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Inequality of energy poverty between groups in Spain

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ABSTRACT

In this paper, we have measured the evolution of energy poverty in Spain for years 2005, 2008, 2012 and 2016. It has been analyzed for different classifications of the household and different characteristics of the main breadwinner such as gender, type of house, education and so on. The variables used to measure energy poverty are three energy accessibility indicators: *the ability to keep the home adequately warm*, *the arrears on utility bills (electricity, water, gas)* and *the presence of a leaking roof, damp walls or rotten windows*. We have also computed the inequality of the energy poverty results between groups for each characteristic. Results suggest that energy poverty in Spain worsened between 2005 and 2016. Specifically, for thinly populated areas and for households in which the main breadwinner have been born outside of Europe.

1. Introduction

Since Boardman's seminal work, Boardman [1]; the concepts of energy poverty or fuel poverty[1] have received a great deal of attention in energy literature and public policy, see also Boardman [2] and Bouzarovski and Petrova [3]. It is widely accepted that access to modern energy, or cleaner energy, can be considered a welfare indicator of society. Hence, we can conclude that the welfare of society is closely linked with the use of or the access to energy services and modern energy technologies.

In the literature there is not a universally accepted definition of energy poverty or fuel poverty (see Refs. [4–6] and [7]. In fact, the concept of energy poverty can be divided into availability and affordability of energy sources. The availability of basic energy resources such as electricity is usually the central issue in developing countries, see González-Eguino [8]; while in developed countries socially and materially affordable domestic energy services are the principal issues.

In this paper, we are going to analyze energy poverty in Spain. For this purpose, we define energy poverty as the lack of essential, affordable, reliable and safe energy services. The variables we use to capture energy poverty are: *the ability to keep the home adequately warm*, *the arrears on utility bills (electricity, water, gas)* and *the presence of a leaking roof, damp walls or rotten windows*. We have decided to use these energy accessibility indicators following a *consensual methodology* denominated by Healy [9] and Healy and Clinch [10] in reference to the consensus existing in European societies around a few minimum living conditions that a household is expected to have.

As mentioned, energy poverty is going to be measured in terms of three energy indicators. Therefore, we are considering that energy poverty is a multidimensional concept. In fact, Pereira et al. [11] argue that energy poverty extends beyond a unique variable and could be measured with a greater degree of accuracy using a multidimensional framework. In the literature we can find many works that measure energy poverty following a multidimensional framework, see Nussbaumer et al. [12]; Sadath and Acharya [13]; Bouzarovski and Tirado [14]; Okushima [15] and Aristondo and Onaindia [16]. All of them follow a 'column-first two stage' or a

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[1] In what follows, the concept of energy poverty and fuel poverty will be equivalent in this paper.

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'row-first two stage' procedure. We will see the two methods and we will conclude that the 'row-first two stage' procedure is more appropriate to use for multidimensional dichotomous variables. In fact, we will see that a quite used 'column-first two stage' procedure is a particular case of the 'row-first two stage' one. Therefore, we will follow a 'row-first two stage' procedure called *counting* to measure energy poverty in Spain.

In a *counting* poverty procedure, the first thing we must do is identify the poor individual. We determine if the individuals are deprived or not in each variable and then if they are poor or non-poor depending on the number of dimensions in which they are deprived. The *union* approach determines poor the individuals deprived in at least one dimension, and the *intersection* one, the individuals deprived in all the dimensions. In fact, we can also identify as poor the individuals who are deprived in at least two dimensions, at least one or two specific dimensions, and so on. This procedure is called the *dual cutoff identification* in Alkire and Foster [17]. Secondly, a deprivation value is assigned to each individual, which depends on the individual deprivation values in all the dimensions, and a unidimensional poverty index is applied to these deprivation levels.

In this paper we follow the procedure to measure energy poverty proposed by Aristondo and Onaindia [16] based on the measures of Chakravarty and D'Ambrosio [18]. We study energy poverty in Spain between 2005 and 2016, for different classifications of the households. This household classifications are done in terms of household types and the breadwinner characteristics.

The results conclude that if we classify the household depending on the *type of household*, *ownership* and *members* the energy poverty values are higher for *thinly* populated areas, semidetached houses and rented houses, respectively. Focusing on the main breadwinner characteristics, we can observe that the individuals that suffer the greatest energy poverty are those that belong to a household whose main breadwinner is a: women, separated, from outside Spain, with no studies, with very bad health and with no work or working a partial time.

