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Andrew Leicester
George Stoye

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Andrew Leicester and George Stoye[1]
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Abstract We use English household-level survey data from 1996 to 2010 to explore whether economic market failures play a significant role in explaining the presence of energy efficiency measures (loft insulation, cavity wall insulation and full double glazing) in residential properties. There appears to be a limited role for credit constraints as proxied by income, receipt of means-tested benefits or educational attainment. Private renters are significantly less likely to own efficiency measures suggesting that failures in the landlord-tenant relationship in the private-rented sector are a key barrier to uptake. More broadly, we find that it is the characteristics of the dwelling rather than those of the occupants which are the most significant explanatory factors. Our results suggest that well-targeted policies to encourage take-up of efficiency measures could focus on private landlords, long-term owner occupiers, those in older properties and those using non-metered fuels as their main heating source. However the key target groups vary across different efficiency measures.

Keywords Energy, energy efficiency, insulation, market failures, environmental policy

JEL classification D12, H23, Q48, Q58

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[1] Address for correspondence: a.leicester@ifs.org.uk (corresponding author); g.stoye@ifs.org.uk; Institute for Fiscal Studies, 7 Ridgmount Street, London WC1E 7AE. Views are those of the authors and not the IFS.

1. Introduction

The UK government has set itself ambitious targets to reduce greenhouse gas (GHG) emissions by 80% relative to 1990 levels by 2050. Rolling 'carbon budgets', recommended by the independent Committee on Climate Change (CCC), set a pathway towards meeting this goal – for example, the third budget requires a cut of 34% by 2020. Achieving that target is likely to require a substantial reduction in emissions from domestic energy use (largely electricity and gas for heating, lighting, cooking, powering appliances and so on). In 2011, the residential sector in the UK generated 130.5 million tonnes of GHG emissions (measured as carbon dioxide equivalent), some 24% of the total. Whilst residential emissions fell by 23% between 1990 and 2011, business emissions fell by 39%, and emissions overall fell by 29%.[2]

One policy intervention to reduce domestic emissions would be through taxes or other measures which raise energy bills and so reduce demand. However, higher prices are likely to have adverse distributional effects and worsen "fuel poverty" (where a household needs to spend more than 10% of their income to heat the home adequately).[3] The key strategy to reduce domestic emissions without worsening fuel poverty has therefore been to promote the installation of energy efficiency measures (Department for Energy and Climate Change, 2012). The CCC estimates that meeting the 2020 target requires near-complete take-up of loft and cavity wall insulation by 2015.[4] Understanding what inhibits take-up of such measures is therefore extremely important.

This paper uses nationally-representative survey data from England to provide direct evidence on the factors which are associated with whether or not households own three measures: loft insulation (of at least 200mm thickness), cavity wall insulation, and double glazing of all windows. Of particular interest is whether it is the characteristics of the dwelling or its inhabitants which appear more strongly related to take-up, whether economic market failures such as credit constraints or failures in the landlord-tenant relationship appear to constrain take-up, and the implications for current and future policy interventions.

A key methodological concern is that the demand for insulation measures and the demand for energy are likely to be jointly determined, and we lack data in recent years on energy use at the household level. We demonstrate that, at least in earlier years, this appears to be unimportant: energy use is exogenous and apparently unrelated to the presence of efficiency measures suggesting that a reduced-form analysis is appropriate. We carry out such analysis on recent data to isolate which factors are associated with ownership of the three measures. By comparing results from several years, we explore how these relationships have changed over time to see whether policies designed to encourage take-up among different groups appear to have been effective.

[2] Figures derived from data on emissions by end-user for 2011 from the Department for Energy and Climate Change, available at https://www.gov.uk/government/publications/final-uk-emissions-estimates.
[3] Note that Hills (2012) proposes a new definition of fuel poverty which would be less sensitive to energy prices. The Government has suggested it will decide on a new definition of fuel poverty by the end of 2012.
[4] See http://www.theccc.org.uk/carbon-budgets/scenarios-to-meet-budgets.

Briefly, our results suggest little role for total income in explaining ownership of efficiency measures. Receipt of means-tested benefits is associated with a lower ownership rate for thick loft insulation but not other measures. We find little compelling evidence that other proxies for credit constraints, such as education or employment status, have any effect on ownership.

Controlling for other factors, the private rental sector appears to lag behind both the social rental and owner-occupier sectors, suggesting failures in the landlord-tenant relationship are a barrier. Policies to address this should be a priority. We also find that owner-occupiers who have been in the same dwelling for a very long period are less likely to own some efficiency measures, and could be a target for future intervention.

More broadly, it is the characteristics of the *dwelling* (especially property age and heating regime) that seem to matter more than the characteristics of the *occupants* in explaining ownership. As far as possible, then, these characteristics should be incorporated into decisions about who to target for policy intervention. Notably, though, we find few examples where the same factors appear to inhibit ownership of all three measures. This suggests that the groups targeted for policy intervention should be measure-specific.

The rest of the paper is structured as follows. Section 2 explores the rationale for government intervention to support domestic energy efficiency, outlines how policy in this sphere has evolved in recent years and discusses previous literature which has explored this issue. Section 3 outlines our empirical approach and economic model. Section 4 describes the data which underlies our analysis and presents some motivational descriptive statistics. Section 5 presents our results. Section 6 offers some discussion of the results and their policy implications, before Section 7 concludes.

2. Background

2.1 The rationale for government intervention

A key question is whether there is a legitimate role for policies which intervene in the market for energy efficiency directly, perhaps by subsidising its installation for some or all households, or mandating that measures have to be installed. The decision to install energy efficiency measures can be seen as a form of investment: households pay an upfront cost to install the measure and then receive future benefits in the form of reduced energy costs (or increased warmth).[5] If the expected discounted value of future benefits outweighs the upfront costs, then the measure should be installed. In principle, rational consumers should be able to make these decisions without direct policy intervention to affect their choice.[6]

In practice, however, there are a number of reasons why policy action could be needed. There may be positive externalities from installation (such as reduced emissions) which would lead to an inefficiently low level of take-up from a social perspective. Even ignoring

[5] The Department for Energy and Climate Change (2012b) estimate that cavity wall insulation reduces annual domestic gas consumption by on average 8.6%, and loft insulation by 2.4%.

[6] There is of course a separate issue as to whether such choices are made based on energy prices which properly reflect the external costs associated with GHG emissions where there is a clear rationale for policy intervention.

this, there may be other market failures which mean that measures which appear to be *privately* optimal to install are not taken up (see Levine et al., 1994 and Linares and Labanderia, 2010). Of particular interest for this study are two economic market failures:

1. **Credit constraints**: consumers may not be able to borrow to finance the upfront cost of the measure, if reduced energy costs are not seen as sufficiently reliable collateral to provide an upfront loan. This would rationalise subsidies to reduce upfront costs, or the creation of a new credit mechanism to finance the installation (such as the new 'Green Deal', discussed below).
2. Failures in the **landlord-tenant** relationship: in the rental sector, tenants usually pay energy bills whilst landlords face the cost of installing efficiency measures. Unless landlords can appropriate the benefits from higher rents (which may be difficult) they would not have the incentive to install them. This could be due to informational issues (an example of the principal-agent problem) – if tenants cannot observe that a home is more efficient then they will not be willing to pay a higher rental price for it than for a less efficient property. Even if a certification system is in place which provides information about efficiency to tenants, there may be other failures if tenants cannot understand or easily interpret the trade-off between rent and energy such that they do not respond to the information, or if there is a lack of trust in the credibility of the certification system. This might then rationalise more direct regulation of the private rented sector.

There are of course other reasons why seemingly cost-effective measures would not be installed, even by owner-occupiers who are not credit constrained. There may be limited information about available efficiency opportunities, or people may be boundedly rational and find it difficult to evaluate upfront installation costs against long-term future benefits. Some costs of installation such as hassle costs from clearing lofts or rooms may be hard to quantify but make it individually rational not to carry out the installation except when these costs are reduced.[7] Finally, consumers may be time inconsistent: that is, they make an optimal *plan* to install measures in the future but fail to do so when the future comes. Such issues also justify particular forms of intervention in the market, such as providing tailored information, mechanisms to reduce hassle costs, and ways in which people could commit to future planned installations.

2.2 Government policy towards domestic energy efficiency in the UK

Domestic energy efficiency has been an active area of government policy for many years. Effective policy design requires empirical knowledge of the factors which constrain takeup. If credit constraints are unimportant, for example, then subsidising efficiency measures will do little to encourage new takeup whilst acting as deadweight transfer to people who would have taken up the measures anyway.

The 1995 Home Energy Conservation Act required each local authority in the UK to identify and implement measures to improve the efficiency of their residential housing stock. Direct measures (such as free installation of energy efficiency measures) were targeted largely on

[7] The idea of 'habit discontinuity' (Verplanken at al., 2008) suggests that hassle costs may be reduced when people go through a life transition such as moving home. This gives an opportunity to target recent movers with information about energy efficiency at a time when they face lower costs of installation.

social housing, suggesting that social tenants ought to have become more likely to have efficiency measures installed from the mid-1990s as a result.

The 2001 Fuel Poverty Strategy partly focused on improving the efficiency of the housing stock. One scheme, Warm Front, provided grants to low-income benefit recipients in private rented or owner-occupied dwellings to install heating and insulation improvements, subject to a cap on the value of total grants each year (£110 million in 2010/11). The fact that eligibility was determined by income and not the energy efficiency of the dwelling was subject to some criticism (House of Commons Public Accounts Committee, 2009) since the funding may not have delivered the maximum energy and carbon benefits, but rather have been taken up more readily by those in the target group who were already relatively energy-conscious. Nevertheless, Warm Front ought to have reduced the importance of low income as a factor constraining take up of efficiency measures over time.

A second scheme, the Decent Homes Programme, was targeted on the social rented sector, with a target to bring all social rented properties to minimum standards (including efficiency standards) by 2010 through direct installation of measures and upgrading heating systems. This scheme ought to have again made social tenants more likely (or less unlikely) to own various efficiency measures over the 2000s.

More recent policies include the Green Deal, which was rolled out nationally from January 2013. It provides credit to those in owner-occupied or private-renter accommodation to install particular energy efficiency measures deemed to be cost-effective. These loans are then repaid (with interest) through increases in energy bills, and are tied to the property rather than the resident meaning that future residents will be obligated to make the repayments. By providing upfront financing to install energy efficiency, the Green Deal may relax credit constraints if these are important barriers.

Some policies have been targeted more explicitly at the private renter sector. Since 2004, the Landlord's Energy Saving Allowance (LESA) has provided an offset of up to £1,500 per dwelling against income or corporation tax for installing efficiency measures. HMRC estimates that the cost of the scheme is very small, only around £5 million per year, implying relatively few measures are financed through the scheme.[8]

A number of policies have been implemented through energy suppliers, rather than through national or local government. These 'supplier obligations' go back to the Energy Efficiency Standards of Performance (EESP) which ran from 1994 until 2002, which required energy companies to spend at least some fixed amount per customer (£1.20 from 2000 onwards) to meet energy saving targets. This was replaced with the Energy Efficiency Commitment (EEC) in 2001, which gave suppliers a collective target to reduce energy use through efficiency improvements. This was in turn replaced by the Carbon Emissions Reduction Target (CERT) from 2008, supplemented with the Community Energy Saving Programme (CESP) from 2009. CERT required companies to engage in actions such as installing efficiency measures and providing energy-saving information to customers in order to reduce overall carbon

[8] No official statistics on the take-up of LESA are available. Some estimates suggest that only around 1 in 500 landlords used the scheme in 2007/08 (http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1744i_ii/1744we12.htm).

emissions by a fixed target; CESP was similar but with actions being focused on low-income areas. Both CERT and CESP were replaced from 2012 by the Energy Company Obligation (ECO), which provides funds to install energy efficiency measures in hard to treat properties. In all cases, these obligations included requirements that at least part of the effort was focused on particular priority groups, usually low-income or otherwise vulnerable households. These obligations are likely to have improved overall takeup of energy efficiency measures since they began as they usually provided free or very heavily subsidised installation, with the largest impacts likely amongst those on low incomes.

Since 2007 (2008 in the private rented sector), an Energy Performance Certificate (EPC) giving information about the current and potential energy efficiency of properties has been required when a home is sold or rented (though an EPC once produced is valid for ten years). This should reduce informational asymmetries between sellers and buyers or between landlords and tenants (at least so long as the EPC is updated regularly) though there is as yet no compelling evidence on how the EPC influences willingness to buy or to rent, and some concern about the nature of the information provided on the EPC and the methods used to determine the ratings (Kelly et al., 2012).

2.3 Previous literature

The paper most similar to ours, and from which we draw our empirical approach, is Brechling and Smith (1992). They use data from the 1986 English House Conditions Survey to analyse the determinants of the ownership of loft insulation, wall insulation and double glazing in residential properties. They find that the characteristics of the property (age, size, dwelling type and so on) are more important in explaining the pattern of ownership than socio-economic characteristics of the residents. They find very little evidence that income constrains take-up, suggesting a limited role for credit constraints. However housing tenure was a strong determinant of ownership, with rented properties being less likely to have the measure installed than privately owned properties. This suggests a stronger role for principal-agent issues or related issues in the private renter sector. This study allows us to assess how far those findings remain true in more recent data.

Scott (1997) replicates the Brechling and Smith approach using data on 1,200 Irish households in 1992. He focuses on three efficiency measures: loft insulation, hot water cylinder insulation and low energy light bulbs. In addition to dwelling and resident characteristics, his model includes household's subjective evaluation of the value of such investments and stated reasons for not taking them up. He finds a significant role for information problems and principal-agent issues. He also finds that low income is a barrier to take-up, in contrast with the Brechling and Smith results for England.

These papers use data on the stock of installed efficiency measures. A number of other studies have examined the flow decision to install such measures instead. Caird et al (2008) use an online sample of 400 individuals in the UK who were asked questions relating directly to their decision whether or not to adopt energy efficiency measures and renewable energy technology. Important drivers of installation included the potential bill savings, stated concern for the environment and (at least for loft insulation) a desire for increased warmth. Hassle costs (trouble in clearing loft, disruption in the home and loss of storage) were found to be a key barrier to taking up thick loft insulation. However, respondents to the survey were self-selected, and on average were considered more environmentally aware than the average population, so it is not clear how generalisable these findings are. The sample sizes of respondents reporting why they did not adopt efficiency measures were also very low.

Nair et al (2010) use survey data from 3,000 owner-occupiers living in detached houses in Sweden asking about their recent investments in energy efficiency measures. Whilst they do not report the significance of individual characteristics in driving these decisions, descriptive statistics suggest that on average, those livings in older buildings, experiencing discomfort from cold drafts, and those with higher incomes, are more likely to invest in measures.

Achtnicht and Madelener (2012) use a survey of owner-occupiers in Germany to analyse the drivers behind the decision to undertake energy retrofit activities. Each household is presented with a choice experiment, choosing either to install a modern heating system or improve thermal insulation. Information on a number of attributes of each retrofit option is provided to the respondent to help inform their choice, including potential energy savings and acquisition costs. After choosing one of the two options, respondents are asked whether or not they would carry out such activity on their own home. Discrete choice analysis of the responses indicate an increased likelihood of undertaking such activities when energy savings potential are greater, but a reduced likelihood as costs rise and payback periods increase. Lower income was found to reduce the likelihood, and a lack of information was found to be a key barrier as well.

Hasset and Metcalf (1995) use US panel data on individual tax returns between 1979 and 1981 together with state-level variation in tax incentives for energy efficiency to estimate the impact of such policies on the take-up of measures in residential buildings. Their analysis controls for individual-specific preferences for energy conservation. They find that tax incentives do increase take-up significantly.

Grösche and Vance (2009) use German household survey data to estimate discrete choice models of whether or not households installed some combination of efficiency measures (roof and wall insulation, new window glazing or replacement of heating equipment) in the years prior to the survey. Explanatory variables in their model are household-specific estimates of the direct cost of installing different combinations of measures and the energy savings from doing so. Each is interacted with household income, energy consumption, region of residence and a proxy for the availability of information about the measures. The parameter estimates are used to derive a measure of each household's willingness to pay for reduced energy consumption. They suggest that around half the households in the sample would be willing to pay the costs of installing a package of efficiency measures even without any subsidy, implying that unless the 'hidden' costs associated with installation are very large, subsidies for energy efficiency would carry a high deadweight cost.

3. Economic model and econometric approach

Our economic framework is based on a model in which households maximise utility, which depends on in-home warmth and the consumption of goods and services. Warmth is generated through some production function which depends on the level of energy consumption and the efficiency with which energy translates into warmth. This will be partly dependent on the presence of insulation and efficiency measures.

In this kind of framework, a number of possible factors present themselves as influencing the ownership of efficiency measures which we aim to incorporate into our model. For example, the cost of installing certain measures will depend in part on the characteristics of the dwelling such as age, size, location and property type. For a given cost of energy, people living in larger or older houses may find it more costly to make their homes more efficient and so prefer to consume more energy to achieve warmth compared to people living in smaller, newer properties.

Failures in the market for insulation suggest that factors such as low income (which may be strongly related to credit constraints) and housing tenure will influence insulation choices. Since insulation is an investment which generates future benefits through reduced energy costs (conditional on warmth), then factors which affect a household's ability to appropriate these benefits (such as intention to move home) could also determine insulation decisions. Recent movers may also insulate more if the hassle costs are lower when moving.

Household preferences between warmth and other consumption will also influence the decision to insulate. Such preferences may be related to the demographic characteristics of the residents. For example, retired people or those with limiting disabilities may spend more time at home and so value warmth more than those who spend most of the day at work.

An econometric model of the ownership of energy efficiency measures therefore needs to take into account the simultaneous choice made by households over insulation (*I*) and energy use (*C*) to achieve warmth. The demand for insulation will depend on energy consumption, which in turn depends on the presence of insulation.

Let X_i be a vector of observable covariates of household *i*, including household socio-economic characteristics and dwelling characteristics. Assume that this vector can be divided into two groups X_{1i} and X_{2i}. Characteristics X_{1i} are those which affect the demand for both energy and insulation. Characteristics X_{2i} affect the demand for energy but not insulation. Then we can write the demand for insulation and energy as follows:

$$I_i = \alpha_1 + \beta_1 C_i + \beta_2 X_{1i} + \varepsilon_{1i} \quad (1)$$
$$C_i = \alpha_2 + \gamma_1 I_i + \gamma_2 X_i + \varepsilon_{2i} \quad (2)$$

The key parameter of interest is β_2 which represents the importance of different factors in determining insulation choices.

A *reduced form* approach would substitute the energy consumption equation into the insulation equation and rearrange to eliminate C_i from the insulation equation. However, without further restrictions, this would not allow us to estimate the direct impact of household and dwelling characteristics on the demand for insulation, since the resulting parameter on X_i would also include the indirect effect of these characteristics on energy demand. To give a simple example, suppose we find that low income is associated with a lower take-up of insulation. We may want to interpret that as evidence that credit constraints are a barrier to take-up. However, it could also arise because poorer households demand less energy and lower energy demand reduces the demand for insulation. If we were willing to assume that the demand for insulation does not depend on energy consumption (β_1 = 0), then we could rule out this latter interpretation. This would appear to be a strong *a priori* assumption.

Direct estimation of equation (1) to test whether consumption affects insulation, though, will lead to inconsistent estimates because the simultaneity of the insulation and energy consumption decisions means that energy use is likely to be endogeneous to insulation decisions. This suggests a *structural* approach using instrumental variables methods, which requires finding instruments X_{2i} which affect the demand for insulation only indirectly through their impact on energy demand.

Normally, estimation proceeds by estimating a reduced-form model for energy consumption as a function of the covariate vector X_i and using predicted values of consumption in place of actual values in the insulation equation. However, insulation outcomes are binary – households either do or do not have different measures. Formally, the model we set out to estimate is given by the following three equations for a set of insulation measures:

$$I_i^* = \alpha_1 + \beta_1 C_i + \beta_2 X_{1i} + \varepsilon_{1i} \quad (3)$$
$$I_i = 1\{I_i^* > 0\} \quad (4)$$
$$C_i = \alpha_3 + \gamma_3 X_i + \varepsilon_{3i} \quad (5)$$

Equation (3) is a latent equation for the underlying unobserved process determining whether or not a household owns a particular insulation measure. Equation (4) is an indicator function taking a value 1 if the latent equation is positive: this represents our observation of whether or not the measure is owned. Equation (5) is the reduced form model for household energy consumption. We assume that the error terms ε_{1i} and ε_{3i} are jointly normally distributed with mean zero.

A range of econometric methods for this kind of setup have been developed. A two-step model is proposed by Newey (1987) drawing on Rivers and Vuong (1988). This involves estimating the consumption equation (5) in the first stage, and including both the residual from this equation and observed energy consumption in a second-stage ownership equation modeled using a probit. The significance of the residual in the ownership model indicates whether or not energy consumption is endogenous to the ownership of the measure.

Alternatively, maximum likelihood (ML) methods can be used to estimate the entire model in a single step. The results from the ML approach are more efficient than the two-stage results, and also recover an estimate of the correlation between the error terms ε_{1i} and ε_{3i} which, if significant, is evidence of endogeneity. Overall there is a strong case for using ML methods over a two-step approach. However the drawback is computational: sometimes the estimates from the ML approach will not converge.

Both the two-step procedure and the ML approach enable us to test the null hypothesis that energy consumption is exogenous in the equation for insulation demand. If this null is not rejected (that is, there is no significant correlation between ε_{1i} and ε_{3i}in the estimating equations above) then the insulation equation can be estimated without the need to instrument consumption, and we can assess directly whether or not energy consumption appears to exert any independent influence on the take-up of insulation. If not, then as shown above, reduced-form estimates of the ownership decision alone can be interpreted as the direct effect of different covariates on ownership.

Brechling and Smith (1992) use data from 1986. They take a sample of households including information on the characteristics of the dwelling and its residents, their energy consumption and their ownership of various insulation measures to estimate the model using a two-step procedure.[9] They find no evidence that energy consumption is endogenous in the insulation equations, and no evidence that consumption is significantly correlated with the ownership of the measures they study.

We extend their study to data from 1996. Whilst still outdated, this is the most recent household survey data from England which contains the necessary information to estimate the structural model. We estimate the model for loft insulation, cavity wall insulation and whole-house double glazing using both two-step and ML methods, and find that the key conclusions from Brechling and Smith hold: energy use is exogenous and insignificant in the ownership models. Given the consistency of the results across the 1986 and 1996 datasets, we proceed to estimate reduced-form models of ownership in more recent years of data from 2002 to 2010, under the assumption that we can still interpret these findings structurally. If this relationship between insulation and energy demand has changed significantly since 1996, this assumption may not be valid. However, there is nothing further we can do to test that empirically given the lack of household-level energy use data.

4. Data and key variables

Our data come from the English Housing Survey (EHS) and its predecessor the English House Conditions Survey (EHCS), commissioned by the Department for Communities and Local Government (DCLG).[10] The data are compiled based on interviews with household members and professional surveyor reports about the dwelling.

The data were produced originally only intermittently, approximately once every five years between 1967 and 1996. These waves included information on efficiency measures and energy use for a subset of households, giving all the necessary information to estimate the structural model outlined in Section 3. We use the 1996 survey to do this, the most recent year available. From 2002, the survey has been run as an annual cross-section on a fiscal year basis. Whilst information about efficiency measures has been maintained, no data on energy use is collected after 1996. We use data from fiscal year 2002 to fiscal year 2010 to estimate reduced-form ownership models for the three efficiency measures, maintaining

[9] Note that they use a slightly different two-step model in which the residuals from the first stage are entered into a second-stage logit model of ownership. Given the assumptions required about the joint distribution of the error terms in the structural model, however, the second stage should strictly be a probit model.
[10] In 2008, the EHS replaced and subsumed two previous surveys, the EHCS and the Survey of English Housing (SEH). For ease of notation, we use the abbreviation EHS throughout when referring to the data. Information on the survey is available at https://www.gov.uk/government/organisations/department-for-communities-and-local-government/series/english-housing-survey.

the assumption (based on the structural analysis of the 1996 data) that the parameter estimates can be interpreted as the direct effect of the covariates on having the measures.

4.1 The 1996 survey

Data from an initial sample of over 13,700 households were collected between January and May 1996. Information on energy efficiency was gathered only for a subsample of households who participated in an additional 'energy survey'. A further subset of this group was included in a 'fuel survey' which recorded actual energy use over the last eight quarters, reported on an annual average basis as a number of kilowatt-hours.[11] This gives a sample of around 2,300 households with all the necessary information for the structural analysis.

We look at three outcome measures of energy efficiency as reported by the surveyor:

- Whether there is loft insulation of 100mm or more.[12]
- Whether any cavity walls appear to be insulated.
- Whether all windows are double glazed.

For each measure, the sample is restricted to those households that could feasibly have the measure installed (e.g. people with no loft are dropped from the loft insulation model). We also exclude any household with an incomplete record of the various regressors used in the modelling. Our analysis is also restricted to the 80% or so of the energy use sample that uses gas as the main heating fuel. The measure of energy consumption is the average kilowatt-hours of gas used. Since gas consumption in the structural model is entered in log form, we exclude around 200 household who report zero consumption (though it seems unlikely that households who use gas for heating would genuinely use no gas at all, suggesting some measurement error with these households).

The covariates used in the structural analysis are similar to those used in the reduced form analysis of more recent data described below. In the ownership equation we include household income,[13] the age, sex, ethnicity and employment status of the household reference person, tenure, dwelling age and type, urban/rural status, length of residence, likelihood of moving within five years, and the presence of central heating. Instruments for gas consumption are the number of adults (aged 17+) and children in various age groups (0 to 4, 5 to 10 and 11 to 16), whether gas is used for cooking on the hob and in an oven, whether gas is used to heat water and whether the water tank has an insulating cover. The key assumption is that these variables have no independent influence on ownership of the various insulation measures. For the use of gas for cooking and heating water this seems quite plausible. For the household composition measures the assumption is perhaps less straightforward, but recall that we are conditioning on the size and location of the dwelling

[11] This information was collected from energy companies for households who agreed to have their usage information released for the survey.

[12] Note that in fact we use a lower bound of 94mm. When the surveyor was unable to inspect the loft to measure the insulation thickness a value for thickness is imputed as part of the survey process based on observed values for similar dwellings. The imputed value often takes on the value 94mm particularly for new dwellings, meaning a threshold of 100mm would classify a large number of dwellings as missing the target and giving a misleading impression of the relationship between dwelling age and the presence of loft insulation.

[13] In the 1996 survey, unlike later years, this refers only to the income of the household head and their spouse.

as well. Given that, it seems quite logical that households with larger numbers of people will use more gas (the home may be more frequently occupied meaning more cooking and heating) but less clear that we would expect a greater number of people to have a bearing on the take up of energy efficiency measures through any other channel.

Descriptive statistics
Sample sizes and some descriptive statistics from the 1996 sample are shown in Table 4.1. It is worth noting that the restricted sample available for this analysis is not necessarily very representative of all households in England in 1996 (for example, social tenants appear to be heavily over-represented). We therefore use weights derived specifically for the sample of households that had energy use records which are calibrated to give nationally representative results for this sample. In the model results reported in Section 5, we control directly for these characteristics and so do not apply the weights.

In 1996, households with various efficiency measures consumed less gas on average than those without: 5.2% less for loft insulation, 3.5% less for cavity wall insulation and 9.5% less for full double glazing. Households with cavity wall insulation and full double glazing tended to have higher incomes than those without. Households without loft insulation or double glazing were more likely to move within five years than those with them, though the reverse was true for cavity wall insulation. Those without measures tended to live in older houses and were more likely to be private renters. Those with cavity wall insulation and double glazing were less likely to be social renters, but those with loft insulation were more likely.

Table 4.1: Sample sizes for analysis and descriptive statistics, 1996 EHCS

	Loft insulation of 100mm or more		Cavity wall insulation		All windows double glazed	
Sample size	1,656		1,123		1,865	
% with measure (unweighted)	57.7%		19.9%		30.2%	
% with measure (weighted)	53.8%		25.1%		33.0%	
Weighted averages of …	With	Without	With	Without	With	Without
Gas consumption (kWh/year)	21,409	22,576	20,863	21,624	20,089	22,192
Annual net income (£)	16,295	16,347	19,540	15,405	17,254	15,249
Weighted % reporting that …	With	Without	With	Without	With	Without
Likely to move within 5 years	23.2	31.7	29.4	23.2	24.9	28.6
Unlikely to move within 5 years	72.3	65.4	68.3	73.3	72.2	66.7
Dwelling built before 1945	41.3	47.3	7.9	25.3	26.0	51.5
Dwelling built after 1980	9.3	10.9	23.2	12.6	17.2	7.0
Tenure is private renter	3.7	7.1	0.0	3.3	3.0	6.9
Tenure is owner occupied	75.2	82.0	82.0	75.1	81.9	71.4
Tenure is social renter	19.6	9.3	14.5	21.0	13.7	20.1

Source: Authors' calculations from 1996 EHCS data. Notes: Income is measured as annual net income of the head of household and their spouse (if present); it does not include income from other household members. Weights are household-level weights for those in the fuel survey subsample of the data.

4.2 The 2002 to 2010 surveys

Since 2002, the survey has covered around 16,000 households per year, around half of which also have a physical survey in which information about efficiency measures (alongside other dwelling characteristics) are collected. Thus our reduced-form ownership analysis focuses on this subset of around 8,000 households each year. Energy efficiency measures are derived from a combination of surveyor estimates, householder self-reports and (where necessary) imputation. We focus attention on three outcomes:

- Whether there is loft insulation of at least 200mm;[14]
- Whether there is cavity wall insulation;
- Whether all windows are double glazed.

Again, we exclude cases where measures could not possibly be present. Our models control for various household and dwelling characteristics drawn from the survey and informed by the economic model described above as factors which, through various channels, might influence the take-up of efficiency measures. The available variables are slightly richer than those in the 1996 survey, and include:

- Household income: we use net household income (after income taxes and council tax) including any housing benefits the household receives in the form of rebates.[15] Income could influence ownership if credit constraints make it hard for poorer households to take-up various efficiency measures.
- Whether anyone in the household is in receipt of means-tested or disability benefits. Receipt of such benefits can passport households into eligibility to receive various efficiency-based policy interventions as described in Section 2, and might also proxy for credit constraints.
- The characteristics of the household reference person including sex, age group, educational attainment, employment status and ethnicity.[16] These characteristics can help capture variation in preference for warmth across different groups and can also proxy eligibility for various policy interventions. Education may also proxy lifetime income and so be correlated with the presence of credit constraints.
- Various characteristics of the dwelling including: type (detached house, terraced house, purpose-built flat, etc.), an estimate of the dwelling size in square metres, a grouped indicator for the year in which the property was built, the geographic region in which the dwelling is situated and the urban/rural status of the dwelling location (city centre, suburban, village etc.). These factors may pick up the costs of installing different efficiency measures.
- Measures of how the household heats its home (the main fuel used for heating and whether or not there is central heating). These factors might reflect household preferences for warmth and the costs of installing various measures.
- Whether *anyone* in the household (not necessarily the household head) is long-term sick, registered disabled, unemployed or retired in which case the household may be occupied more frequently.

[14] We did not use a 200mm threshold in 1996 since only around 3% of the sample achieved this.
[15] Full details of income measures in the EHS are available from http://www.decc.gov.uk/assets/decc/Statistics/fuelpoverty/614-fuel-poverty-methodology-handbook.pdf. We use the 'full income' measure defined on pages 6 to 7. Since we control for household composition in the model we use unequivalised income.
[16] The household reference person is the person primarily responsible for paying the rent or mortgage. Where there is more than one joint reference person, the individual with the highest income is used.

- Household composition including number of adults and dependent children. All else equal we might expect the preference for warmth to depend on the number of people in the household.
- Housing tenure interacted with measures of duration of residence in the property. Principal-agent issues might affect take-up of efficiency measures for those who do not own their own homes. Recent movers may be more likely to take up measures if hassle costs are low at the time of moving. It may be that the relationship between duration and ownership differs across tenure types.
- How likely the respondent estimates it is that they will move in the next five years.[17] When people expect to move soon they may be less willing to invest in efficiency measures if they would not expect to recoup the costs.

We group the nine years of data into three periods of three years (fiscal years beginning 2002 to 2004, 2005 to 2007 and 2008 to 2010) and run separate ownership models for each efficiency measure in each period (including fiscal year dummy variables). This allows us to explore whether factors correlated with ownership vary over time in ways which might relate to the various policy interventions we described in Section 2, and allows variables to flexibly impact ownership in different ways over time.[18]

Descriptive statistics
Table 4.2 displays annual sample sizes of households who had a physical survey and where each measure could potentially be installed given the characteristics of the dwelling. It also shows the proportion of households owning each measure. Again, we use household-level weights to correct for sampling variation in these descriptive analyses.

The prevalence of all three measures increased substantially between 2002 and 2010. In 2002, fewer than 10% of households owned loft insulation of 200mm or more. This more than tripled to 32.5% by 2010. Ownership rates of the other measures rose by around twenty percentage points over the period. Comparing Tables 4.1 and 4.2 there is also a clear rise in cavity wall insulation and full double glazing rates between 1996 and 2002.

To shed some initial light on the two key economic constraints on ownership set out in Section 2, we look in Figure 4.1 at how ownership rates among the eligible population for each measure have evolved over time according to housing tenure (broken down into private tenants, social tenants and owner-occupiers). Figure 4.2 looks at ownership rates across the income distribution (dividing households into within-year deciles of equivalised income) at the start and end of our data period.

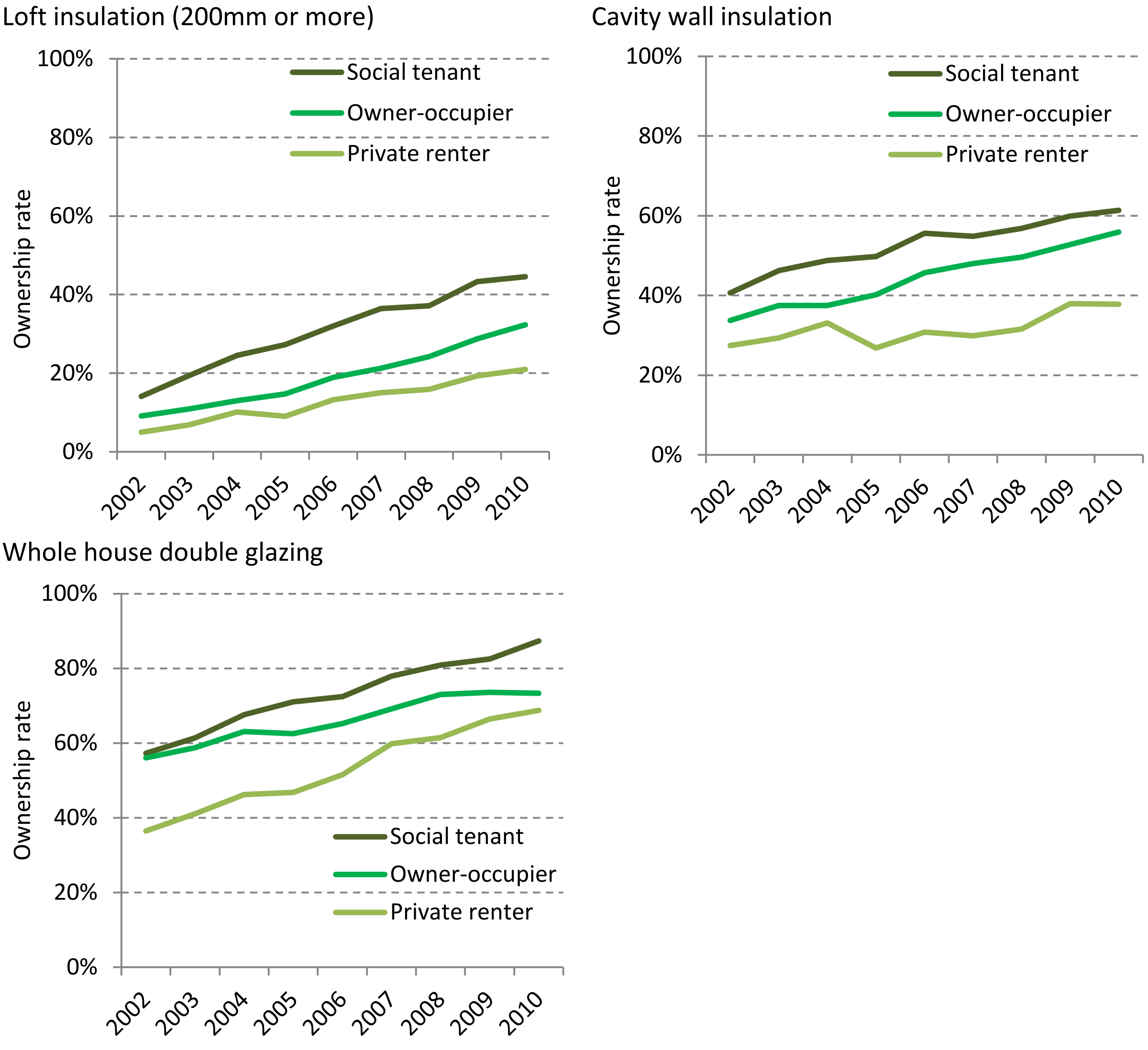
[17] This variable is not available from 2008 onwards and so is excluded in later years.
[18] We ran year-specific models as well; results are available on request. In individual years the sample sizes for specific measures were much lower, meaning the significance of individual covariates was often harder to determine and leading to some year-to-year volatility in the estimates.

Table 4.2: Sample sizes for analysis and descriptive statistics, EHCS and EHS 2002–2010

	Loft insulation of 200mm or more		**Cavity wall insulation**		**All windows double glazed**	
	Sample size	% with measure	Sample size	% with measure	Sample size	% with measure
2002	7,099	9.5%	5,456	34.8%	8,208	54.4%
2003	6,750	11.8%	5,388	38.7%	7,742	57.5%
2004	7,094	14.4%	5,723	39.4%	8,131	62.1%
2005	6,830	16.0%	5,473	41.1%	7,927	62.4%
2006	6,724	20.3%	5,460	46.4%	7,719	64.9%
2007	6,792	22.7%	5,691	47.4%	7,883	69.5%
2008	6,617	24.9%	5,446	49.0%	7,640	72.7%
2009	6,918	29.5%	5,714	52.4%	7,872	74.0%
2010	7,049	32.5%	5,819	54.8%	8,174	75.0%

Source: Authors' calculations from 2002–2010 EHCS/EHS data. Notes: All figures are weighted at the household level. Households in dwellings where installing specific measures are not possible are excluded from the appropriate calculations.

Figure 4.1: Proportion of households with efficiency measures by tenure, 2002–2010

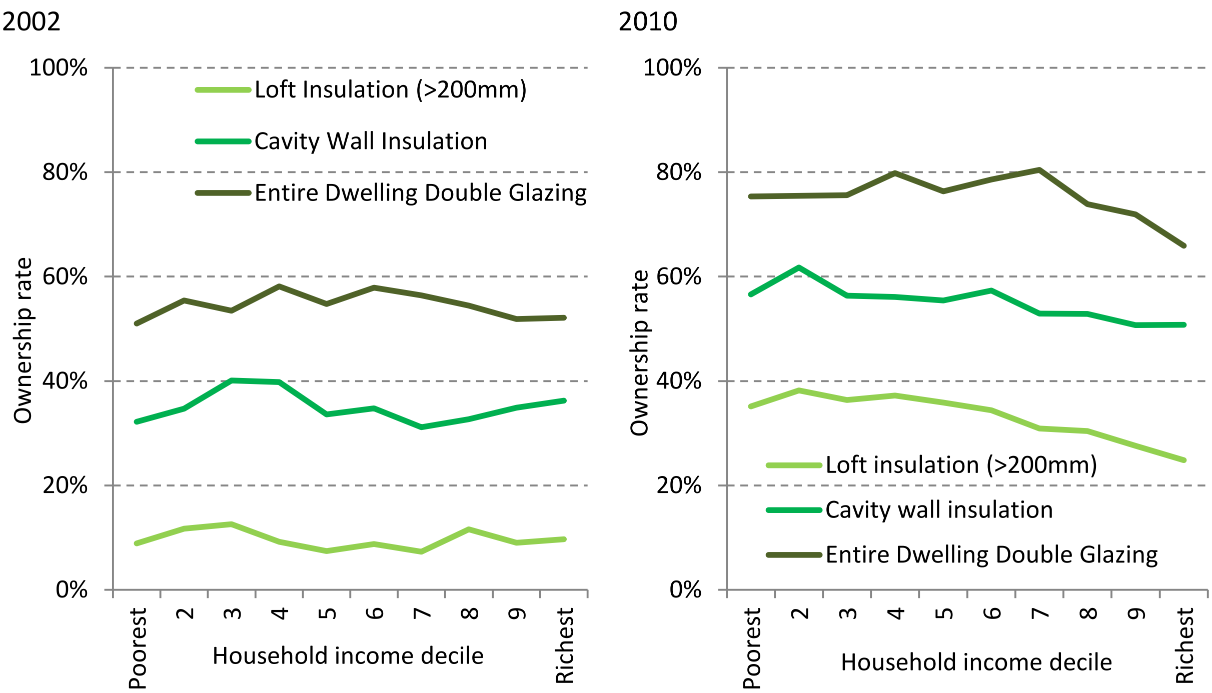


Source: Authors' calculations from 2002 – 2010 ECHS/EHS data. Notes: All figures are weighted at the household level. Households in dwellings where installing specific measures are not possible are excluded from the appropriate calculations.

There are some striking similarities in the trends by tenure group across the three measures. Social tenants are more likely to own each measure than owner-occupiers, with private tenants being less likely to own each measure than owner-occupiers. Trends in ownership rates have risen for each tenure type and each measure. However, for loft and cavity wall insulation, the gap between private tenants and other groups has increased over time. For double glazing, the gap has diminished. This could of course reflect changes in the composition of people and dwellings in different tenancy groups.

Figure 4.2 shows that ownership rates increased at all points of the income distribution between 2002 and 2010. However, looking at the within-year relationship between income and ownership there are some interesting differences between the start and end of the period. In 2002, ownership rates for each measure are roughly flat across the income distribution. In 2010, higher income households appear to be *less* likely to own measures than lower income households. The downward gradient is particularly clear for loft insulation. For double glazing there is a noticeable difference between the top three income deciles, where ownership rates start to decline, and the rest of the distribution where ownership rates are flat.

Figure 4.2: The proportion of households with ownership of energy efficiency measures by equivalised income decile, 2002 and 2010 ECHS/EHS



Source: Authors' calculations from 2002 – 2010 ECHS/EHS data. Notes: All figures are weighted at the household level. Income decile is based on within-year equivalised total income. Households in dwellings where installing specific measures are not possible are excluded from the appropriate calculations.

Taken by themselves, these results are suggestive that credit constraints may be relatively unimportant in determining ownership of these measures but that failures in the landlord-tenant relationship remain a key barrier. However it is important to understand how different measures interact in relation to take-up of the measures: for example, the downward gradient between ownership and income could be driven by high take-up rates in the social renter sector which have followed policy interventions targeted on this group. Once we control for both simultaneously the income relationship may change. The same may be true of other socio-economic or dwelling characteristics – richer people may tend to live in harder-to-treat dwellings, for example. Thus we turn now to our detailed modelling results.

5. Results

5.1 Structural analysis of 1996 data

As described in Section 3, we carry out both two-step and maximum likelihood approaches to the instrumental variables model using the 1996 data to explore the endogeneity and statistical significance of gas consumption in the ownership equations. Our findings are not sensitive to the modelling approach, so here we focus on the maximum likelihood model. Note that in the two-step model, tests of the overidentifying restrictions are unable to reject (at the 5% level) the null hypothesis that the instruments are valid. Details of the results using the two-step method are available on request.

In common with Brechling and Smith's (1992) analysis of 1986 data, we find no evidence in the 1996 survey that gas consumption is endogenous in the ownership equations, or that gas use significantly affects ownership of efficiency measures. This suggests that unless the relationship between energy efficiency measures and energy consumption has changed significantly since 1996 (which cannot be ruled out), we can structurally interpret the parameters from reduced form models run on more recent data, and that excluding unobserved energy consumption from the ownership models will not have any material effect on our results.

Appendix A contains the full regression results from the maximum likelihood estimation of the instrumental variables probit model. For each measure the results for the model of log gas consumption (equation (5) above) and the ownership model of the insulation measure (equations (3) and (4)) are shown, along with the results (p-value) of a Wald test that gas consumption is exogenous in the ownership equation. An insignificant result (p-value in excess of 0.05) indicates there is insufficient evidence to reject the null hypothesis that gas consumption is exogenous. This is the case for all measures (p-values are 0.141, 0.400 and 0.164 for loft insulation of at least 100mm, cavity wall insulation and whole-house double glazing respectively). The coefficients on gas use (-0.557, -0.697 and +0.357 respectively) are all insignificant at the 5% significance level; for loft insulation the coefficient is significant only at the 10% level.

Looking at the other covariates in the ownership equations yields some interesting findings, and we assess below how far these appear to change in later years. There is no evidence that income plays an independent significant role in determining ownership of efficiency measures. If income is a reasonable proxy for whether or not households face credit constraints which could prevent them paying for measures, this is suggestive that even in 1996 this was a relatively unimportant issue, other factors being equal.

Characteristics of the household members play a relatively limited role in determining ownership. There are no clear consistent effects across different measures of age or employment status. For example, even conditional on duration of residence, households headed by older people appear less likely to have full double glazing, but there is no effect of age for the other measures. Households headed by someone who is part-time employed or a housewife, who may spend more time in the home, are more likely to have cavity wall insulation relative to households headed by a full-time employee. But this does not hold for other measures, and households headed by those who are unemployed or retired (who might also be at home more often) appear no more likely to have cavity wall insulation. The results for region and area type are equally inconsistent from measure to measure: houses in rural areas are more likely to have double glazing and (weakly) more likely to have cavity wall insulation than those in city centres, but no more likely to have loft insulation.

Housing tenure plays some role in determining ownership, but again the findings are not completely consistent across different measures. Relative to owner occupiers, private renters are less likely to own all measures, but the coefficients are only ever significant at the 10% level at most. Social renters are significantly less likely to have full double glazing but significantly *more* likely to have loft insulation (with no significant difference for cavity wall insulation), broadly confirming the pattern in Table 5.1. This suggests that efforts to improve the insulation standards of the social housing stock by 1996 were not spread evenly across different measures.

There is no evidence that people who have recently moved (less than 2 years duration of residence) have higher ownership rates; indeed those with very longer tenures are more likely to have cavity wall insulation. Plans for moving in the relatively near future, which might limit the extent to which benefits from insulation can be appropriated, also have no clear relationship with ownership across different measures. In the case of double glazing the effect is as expected: those who plan to move are less likely to own. For the other measures there is no consistent impact: for example, for cavity wall insulation, those who say it is not very likely they will move appear less likely to own than those who say it is very likely they will do so.

The characteristics of the dwelling appear to have some relationship with ownership, though again there is some inconsistency across measures in the impact of different factors. Older houses are much less likely to have full double glazing and somewhat less likely to have cavity wall insulation, but for loft insulation there is no strong effect. Neither the size nor type of dwelling has any relationship with ownership.

The main value of the 1996 results is in confirming that the exogeneity and unimportance of gas consumption in models of insulation ownership found in the 1986 data still held ten years later. The relatively small sample sizes in the 1996 dataset make it hard to capture consistent and significant effects of different dwelling and resident characteristics on ownership. Maintaining the assumption that our results so far allow us to interpret reduced form ownership models in a structural way, we now turn to an analysis of larger samples in more recent data to see whether we can find more convincing evidence of factors associated with ownership and whether there appears to be any change in these factors over time which might relate to policy changes discussed above.

5.2 Reduced-form analysis of recent survey data (2002 to 2010)

Full results from the probit models for ownership of cavity wall insulation, 200mm or more of loft insulation and full double glazing are shown in Appendix B. Table 5.1 summarises some of the key results related to the variables discussed in Section 4. Given the non-linear nature of the probit model, to ease interpretation we present average marginal effects (results from the probit models themselves are available on request).

Table 5.1: Key results (average marginal effects) from reduced-form models

Omitted comparator	Variable	Cavity wall insulation			200mm+ loft insulation			Full double glazing		
		2002 – 2004	2005 – 2007	2008 – 2010	2002 – 2004	2005 – 2007	2008 – 2010	2002 – 2004	2005 – 2007	2008 – 2010
Occupant characteristics										
–	Log income	-0.00	0.05	0.12	-0.09	-0.05	-0.13^{**}	0.32^{***}	0.03	0.05
–	Log (income^2)	0.00	-0.00	-0.01	0.01	0.00	0.01^{*}	-0.02^{***}	-0.00	-0.00
No means tested benefits	Receives means tested benefits	-0.03^{***}	-0.03^{***}	-0.01	-0.03^{***}	-0.04^{***}	-0.03^{***}	-0.01	-0.00	0.01
Owner occupied (< 2 years)	Owner occupied (6–10 years)	0.04^{**}	0.02	-0.05^{*}	-0.01	-0.02	-0.05^{***}	0.00	0.01	0.03^{*}
Owner occupied (< 2 years)	Owner occupied (> 20 years)	0.05^{**}	0.02	0.02	-0.05^{***}	-0.08^{***}	-0.10^{***}	-0.04^{***}	-0.05^{***}	-0.05^{***}
Owner occupied (< 2 years)	Private renter (< 2 years)	0.01	-0.03	-0.11^{***}	-0.04^{***}	-0.04^{**}	-0.11^{***}	-0.11^{***}	-0.04^{**}	-0.03^{*}
Owner occupied (< 2 years)	Private renter (2–5 years)	0.01	-0.03	-0.14^{***}	-0.05^{***}	-0.04^{**}	-0.11^{***}	-0.18^{***}	-0.08^{***}	-0.04^{**}
Owner occupied (< 2 years)	Private renter (> 5 years)	-0.01	-0.13^{***}	-0.13^{***}	-0.07^{***}	-0.07^{***}	-0.13^{***}	-0.19^{***}	-0.15^{***}	-0.10^{***}
Owner occupied (< 2 years)	Social renter (< 2 years)	0.09^{***}	0.06^{**}	0.01	0.03^{**}	0.06^{***}	0.02	-0.04^{**}	-0.04^{**}	0.02
Owner occupied (< 2 years)	Social renter (6–10 years)	0.15^{***}	0.13^{***}	0.02	0.04^{***}	0.06^{***}	0.05^{*}	-0.05^{***}	-0.01	0.05^{**}
Owner occupied (< 2 years)	Social renter (> 20 years)	0.24^{***}	0.21^{***}	0.16^{***}	0.06^{***}	0.08^{***}	0.03	-0.09^{***}	-0.02	0.05^{**}
V. unlikely to move w/i 5 years	V. likely to move within 5 years	-0.04^{***}	-0.04^{***}	–	-0.02^{**}	-0.03^{***}	–	-0.04^{***}	-0.02^{**}	–
Dwelling characteristics										
Semi-detached	Converted flat	-0.21^{***}	-0.13^{***}	-0.22^{***}	-0.05^{**}	-0.05	-0.03	-0.03^{*}	-0.07^{***}	-0.04^{**}
Semi-detached	Purpose-built flat	-0.08^{***}	-0.06^{***}	-0.06^{***}	-0.02^{*}	-0.02	-0.03^{*}	0.05^{***}	0.02^{*}	0.02
Built 1965–1974	Built < 1850	-0.17^{***}	-0.32^{***}	-0.33^{***}	0.02	-0.00	-0.05^{**}	-0.34^{***}	-0.35^{***}	-0.32^{***}
Built 1965–1974	Built 1919–1944	-0.05^{***}	-0.03^{**}	-0.04^{***}	0.02^{***}	0.03^{***}	0.01	-0.11^{***}	-0.10^{***}	-0.15^{***}
Built 1965–1974	Built > 1990	0.26^{***}	0.16^{***}	0.06^{***}	0.13^{***}	0.17^{***}	0.15^{***}	0.31^{***}	0.29^{***}	0.19^{***}
–	Floor area $m^2 \times 100$	-0.09^{**}	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
Fuel characteristics										
Main fuel gas	Mainly solid fuel	-0.00	-0.03	-0.08^{**}	-0.00	-0.03	-0.02	-0.10^{***}	-0.10^{***}	-0.09^{***}
Main fuel gas	Communal fuel	0.01	-0.03	-0.07^{**}	0.03	-0.05^{*}	-0.13^{***}	-0.06^{***}	-0.08^{***}	-0.11^{***}
No central heating	Central heating	0.03	0.04	0.08^{**}	0.02	0.06^{***}	0.03	0.08^{***}	0.10^{***}	0.07^{***}
	Observations	16,567	16,610	16,954	20,943	20,323	20,550	24,081	23,499	23,642
	Mean of dependent variable	0.387	0.475	0.539	0.129	0.221	0.315	0.568	0.662	0.756
	Pseudo R^2	0.070	0.073	0.079	0.069	0.085	0.081	0.105	0.118	0.151

Source: Authors' calculations from 2002 – 2010 ECHS/EHS data. Notes: * = significant at 10% level; ** = significant at 5% level; *** = significant at 1% level. Figures are average marginal effects from the probit model. Parameters are relative to the omitted comparator stated where applicable. Standard errors are not shown on this table to preserve space; full results including standard errors can be found in Appendix B.

The importance of occupant characteristics

As with the 1996 findings, we find no compelling evidence that household income is related to whether or not efficiency measures are present. The strongest effect is seen for double glazing in 2002–04, when a 10% increase in income was associated with an increase of around 3 percentage points in the probability of owning. However this effect is not seen in later years. Indeed, the in most recent period we find some evidence that higher income households are *less* likely to own thick loft insulation.

This suggests little role for credit constraints inhibiting take up of energy-efficient measures. Other proxies for credit constraints present mixed messages. Perhaps the most consistent result is that receipt of means-tested benefits reduces the probability of owning thick loft insulation by 3 to 4 percentage points over the whole period. The effect of benefit receipt on cavity wall insulation appears to fade in the most recent data, and is not present at all for double glazing. We also find no evidence that low education reduces the probability of ownership: indeed, the most consistent result is that houses headed by someone with a degree are much *less* likely to have full double glazing than those headed by someone with compulsory education. Low education might also relate to bounded rationality or difficulty in processing the long-term nature of efficiency measures as an investment; again these results suggest little role for that channel.

The role of the characteristics of the household head (age, employment status and ethnicity) and household composition (numbers of adults and dependent children) in determining ownership is relatively limited, and varies across the different measures and across time without any clear pattern. The most consistent pattern is that households with more adults or headed by someone of Asian ethnicity tend to be significantly more likely to have fully double glazed homes. We also find some evidence in the most recent period (2008–10) that households headed by someone who is retired are more likely to have cavity wall and loft insulation (though not double glazing) – this could reflect either stronger preferences for certain measures once someone retires (reflecting time spent at home, say) or the impact of measures which have been partly targeted on older households. We look more specifically at this first possibility by conditioning on whether there is *anyone* in the household (not necessarily the head) who is likely to be at home more during the day (someone who is retired, registered disabled or unemployed). There are some significant effects which tend to be positive, but the effects are not consistent across time or measure.

Tenure type and duration of residence are more significantly related to the presence of efficiency measures. Private renters tend to be much less likely to own each measure than owner occupiers. In 2008–10, private renters who had been in their property for less than two years were 11 percentage points less likely to have cavity wall insulation, 11 percentage points less likely to have thick loft insulation and 3 percentage points less likely to have full double glazing than owner occupiers in their property for less than two years. The negative relationship between private rental and ownership appears to have strengthened over time for cavity wall and loft insulation but somewhat weakened for double glazing. However, except for double glazing, there does not appear to be much impact of length of residence among private renters: those who have been in the same property for a long time do not seem much less likely to own the measures than those private renters who have been in their property for a short duration.

The effect of social renting on ownership appears to be the inverse of the private renter results. For cavity wall and loft insulation, social renters had been much more likely to own the measure than owner occupiers in the earlier periods, but the effect is no longer statistically significant in the most recent period. By contrast, having been significantly *less* likely to have full double glazing in 2002–04, social renters were typically *more* likely to have it in 2008–10. Recall that a number of policies were targeted explicitly on social tenants before and during this data period: the Home Energy Conservation Act 1995 should have increased the ownership of measures among social renters from the mid 1990s, for example, and the Decent Homes Programme had explicit targets to improve the efficiency of the social rented housing stock by 2010. It may be that these policies largely affected different types of measures at different times. For example, the definition of 'decent home' (DCLG, 2006) suggests that insulation against external noise is one of the criteria, which might account for a relative improvement in the ownership of double glazing in the social renter sector over the period studied. By contrast, if measures delivered following the Home Energy Conservation Act were more focused on loft and wall insulation, then this could explain why social rented properties were already more likely to own them in 2002 after which other tenancy groups began to catch up.

Social renters who have been in the same property for more than 20 years are 16 percentage points more likely to have cavity wall insulation than owner occupiers who have been resident in their home for less than two years. Social renters who have been in their property for less than two years are no more likely to have it than owner occupiers with the same length of residence. This duration effect has persisted for cavity wall insulation, but no similar effect is clear for other measures among social renters.

Owner occupiers with longer tenure duration are generally less likely to own the measures. The effect of long residence is particularly clear for thick loft insulation and if anything appears to have become more acute over time. In 2008–10 owner occupiers resident for more than 20 years were around 10 percentage points less likely to have thick loft insulation than those resident for less than two years. The effect is around 5 percentage points for full double glazing, and is not significant for cavity wall insulation.

The importance of dwelling characteristics

There is much more compelling evidence that physical dwelling attributes are quite strongly correlated with ownership of various measures. Property age appears to be a particularly important factor: older properties are typically much less likely to contain measures relative to newer properties, although the effect varies across different measures. The strongest impact of property age is found for full double glazing. Relative to properties built between 1965 and 1974, those built before 1850 were around 32–35 percentage points less likely to be fully double glazed in different periods, whilst those built after 1990 were around 19–30 percentage points more likely to be fully double glazed. Similar trends emerge looking at cavity wall insulation. For thick loft insulation the size of the older property effect is somewhat smaller at around 5 percentage points and is not stastistically significant in earlier periods, though there remains a large significant effect of newer-build properties.

These results are perhaps unsurprising: newer properties are either more likely to include these measures in the initial construction (for example because of changes in building regulations over time) or are easier and cheaper to renovate.[19] Unfortunately we do not have more fine-grained evidence on the age of particularly newer properties which might allow us to relate dwelling age to changes in building regulation standards more directly.

Property type is also an important factor related to efficiency. Relative to those in semi-detached homes, people in flats (and in particular converted flats rather than purpose builds) tend to be less likely to own all measures. The effect is strongest and most persistent for cavity wall insulation: in 2008–10, those in converted flats were 22 percentage points less likely to have it than those in semi-detached homes, and those in purpose-built flats 6 percentage points less likely. There is little evidence, particularly in the most recent period, that those in flats are less likely to have thick loft insulation (recall that we condition our model for each measure on those properties where measures can potentially be installed). For full double glazing in earlier periods, purpose built flats were *more* likely to be double glazed than semi-detached houses, whilst converted flats have been somewhat less likely to have it in all periods. Aside from flats, there is evidence that bungalows are more likely to have all measures (particularly cavity wall and thick loft insulation), that terraced houses are more likely to have full double glazing, and that mid-terraces are less likely to have cavity wall insulation whereas end-terraces are not.

Conditional on property age and type, there is no consistent evidence that the physical size of the property has any relationship with the presence of the different efficiency measures.

