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The determinants of energy efficient retrofit investments in the English residential sector

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ABSTRACT

Meeting the UK's long-term carbon emissions target implies significant energy performance improvements of the existing residential building stock that is amongst the oldest and least energy efficient in Europe. A better understanding of the key determinants of energy efficient retrofit investments in the residential sector is therefore crucial for the design of effective policies aimed at reducing energy demand and CO_2 emissions. This article uses combined data from "English Housing" surveys and employs a probit model in order to investigate the dwelling-related and households characteristics influencing energy efficient retrofit investments in the English residential sector.

The results show that couples with independent child(ren) living in detached or semi-detached houses built before 1990 and with a length of residence higher than 1 year are more likely to invest in retrofits measures; compared to households living in the North East region, households living in London are less likely to invest. While there is empirical evidence supporting the landlord-tenant problem, households that have taken out a mortgage are more likely to invest in energy efficient retrofit measures than outright owners. To maximise their impact and effectiveness, future energy efficiency policies should target specific household groups with the lowest rate of retrofit uptake.

1. Introduction

The UK government has acknowledged improvements of energy efficiency in the residential sector as having a key role to play in decarbonising the economy, securing the supply of energy, and reducing energy demand (DECC, 2012; UK's National Energy Efficiency Action Plan, 2014, 2017). In spite of these and other benefits, large potentials remain untapped (Payne et al., 2015). Numerous market and behavioural barriers such as credit constraints, imperfect information, landlord-tenant problem, and heuristic-decision making prevent households from investing in energy efficiency solutions (Allcott and Greenstone, 2012). The role of policy is to overcome these impediments and to strengthen the actor specific incentives.

In 2015, the residential sector was responsible for the 29% of the total final energy consumption in the UK (BEIS, 2017a) and for the 23% of the total CO_2 emissions (BEIS, 2017b). Gas was the predominant source of energy in 2015 representing 63.9% of the total final energy residential consumption, followed by electricity (23.1%), petroleum (6.3%), bioenergy and waste (5.1%), and solid fuel (1.6%). Approximately 70% of energy in the residential sector was used for space heating, about 15.6% for electricity for appliances and lighting, roughly 12.4% for water heating, and a small part for cooking (2%).

The UK has around 27 million homes across a wide range of housing types, including a significant proportion of older buildings and dwellings. Much of the UK's housing was built before the links between energy use and climate change were understood and when there were very different expectations of thermal comfort (Palmer and Cooper, 2013). Approximately 10.3 million of the homes across the UK, equivalent to about the 40% of the existing housing stock, are classed as 'hard-to-treat'. 'Hard-to-treat' homes are dwellings that possess solid walls, no loft space to insulate, no connection to the gas network or are high-rise. Consequently, these dwellings cannot be upgraded easily or cost effectively using conventional measures (Dowson et al., 2012). Besides the old housing stock, the growth of the private rented sector and the rising number of households contribute to lower levels of energy efficiency and higher levels of energy consumption as a whole, respectively (DCLG, 2015b; BEIS, 2017a).

The prevalence of dwellings in the national stock built to low standards of energy performance (Nicol et al., 2014; UK's National Energy Efficiency Action Plan, 2014) makes the retrofit challenge enormous. It has been estimated that four out of five homes that will be occupied in 2050 have already been built (Council, UK Green Building, 2017) and that to meet the UK's 80% greenhouse gases reduction target by 2050 one home would need to be retrofitted every minute (Stafford et al., 2011).

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UK policymakers have long struggled to make the existing residential buildings more energy efficient. Driven also by the EU actions – (e.g., Energy Services Directive 2006/32/EC; Energy Performance of Building Directive 2010/31/EU; Energy Efficiency Directive 2012/27/EU) – the UK policies stimulating domestic energy efficient retrofit investments have undergone significant structural reforms over the last decade, which have led to mixed results regarding their effectiveness (Marchand et al., 2015; Rosenow and Eyre, 2015, 2016; Kern et al., 2017). To speed up the renovation rate of the residential building stock, between 2012 and 2013 the UK government decided to radically overhaul the relatively successful existing system at an unprecedented pace (Rosenow and Sagar, 2015) by launching the Energy Company Obligation (ECO) and the Green Deal (GD). Initially, the ECO differed from previous energy efficiency schemes (Carbon Emissions Reduction Target, Community Energy Saving Programme, and Warm Front) by focusing on more expensive insulation measures (e.g., solid wall insulations) in homes that are 'harder-to-treat' (Parliament UK, 2016a). Almost all support for low cost measures (e.g., loft and cavity wall insulation) was introduced through the GD that failed to deliver retrofits to a large number of homes as it was attached to a number of weakness such as high interest rate, under-promotion, and narrow engagement with consumers, which have been extensively discussed in the literature (Booth and Choudhary, 2013; Pettifor et al., 2015; Rosenow and Eyre, 2016). As a result, the uptake of domestic energy efficient retrofit measures that increased notably until late 2012, dramatically declined in the following years, reflecting the design change and weakening of energy efficiency policies (Rosenow, 2012; Mallaburn and Eyre, 2014; Climate Change Committee, 2016a, 2017; Parliament UK, 2017). The total number of cavity, loft, and solid wall insulation installed under government schemes in 2015 was down 49% on 2014 and 87% on 2012 (Climate Change Committee, 2016a), and progress in delivering insulation kept slowing also during 2016 (Climate Change Committee, 2017).

It is therefore clear that in order to reverse the negative trend of retrofit uptake the domestic energy efficiency policies need to be reconsidered. Identifying the types and levels of causation driving energy efficient retrofit investments can be crucial to create opportunities for future energy policies to have a greater impact (Trotta, 2018).

Thus, the aim of this study is to investigate the dwelling-related and households characteristics that have an influence on energy efficient retrofit investments in the English residential sector by using combined data from the "English Housing Survey, 2012: Housing Stock Data" and the "English Housing Survey, 2013: Housing Stock Data". Energy efficient retrofit measures such as wall insulation, biomass boiler, and replacement of old storage heater, typically involve changes or upgrades to the building envelope and to the heating and hot water systems (Gardner and Stern, 2008). The majority of these retrofits are directed toward reducing space and water heating use that is by far the largest portion of households energy use representing 80% of final energy consumption (BEIS, 2017a).

The factors that affect the decision to invest in energy efficient retrofits and to reduce energy consumption can have multiple origins, such as socio-demographic, psychological, and physical characteristics of the dwelling (Frederiks et al., 2015). In this study, a major focus is given to the dwelling-related characteristics that have the highest explanatory power in the energy consumption of the English residential sector (Huebner et al., 2015) and can then have an influence on retrofit measures that reduce energy consumption, especially space heating (Hamilton et al., 2016; Steemers and Yun, 2009). Despite an expanding literature, the empirical evidence of the impact of the determinants of energy efficient retrofit investments in the English residential sector has not been conclusive to date.

The remainder of the paper is organised as follows. Section 2 provides a literature review about the determinants of energy efficient retrofit investments in the UK and recent evolution of the domestic energy efficiency policy; Section 3 describes the data and methodology used in the study; Section 4 presents the results of the econometric estimation, in which dwelling-related and households characteristics influencing the retrofit uptake are analysed; and Section 5 concludes the paper by providing implications for energy efficiency policy.

2. Literature review

Most of the studies on household energy use have investigated how socio-demographic, psychological, and dwelling characteristics can predict residential energy consumption (see Frederiks et al., 2015, and Jones et al., 2015 for an overview), while few others have analysed the role of some of these factors on the uptake of energy efficient retrofit measures. For example, Nair et al. (2010) use a novel survey of 3000 of owners of detached houses in Sweden to examine the role of personal (e.g., education, income) and contextual factors (e.g., building age, thermal comfort) in influencing energy efficient retrofit investments and energy conservation behaviours. They find that the likelihood of investing in new building envelope components and other energy efficiency measures increases with thermal discomfort, age of the house, higher levels of education and income, past energy efficiency investments made, and perceived high costs of energy.

Jakob (2007) provides a comprehensive overview and analysis of the drivers and barriers of retrofit investments in Swiss households who live and own a single-family house. The estimation results show that, differently from socio-economic characteristics (e.g., age, income, education, professional occupation), the technical building characteristics such as building age, damages to building elements, and the general renovation activity have a strong impact on the retrofit uptake.

In Canada, Gamtessa (2013) examines what types of households chose to invest in energy efficient retrofit measures in response to a program of the government (EnerGuide for Houses) providing financial incentives and home energy audits. Ownership, building obsolescence, higher levels of income, and higher proportion of eldery household members are characteristics positively associated with retrofit investments; on the other hand, large floor area and household size, and attached/row, mobile, and multi-floor homes are negatively associated with retrofit investments.

In the UK, a first attempt to model energy efficient retrofit decisions in households has been made by Brechling and Smitch (1994); by using a sample of nearly 7000 households they analyse the patterns of take-up of loft insulation, wall insulation, and double-glazing. They find that tenure plays a strong role in domestic energy efficiency decisions, while income level has a very small influence. Compared to the socio-economic characteristics of the households, the dwelling features are found to be better predictors of retrofit investments. Building on the study of Brechling and Smitch (1994), Tovar (2012) uses the English House Condition Survey (from 2003 to 2007) and identifies a number of characteristics (e.g., tenure, income, length of residence, age of the respondent, dwelling type and age) influencing the British households' adoption of cavity insulation, loft insulation, and the upgrade to the boiler.

Hamilton et al. (2014) by using the Home Energy Efficiency Database (HEED) examine the historical incidence of energy efficiency installation in the housing stock during the period 2000–2007, and the household profile with respect to the uptake of retrofit measures in 2007. Main findings include a misalignment of landlord-tenant interests, an inverted 'U-shape' curve between the age of a dwelling and retrofit measures, and that the probability of retrofit uptake increases with detachedness, higher levels of income, and whether living in the north or western regions of England. In a subsequent study, Hamilton et al. (2016) analyse the retrofit uptake from 2002 to 2007 and the change in gas use from 2005 to 2007 of 168,998 English dwellings. They find that retrofits have a significant impact on reducing space-heating demand, and that combining retrofits into single package displays a dose-response like effect on energy demand. More recently, Trotta (2018) by using data from the "Survey of Public Attitudes and Behaviours towards the Environment, 2009", investigates the different factors driving energy efficient retrofit investments, the adoption of energy efficient appliances and the habitual