Finally, we have analyzed the inequality of energy poverty results between groups in order to identify the classifications with the highest differences between groups. And we have conclude that the classifications named *rest of the word*, *very bad health* and *no studies* reflect the highest differences between groups with respect to energy poverty.

The remainder of the paper is structured as follows. Section 2 shows how to measure energy poverty. Section 3 presents some notations and the poverty indices used. Finally, sections 4 and 5 are devoted to the empirical results and conclusions, respectively.

2. Measuring energy poverty

As mentioned, there is an agreement that energy poverty is a multidimensional phenomenon where several findings have been made in theoretical and empirical aspects. However, there is not an official definitions of energy poverty for European countries. The most widely accepted definition of energy poverty is one in which the household needs to spend more than 10% of its income on fuel use, which can include heating, electricity and hot water, see Boardman [1]. It is known as the 10% *measure* in this research field. The 10% *measure* has been widely used in energy poverty studies such as Boardman [2]; Heindl and Schüssler [19]; Phimister et al. [20]; Okushima [21] and Pachauri et al. [5].

However, this methodology has some drawbacks, since with the use of the 10% *measure*, it is possible that rich households that are over-consuming energy are identified as energy poor, see Hills [22] and Hills [23]. These papers emphasize that energy poverty should be measured looking at fuel prices, low incomes, and energy efficiency. In fact, there is much discussion on how to define and identify fuel poverty, and numerous criticisms have been made of the expenditure approach, see Healy and Clinch [10]; Liddell et al. [24] and Moore [25]. However, all literature on energy poverty measurement concludes that energy poverty is a multidimensional problem, rather than a unidimensional one of energy costs or expenditures.

Considering the limitations of the expenditure approach, some authors, pioneered by Gordon et al. [26]; analyze energy poverty using subjective variables that are based on the *inability to afford the basic necessities of life*. For example, Healy and Clinch [10] use a *consensual approach* to energy poverty by analyzing it using subjective variables such as the absence of central heating and the ability to keep a household warm. Nevertheless, this approach also has some flaws such as the inclusion of the likelihood of errors of exclusion, since there are households that do not identify themselves as energy poor, see Dubois [27]. However, the use of a *consensual methodology* enables researchers to measure energy poverty for any European country, and more over, to obtain comparative results. Some results based on subjective energy poverty indicators can be found in Healy and Clinch [10]; Tirado Herrero et al. [28] and Thomson and Snell [29].

In this work we follow the above papers and we will measure energy poverty in Spain using three subjective energy poverty indicators. The variables are: *the ability to keep the home adequately warm*, *the arrears on utility bills (electricity, water, gas)* and *the presence of a leaking roof, damp walls or rotten windows*.

3. Notations and some methods to measure energy poverty

Let $n \geq 2$ be the number of individuals and let $k \geq 2$ be the number of dimensions under consideration. Let $X = (x_{ij})$ denote a $n \times k$ deprivation matrix, where the x_{ij} value is the deprivation of individual i in dimension j, where $i = 1, 2, \cdots, n$ and $j = 1, 2, \cdots, k$.

In what follows we assume that k is fixed and given, while n is allowed to range across all positive integers. Thus the domain of matrices under consideration is given by $\cup_{n \geq 1} R_{+}^{n \times k}$.

We assume that the dimensions are represented by binary variables, 0 for non deprived and 1 for deprived. Then, the dimension value of each individual i is identified by a deprivation vector $\mathbf{x}_{i\cdot} \in \{0, 1\}^k$, that is $\mathbf{x}_{i\cdot} = (x_{i1}, x_{i2}, \cdots, x_{ik})$, where $x_{ij} = 1$ when individual i is deprived in attribute j and $x_{ij} = 0$ otherwise.

Let us define $\mathbf{w} = (w_1, \cdots, w_k) \in R_{++}^{k}$ the vector of weights summing to *1*, where w_j is the weight assigned to attribute j.

Now, we will focus on two general procedures to measure multidimensional poverty for this kind of variables: the 'column-first two stage' and the 'row-first two stage' procedures. The following subsections present these procedures.

3.1. Column-first two stage procedure

If a 'column-first two stage' procedure, firstly the unidimensional poverty value in each dimension may be computed, that is, the energy poverty for each dimension. Then, the weighted dimensional poverty values are aggregated in order to get a single poverty value. Summarizing, firstly the column, dimensional, values are aggregated and secondly the row ones. The ways to aggregate the values in the two steps can be numerous. In fact, we could use different functions such as any r-order mean and so on.

The most used procedure in the literature, computes the arithmetic mean in the first step and the weighted arithmetic mean in the second one as follows: