: Hidden fuel poverty, energy consumption, energy efficiency, targeting

1. Introduction

Fuel poverty is a prevalent issue in Europe in which households are unable to keep their homes warm. Approximately 8% of European households experience this condition (European Commission, 2022a, b). Its appropriate measurement is a crucial aspect for both understanding it and addressing it. Fuel poverty poses significant challenges to individuals' health, well-being, and overall quality of life (Navarro et al., 2010 or Mohan, 2021). To assess and effectively combat this problem, a formal and standardized approach to fuel poverty measurement is essential. The measurement of fuel poverty involves the quantification of various socio-economic and energy-related indicators to determine the extent and severity of energy poverty within a given population. These indicators typically include income level, energy expenditure, and energy efficiency of dwellings (Tovar Reanos and M. Lynch, 2021). By combining these factors, policy analysts and researchers can obtain a comprehensive overview of the scale and characteristics of fuel poverty within a specific area. However, even though there is a plethora of articles regarding the measurement of fuel poverty, very few articles attempt to identify those with extremely low energy consumption profiles. Our understanding of hidden poverty is still narrow. To fill this gap, we use expenditure-based and self-reported metrics for fuel poverty for two countries that have recently launched official strategies to tackle fuel poverty. We analyse measurement, driver identification, and effectiveness in targeting using Spanish and Irish data. We contribute to the narrow literature that uses cross country data to identify differences and similarities in fuel poverty measurement and the use of policies to tackle this condition. This will help to learn from the experience of both countries implementing policies to tackle fuel poverty. This knowledge will bring new insights to enhance the policy design in Europe.

Hidden fuel poverty is a pervasive issue that tends to linger unnoticed within communities, resulting in significant challenges for individuals and households. Hidden fuel poverty delves further into the realm of invisibility, making it a more covert problem. This lesser-known form of fuel poverty arises when individuals appear to comfortably manage their energy bills on the surface, yet they compromise their well-being in various ways to achieve this facade of stability. Often, hidden fuel poverty surfaces when individuals resort to harmful coping strategies, sacrificing essential needs to meet their energy expenses. Eisfeld and Seebauer (2022) using data from Austria, find that one-third of those not considered income-poor or energy-poor self-impose restrictions in energy use to escape from being in fuel poverty. Cong et al. (2021) used US data and find that some households tend to delay using cooling systems when facing higher outdoor temperatures. They also found that only a small number

of these households are identified by using a 10% threshold of the ratio of energy expenditure and income to measure fuel poverty. Barrella et al. (2021) estimate the minimal energy required using computational models and Spanish data. They found that the use of energy expenditure to compute under consumption can overestimate the number of households in hidden poverty.

Boardman (1991) introduced a metric in which a household that spends 10% or more of its disposable income before housing costs is in fuel poverty. "Low Income High Cost" (LIHC) is another indicator developed by Hills (2012). When a household spends more than the median expenditure on energy, and their income after that expenditure is below 60% of the median net (after tax) income is classified as fuel poverty. Self-reported metrics for fuel poverty have also been analysed in the literature. Most of them used the EU Survey on Income and Living Conditions (EU-SILC) in which households report being unable to keep the home adequately warm among other metrics.

Regarding the effectiveness of policy interventions specifically targeted at energy poverty, Charlier et al. (2019) find that living in energy-efficient social housing reduces the incidence of energy poverty. Therefore, they argue that policies should favour improving energy efficiency instead of short-term measures, such as subsidizing energy bills. Simshauser (2021) notes that targeted policies rarely achieve full coverage of vulnerable households. Social welfare schemes are often enrolment-dependent, and therefore participation rates can be low. Bednar and Reames (2020) point out that US initiatives targeting energy poverty often fail because policies seek to reach a greater number of households without considering the specific vulnerabilities or the results obtained. In the case of Spain, García Alvarez & Tol (2021) apply differences-in-differences and propensity score matching to household data between 2008 and 2011 finding no statistically significant impact of a subsidy to protect vulnerable households; this may be because eligible households did not apply or due to problems in their identification strategy. Bagnoli & Bertoméu-Sánchez (2022), using Spanish data from the Household Budget Survey (HBS) from 2006 to 2017, rely on a difference-in-differences approach to measure the causal impact on energy poverty of a policy called Bono Social which entails a discount on electricity prices for vulnerable consumers, and to further analyze how the introduction of the Bono affected the consumption behaviour of households. They find that, on average, the introduction of the policy has reduced the likelihood of energy poverty in households eligible for the social subsidy. Nevertheless, the magnitude of the effect is quite modest. However, they do not have information about who is receiving the transfer, and it is not easy to identify those who have the right to receive it because of several reasons, including regional heterogeneities in the conditions to qualify. Finally, Barrella et al. (2021) show that, in 2019, 45% of households had low absolute energy expenditures, but only 56% of these (25% of the total households) were suffering from hidden energy poverty, and several key factors have been identified, i.e., household size, housing's energy efficiency and tenure, and locality's degree of urbanisation.

Very few articles compare the effectiveness of measurement and targeting across different countries. Kyprianou et al. (2019) provide an overview of how fuel poverty is measured, and the policies used across 5 European countries. In Spain the number of people suffering from energy poverty was growing as the 2008 crisis hit society and in particular the most disadvantaged classes. For all these reasons, fuel poverty became an issue of maximum interest in that country, reaching the social and political forefront. During those years the population participated in political manifestations and marches in different cities and the new political parties, born at that time, included energy poverty among their proposals. In 2016, a law that prohibits electricity cuts to vulnerable families was approved (BOE, 2016). And finally in April 2019, under a different government, the National Strategy against Energy Poverty (ENPE, Estrategia Nacional contra la Pobreza Energética) was approved by law (Ministerio para la Transición Ecológica, 2019). The strategy defines the concept of Energy Poverty and establishes the four indicators that will be used to measure energy poverty. These indicators coincide with those established by the European Poverty Observatory (2019). Ireland and the UK have

been forerunners regarding the analysis of fuel poverty. Ireland has recently launched its Action Plan to tackle fuel poverty (DECC,2022). The plan considers developing metrics that can identify those in fuel poverty.
The literature that analyses energy under consumption in Europe is limited. Comparative studies across countries that address measurement and targeting policies to alleviate fuel poverty are rare in the literature. In this article, we provide a comparative analysis of the drivers of hidden energy poverty in Ireland and Spain. We measure the efficacy of using expenditure-based metrics to identify vulnerable households with low energy consumption. We also analyse the differences in criteria used for granting aid to overcome high energy costs in both countries and their efficacy in targeting those that report not being able to afford adequate heat levels. The use of different data sources as the Household Budget Survey and the SILC EU together with different econometric methods that range from logistic to quantile regressions have allowed us to characterize energy poverty and hidden energy poverty in Ireland and Spain.

We found similar patterns across the two countries. The metrics for hidden poverty are more effective in identifying low-income households with low levels of energy consumption than other metrics like the 10% metric that is currently used in Ireland. Being unemployed increases the probability of having extreme consumption levels, which indicates that households in low-income levels could face energy deprivation. We also found differences across countries. For instance, Ireland is more effective in reaching a larger proportion of households in fuel poverty than Spain. We believe that this comparative exercise provides useful insights for policy design not only for these two countries but also for other European countries. The rest of the paper contains three sections. Section 2 is devoted to describing in detail the data and the methodology used. In Section 3, the results for the propensity to be energy-poor adjusted under subjective and objective measures are presented. In Section 4, we provide some policy implications of our results and a summary of the main conclusions.

2. Data and methods

2.1 Data

The data used for this paper come from different surveys. On the one hand, the Household Budget Survey (HBS) was obtained from the Irish Social Science Data Archive (ISSDA) for Ireland, and the Household Budget Survey (HBS) was obtained from the National Statistics Institute (INE) for Spain. Both surveys contain data referring to 2015. This year has been used as it is the last one published in the case of Ireland. This survey has been used to calculate the 10% and LIHC metrics, as well as the Hidden Energy Poverty (HEP) metrics.
The Irish survey has 5,993 observations, and the Spanish one has 22,130 observations. On the other hand, the EU-SILC for the year 2021 has been used for both countries. From this survey, we used the metric of inability to keep the home adequately warm that we interpret as an indicator of low energy consumption. For Ireland, this survey has 4,846 observations, and for Spain there are 21,007 observations. Finally, we estimate household energy efficiency for Spain, based on a database we have generated containing all the energy certificates of homes registered in the different Spanish autonomous communities; apart from Madrid, Valencia and Extremadura, there are more than 3,3 million of registered dwellings. A distinction is made between household types (in a flat block, detached house, and semi-detached house) and date of construction (under and over 25 years old[1]).

[1] Most of the data has been obtained from the Spanish government's open data portal https://datos.gob.es/, and in the case of Asturias, Cantabria, Catalonia, Murcia and the Basque Country from their respective regional government portals.

To estimate energy efficiency of the dwelling for the Irish case, we follow Tovar and Lynch (2022) and use their estimated parameters of the relationship between energy efficiency and dwelling characteristics. The authors used data from the Sustainable Energy Authority of Ireland (SEAI) on the registration of completed Energy Performance Certificates (EPCs), termed Building Energy Ratings (BERs). This dataset provides information on dwelling characteristics and energy requirements, expressed as kWh/m2, of 872,056 dwellings. Using the coefficients of the regression, we later predict BERs for households in the Irish HBS using common dwelling variables in both data sets.

The Spanish HBS includes electricity, gas, liquid and solid fuels, for each of which the monetary expenditure and physical units are specified. The physical units of the different fuels and gas have been converted to kWh[2]. The Irish HBS does not provide information in physical quantities. We used prices for kWh provided by the SEAI to convert energy expenditure into kWh[3].

In Tables 1a, 1b, 2a and 2b, we report descriptive statistics of the main variables as the number of household members, income and expenditure per household and per adult equivalent, expenditure and energy consumption per household and per adult equivalent, and energy efficiency expressed in kWh/m2. Note that in Ireland, the value of the variable referring to the age of the head of household is given by age groups. The Reduced Utility Costs (RUC) variable as provided in the SILC data does not allow us identifying those recipients with specific energy subsidies, RUC comprises any subsidies for utility costs.

Summary statistics

Table 1a.- Summary House Budget Survey, Spain - 2015

Variable	Mean	Std. Dev.	Min	Max
Nº of members by HH	2,50	1,26	1,00	16,00
Nº of equivalent adults by HH	1,68	0,56	1,00	6,90
Age of head of HH	54,18	16,02	17,00	85,00
Floor area (m2)	100,26	46,10	35,00	300,00
HH expenditure	27419,52	16866,54	880,18	238152,30
Expenditure per Equivalent Adult	16682,17	9236,89	419,13	145560,70
HH Income	22357,29	15037,89	0,00	205200,00
Income per Adult Equivalent	13602,79	8314,03	0,00	108248,00
HH Energy Expenditure	1044,84	805,43	0,00	29700,44
Energy Expenditure per Equivalent Adult	647,69	457,88	0,00	8485,84
HH Energy Consumption	7678,91	12433,12	0,00	1206834,00
Energy Consumption per Equivalent Adult	4751,99	7698,16	0,00	804555,90
HH Energy Expenditure to Income Ratio	0,06	0,05	0,00	0,82
kWh/m2	205,35	44,16	134,97	343,63

Table 1b.- Summary EU-SILC, Spain – 2021

Variable	Mean	Std. Dev.	Min	Max
Nº of members by HH	2,49	1,29	1,00	10,00

[2] according to the following conversions: natural gas consumption is converted to kWh, 1 m3 - 11.02 kWh; liquefied gas (butane) consumption is converted to kWh, 1 kg3 - 13.695 kWh; liquid fuels (diesel) consumption is converted to kWh, 1 lt - 10.96 kWh and solid fuels (coal) consumption is converted to kWh, 1 kg - 7.25 kWh. These values are taken from the Alliance for Sustainability Leadership in Education (http://www.eauc.org.uk/file_uploads/ucccfs_unit_converter_v1_3_1.xlsx)

[3] Average energy prices used in this research are provided by Curtis et al. (2020).

Nº of equivalent adults by HH	1,68	0,57	1,00	4,60
HH Income	30552,05	22368,21	-32331,00	296305,00
Income per Adult Equivalent	18246,44	11910,05	-32331,00	205071,10
Number Rooms	4,72	1,11	1,00	6,00
RUC subsidy	0,08	0,27	0,00	1,00

Table 2a.- Summary House Budget Survey, Ireland

Variable	Mean	Std. Dev.	Min	Max
Nº of members by HH	2,73	1,48	1,00	13,00
Nº of equivalent adults by HH	1,75	0,62	1,00	6,00
Age of head of HH[4]	5,19	1,60	2,00	8,00
HH expenditure	43369,45	30220,72	1373,32	445793,40
Expenditure per Equivalent Adult	24628,64	16255,60	1373,32	391922,50
HH Income	46226,67	51668,49	0,00	864320,60
Income per Adult Equivalent	25637,86	27050,98	0,00	345728,30
HH Energy Expenditure	1993,39	1403,54	0,00	42982,16
Energy Expenditure per Equivalent Adult	1209,40	906,17	0,00	22358,44
HH Energy Consumption	17807,25	16744,40	0,00	562503,50
Energy Consumption per Equivalent Adult	10896,91	11176,81	0,00	321138,90
HH Energy Expenditure to Income Ratio	0,09	0,14	0,00	1,00
kWh/m2	259,62	88,21	46,18	602,80

Table 2b.- Summary EU-SILC, Ireland - 2021

Variable	Mean	Std. Dev.	Min	Max
Nº of members by HH	2,60	1,47	1,00	11,00
Nº of equivalent adults by HH	1,70	0,63	1,00	5,10
HH Income	54056,22	42418,57	0,00	1172000,00
Income per Adult Equivalent	31076,32	21156,83	0,00	586000,00
Number Rooms	5,15	1,05	1,00	6,00
RUC subsidy	0,34	0,47	0,00	1,00

2.2 Methods

2.2.1 Measurement

We analyse three different metrics for fuel poverty. The first two have been used extensively in the literature. First, we use the "10%" metric. This indicator classifies a household is in fuel poverty if the ratio of energy expenditure (EE) to income (I) is more than 10% (see Boardman, 1991).

10%: $EE/I > 10\%$

[4] In Ireland, the value of the variable referring to the age of the head of household is given by age groups. Group 5 refers to the age group between 45 and 54 years. Group 2 goes from 15 to 24 years of age, and group 8 refers to those over 75 years of age.

The second indicator is the Low Income High Cost (LIHC); a household is in fuel poverty if the energy expenditure is greater than the national median energy expenditure and their income is below 60% of the median income.

LIHC: $EE > Median(EE)\ \&\ I < 0.6 * Median(I)$

Finally, we use an indicator of Hidden energy poverty (HEP) or M/2: a household is in fuel poverty if energy expenditure is less than half of the national median energy expenditure. This indicator makes it possible to distinguish those households that prioritize other necessities, i.e., food expenditure, over energy consumption. It responds to the well-known "eating or heating" effect (Bhattacharya et al. 2003).

HEP: $EE < Median(EE)/2$

Once we have determined whether a household is in fuel poverty according to each of the above indicators, we rank the households by their consumption and assign the decile to which each household belongs. This classification is going to allow us to adjust both the probability of being at the bottom of the consumption distribution of energy as well as the determinants of energy consumption. The two methods are explained in the next subsection.

2.2.2 Estimation Methods

Since we like to identify the factors characterizing the probability of observing a household in poverty as well as their energy consumption, we are going to use discrete choice and linear regression models. First, to identify the determinants of the probability of belonging to specific parts of the consumption distribution of energy, in this case to the first quantile, we postulate a reduced form based on a logistic regression. We use the following specification:

$$y_i^* = \delta' Z_i + \varepsilon_i \qquad (1)$$

where y_i^* is the latent index and Z_i is a set of controls, including building-specific variables and household characteristics, δ is a set of parameters to be estimated, and ε_i is the error term assuming to follow a logistic distribution (Greene, 2003). The expected value of the observed variable measures the probability that the household lies in the first quantile of the energy consumption distribution, which for the logistic model is expressed as follows:

$$\Pr\,(y_i = 1\,|Z_i) = \frac{exp(\delta' Z_i)}{1 + exp(\delta' Z_i)}$$

On the other hand, energy consumption is a continuous variable for which we can use linear regression models. However, we feel that the value of energy consumption to identify the factors contributing to energy poverty is better characterized at other moments of the distribution different from the mean. Since we are interested in the sample of households lying below certain values of energy consumption as previously stated in the different indicators, we assume a quantile regression model, $Quant_\theta\,(Y_i|X_i) = X_i\beta_\theta$, adopting the following specification that mimics a linear regression estimated with respect to the expected value:

$$Y_i = X_i\beta_\theta + u_i \qquad (2)$$

where Y_i is energy consumption of household *i*; X_i represents the matrix of explanatory variables, which could share variables with Z_i; β_θ is the parameter vector corresponding to the quantile θ; and

u_i is the random disturbance. Since we are estimating the previous specification in cross-sections, we assume it corresponds to a reduced form and, consequently, X_i are strictly exogenous variables. In these circumstances, the only assumption we need to get consistent estimates of β_θ is $Quant_\theta(u_i|x_i) = 0$. The quantile regression method (Koenker & Basset, 1978), provides some advantages under certain conditions, constituting an alternative to OLS either due to the characteristics of the dependent variable or because the behaviour of the households could be different at different points of the distribution of the dependent variable, i.e., the expected value of the dependent variable conditional on the explanatory variables is not representative (see, for instance, Arellano, 2017 or Chasco-Yrigoyen & Sánchez-Reyes 2012).

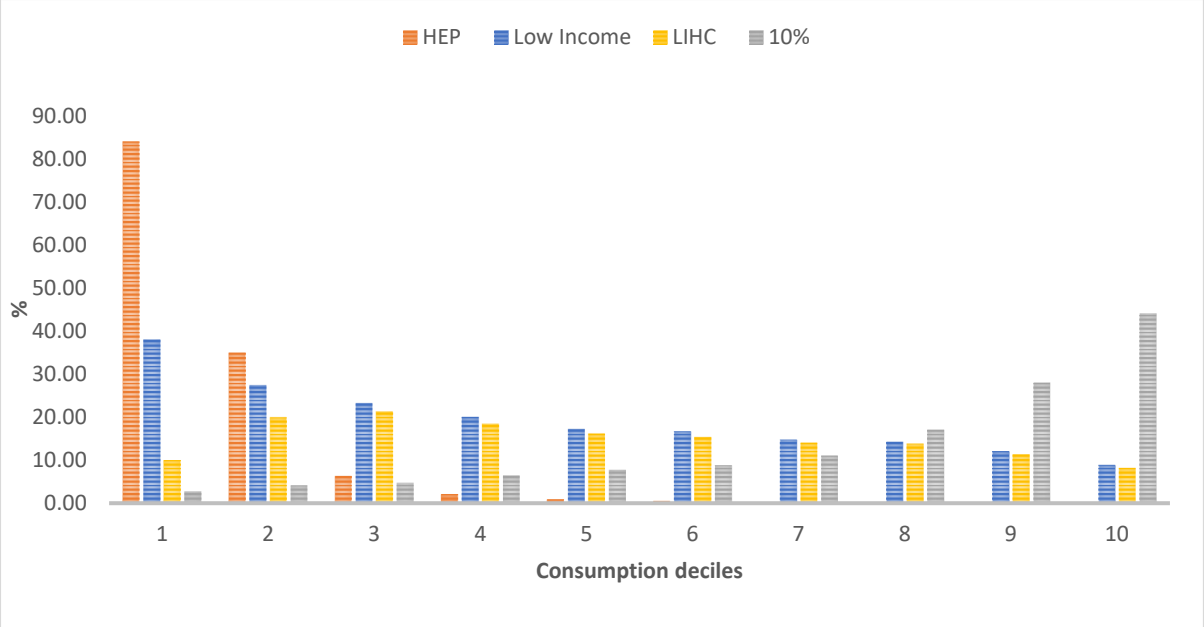
The adjustment of the discrete choice models assumes that the probability of observing a household in the first quantile of the distribution of energy consumption, which we assume without loss of generality takes a value of 1, can be explained by a full set of socio-demographic variables included in Z_i. The estimation of quantile and inter quantile regressions uses energy consumption per equivalent adult as the dependent variable. Since equations (1) and (2) are considered reduced forms, we use a wide range of explanatory variables in Z_i and X_i, including the number of household members, the age of the head of household, the sex of the head of household, the type of household, the education of the head of household (low, medium and high), whether any member of the household works if all of them are unemployed, the type of ownership of the household (owner, rent, and rent-free), the type of house (apartment or flat, detached and semi-detached), the environment of the house (urban or rural), the size of the house (small, medium and large) and the energy efficiency.

3 Results

3.1 Measurement

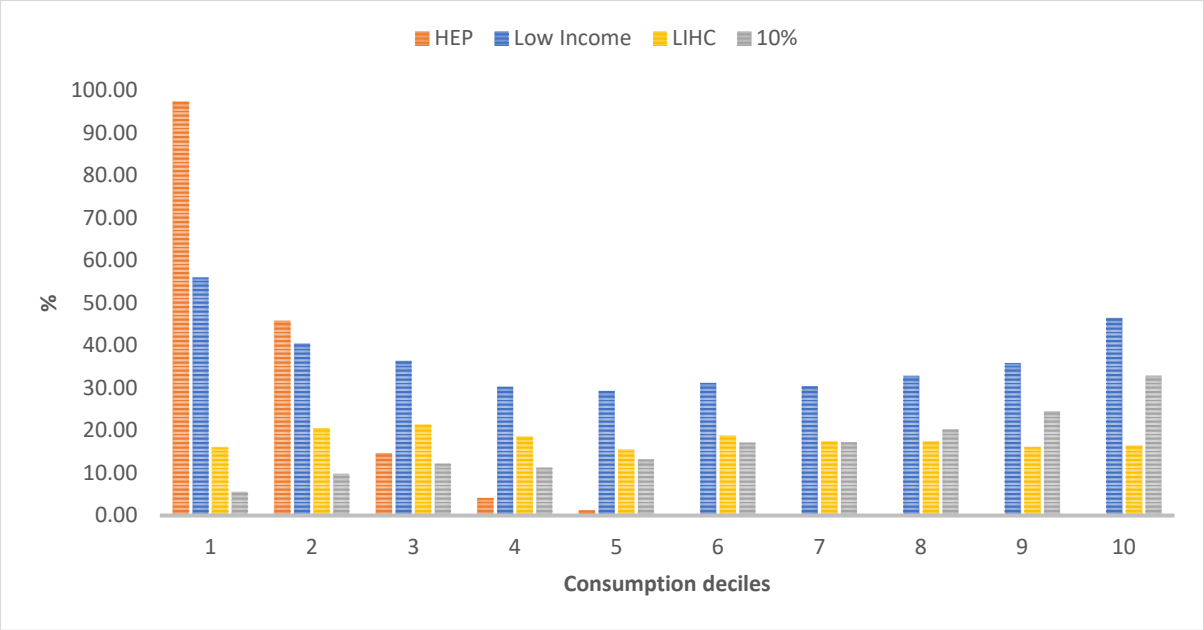
Figure 1 shows the distribution by household consumption deciles according to the following indicators: HEP, Low Income, 10% indicator and LIHC for Spain. The average share of HEP households is 12.6%, the number of low-income households is 19.1%, the number of households in poverty with the 10% indicator is less than fourteen percent (13.9%), and finally the share of LIHC households is 14,8%.
The decile distribution indicates that households in HEP are mainly placed in the bottom two deciles, while in the 10% indicator, they are placed in the top deciles. Therefore, as we have previously mentioned, these expenditure-based metrics are picking up an insufficient number of households in the first deciles compared to the HEP indicator.

Fig. 1. Efficacy of expenditure-based metrics to quantify underconsumption levels in Spain



In the case of Ireland, the shape of Figure 2 is similar to Spain, with HEP at 14.9%, the proportion of low-income households is 37.2%, the share of households in poverty with the 10% indicator is 17.3%, and the proportion of LIHC households is 17,7%. Again, these expenditure-based indicators are showing an insufficient number of households in the first decile compared to the HEP indicator.

Fig. 2. Efficacy of expenditure-based metrics to quantify underconsumption levels in Ireland



The next indicator is subjective. It gives the percent of households, and it is calculated from the EU-SILC. It is an indicator of the inability to keep the home at an adequate temperature. This can be interpreted as an indicator of living with low energy consumption levels.

Fig. 3. Inability to keep home adequately warm[5].

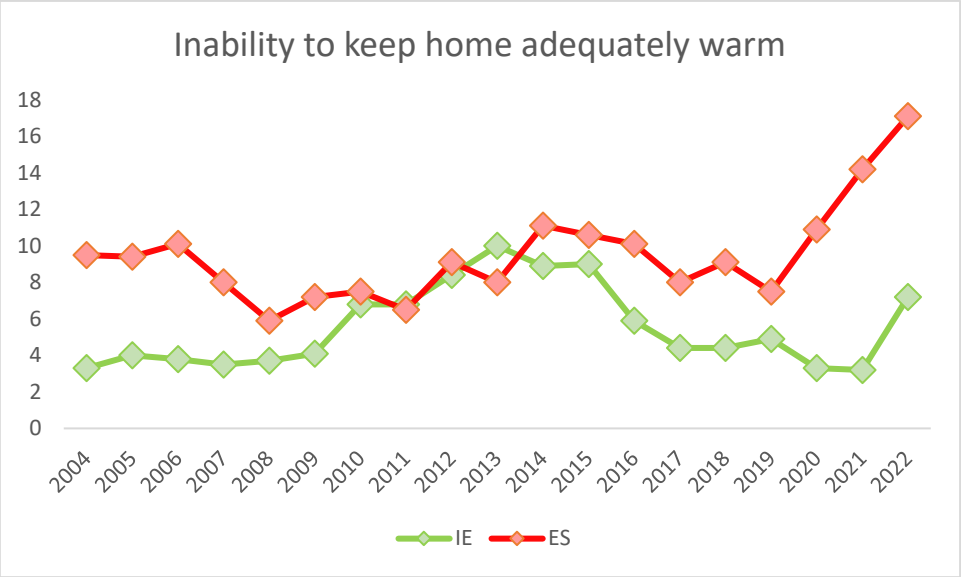


Fig. 3 shows the behavior of the inability to keep home adequately warm indicator, for all years between 2004 and 2022. In Spain, the indicator has shot up over the last 3 years by more than 10%, reaching 17% by the end of the period. In the Irish case, after several years below 5%, it has risen to 7% in the last year. The pandemic affected Spanish households because strict lockdown happened at the end of the winter and an unexpectedly cold early spring strongly increased the average share of housing energy. The energy price shocks caused by the recovery of the supply chain and other sources affected the subjective probabilities, both in Ireland and Spain.

3.2 Low energy consumption levels

In this section, we analyse the factors characterizing households being at the bottom quantile of the consumption distribution of energy as well as the drivers of the consumption of households in the first and third quartiles of the consumption distribution. In the first analysis the dependent variable is an index (binary variable) and, in the second analysis the dependent variable is household energy consumption by equivalent adult, positive coefficients imply that consumption tend to go to the upper bound of consumption level.

3.2.1 What does characterize low consumption levels? Discrete choice approach

We estimate model (1) under the following observability rule:

$$y_i^* = \begin{cases} 1 \; if \; \delta' Z_i > \varepsilon_i \\ 0 \; otherwise \end{cases}$$

In such a way such that $1\left(\delta' Z_i > \varepsilon_i\right)$ indicates that the household is observed at the bottom quantile of the energy consumption. We provide odd ratios and marginal effects in Tables 3 and 4. A number

5 The data used for this graph comes from: https://indicator.energypoverty.eu/

higher than one for an odd ratio indicates that this variable increases the probability that the household will be in the first quantile of consumption, whereas the opposite holds for values that are less than one. Marginal effects inform us about the change in the probability corresponding to a one percent increase in the explanatory variable when it is continuous, and the change from one regime to the alternative in the case of a discrete 0-1 dependent variable. Since the baseline corresponds to 0, the marginal effect measures the effect of a household getting the corresponding attribute.

The results for Spain show that renters are twice as likely to have low consumption levels than owners, and unemployed households are 1,47 times more likely to be in this condition than employed households. The probability of being at the bottom quantile of energy consumption increases 12.6% in the case of renters with respect to owners. When the head of the household is unemployed, the probability of low energy consumption increases 5.72% compared to an employed head. Living in single-family dwellings also contributes to an increase in the likelihood of extreme low consumption (3%). An additional member of the households reduces the probability of being at the bottom quantile of the energy consumption distribution (3,87%), in many cases because of the contribution to household income of additional members. Both the age and gender of the head show positive marginal effects. For individuals aged 65 or over there is a reduction of 4,30 %. This effect could be due to the updating of pensions according to inflation while real wages were devaluated. Marital status also affects the probability of being at the bottom of the energy consumption distribution, with married couples without and with 1 or 2 children showing up to 11% less probability. Households in which the head has a higher level of education (4%), the size of the dwelling (11%), and living in a rural area (1,67%), are also relevant attributes reducing the probability of being at the bottom of the energy consumption distribution.

In the Irish case, only unemployment (9,86%), rent-free (9,41%), and low energy efficiency (0,03%) increase the probability of a household being in Quantile 1 consumption. Number of members (1,27%), age of the head (3,81%), sex (3,09%), married couple only or with children (8%), education (3,5%), single-family dwellings (23%) and large dwellings (21%) push the probability in the opposite direction.

Table 3.- Logistic Regression. Dependent variable: Household consumption in Q1, Spain

Logistic regression - Consumption HH Q1	Coef.	St.Err.	Sig	Marginal effects
Number of members	0,771	0,024	***	-3,87%
Age of the household	0,986	0,002	***	-0,21%
Sex (0-Male, 1-Female)	0,927	0,038	*	-1,12%
Household_type: (Base 1 adult)	1,000	,		
Adult aged 65 and over	0,789	0,065	***	-4,30%
Married couple only	0,513	0,036	***	-11,03%
Married couple with 1 child	0,491	0,048	***	-11,62%
Married couple with 2 children	0,482	0,058	***	-11,88%
Married couple with 3 children	0,799	0,15		-4,09%
Single adult with children	0,715	0,086	***	-5,98%
All other households	0,568	0,053	***	-9,56%
Education (base Low)	1,000	,		
Medium	0,758	0,034	***	-4,18%
High	0,629	0,033	***	-6,68%

Unemployment	1,468	0,071	***	5,72%
Type of property (base Owned)	1,000	,		
Rented	2,061	0,102	***	12,09%
Rent-free	2,454	0,165	***	15,58%
Type of building (base Apartment/Flat)	1,000	,		
House detached	1,291	0,09	***	3,80%
House semi-detached	1,495	0,071	***	6,20%
Area (base Urban)	1,000	,		
Rural	0,893	0,046	**	-1,65%
Energy efficiency (kWh/m2)	0,996	0	***	-0,06%
Dwelling Size: (Base Small)	1,000	,		
Medium	0,533	0,033	***	-11,11%
Large	0,260	0,0	***	-20,14%
Constant	6,550	0,98	***	

Note:. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table 4.- Logistic Regression. Dependent variable: Household consumption in Q1, Ireland

Logistic regression - Consumption HH Q1	Coef.	St.Err.	Sig	Marginal effects
Number of members	0,921	0,039	*	-1,27%
Age of the household	0,781	0,026	***	-3,81%
Sex (0-Male, 1-Female)	0,818	0,058	***	-3,09%
Household_type: (Base 1 adult)	1,000	,		
Adult aged 65 and over	0,838	0,122		-3,17%
Married couple only	0,444	0,059	***	-12,70%
Married couple with 1 child	0,621	0,122	**	-8,03%
Married couple with 2 children	0,472	0,095	***	-11,90%
Married couple with 3 children	0,552	0,140	**	-9,76%
Married couple with 4 children	0,345	0,137	***	-15,67%
Single adult with children	0,973	0,174		-0,51%
All other households	0,799	0,114		-3,99%
Education (base Low)	1,000	,		
Medium	0,803	0,086	**	-3,59%
High	0,665	0,083	***	-6,40%
Unemployment	1,896	0,159	***	9,86%
Type of property (base Owned)	1,000	,		
Rented	1,110	0,111		1,63%
Rent-free	1,731	0,446	**	9,41%
Type of building (base Apartment/Flat)	1,000	,		
House detached	0,198	0,092	***	-31,02%
House semi-detached	0,313	0,143	**	-23,98%
Apartment/Flat	1,083	0,491		1,83%

Area (base Urban)	1,000	,		
Rural	1,189	0,127		2,70%
Energy efficiency (kWh/m2)	1,002	0,000	***	0,03%
Dwelling Size: (Base Small)	1,000	,		
Medium	0,928	0,229		-1,48%
Large	0,500	0,118	***	-12,40%
Constant	7,369	3,760	***	
Note:. ∗p < 0.1, ∗∗p < 0.05, ∗∗∗p < 0.01.				

3.2.1 Quantile regression analysis

Tables 5 and 6 display the coefficients from our quantile regression for Q1 and Q3 quantiles, and the difference between these estimates (Q3-Q1). The column Q1 shows the results for the quantile regression for the Quantile 1, the column Q3 shows the results for the quantile regression for quantile Q3, and finally, the last column displays their difference Q3-Q1.
The factors that show the increase in consumption are the age of the household head, level of education, rural location, and house size. Factors that tend to decrease consumption are the number of members, unemployment, the house being rented or rent-free, and single-family houses. By rent-free houses, we are considering all other forms of having a home for which no rent is paid; social housing, squats, shacks, settlements, etc. These results coincide with claims in which it is indicated that in Spain the main people affected are the elderly living alone, unemployed families, and those living in precarious conditions or in settlements[6](Médicos del Mundo, 2021).

Regarding energy efficiency, Table 5 shows that having low energy efficiency (e.g., higher kWh/m2), increases the consumption per equivalent adult, and it has a stronger effect at higher consumption levels. However, the magnitude is very small, representing only an increase in energy expenditure around 0,1% and 0,33% per household in Q1 and Q3 respectively, with respect to average consumption of the population. Those families living in rented houses in Q1 spend 456 € per year and equivalent adult less than households in the base situation and 854 € less per year and adult equivalent when they are in a rent-free situation. This amount of energy expenditure per adult equivalent is 9,6% and 18% less than the average energy consumption of Spanish households. The relative reduction in energy expenditure with respect to respect to the average consumption of representative Spanish households are 14,5% and 25,2% if they are in the third quantile of the energy consumption.

Another interesting result is that while households living in detached or semi-detached houses spend in energy a significantly lower amount than households living in flats or apartments if they are at the bottom of the energy consumption distribution, the reverse is true in Q3. Since the size of the house positively affects energy consumption unconditionally to the regression results in Q1 or Q3, this factor could reveal hidden energy poverty. Finally, the location of the house (ruralnon-rural) plays a big difference in the regression results in Q1 and Q3. Houses in rural areas are not normally well-equipped for heating (and/or cooling), but while households in Q3 spent a significantly higher amount of energy (47% more than the average baseline household), households in Q1 only spent 2% more than the average baseline household).

[6] https://www.medicosdelmundo.org/actualidad-y-publicaciones/noticias/medicos-del-mundo-alerta-del-drama-sanitario-que-provoca-la

Table 5.- Quantile Regression for Consumption per Equivalent Adult, Spain

Quantile regression – Consumption per Adult Equivalent	**Q1**	**St.Err.**	**Sig**	**Q3**	**St.Err.**	**Sig**	**Q3-Q1**	**St.Err.**	**Sig**
Number of members	-132,7	16,7	***	-360,5	38,1	***	-227,7	32,0	***
Age of the household	11,9	1,2	***	40,3	4,3	***	28,5	4,6	***
Sex (0-Male, 1-Female)	35,4	26,0		190,4	103,0	*	155,1	90,2	*
Household_type: (Base 1 adult)									
Adult aged 65 and over	164,9	80,5	**	1071,2	311,5	***	906,3	383,9	**
Married couple only	191,6	49,9	***	284,7	171,9	*	93,1	195,1	
Married couple with 1 child	217,9	69,6	***	237,7	185,1		19,8	195,0	
Married couple with 2 children	175,3	77,0	**	225,1	228,1		49,9	190,5	
Married couple with 3 children	194,2	123,9		-4,3	310,9		-198,5	262,9	
Single adult with children	47,2	79,4		-51,9	300,8		-99,1	203,1	
All other households	-12,1	70,5		-512,8	226,0	**	-500,8	224,2	**
Education (base Low)									
Medium	183,8	21,3	***	505,8	114,0	***	322,0	82,8	***
High	394,2	36,2	***	782,2	111,6	***	388,0	84,2	***
Unemployed	-303,7	39,6	***	-646,9	107,9	***	-343,2	121,0	***
Type of property (base Owned)									
Rented	-456,1	33,7	***	-690,8	89,1	***	-234,7	82,2	***
Rent-free	-853,9	60,6	***	-1195,1	148,0	***	-341,2	172,4	**
Type of building (base Apartment/Flat)									
House detached	-76,3	37,6	**	3064,0	317,1	***	3140,2	389,2	***
House semi-detached	-309,1	33,5	***	249,2	130,1	*	558,4	117,6	***
Area (base Urban)									
Rural	97,3	36,9	***	2249,4	267,7	***	2152,1	232,4	***
Energy efficiency (kWh/m2)	4,4	0,4	***	26,1	0,8	***	21,8	1,0	***
Dwelling Size (base Small)									
Medium	439,6	47,8	***	1084,3	149,9	***	644,7	114,3	***
Large	1169,0	84,0	***	4122,2	239,2	***	2953,2	340,9	***
Constant	148,9	115,2		-2579,7	247,9	***	-2728,6	169,6	***

Note:. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

In the case of Ireland, consumption increases with the age of the head of the household, the level of education, and living in single-family houses. Number of members, unemployment of household head, rent-free and energy efficiency drives down consumption. It is very important to note here how energy efficiency in households implies lower consumption. The higher the energy efficiency, the lower the consumption for households at Q1 but not at Q3, and with a magnitude of reduction very small.

Table 6.- Quantile Regression for Consumption per Equivalent Adult, Ireland

Quantile regression – Consumption per Adult Equivalent	Q1	St.Err.	Sig	Q3	St.Err.	Sig	Q3-Q1	St.Err.	Sig
Number of members	-595,05	87,32	***	-1392,4	140,15	***	-797,4	141,76	***
Age of the household	569,58	80,6	***	942,74	125,54	***	373,2	91,87	***
Sex (0-Male, 1-Female)	412,87	177,78	**	409,39	238,8	*	-3,5	241,69	
Household_type: (Base 1 adult)									
Adult aged 65 and over	1141,24	471,53	**	930,26	891,66		-211,0	689,53	
Married couple only	1387,41	225,42	***	-685,94	730,14		-2073,4	431,89	***
Married couple with 1 child	430,77	370,88		-2137,2	877,54	**	-2568,0	616,3	***
Married couple with 2 children	167,57	390		-2065,3	758,14	***	-2232,9	707,63	***
Married couple with 3 children	-270,62	482,06		-1985,6	967,23	**	-1715,0	789,96	**
Married couple with 4 children	1049,1	680,87		-569,13	1080,2		-1618,2	748,45	**
Single adult with children	-908,77	484,08	*	-2021,7	952,75	**	-1112,9	885,91	
All other households	-568,04	318,56	*	-3082,8	832,45	***	-2514,8	602,8	***
Education (base Low)									
Medium	742,56	311,03	**	488,25	469,95		-254,3	358,4	
High	1190,45	343,13	***	1054,97	400,73	***	-135,5	462,13	
Unemployed	-1433,2	173,44	***	-1203	239,48	***	230,2	341,01	
Type of property (base Owned)									
Rented	65,97	198,8		42,31	338,4		-23,7	366,65	
Rent-free	-1606	680,57	**	-125,68	1183,8		1480,3	837,62	*
Type of building (base 0: Other)									
House detached	3910,59	908,41	***	4771,64	3155		861,1	3123,6	
House semi-detached	2693,25	857,83	***	3131,76	3008,7		438,5	3193,5	
Apartment/Flat	706,92	840,16		-997,67	2811,5		-1704,6	3151,2	
Area (base Urban)									
Rural	56,23	338,32		249,82	456,12		193,6	330,05	
Energy efficiency (kWh/m2)	-5,48	0,78	***	-2,76	1,83		2,7	1,47	*
Dwelling Size: (Base Small)									
Medium	526,19	374,52		1474,19	973,14		948,0	880,27	
Large	1714,93	408,37	***	3627,62	1103,1	***	1912,7	1167,6	
Constant	612,81	991,54		7815,58	2743,9	***	7202,8	2833,8	**

Note:. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

For Ireland, we can also see that for the quantile 3, equivalent consumption reduces as the number of members in the household increases. Table 6 shows that being unemployed has a stronger effect at low levels of consumption (e.g., Q1). Therefore, being in this condition will drive low consumption levels to their low bound faster than in higher consumption levels. We can also see that low energy efficiency levels have the same effect, but the magnitude is very limited and only significant in Q1. Unlike the Spanish case, these findings indicate that in Ireland, households with low energy efficiency levels tend to reduce their consumption. More research is needed to investigate whether the differences in behavior can be attributed to factors like the fact that in Spain energy for both cooling and heating is needed.

In Ireland, the differences in energy expenditure in detached and semi-detached houses are really relevant in both parts of the energy expenditure distribution and, contrary to Spain, households living

in this kind of house both in Q1 and Q3 spend more than average on energy. In the case of dwelling size, only those living in large households spend significantly more than average. This variable shows differences in the results at quantile 1 (15,8% more expenses than average baseline household) and quantile 3 (33,3%).

3.3 Targeting of fuel poverty

In this section, we use the SILC data to analyse the drivers of receiving social assistance for high energy prices. This variable collects information if the household has its utility cost reduced or fully covered by the central/local government of Non-Profit Institutions Serving Households (NPISHs). The reduction could be for one item (e.g. electricity) or all of them[1] (European Commission, 2022c). This variable is named Reduced Utility Cost (RUC) in the SILC data. Regarding energy subsidies, in Ireland the main policy instrument to help vulnerable households face the cost of energy is called fuel allowance. In Spain, there is a social bonus for electricity that is in practice a discount on the electricity bill. In Ireland, it is a means-tested social transfer, whereas in Spain there is a mix of criteria that includes having a large family regardless of income level[7].

- **3.3.1 Probability to being a recipient.**

Tables 7 and 8 display which variables determinate being a recipient of this government aid. The dependent variable is whether the household receives the RUC subsidy, the values in the column Coef. are odd-ratios. In Spain, the highest coefficient corresponds to that of large families, remembering that the mere fact of being a large family entitles one to the social bonus. Other values with odd-ratios higher than 1 and significant are single-family houses, households with problems that face unexpected financial expenses and those with difficulties to make ends meet.

Table 7.- Logistic Regression a HH with RUC, Spain (Logistic regression, odd ratios).

HH with RUC subsidy	Coef.	St.Err.	Sig
House: base Detached house	1	,	
Semi-detached house	1,22	0,11	**
Apartment or flat in a building with <10 dwellings	0,94	0,09	
Apartment or flat in a building with >=10 dwellings	0,93	0,07	
No Capacity to face unexpected financial expenses	1,86	0,12	***
Inability to make ends meet	1,57	0,11	***
Owner	0,89	0,02	***
Number of rooms	1,07	0,03	**
Household: base One person household	1	,	
2 adults, no dependent children, both adults under 65 years	0,43	0,05	***
2 adults, no dependent children, at least one adult >=65 years	0,78	0,07	***
Other households without dependent children	0,63	0,08	***

[7] More information https://www.bonosocial.gob.es/ and https://www.cnmc.es/bono-social. At the time of high price shocks in electricity markets and after the invasion of Ukraine, the Spanish government adopted other measures such as the reduction of Value Added Tax rates for electricity. Contrary to other EU countries both heating and cooling are based on electricity services.

Single parent household, one or more dependent children	1,63	0,17	***
2 adults, one dependent child	0,6	0,07	***
2 adults, two dependent children	0,73	0,08	***
2 adults, three or more dependent children	11,3	1,21	***
Other households with dependent children	1,64	0,2	***
Other (these household are excluded from Laeken indicators calculation)	0,89	0,92	
log_rent	0,65	0,02	***
Constant	3,73	1,27	***

In Ireland, the highest coefficient corresponds to the household with a person >= 65 years old. Other values with odd-ratios higher than 1 and significant are households with problems when facing unexpected financial expenses and those with difficulties to make ends meet.

Table 8.- Logistic Regression a HH with RUC subsidy, Ireland (Logistic regression, odd ratios).

HH with RUC subsidy	Coef.	St.Err.	Sig
House: base Detached house	1	,	
Semi-detached house	1,05	0,09	
Apartment or flat in a building with <10 dwellings	0,63	0,2	
Apartment or flat in a building with >=10 dwellings	0,69	0,23	
No Capacity to face unexpected financial expenses	2,07	0,22	***
Inability to make ends meet	1,23	0,16	
Owner	0,94	0,04	
Number of rooms	0,94	0,05	
Household: base One person household	1	,	
2 adults, no dependent children, both adults under 65 years	0,29	0,05	***
2 adults, no dependent children, at least one adult >=65 years	4,57	0,54	***
Other households without dependent children	1,94	0,34	***
Single parent household, one or more dependent children	0,67	0,12	**
2 adults, one dependent child	0,29	0,07	***
2 adults, two dependent children	0,29	0,06	***
2 adults, three or more dependent children	0,29	0,07	***
Other households with dependent children	0,95	0,22	
Other (these household are excluded from Laeken indicators calculation)	1	,	
log_rent	0,2	0,02	***
Constant	16748156	16257592	***

- **3.3.1 Targeting efficacy.**

Tables 9 and 11 display the differences in socioeconomic and dwelling characteristics between recipients of government aid and the rest of the sample for Spain and Ireland. For Spain, Table 9 shows that the RUC subsidy reaches around 16% of the households in fuel poverty. Most of these households are owners of the dwelling and have no dependent children. They also report having issues in making the ends meet. Reaching 16% of households in fuel poverty can be the result of the policy design that includes large families who are entitled to the Bono Social regardless of their income level. Thus, we find that 9.75% of the households that receive the Bono Social are large families whose income level is from decile 6 to 10 (see Table 11). This confirms that this policy does not fully target low-income households.

Table 9. Difference in means of fuel poor and non fuel poor. Spanish Households

	Mean			t-test	
Variable	**Fuel poor**	**Rest**	**%bias**	**t**	**p>|t|**
HH with RUC subsidy	0,15866	0,06609	29,6	17,85	0
Semi-detached house	0,15941	0,16922	-2,6	-1,36	0,173
Apartment or flat in a building with <10 dwellings	0,23264	0,18063	12,9	6,9	0
Apartment or flat in a building with >=10 dwellings	0,46054	0,48402	-4,7	-2,44	0,015
No Capacity to face unexpected financial expenses	0,77851	0,24865	125	64,08	0
Inability to make ends meet	0,56582	0,13246	102	61,35	0
Owner	2,1511	1,7814	32,3	17,57	0
Number of rooms	4,3817	4,8282	-38,8	-21,06	0
2 adults, no dependent children, both adults under 65 years	0,13101	0,13583	-1,4	-0,73	0,464
2 adults, no dependent children, at least one adult >=65 years	0,12724	0,16197	-9,9	-4,97	0
Other households without dependent children	0,09519	0,10615	-3,6	-1,86	0,063
Single parent household, one or more dependent children	0,0754	0,04528	12,7	7,2	0
2 adults, one dependent child	0,09299	0,10839	-5,1	-2,6	0,009
2 adults, two dependent children	0,0666	0,13947	-24,1	-11,35	0
2 adults, three or more dependent children	0,03299	0,02749	3,2	1,72	0,085
Other households with dependent children	0,05027	0,04471	2,6	1,38	0,166
Other (these household are excluded from Laeken indicators calculation)	0,00063	0,0009	-1	-0,48	0,632
log_rent	9,6465	10,184	-67,1	-35,1	0

Table 10.- Distribution of HH receiving RUC subsidies by income deciles according to household type - Spain

Decil Income	HH RUC subsidy	One person HH	2 adults, no dependent children, both adults under 65 years	2 adults, no dependent children, at least one adult >=65 years	Other households without dependent children	Single parent household, one or more dependent children	2 adults, one dependent child	2 adults, two dependent children	2 adults, three or more dependent children	Other households with dependent children
						%				
1	320521,7	35,59	9,9	5,74	2,61	13,42	8,11	6,4	13,54	4,7
2	327610,3	35,52	4,75	18,89	6,52	8,1	8,46	4,08	10,25	3,42
3	313951,3	58,16	4,13	7,91	4,63	5,08	2,82	4,65	7,73	4,89
4	167064	27,2	7,91	14,54	13,64	5,6	7,69	5,02	10,25	8,15
5	113021	12,7	3,76	18,49	9,26	6,51	5,92	6,35	17,01	20
6	99460,9	11,74	7,53	14,03	10,37	5,16	4,01	6,6	20,3	20,27
7	74189,3	2,83	0,8	10,37	16,68	5,42	5,91	10,71	36,66	10,61
8	45989,5	14,1	5,02	18,37	8,01	1,22	6,58	2,4	25,11	19,18
9	45592,3	3,29	0,00	2,59	6,72	6,13	0,00	22,04	46,76	12,48
10	38960	2,58	1,78	2,35	0,00	0,89	11,86	8,76	64,15	7,63
TOTAL	**1546360,2**	**32,05**	**5,74**	**11,8**	**6,91**	**7,44**	**6,35**	**6,02**	**15,7**	**7,98**

Unlike Spain, In Ireland the aid reaches around 60% of the households in fuel poverty. Most of these households also report having financial issues when facing the cost of living.

Table 11. Difference in means of the recipients and non-recipients in Ireland.

	Mean			t-test	
Variable	**Fuel poor**	**Rest**	**%bias**	**t**	**p>|t|**
HH with RUC	0,57746	0,36437	43,6	5,19	0
Semi-detached house	0,57746	0,45412	24,8	2,91	0,004
Apartment or flat in a building with <10 dwellings	0,08451	0,02917	24	3,77	0
Apartment or flat in a building with >=10 dwellings	0,06338	0,04237	9,4	1,22	0,224
No Capacity to face unexpected financial expenses	0,80282	0,23044	139,5	15,98	0
Inability to make ends meet	0,62676	0,10332	129,2	19,75	0
Owner	2,493	1,7519	64	8,47	0
Number of rooms	4,9802	5,3514	-35,7	-4,43	0

2 adults, no dependent children, both adults under 65 years	0,11268	0,10459	2,6	0,31	0,757
2 adults, no dependent children, at least one adult >=65 years	0,07042	0,1892	-35,9	-3,59	0
Other households without dependent children	0,04225	0,07419	-13,7	-1,44	0,15
Single parent household, one or more dependent children	0,12676	0,04698	28,5	4,33	0
2 adults, one dependent child	0,07746	0,06611	4,4	0,53	0,593
2 adults, two dependent children	0,05634	0,11033	-19,6	-2,04	0,042
2 adults, three or more dependent children	0,0493	0,08099	-12,9	-1,37	0,17
Other households with dependent children	0,02113	0,04953	-15,4	-1,55	0,121
Other (these household are excluded from Laeken indicators calculation)	0	0,00021	-2,1	-0,17	0,862
log_rent	10,134	10,706	-76,4	-9,67	0

Table 12 shows that the majority that receive the aid is one person household. The second largest group is 2 adults with a member in retirement age and no children. This is due to the policy design in which these household types are particularly targeted.

Table 12.- Distribution of HH receiving RUC subsidy by income deciles according to household type - Ireland

HH Decil Income	HH RUC subsidy	One person HH	2 adults, no dependent children, both adults under 65 years	2 adults, no dependent children, at least one adult >=65 years	Other households without dependent children	Single parent household, one or more dependent children	2 adults, one dependent child	2 adults, two dependent children	2 adults, three or more dependent children	Other households with dependent children
					%					
1	159147,7	73,2	3,38	5,24	0,51	11,02	1,32	1,54	3,14	0,65
2	148719,2	54,93	5,01	21,05	2,78	7,27	2,39	3,92	2,52	0,12
3	86621,3	21,34	6,00	29,37	3,38	16,47	9,69	5,30	2,23	6,22
4	66899,2	28,96	4,61	30,02	6,82	17,92	2,21	0,30	1,89	7,26
5	66287,1	27,2	4,52	31,58	6,00	9,01	3,79	6,75	4,96	6,19
6	39043,6	32,18	4,72	41,63	16,3	2,37	0,00	0,79	0,62	1,39
7	27448,5	29,48	3,72	35,11	14,85	0,00	0,00	7,01	1,29	8,54
8	22030,8	26,44	6,62	38,14	15,98	4,72	0,00	0,72	0,00	7,38
9	17519,8	41,55	1,10	40,08	11,83	0,00	0,89	0,00	0,00	4,54
10	17301,7	41,92	0,00	47,06	5,01	0,00	3,25	1,20	0,00	1,55
TOTAL	**651018,8**	**45,33**	**4,4**	**23,89**	**5,12**	**9,61**	**2,88**	**3,09**	**2,43**	**3,25**

3. Discussions and conclusions

In this article, we show that the official metrics used in Spain to quantify hidden poverty identify a higher number of vulnerable households with low consumption levels in fuel poverty than other expenditure-based metrics in Spain and Ireland. This is an important fact because hidden poverty is

still a topic that is not widely addressed in the academic or policy arena. The complexity of identifying hidden fuel poverty lies in the subtle and silent nature of its existence. Unlike other manifestations of deprivation, such as visible homelessness or extreme destitution, hidden fuel poverty does not present itself as an easily identifiable issue. Instead, it festers beneath the radar, making it challenging to identify and address through traditional means.

Our analysis using quantile regressions shows that energy efficiency has an important potential to drive low consumption levels in Ireland. We see that single households and unemployed households tend to be at risk of having extremely low levels of energy consumption. While social welfare policies to tackle income poverty could help, they will not solve the problem totally because it is a multidimensional issue. It also requires considering the promotion of energy efficiency technologies regarding financial and non-financial barriers and information campaigns on energy saving. The Spanish government (Ministerio para la Transición Ecológica, 2021) has launched the National Integrated Energy and Climate Plan (PNIEC) 2021-2030, which addresses among others the importance of energy efficiency to reduce household consumption. Ireland has recently launched its Action Plan to tackle fuel poverty (DECC,2022). A central strategy to tackle fuel poverty is the provision of free retrofits for low-income households.

Measurement of fuel poverty is a common problem in both countries. In Spain, hidden poverty measurement is considered in the national strategy. Regarding targeting, we found that in Ireland a larger proportion of households in fuel poverty are covered by government aid than in Spain. It is possible that the Spanish government may need to adjust its policy regarding who receives the RUC subsidy and make an extra effort to ensure that assistance is sought by those who need it most. Pillai et al. (2023) recently showed that Irish households that report struggling to cope with the cost of living and fuel poverty are not currently protected under current policies to tackle this condition because they do not qualify for help. In Ireland, our results show that government aid is quite good at targeting low-income households; however, there is still room for improvement in covering vulnerable households that are not currently covered. In particular, there is around 40% of households that report being in fuel poverty and that are uncovered by the aid.

Concerted efforts from society, policymakers, and relevant stakeholders are crucial in tackling hidden fuel poverty. Public awareness campaigns, improved data collection, and targeted resources for vulnerable populations are crucial steps in illuminating this hidden crisis. By shedding light on hidden fuel poverty, we can work towards developing effective policies, sustainable solutions, and support mechanisms to alleviate its deeply-rooted effects on susceptible households. Hidden fuel poverty perpetuates a distressing cycle of vulnerability and deprivation within society. It demands immediate attention and intervention to provide appropriate assistance, enhance living conditions, and protect those affected. By recognizing its existence, we can collectively strive towards a fairer and more equitable society where no one silently suffers the consequences of inadequate energy provision.

References

Arellano, M. (2017). Econometría de la desigualdad: de la persona promedio a la persona cuantil. In García, J., González-Páramo, J. M. & Matas, A. (eds.). Análisis empíricos sobre la economía española. Ensayos en homenaje a Josep Lluis Raymond Bara, Funcas, Thomson Reuters Aranzadi.

Bagnoli, L. y Bertoméu-Sánchez, S. (2022). How effective has the electricity social rate been in reducing energy poverty in Spain. Energy Economics, 106, 105792. https://doi.org/10.1016/j.eneco.2021.105792

Barrella, Roberto & Romero Mora, José Carlos & Linares, Jose & Arenas Pinilla, Eva & Asín, María & Centeno, Efraim. (2021). The dark side of energy poverty: Who is underconsuming in Spain and why?. Energy Research & Social Science. 86. 102428. 10.1016/j.erss.2021.102428.

Bednar, D.J. and Reames, T.G. (2020) Recognition of and response to energy poverty in the united states. Nature Energy 5, page 432–439. doi: https://doi.org/10.1038/ s41560-020-0582-0.

Boardman B (1991) Fuel poverty: from cold homes to affordable warmth. London: Pinter Pub Limited.

Boletín Oficial del Estado (BOE). (2016). Real Decreto-ley 7/2016, de 23 de diciembre, por el que se regula el mecanismo de financiación del coste del bono social y otras medidas de protección al consumidor vulnerable de energía eléctrica. https://www.boe.es/eli/es/rdl/2016/12/23/7

Bhattacharya J, DeLeire T, Haider S, Currie J. (2003). Heat or eat? Cold-weather shocks and nutrition in poor American families. American Journal of Public Health, 93(7):1149-54. doi: 10.2105/ajph.93.7.1149.

Charlier D., Legendre B., and Risch A. (2019). Fuel poverty in residential housing: providing financial support versus combatting substandard housing. Applied Economics, 51 (49):53695387. doi: 10.1080/00036846.2019.1613501. URL https://doi.org/10.583 1080/00036846.2019.1613501

Chasco-Yrigoyen, C., & Sánchez-Reyes, B. (2012). Externalidades ambientales y precio de la vivienda en Madrid: Un análisis con regresión cuantílica espacial. Revista Galega de Economía, 21(2), 277-296.

Cong, Shuchen & Nock, Destenie & Qiu, Yueming & Xing, Bo. (2021). The Energy Equity Gap: Unveiling Hidden Energy Poverty. 10.21203/rs.3.rs-712945/v1.

Curtis J., Tovar M., Grilli g. (2020). Access to and consumption of natural gas: Spatial and socio-demographic drivers, Energy Policy. Vol. 143,

DECC (2022). Energy Poverty Action Plan, Department of the Environment, Climate and Communications. https://www.gov.ie/en/publication/159cb-energy-poverty-action-plan/#

Eisfeld, Kristina & Seebauer, Sebastian. (2022). The energy austerity pitfall: Linking hidden energy poverty with self-restriction in household use in Austria. Energy Research & Social Science. 84. 102427. 10.1016/j.erss.2021.102427.

EPOV (2019). Addressing Energy Poverty in the European Union: State of Play and Action. URL: https://energy-poverty.ec.europa.eu/discover/practices-and-policies-toolkit/publications/epov-addressing-energy-poverty-european-union-state-play-and-action_en

European Commission. (2022c). Methodological guidelines and description of EU-SILC target variables. https://circabc.europa.eu/ui/group/853b48e6-a00f-4d22-87db-c40bafd0161d/library/de23ebb5-9f97-47ca-a46d-570bdebc6727/details. Accessed on 05/01/2023

European Commission. Energy poverty in the EU. (2022a). URL https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty_en. Accessed on 02/02/2022.

European Commission. EU energy poverty advisory hub. (2022b). URL https://energy-poverty.ec.europa.eu/index_en. Accessed on 02/02/2022.

García Alvarez, G. y Tol, R. S. J. (2021). The impact of the Bono Social de Electricidad on energy poverty in Spain. Energy Economics, 103, 105554. https://doi.org/10.1016/j.eneco.2021.105554

Greene, W. H. and Hensher, D. A. (2009). Modeling ordered choices: A Primer. Cambridge university press, Cambridge, UK. https://doi.org/10.1037/0021-9010.91.1.97

Hills J (2012) Getting the Measure of Fuel Poverty – Final Report of the Fuel Poverty Review. Centre for Analysis of Social Exclusion, CASE Report 72, London, UK.
Koenker, R. y Basset, G. (1978). Regression Quantiles. Econometrica, Vol.46, nº 1, pp. 33-50.

Médicos del Mundo. (2021). Médicos del mundo alerta del drama sanitario que provoca la pobreza energética. https://www.medicosdelmundo.org/actualidad-y-publicaciones/noticias/medicos-del-mundo-alerta-del-drama-sanitario-que-provoca-la. Accessed on 05/01/2023

Ministerio para la Transición Ecológica. (2019). Estrategia nacional contra la pobreza energética. https://www.miteco.gob.es/es/ministerio/planes-estrategias/estrategia-pobreza-energetica.html

Ministerio para la Transición Ecológica. (2021). Plan Nacional Integrado de Energía y Clima 2021-2030. https://www.miteco.gob.es/content/dam/miteco/es/cambio-climatico/planes-y-estrategias/pniec_eae_dea_tcm30-521885.pdf

Mohan, G. (2021). Young, poor, and sick: The public health threat of energy poverty for children in Ireland, Energy Research and Social Science, Vol 17, 101822

Navarro, C., Ayala, L. & Labeaga, J. M. Housing deprivation and health status: evidence from Spain. Empirical Economics, 38, 555-582

Simshauser P. (2021). Vulnerable households and fuel poverty: Measuring the efficiency of policy targeting in Queensland. Energy Economics, 101:105405. ISSN 0140-9883. doi:https:602 //doi.org/10.1016/j.eneco.2021.105405.

Tovar Reanos, M. A. and Muireann A. L. (2020). Are energy poverty metrics fit for purpose? An assessment using behavioural microsimulation. Sustainable Cities and Society, 81(7–8):103817.