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Estimating fuel poverty at household level: An integrated approach

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ABSTRACT

Fuel poverty occurs when households are unable to heat their home to adequate standards at reasonable cost. Affordable warmth schemes commonly aim to improve the energy efficiency of housing, which makes home heating more affordable. Authorities require identification tools, ideally at household-level, in order to implement these schemes effectively. This study develops a household-level fuel poverty indicator by integrating data from a large household survey ($N = 1595$) with other datasets (including GIS) within a reduced data framework. The model is based on the UK's Standard Assessment Procedure (SAP), but makes several adjustments to account for household size, electricity consumption, occupancy patterns and up-to-date, local fuel prices. Predicted SAP ratings, calculated by a standardised version of the model, correlate well with empirical measurements. The 'household-based' metric developed in this study is argued to provide more realistic estimates of energy costs. Fuel poverty is prevalent amongst the households in this study, although a severity classification shows that not all households experience fuel poverty in equal measure. This study provides several important insights for affordable warmth policies across Europe, including the efficacy of area-based targeting tools. A two-part approach, combining area- and household-level targeting, may yield the most effective results.

1. Introduction

An underlying tenet of sustainable energy is that an adequately warm home should be available to everyone at an affordable cost. However, many households fail to attain 'affordable warmth' due to a combination of factors, related to low incomes, energy-inefficient housing and high energy prices. Such households are said to be in 'fuel poverty', a condition where they need to spend more than 10% of their income on maintaining a healthy standard of warmth in their homes [1]. Fuel poverty is associated with adverse impacts on physical health, mental well-being and quality of life [2] making it a prominent social issue across the European Union (EU), e.g. in the UK [3], France [4], Greece [5] and central and eastern Europe [6,7].

Improving the energy efficiency of housing is a sustainable and effective way of alleviating fuel poverty, as well as promoting carbon reduction [1]. Recent meta-analyses suggest that energy efficiency improvements are associated with significant improvements to occupant health and well-being [8,9]. The Energy Performance of Buildings Directive (EPBD) requires authorities in EU Member States to ensure that all dwellings conform to very high efficiency standards and, where necessary, that dwellings are subjected to energy efficiency improvements [10]. A large number of energy efficiency programmes operate across Europe, e.g. eco-PTZ in France [11], Energy Company Obligation and Green Deal in England [12] and Warm Homes in Northern Ireland [13]. Whilst funded in different ways—some by the State and some by utility companies—all of these schemes offer eligible households measures to improve energy efficiency and make their home more affordable to keep warm, e.g. the Northern Ireland Warm Homes scheme provides government-subsidised measures, including central heating replacements and insulation improvements [13].

To ensure effective and fair implementation, authorities need to know which households to target for such investment. All fuel poor households should benefit from energy efficiency improvements, but households which are experiencing particularly severe fuel poverty, should be targeted as a priority [14]. In order to identify households most in need, fuel poverty must be measured accurately. Before proceeding, it is worth noting the different ways in which fuel poverty can be defined. Fuel poor households can be identified *objectively* by comparing the ratio of required fuel expenditure to household income against the 10% threshold. This is the

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case in the UK, where House Conditions Surveys gather relatively detailed expenditure and income data [15]. Fuel poor households can also be identified using *subjective* measures, which are related to householder perceptions of thermal comfort and affordability of energy bills. Fuel poverty data in continental Europe typically rely on these data, which are available from EU Statistics on Income and Living Conditions (EU-SILC). It is worth noting that these differential definitions produce inconsistencies in the measurement of fuel poverty across the EU [16].

However fuel poverty is defined, there are problems in identifying households most in need of energy efficiency improvements. For example, the House Conditions Surveys required to calculate fuel poverty in the UK rely on sample sizes which are too small to assist in targeting affordable warmth strategies and can only provide fuel poverty data at broad regional level [17]. EU-SILC data also rely in limited sample sizes and report data at national level. The lack of statistics at a local level results in the use of proxy indicators to measure a household's fuel poverty status and to define its eligibility for energy efficiency measures. In the UK, social welfare benefits have been historically used as a proxy for identifying households in need of measures. But these proxy indicators have been found not to be strongly correlated with greatest household need, meaning there is no way of being sure that remedial measures are delivered to households in fuel poverty, never mind those most in need [4,18]. In 2006/07, 30% of the households assisted through the Northern Ireland Warm Homes scheme were not at risk of fuel poverty. Only 16% were classed as 'energy inefficient' households, for whom fuel poverty is much more likely [13].

Area-based targeting of affordable warmth strategies is emerging as a solution to this problem. Walker et al. [19] outline how area-based targeting can identify small areas, each comprised of around 125 households that may be at elevated risk of fuel poverty. These areas are identified using an area-based statistical algorithm, which included variables such as tenure, income, property age and type, degree day demand and fuel source. The algorithm was used to generate maps, from which areas of high need could be identified [20]. A recent energy efficiency scheme in Northern Ireland, known as the Affordable Warmth Pilot (AWP), adopted this approach to target Warm Homes energy efficiency measures towards households most in need. Comparable geographical targeting techniques are also used in other parts of Europe, e.g. in France [11].

Area-based approaches may be a useful step towards targeting resources to households most in need, but, on their own may be insufficient. Measures themselves are delivered to individual households and must be specific to what is required in each dwelling. Offering the same measures to every household in an area is unlikely to be logical or fair, as each household will likely require a distinct set of measures. Therefore, households should ideally be differentiated according to their characteristics and levels of need. To this end, this paper outlines the development of a *household-level* fuel poverty indicator, the need for which arises from the broader objective of targeting areas of high fuel poverty prevalence and households most in need. Such an indicator can be used to identify households and facilitate the fair and appropriate distribution of resources. The remainder of the paper is structured as follows. Section 2 presents an outline of energy cost modelling and fuel poverty, including a critique of standardised energy cost models and the refinements which are required for a more realistic assessment of fuel poverty. Section 3 outlines data collection and the modelling approach, how energy costs were initially calculated using a standardised measure of energy efficiency (SAP ratings), and how the model was subsequently adjusted to yield more meaningful estimates of energy costs and fuel poverty. Section 4 presents model results for energy efficiency and fuel poverty. Section 5 discusses key results, implications for policy and opportunities for further research. Concluding remarks are offered in Section 6.

2. Modelling domestic energy costs and fuel poverty

This study uses an objective, expenditure method to characterise the fuel poverty status of households, based on (1) the household's required expenditure on energy and (2) household income. Whilst self-assessed income data can be collected relatively easily via survey, 'needs to spend' on energy must be modelled and requires some discussion before proceeding.

2.1. Modelling energy costs using standardised, 'building only' approaches

A number of recent studies show how domestic energy costs can be estimated using building-physics calculations, e.g. [21–25]. Energy consumption is estimated using a range of physical parameters, e.g. efficiency of heating systems, thermal characteristics of dwelling elements (walls, roof, floor, windows and doors), internal temperatures, heating patterns, ventilation rates, energy consumption of appliances, number of occupants, external temperatures. For example, domestic energy efficiency in the UK is modelled using the Standard Assessment Procedure (SAP). SAP estimates the energy requirements and costs associated with achieving adequate levels of space heating, hot water and fixed lighting, based on empirical relationships and heat-balance formulae [26]. SAP is designed to measure costs specific to the building alone and therefore excludes parameters such as property size, household size and composition and ownership of appliances (e.g. washing machines, refrigerators, home entertainment systems). This process of standardisation yields a metric (a SAP 'rating') which provides a consistent and comparable ranking of homes on a scale of 1 (very inefficient) to 100 (very efficient) [27].

Historically, SAP has always been intended as a measure of the property's building fabric and heating kit. Household effects are ignored as they disrupt the standardised nature of the metric, i.e. the house does not change, but the characteristics of the occupants can and do change (e.g. people move house). Nonetheless, household characteristics may have significant impacts on the domestic energy requirements. For instance, elderly and infirm occupants have distinct physiological characteristics in terms of thermal comfort and could be expected to heat their homes to higher temperatures as result, e.g. fuel poverty modelling in Scotland assumes that houses occupied by this demographic group are heated to 23 °C, whereas 21 °C is considered sufficient for the rest of the population [28]. This results in extra fuel being used to maintain rooms at higher temperatures. Such effects are evidenced in field studies, e.g. Fell and King [29] describe a wide variation in gas consumption amongst households living in dwellings of similar size, type and location. The diversity found indicates the extent to which the household itself—who lives in the house, how much of the time, how active they are—influences energy need and therefore fuel poverty [23,30].

Due to SAP's focus on the physical properties of the dwelling, it does not capture this important 'household' effect and thus may be a limited predictor of energy costs and fuel poverty [27,31]. Therefore, before proceeding, some of the specific shortcomings of SAP require some discussion. Firstly, rather than using the actual number of occupants, SAP simulates occupancy as a function of property floor area. In other words, larger houses are assumed to be occupied by more people, which is not always the case. Adopting a 'synthetic' household size has knock-on effects on hot water and electricity demand, which are known to be heavily influenced by the number of occupants [32,33]. In fact, SAP excludes energy associated with electricity demand, despite ownership and use of domestic appliances being practically universal and increasing over time [27]. Thus, it is becoming an increasingly important contributor to fuel poverty. SAP also assumes that all households are occupied