Energy Policy 118 (2018) 211–220

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Willingness-to-pay and free-riding in a national energy efficiency retrofit grant scheme

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ARTICLE INFO

Keywords:
Willingness to pay
Free-riders
Energy efficiency
Retrofit

ABSTRACT

Many national grant aid schemes exist to encourage households to invest in residential energy efficiency retrofits, but these can also be availed of by free-riders, which are households that would invest in a retrofit even in the absence of financial support. We use a McFadden's choice model to estimate willingness-to-pay for energy efficiency using data from a national residential energy efficiency grant scheme, estimating average marginal willingness-to-pay of €0.127 /*kWh*/*yr* for retrofits that affect the efficiency of energy use required for space and water heating (e.g. boiler upgrades, heating controls). The results of this analysis are used to estimate the extent to which free-riding has occurred in the scheme. Less efficient and larger households are willing to pay more for energy efficiency improvements, while households that had previously retrofitted via the scheme were willing to pay over twice as much as those retrofitting for the first-time. Free-riding varies by retrofit measure, with solar collector retrofits possessing close to zero free-riders, while free-riders comprised over 33% of heating controls retrofits.

1. Introduction

With an estimated 67% of residential energy used for space heating, and a further 14% used for water heating (European Commission, 2011), they present the best opportunity for energy efficiency improvements within the residential sector, while also reducing energy bills and improving comfort levels. In order to facilitate energy efficiency retrofit works in the home, the Sustainable Energy Authority of Ireland (SEAI) administers the Better Energy Homes (BEH) scheme as a means of contributing to a policy target of a 20% reduction in Ireland's energy use by 2020 compared to projections made in 2007, as mandated by the European Union (European Parliament and the Council of the European Union, 2012). At present, grant aid is available for up to four energy efficiency retrofit measures. These are roof insulation upgrades, wall insulation upgrades, boiler and/or heating controls upgrades and solar collector installation.

The presence of grant aid provides an incentive for households to engage in energy efficient renovations. From the introduction of the BEH scheme in March 2009 through July 2016, over 179,000 homes received financial support to engage in residential retrofit works. While this does not include retrofits conducted under other grant aid schemes or retrofits conducted without grant aid, this accounts for slightly over 10% of private dwellings in Ireland.[1] Grants under the scheme currently cover approximately 35% of the costs of retrofit works but it is unknown what the optimal level of aid should be in order to induce more retrofits and in turn contribute to Ireland's energy efficiency targets. By gaining an understanding of how much households are willing to pay for energy efficiency improvements, the level of grant aid provided can be adjusted to increase the level of energy efficiency retrofits or to reduce deadweight loss from the scheme.

Two questions are addressed in this research: first, how much are households willing to pay for residential energy efficiency improvements and, second, to what extent does free-riding occur in the BEH scheme? We estimate the determinants of the choices made by BEH-participant households and derive estimates of the average marginal willingness-to-pay for energy efficiency improvements. We compare estimated willingness-to-pay to the cost of retrofits undertaken and assess the degree to which free-riding has occurred over the lifetime of the scheme. We find that upwards of 7% of participants would have undertaken a retrofit even in the absence of grant aid, and a further 8% would have occurred with a lower level of grant aid than was available. This varies across retrofit measures, with heating controls retrofits possessing a much higher rate of free-riding. We find that households who had previously completed a retrofit under the BEH scheme were

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[1] Based on Irish Census 2011, table CNA33.

https://doi.org/10.1016/j.enpol.2018.03.057
Received 29 August 2017; Received in revised form 15 February 2018; Accepted 25 March 2018

willing to pay over two times more than those retrofitting for the first time.

The remainder of the paper is organised as follows. Section 2 provides a review of the literature and Section 3 describes the data and methods of analysis used, while Section 4 discusses the results of the research and Section 5 concludes.

2. Literature review

The relevant literature can be divided into three areas. Firstly, literature on willingness-to-pay for energy efficiency is discussed in the international context. This is followed by the literature on free-riding in residential retrofitting and, finally, literature on energy efficiency retrofitting in the Irish context. Various studies have used discrete choice experiments to estimate willingness-to-pay for energy efficiency improvements across a number of countries (Achtnicht, 2011; Banfi et al., 2008; Farsi, 2010; Grösche and Vance, 2009; Kwak et al., 2010). Although the approaches are broadly similar, the models estimated have methodological differences including fixed effects, random effects, and mixed effects logits. The valuation metric across the studies also varies substantially. For instance, Banfi et al. (2008) evaluate willingness-to-pay for energy efficiency measures as a percentage of the value of the respondent's home; Kwak et al. (2010) estimate willingness-to-pay as dollar values for specific technologies; while Farsi (2010) relate willingness-to-pay to monthly rent. Achtnicht (2011) pursue another approach where willingness to pay for emissions reductions are examined in the context of residential energy retrofits. The paper by Grösche and Vance (2009), which examines residential energy retrofits in Germany, is closest to the analysis in this paper. They use a number of estimation approaches, including estimating conditional logit and random effects logit. Their willingness-to-pay metric is €/kWh, which allows for easy comparison across studies. Their estimates for willingness-to-pay for residential energy efficiency improvements are €3.28/kWh in east Germany and €1.72/kWh in west Germany.

An alternative approach to using choice experiment data is combining information on households' actual energy efficiency decisions with simulated data on alternative retrofit options potentially facing households. Cameron (1985) estimates a nested logit model to examine household behaviour and, specifically, whether they had engaged in a number of energy efficiency renovations, the results of which were used to examine the appropriateness of financial incentives to retrofit. The dataset comprises survey data on the retrofit investment that households actually made and simulated data on the retrofit options available to households. The simulated data was intended to be equivalent to an "informed rough estimate" a homeowner might have obtained from consulting with building contractors or reading any of the then-available guides to home retrofits (Cameron, 1985). The current paper follows a similar data strategy, which is described in the next section, with data on the revealed retrofit option and simulated data on choice alternatives.

There are a number of studies that examine free-riding within the context of energy efficiency retrofits (Alberini et al., 2014; Boomhower and Davis, 2014; Grösche and Vance, 2009; Nauleau, 2014; Olsthoorn et al., 2017). These studies find that free-rider shares in residential energy efficiency programmes range from 40% to 96%. While grant providers cannot usually discriminate between free-riders and non free-riders, even if they could distinguish between them ex ante, the high levels of free-rider-ship questions the cost-effectiveness of energy efficiency grant programmes. Most assessments use econometric methods to compare activity levels (i.e. retrofits) pre and post some threshold, usually a change in a tax credit. Both (Grösche and Vance, 2009) and Olsthoorn et al. (2017) use choice experiments to collect their data but unlike the other ex post studies, their definition of free-riders relates to planned investment in a new heating system. The identification of free-riders in this paper is closest to that employed by Grösche and Vance (2009), where estimated willingness to pay is compared with observed retrofit costs to identify free-riders. In our case observed retrofit costs are households' actual costs from the administrative dataset for the chosen retrofit option and estimated costs otherwise, not attribute levels from a choice experiment.

In the Irish context, research has focussed on a number of aspects surrounding residential energy efficiency. For instance, Aravena et al. (2016) examine the propensity to apply for retrofit grant aid, while McCoy and Lyons (2017) examine the propensity to retrofit following the introduction of electricity smart metres. Collins and Curtis (2016) examine drivers of retrofit depth in Ireland, while both Aravena et al. (2016) and Collins and Curtis (2017) investigate the likelihood of homes abandoning an application for retrofit grant aid using stated and revealed preference data, respectively. In terms of the outcomes of retrofitting and the benefits of energy efficiency, Clinch and Healy (2000) examine monetary returns to investing in energy efficiency retrofits and environmental benefits of same, while Hyland et al. (2013) investigate the reflection of energy efficiency labelling in property prices. Carroll et al. (2016) use a stated preference survey to estimate the willingness-to-pay of renters for energy efficiency labels in rental apartments. To the authors' knowledge, however, there does not exist any literature with regard to the willingness-to-pay of home owners for energy efficiency improvements or free-riding in grant aid schemes in Ireland.

3. Data and empirical methods

3.1. The Better Energy Homes scheme

The Better Energy Homes (BEH) scheme commenced in 2009 and is administered by the Sustainable Energy Authority of Ireland (SEAI). It is a grant aid scheme for households to engage in energy efficiency improvements, with grants available for various energy efficiency measures (EEMs). Grants are available for roof/attic insulation, one of three types of wall insulation (cavity insulation, external wall insulation or internal dry-lining), three types of boiler upgrade (oil boiler or gas boiler with heating controls upgrade or heating controls upgrade only) and solar collector (panel or tube) installation. This means that a household may adopt up to a maximum of four EEMs as only one type of wall insulation or boiler upgrade may be awarded grant aid. Upgrades must satisfy SEAI technical standards for grant applications to be successful. The level of grant aid available has changed over time, with information on the dates of these amendments and the changes made detailed in Table 1.

While the BEH scheme was introduced in March 2009, a building energy performance certificate, known locally as a Building Energy Rating (BER), did not become mandatory until June 2010. Our dataset comprises applications to the BEH scheme from the introduction of this mandatory BER assessment through July 2016. The Irish BER is an energy label pertaining to the the energy efficiency of a home. Homes are assigned to a 15-point alphanumeric scale ranging from A1 to G, with A1 being the most energy efficient. Grades are assigned based on the energy required for space heating, ventilation, water heating and lighting, less savings from energy generation technologies. For retrofits made under the BEH scheme, a pre-retrofit works is estimated as part of the final BER assessment. When assessing a property's post-works BER, a pre-works BER is estimated using information on the pre-works characteristics of those aspects of the home altered during retrofitting works.

Applications to the grant scheme are generally made privately, with a household first contacting an SEAI registered contractor, before applying for the grant. The contractor then installs the relevant retrofit measures, which is followed by a BER assessment and processing of the grant application. Some applications are made via 'obligated parties', which are energy distributors and retail energy sales companies. We do not include applications made via obligated parties in our analysis as we do not possess information on other incentives offered by these