The importance of fuel-based characteristics

The way in which dwellings are heated has some relationship with the presence of efficiency measures. Households without central heating are less likely to have the various measures, though the significance of the effect varies across measures and periods. The most consistent finding is that lacking central heating is associated with a 7–10 percentage point reduction in the probability of having full double glazing. It may be that households install central heating at the same time as other measures, or that the presence of central heating is correlated with a stronger overall preference for warmth.

Households who use solid fuel (such as coal) or have some communal heating system also tend to be less likely to have efficiency measures. Again the effect is particularly consistent for double glazing: relative to those using gas to heat the home, those with communal or solid fuel systems tend to be around 10 percentage points less likely to have full double glazing. In the most recent period, communal heating also reduces the probability of having cavity wall insulation by 7 percentage points and thick loft insulation by 13 percentage points. Solid fuel reduces the probability of cavity wall insulation by 8 percentage points, but has no effect on the probability of loft insulation.

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[19] Building regulations for new homes in England do not specify that a particular efficiency measure needs to be installed, but do set out minimum standards of performance for heat loss from walls and roofs from which it is possible to estimate the necessary level of loft or cavity wall insulation. Homes built since 2002, for example, have had standards for roofs which imply a minimum loft insulation thickness of 250mm. For a summary see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65976/6862-need-report-annex-g.pdf.

The importance of regional characteristics
There appear to be some fairly consistent regional effects. Households in the North and Midlands tend to be significantly more likely to have cavity wall and thick loft insulation than those in the South, though do not appear to be any more likely to have full double glazing. Households in London are much less likely to own some measures than those in other Southern regions (in the most recent period, London households were 12 percentage points less likely to have cavity wall insulation and 10 percentage points less likely to have full double glazing; there was no significant effect for thick loft insulation). Given that we control for a range of other dwelling and resident characteristics it is not immediately clear why London in particular appears to have a lower take up of measures than other regions (if it were a climate effect we might expect other southern regions to show a similar effect, for example), and it may be an interesting issue to explore further.

Aside from region, the type of area in which dwellings are located also appears to be related to ownership of efficiency measures, but again the effects vary across measure. People in both urban residential areas and rural areas tend to be less likely to have cavity wall insulation than those in suburbs. By contrast, those in city centres tend to be less likely to have double glazing whereas those in rural residential areas tend to be more likely to have it. There is no systematic effect of area type for loft insulation.

Summary
Broadly, the results point to the dwelling characteristics being more important correlates with ownership of different efficiency measures than the characteristics of the residents. If dwelling characteristics reflect the cost of installing measures in different homes then this is perhaps unsurprising. Housing tenure and duration of residence also play a role, but with differential trends in their effect across different measures over time. Income does not appear to matter for ownership, and there is little consistent evidence to support credit constraints being a significant barrier to take up other than a persistent effect of means-tested benefit receipt on the likelihood of having thick loft insulation.

Indeed, perhaps the most consistent finding is just how *in*consistent the relationship between particular observable dwelling and resident characteristics and ownership of efficiency measures is across measures and time. It is hard to find many examples of characteristics which have the same correlation with ownership for all measures, and even harder across all periods. Being a private renter, living in an old (pre-WW2) or new (post-1990) property, relying on solid or communal fuel for heating and living London are perhaps the best examples of consistent effects that reduce ownership rates.

A final point worth noting regards the extent to which the covariates in our ownership equations appear to explain the probability of ownership of the different measures. Although there is no simple 'goodness-of-fit' measure equivalent to the R^2 in linear models, McFadden's Pseudo-R^2 measure for probit estimates, reported at the foot of the tables in Appendix B, serves a similar function. Overall, the values are low, in the order of 7–8% for cavity wall insulation, 7–9% for loft insulation and 11–15% for full double glazing. Whilst low explanatory power is not uncommon for cross-sectional models, this suggests significant unobserved heterogeneity in whether or not households own these measures which cannot be accounted for by the variables in our data. We discuss this further in the next section.

6. Discussion and policy implications

The results suggest little convincing evidence that credit constraints are a significant barrier to owning different efficiency measures. Poorer households or those with low educational attainment do not appear to be any less likely to have loft insulation, cavity wall insulation or full double glazing (controlling for other factors) than richer households. Policies which simply subsidise efficiency measures may therefore be associated with a large amount of deadweight cost, and credit constraints would not provide a compelling rationale to offer small-scale loans to pay for installation of relatively inexpensive measures (as under the Green Deal). This does not imply that a loan mechanism would not be useful for more expensive efficiency measures or packages of measures which add up to be quite costly.

The main caveat to this is that receipt of means-tested benefits, which is often used as an indicator for eligibility for particular policy interventions designed to boost efficiency, does appear to be correlated with lower ownership rates, at least for loft insulation. The effect of benefit receipt on whether or not cavity wall insulation is present has diminished over time. This may suggest that policies such as WarmFront (from 2001) and CERT (from 2008) which linked eligibility for assistance with insulation in part to receipt of means-tested benefits have been at least somewhat successful, though there appears to be a continued rationale for using benefit receipt as a criterion for intervention. It is of course worth bearing in mind that the composition of those who receive means-tested benefits is likely to have changed somewhat over time, particularly given the increase in unemployment since the onset of recession in 2008, though we condition on other characteristics as far as we can.

There appears to be much stronger evidence for principal-agent problems or other landlord-tenant failures in the market for energy efficiency. Housing tenure is significantly related to ownership of different measures. The private renter sector continues to lag behind other tenure types and these differences are not fully explained by resident or dwelling characteristics. Being a private renter is one of the few characteristics which exerts a significant and negative effect on the probability of ownership across all three measures, and if anything it appears private rental is becoming increasingly associated with low take-up for cavity wall and loft insulation. By contrast, social tenants are, if anything, more likely to own different measures. Whilst it may be more straightforward for local authorities and policy makers to influence take-up in the social rented sector directly, these findings do indicate that the private renter sector should be a focus of policy going forward. Policies such as the Landlords Energy Saving Allowance have provided tax incentives for landlords to install various measures (including loft and wall insulation) since 2004 but it is hard to see any clear impact of that in reducing the ownership gap between the private rented and other sectors since then, except perhaps for double glazing.[20] This suggests that regulatory measures which require landlords to install measures (either through the Green Deal or through more direct regulation of the efficiency standard of let properties) may be required,

[20] There appears to be no clear statistics or evaluation of the LESA which makes it hard to know whether these trends accord with the sorts of measures landlords have typically installed under the scheme. As noted above, though, LESA is a fairly small scheme overall.

and indeed it looks as if policy will move in that direction. Under the 2011 Energy Act, private-rented properties must have a minimum efficiency standard (not yet determined) from 2018, providing this standard can be met at no up-front cost to landlords through measures available under the Green Deal or supplier obligations. If not, then landlords will still have to carry out everything which is available under these mechanisms in order to be able to rent out a less efficient property. Failure to comply with this will see landlords face a penalty of up to £5,000, though it is not yet clear how landlords with less efficient homes will demonstrate their compliance.

Although installation incentives are aligned in owner-occupied properties, it does appear that people who have lived in the same owner-occupied home for a very long time are less likely to have thick loft insulation and full double glazing (though there is no effect for cavity wall insulation). Long duration owner-occupiers could become a target for intervention, if they can be readily identified by policy makers. The most striking relationship between duration of owner-occupation and ownership of measures is for loft insulation: it may be that as duration of tenure increases, owner-occupiers accumulate more in their lofts which increases the hassle costs of later having insulation installed. Targeting long-duration owners with help in clearing their loft rather than low priced installation could be an effective intervention.

There is little evidence that those with very short duration of tenure (irrespective of tenure type) are more likely to have the measures than those with longer durations, as might be expected if moving home is used as an opportunity to install measures at a point when relative hassle costs are low or former habits are subject to change.

We find consistent evidence that people who plan to move in the near future are less likely to own measures than those who do not (though this variable was missing in the most recent period of data from 2008). Assuming then that this still holds, this suggests that people take account of the fact that they will be not appropriate the future benefits of installing measures which are tied to the property not the resident. The design of the Green Deal, in which repayments are linked to the dwelling, therefore appears sensibly designed to encourage even those who plan to move to make use of the scheme.
More generally, if policy makers are concerned with how they can spend a certain amount of money on efficiency policies (whether through tax-funded or bill-funded measures which are funneled through energy suppliers) to achieve the best improvement in the condition of the housing stock, then it appears that targeting the money on certain types of property is more effective than targeting the money on certain types of resident. Older houses, flats and properties which use solid fuel, communal fuel or do not have central heating would appear to offer the largest potential for improved efficiency. The feasibility of including dwelling characteristics in the design of interventions should be carefully considered.

As noted above, we find that the significance (and even the sign) of the correlation between ownership of an efficiency measure and particular dwelling and resident characteristics tends to vary across measures, with a few notable exceptions. This suggests that policies designed to improve take-up of measures may need to target different groups of households for different measures.

There are some limitations to our results which could be addressed in future work. We are not able to say much about other economic market failures which might inhibit take-up of efficiency measures, such as information and understanding about energy efficiency, or the possible importance of time inconsistency. Evidence on these issues might require additional data collection on residents' knowledge about efficiency measures or experimental collection of measures of time preference.

The relatively overall low explanatory power of our ownership models suggests that there are many unobserved factors which determine whether or not efficiency measures are present. This could include unobserved heterogeneity in household-level preferences and attitudes towards insulation and energy. Martinsson et al (2011), for example, use Swedish survey data and find that self-reported frequency of individual-level energy saving behaviour is strongly positively correlated with an index of environmental attitudes.[21] A future wave of the survey could ask residents (and landlords) who do not have various measures why not, and include other attitudinal questions towards environmental issues.

Further, we look only at the stock measure of whether households currently have or do not have particular measures. This means, for example, we associate current resident characteristics with ownership of measures which may have been installed by previous owners or tenants of the property (and so implicitly we assume that the characteristics of current residents are similar to those of previous residents). We do not look at the flow decision of whether to install or improve efficiency over time. The survey does include measures of whether the dwelling has had insulation measures installed in the last year, and whether any kind of support for the installation was received through energy providers or government policy. In principle, this would seem like a ripe area for future exploration, though the survey does not include any information on recent changes in circumstances which might be correlated with the decision to install particular measures and so we would still have to rely on current characteristics as explanatory variables.

7. Conclusions

Despite the potential benefits of installing efficiency measures, and considerable progress in ownership rates in recent years, there still appears to be scope to raise their penetration yet further, even for relatively straightforward measures. By 2010, only around a third of homes with lofts had insulation exceeding 200mm in thickness, only 55% of homes with cavity walls had insulation, and only 75% of homes had full double glazing. Understanding which factors are associated with ownership of these measures could help policy makers and energy companies target their efforts more carefully and understand what market failures may be inhibiting take-up. We use data on English housing and residents to explore the issues.

Simply estimating a model of whether or not households own a particular energy efficiency measure as a function of various characteristics risks conflating the demand for energy with the demand for energy efficiency measures. As far as we are able, we demonstrate that these concerns are not important and that energy use itself does not appear to be an

[21] It is notable, though, that even including this measure and its interaction with observed socio-economic and dwelling characteristics in their model, they still were unable to account for more than around 7% of the observed variation in energy-saving behaviour.

important determinant of the ownership of different measures. However, because of a lack of consistent household-level data which records energy use alongside detailed dwelling and occupant characteristics, we are only able to show that this result holds in 1996. Together with an earlier paper demonstrating the same finding in 1986, we assume that the same finding holds in more recent years and proceed to estimate ownership models which exclude energy use altogether.

This is, though, somewhat unsatisfactory. Given the enormous policy importance attached to energy and climate change in recent years, it is somewhat startling that there is not a single representative household-level dataset collected on a regular basis that records energy use alongside other characteristics. One important conclusion of our work is that this data should be collected again. This would allow much important work to be done, particularly if it could be linked to repeated observations of the same household over time in a panel study, and incorporate dwelling characteristics alongside resident characteristics. DECC has begun to collect data as part of the National Energy Efficiency Database (NEED)[22] which records at the dwelling level measures of whether efficiency measures were installed under various schemes along with estimates from local area information of the characteristics of the inhabitants and data from suppliers of energy use. This data could be extremely valuable, particularly if it could be linked to existing panel datasets at the dwelling level which would allow for accurate measures of resident characteristics to be added to the efficiency and energy use data.

Broadly speaking, our empirical results offer little evidence that credit constraints are a significant market failure inhibiting take-up of efficiency measures, but considerable support for the idea that failures in the landlord-tenant relationship are a substantial barrier. We also find that certain dwelling characteristics, such as property age and heating type, are important determinants of the presence of energy efficiency measures. If feasible, these factors should be built into the design of future policies aimed at improving the energy efficiency of the housing stock.

[22] See https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/national-energy-efficiency-data-need-framework.

References

Achtnicht, M. and R. Madelener (2012), *Factors Influencing German House Owners' preferences on Energy Retrofits,* FCN Working Paper 4

Brechling, V. and S. Smith (1992), *The Pattern of Energy Efficiency Measures Amongst Domestic Households in the UK*, IFS Commentary 31, London: IFS

Caird, S., R. Roy and H. Herring (2008*), '*Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies', *Energy Efficiency*, 1(2), 149–66 http://oro.open.ac.uk/10827/1/CairdRoy&Herring_EnergyEfficiency_FinalRevised11Apr08.pdf

Department for Communities and Local Government (2006), *A Decent Home: Definition and Guidance for Implementation*, London: DCLG (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7812/138355.pdf)

Department for Energy and Climate Change (2012a), *The Energy Efficiency Strategy: the Energy Efficiency Opportunity in the UK*, London: DECC (http://www.decc.gov.uk/assets/decc/11/tackling-climate-change/saving-energy-co2/6927-energy-efficiency-strategy--the-energy-efficiency.pdf)

Department for Energy and Climate Change (2012b), *National Energy Efficiency Data-Framework*, London: DECC (http://www.decc.gov.uk/assets/decc/11/stats/energy/energy-efficiency/6861-need-report-nov-2012.pdf)

Grösche, P. and C. Vance (2009), 'Willingness to pay for energy conservation and free-ridership on subsidization: evidence from Germany', *The Energy Journal*, 30(2), 135–54

Hassett, K. and G. Metcalf (1995), 'Energy tax credits and residential conservation investment: evidence from panel data'*, Journal of Public Economics*, 57(2), 201–7

House of Commons Public Accounts Committee (2009), *The Warm Front Scheme*, London: The Stationery Office Limited (http://www.publications.parliament.uk/pa/cm200809/cmselect/cmpubacc/350/350.pdf)

Hills, J. (2012), *Getting the measure of fuel poverty: final report of the Fuel Poverty Review*, London: Centre for Analysis of Social Exclusion (http://www.decc.gov.uk/assets/decc/11/funding-support/fuel-poverty/4662-getting-measure-fuel-pov-final-hills-rpt.pdf)

Kelly, S., D. Crawford-Brown, M. Pollitt (2012), 'Building performance evaluation and certification in the UK: is SAP fit for purpose?', *Renewable and Sustainable Energy Reviews*, 16(9), 6861–78

Levine, M., E. Hirst, J. Koomey, J. McMahon and A. Sanstad (1994), *Energy Efficiency, Market Failures and Government Policy*, mimeo (http://emp.lbl.gov/sites/all/files/Energy%20Efficiency,%20Market%20Failures,%20and%20Government%20Policy.pdf)

Linares, P. and X. Labanderia (2010), 'Energy efficiency: economics and policy', *Journal of Economic Surveys*, 24(3), 573–92

Martinsson, J., L. Lundqvist and A. Sundström (2011), 'Energy saving in Swedish households. The (relative) importance of environmental attitudes', *Energy Policy*, 39(9), 5182–91

Nair, G., L. Gustavsson and K. Mahapara (2010), 'Factors influencing energy efficiency investments in existing Swedish residential buildings', *Energy Policy*, 38(6), 2956–63

Newey, W. (1987), 'Efficient estimation of limited dependent variable models with endogenous explanatory variables', *Journal of Econometrics*, 36(3), 231–50

Rivers, D. and Q. Vuong (1988), 'Limited information estimators and exogeneity tests for simultaneous probit models', *Journal of Econometrics*, 39(3), 347–66

Scott, S. (1997), 'Household energy efficiency in Ireland: A replication study of ownership of energy saving items', *Energy Economics*, 19, 187–208

Verplanken, B., I. Walker, A. Davis and M. Jurasek (2008), 'Context change and travel mode choice: combining the habit discontinuity and self-activation hypotheses', *Journal of Environmental Psychology*, 28(2), 121–7

Appendix A: Structural ownership model, 1996

Table A.1 shows the results for maximum likelihood estimation of the structural model (equations (3) to (5) above) of whether households own three efficiency measures (at least 100mm of loft insulation, cavity wall insulation and full double glazing). Parameter estimates for the gas consumption and ownership equations are shown in each case. For each measure the p-value from Wald test whose null hypothesis is that gas consumption is exogenous in the ownership model is also shown.

Table A.1: Maximum likelihood results of structural model for ownership of efficiency measures, 1996 EHCS

		100mm+ loft insulation		Cavity wall insulation		Full double glazing	
		Consumption	Ownership	Consumption	Ownership	Consumption	Ownership
	Constant	10.230***	2.322	5.541*	0.814	9.720***	-4.058
		(2.349)	(6.234)	(2.833)	(8.263)	(2.253)	(6.337)
	Log gas consumption		-0.557*		-0.697		0.357
			(0.299)		(0.527)		(0.336)
	Log income	-0.539	0.097	0.333	0.346	-0.448	0.107
		(0.497)	(1.215)	(0.601)	(1.755)	(0.481)	(1.254)
	$(\text{Log income})^2$	0.034	0.003	-0.009	0.006	0.030	-0.002
		(0.026)	(0.064)	(0.032)	(0.092)	(0.026)	(0.067)
	Dwelling floor area (m^2)	-0.006*	-0.008	-0.005	0.008	-0.005*	0.004
		(0.003)	(0.008)	(0.004)	(0.013)	(0.002)	(0.008)
	Approx. dwelling perimeter	0.186***	0.221	0.172**	-0.118	0.165***	-0.192
		(0.062)	(0.164)	(0.086)	(0.268)	(0.057)	(0.173)
	Dummy: head male	-0.086**	0.157*	-0.082*	-0.036	-0.095***	0.153*
		(0.037)	(0.0908)	(0.043)	(0.125)	(0.034)	(0.0866)
Age of head	26 to 39	-0.027	0.169	0.045	-0.001	-0.041	-0.269
(excluded: under 26)		(0.074)	(0.182)	(0.088)	(0.271)	(0.067)	(0.169)
	40 to 59	-0.069	0.194	0.028	0.078	-0.077	-0.410**
		(0.078)	(0.192)	(0.094)	(0.281)	(0.071)	(0.182)
	60+	-0.029	0.277	0.100	-0.052	-0.027	-0.410*
		(0.090)	(0.224)	(0.106)	(0.319)	(0.083)	(0.211)

Employment status of head	Part-time employed	0.082	0.042	0.154**	0.552**	0.075	-0.010
(excluded: full-time employed)		(0.060)	(0.150)	(0.077)	(0.221)	(0.059)	(0.154)
	Unemployed (<9 months)	0.313***	-0.409			0.156	-0.167
		(0.107)	(0.298)			(0.100)	(0.262)
	Unemployed (9 months+)	0.096	-0.062	0.173**	0.198	0.092	-0.198
		(0.064)	(0.165)	(0.079)	(0.261)	(0.060)	(0.165)
	Retired	0.024	0.109	0.018	0.246	0.011	0.023
		(0.057)	(0.142)	(0.070)	(0.204)	(0.055)	(0.143)
	Sick or disabled	0.018	-0.058	0.125	-0.027	0.020	-0.150
		(0.065)	(0.163)	(0.076)	(0.253)	(0.062)	(0.163)
	Housewife	0.026	0.111	0.148**	0.375*	0.054	0.169
		(0.062)	(0.152)	(0.072)	(0.223)	(0.058)	(0.151)
	Other	-0.082	0.517*	-0.248	-0.534	-0.043	-0.144
		(0.119)	(0.309)	(0.154)	(0.602)	(0.117)	(0.343)
Housing tenure	Social renter	0.000	0.613***	-0.062	0.110	-0.022	-0.213**
(excluded: owner occupier)		(0.036)	(0.091)	(0.044)	(0.127)	(0.035)	(0.089)
	Private renter	-0.120*	-0.358*	-0.105	-0.814	-0.143**	-0.413*
		(0.073)	(0.186)	(0.116)	(0.533)	(0.068)	(0.215)
	Other	-0.110	-0.091	-0.116	-0.063	-0.083	0.240
		(0.122)	(0.300)	(0.158)	(0.457)	(0.118)	(0.300)
Dwelling type	Terraced	-0.150***	0.059	-0.117*	-0.269	-0.147***	0.040
(excluded: detatched house)		(0.050)	(0.133)	(0.062)	(0.182)	(0.050)	(0.135)
	Semi detatched	-0.074	0.110	-0.068	-0.015	-0.070	-0.083
		(0.045)	(0.117)	(0.056)	(0.162)	(0.047)	(0.120)
	Flat	-0.292***	-0.245	-0.164**	-0.233	-0.261***	0.121
		(0.073)	(0.207)	(0.075)	(0.236)	(0.061)	(0.184)

Geographic region (excluded: London)	Midlands	-0.087**	-0.105	-0.084*	0.027	-0.082**	0.105
		(0.039)	(0.100)	(0.051)	(0.163)	(0.037)	(0.100)
	Eastern	-0.026	-0.231*	-0.121*	0.352*	-0.052	0.438***
		(0.051)	(0.127)	(0.063)	(0.201)	(0.049)	(0.120)
	South East	-0.161***	-0.061	-0.172***	0.107	-0.197***	0.419***
		(0.054)	(0.143)	(0.060)	(0.212)	(0.051)	(0.137)
	South West	0.035	0.172	-0.083	0.225	0.0463	0.442***
		(0.054)	(0.134)	(0.066)	(0.202)	(0.053)	(0.136)
	North East	0.040	-0.157	0.030	0.0288	0.040	0.054
		(0.049)	(0.121)	(0.057)	(0.177)	(0.047)	(0.123)
	North West	0.100**	0.165	0.111**	0.215	0.103**	-0.052
		(0.042)	(0.106)	(0.051)	(0.157)	(0.040)	(0.110)
Ethnicity of head (excluded: white)	Black	0.124	0.089	-0.031	-0.141	0.132	-0.172
		(0.107)	(0.272)	(0.150)	(0.437)	(0.089)	(0.250)
	Head Asian	-0.256***	-0.364*	-0.758***	-0.359	-0.248***	0.116
		(0.086)	(0.204)	(0.186)	(0.644)	(0.083)	(0.219)
	Other	0.116	0.779*			0.141	0.128
		(0.166)	(0.459)			(0.154)	(0.420)
Type of area (excluded: city centre)	Urban	-0.092	-0.413	0.078	0.429	0.101	0.146
		(0.109)	(0.274)	(0.161)	(0.586)	(0.093)	(0.266)
	Suburban	-0.097	-0.288	0.085	0.746	0.097	0.093
		(0.109)	(0.273)	(0.158)	(0.577)	(0.092)	(0.263)
	Rural residential	-0.047	-0.092	0.190	0.931	0.151	0.025
		(0.115)	(0.288)	(0.163)	(0.588)	(0.100)	(0.282)
	Village	0.126	-0.248	0.379	1.085	0.318**	-0.272
		(0.149)	(0.369)	(0.262)	(0.832)	(0.139)	(0.420)
	Rural	0.097	-0.186	0.402	1.473*	0.283	1.326**
		(0.206)	(0.504)	(0.282)	(0.817)	(0.200)	(0.552)

Duration of residence	2 to 5 years	-0.054	0.034	-0.108*	-0.083	-0.082*	0.188
(excluded: <2 years)		(0.052)	(0.131)	(0.060)	(0.186)	(0.047)	(0.122)
	5 to 10 years	-0.017	-0.058	-0.040	-0.041	-0.043	0.0182
		(0.048)	(0.119)	(0.055)	(0.165)	(0.044)	(0.114)
	10 to 20 years	0.018	0.076	-0.015	0.0734	0.0036	0.111
		(0.050)	(0.125)	(0.059)	(0.173)	(0.046)	(0.120)
	20+ years	0.003	-0.086	-0.0096	0.414**	-0.014	0.146
		(0.054)	(0.135)	(0.063)	(0.187)	(0.050)	(0.130)
Likelihood of move within 5 yrs	Very likely	-0.027	-0.133	-0.024	0.030	-0.018	-0.250**
(excluded: not at all)		(0.044)	(0.108)	(0.054)	(0.158)	(0.042)	(0.113)
	Fairly likely	0.033	-0.009	0.011	-0.104	0.042	-0.195*
		(0.042)	(0.103)	(0.052)	(0.151)	(0.040)	(0.107)
	Not very likely	0.060*	0.109	0.065*	-0.267**	0.069**	0.105
		(0.032)	(0.082)	(0.039)	(0.130)	(0.031)	(0.085)
	Don't know	-0.036	0.236	-0.039	-0.396*	-0.013	-0.082
		(0.061)	(0.157)	(0.076)	(0.239)	(0.056)	(0.146)
Year dwelling built	1900 to 1918	0.061	0.083	0.210	-0.046	0.054	0.223
(excluded: pre-1900)		(0.051)	(0.127)	(0.142)	(0.540)	(0.051)	(0.152)
	1919 to 1944	-0.018	0.158	0.198	0.411	-0.025	0.553***
		(0.047)	(0.116)	(0.122)	(0.425)	(0.046)	(0.134)
	1945 to 1964	-0.030	0.218*	0.169	0.578	-0.016	0.788***
		(0.050)	(0.125)	(0.121)	(0.417)	(0.048)	(0.141)
	1965 to 1980	-0.127**	0.092	0.091	0.768*	-0.121**	0.886***
		(0.053)	(0.140)	(0.122)	(0.415)	(0.051)	(0.142)
	1981 onwards	-0.247***	-0.021	-0.013	0.908**	-0.259***	1.222***
		(0.063)	(0.175)	(0.126)	(0.430)	(0.059)	(0.162)
	Dummy: central heating	0.375***	0.513***	0.252***	0.301	0.351***	0.013
		(0.055)	(0.158)	(0.071)	(0.246)	(0.052)	(0.188)
	Dummy: gas hob	0.132***		0.101*		0.124***	
		(0.041)		(0.052)		(0.041)	
	Dummy: gas oven	-0.051		-0.035		-0.056	
		(0.039)		(0.052)		(0.038)	
	Dummy: water heat by gas	0.101		0.117		0.132**	

	(0.062)		(0.078)		(0.059)	
Dummy: tank insulated	0.035		0.063		0.040	
	(0.034)		(0.041)		(0.033)	
Kids aged 0-4	0.045		0.070*		0.050*	
	(0.029)		(0.037)		(0.029)	
Kids aged 5-10	0.042*		0.047		0.053**	
	(0.024)		(0.032)		(0.023)	
Kids aged 11-16	0.103***		0.094***		0.099***	
	(0.023)		(0.031)		(0.024)	
People aged 17+	0.103***		0.078***		0.103***	
	(0.019)		(0.025)		(0.019)	
Mean dependent variable	9.82	0.577	9.73	0.199	9.77	0.302
Observations	1,656		1,123		1,865	
Exogeneity test (p-value)	0.141		0.400		0.164	

Note: standard errors in parentheses. * = significant at 10% level; **= 5% level; *** = 1% level. In the ownership equations, gas consumption is instrumented by dummies for gas hob and oven, whether water heated by gas and the tank insulated and numbers of adults and children. In the cavity wall regression, short-term unemployment and other ethnicity are perfect predictors of ownership and so these observations are excluded. As described in Section 4, the threshold for loft insulation is actually 94mm given the way values can be imputed. Dwelling perimeter is the square root of the floor area variable.

Appendix B: Average marginal effects from reduced-form ownership probit models, by period and measure

Omitted comparator	Variable	Cavity wall insulation			Loft insulation (200mm+)			Full double glazing		
		2002–04	**2005–07**	**2008–10**	**2002–04**	**2005–07**	**2008–10**	**2002–04**	**2005–07**	**2008–10**
	Log income	-0.004	0.045	0.122	-0.086	-0.050	-0.134**	0.316***	0.033	0.048
		(0.132)	(0.080)	(0.098)	(0.080)	(0.060)	(0.065)	(0.105)	(0.053)	(0.046)
	Log ($income^2$)	0.000	-0.003	-0.007	0.005	0.003	0.006*	-0.015***	-0.001	-0.002
		(0.007)	(0.004)	(0.005)	(0.004)	(0.003)	(0.003)	(0.005)	(0.003)	(0.002)
Female head	Male head	0.008	0.007	0.017**	0.003	-0.011*	0.001	-0.008	0.004	0.004
		(0.008)	(0.008)	(0.008)	(0.005)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
Age group of head: under 25	26–39	-0.014	-0.022	-0.020	0.017	0.025	0.011	0.001	-0.014	-0.006
		(0.020)	(0.021)	(0.020)	(0.012)	(0.016)	(0.018)	(0.015)	(0.015)	(0.014)
	40–59	-0.011	-0.019	-0.020	0.017	0.036**	0.026	-0.011	-0.012	-0.016
		(0.020)	(0.021)	(0.020)	(0.013)	(0.017)	(0.018)	(0.016)	(0.016)	(0.014)
	60+	-0.013	0.014	-0.023	0.002	0.068***	0.034	-0.046**	-0.045**	-0.026
		(0.025)	(0.026)	(0.025)	(0.016)	(0.020)	(0.022)	(0.020)	(0.020)	(0.017)
Employment status of head: full-time employed	Part-time employed	-0.001	-0.006	0.021	0.014	0.003	0.017	-0.015	-0.010	-0.005
		(0.016)	(0.016)	(0.015)	(0.009)	(0.011)	(0.012)	(0.013)	(0.012)	(0.010)
	Retired	0.010	0.008	0.074***	0.007	0.026	0.040**	-0.015	-0.017	-0.001
		(0.024)	(0.024)	(0.019)	(0.015)	(0.018)	(0.016)	(0.020)	(0.019)	(0.013)
	Unemployed	0.055*	-0.045	-0.010	-0.005	-0.009	0.007	-0.018	-0.027	-0.027
		(0.032)	(0.031)	(0.026)	(0.019)	(0.022)	(0.022)	(0.024)	(0.023)	(0.018)
	Full-time education	-0.030	-0.045	0.019	0.015	0.011	-0.038	0.032	0.005	-0.005
		(0.042)	(0.042)	(0.041)	(0.023)	(0.030)	(0.036)	(0.027)	(0.026)	(0.024)
	Inactive	0.018	-0.008	0.024	-0.008	0.003	-0.004	-0.019	-0.023*	0.015
		(0.015)	(0.015)	(0.015)	(0.009)	(0.012)	(0.013)	(0.013)	(0.012)	(0.011)

	Owner-occupier, 2–5 years	0.020	0.031	0.006	0.009	0.010	-0.029	0.000	0.012	0.034*
		(0.020)	(0.022)	(0.024)	(0.011)	(0.015)	(0.020)	(0.016)	(0.017)	(0.017)
	Owner-occupier, 6–10 years	0.041**	0.020	-0.045*	-0.011	-0.022	-0.053***	0.004	0.005	0.031*
		(0.021)	(0.022)	(0.024)	(0.012)	(0.016)	(0.020)	(0.017)	(0.017)	(0.017)
	Owner-occupier, 11–20 years	0.042**	-0.008	-0.041*	-0.039***	-0.058***	-0.111***	-0.040**	-0.008	0.004
		(0.020)	(0.022)	(0.024)	(0.012)	(0.016)	(0.020)	(0.016)	(0.017)	(0.017)
	Owner-occupier, > 20 years	0.050**	0.022	0.019	-0.049***	-0.075***	-0.096***	-0.043***	-0.045***	-0.046***
		(0.021)	(0.022)	(0.025)	(0.012)	(0.016)	(0.020)	(0.017)	(0.017)	(0.017)
	Private renter, < 2 years	0.008	-0.033	-0.109***	-0.043***	-0.040**	-0.113***	-0.114***	-0.041**	-0.034*
		(0.025)	(0.027)	(0.026)	(0.015)	(0.020)	(0.022)	(0.018)	(0.019)	(0.018)
Tenure: owner-occupier, < 2 years	Private renter, 2–5 years	0.014	-0.027	-0.141***	-0.049***	-0.044**	-0.106***	-0.175***	-0.079***	-0.043**
		(0.029)	(0.029)	(0.029)	(0.017)	(0.021)	(0.024)	(0.021)	(0.020)	(0.019)
	Private renter, > 5 years	-0.009	-0.123***	-0.129***	-0.071***	-0.069***	-0.132***	-0.189***	-0.146***	-0.098***
		(0.035)	(0.033)	(0.033)	(0.020)	(0.022)	(0.026)	(0.024)	(0.022)	(0.021)
	Social renter, < 2 years	0.087***	0.061**	0.013	0.033**	0.055***	0.017	-0.040**	-0.044**	0.024
		(0.023)	(0.026)	(0.029)	(0.015)	(0.020)	(0.025)	(0.020)	(0.021)	(0.021)
	Social renter, 2–5 years	0.101***	0.089***	0.049*	0.043***	0.056***	0.044*	-0.044**	-0.001	0.053***
		(0.021)	(0.023)	(0.026)	(0.013)	(0.017)	(0.023)	(0.018)	(0.019)	(0.020)
	Social renter, 6–10 years	0.145***	0.132***	0.024	0.040***	0.060***	0.045*	-0.052***	-0.007	0.048**
		(0.022)	(0.024)	(0.027)	(0.013)	(0.018)	(0.023)	(0.019)	(0.019)	(0.020)
	Social renter, 11–20 years	0.183***	0.133***	0.080***	0.032**	0.043**	0.041*	-0.078***	-0.032*	0.037*
		(0.022)	(0.024)	(0.027)	(0.014)	(0.018)	(0.023)	(0.019)	(0.019)	(0.020)
	Social renter, > 20 years	0.238***	0.214***	0.163***	0.060***	0.082***	0.025	-0.093***	-0.016	0.050**
		(0.023)	(0.025)	(0.029)	(0.013)	(0.018)	(0.023)	(0.019)	(0.019)	(0.020)
	Black	0.028	-0.041	-0.009	-0.020	-0.009	-0.039*	0.031*	-0.001	-0.000
		(0.026)	(0.025)	(0.024)	(0.018)	(0.020)	(0.022)	(0.018)	(0.016)	(0.015)
Ethnicity of head: white	Asian	-0.022	-0.002	-0.011	0.005	-0.009	-0.002	0.067***	0.024	0.050***
		(0.026)	(0.024)	(0.023)	(0.014)	(0.017)	(0.018)	(0.017)	(0.016)	(0.014)
	Other	-0.035	-0.005	-0.025	-0.000	0.022	-0.064***	-0.022	-0.037**	-0.011
		(0.032)	(0.029)	(0.027)	(0.019)	(0.022)	(0.024)	(0.023)	(0.019)	(0.016)

How likely to move within 5 years: very unlikely	Very likely	-0.039***	-0.036***	–	-0.019**	-0.025***	–	-0.036***	-0.021**	–
		(0.012)	(0.012)		(0.007)	(0.009)		(0.010)	(0.009)	
	Fairly likely	-0.032***	-0.024**	–	-0.031***	-0.013	–	-0.031***	-0.026***	–
		(0.012)	(0.012)		(0.007)	(0.009)		(0.010)	(0.009)	
	Not very likely	-0.011	-0.008	–	-0.011*	-0.006	–	-0.016**	-0.018**	–
		(0.009)	(0.010)		(0.006)	(0.007)		(0.008)	(0.008)	
	Don't know	-0.052**	-0.020	–	-0.036**	0.002	–	-0.026	0.006	–
		(0.026)	(0.021)		(0.017)	(0.016)		(0.021)	(0.016)	
	No. of dependent children	-0.003	-0.004	-0.004	0.002	0.005	0.003	-0.000	0.007**	-0.004
		(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)
	No. of adults	0.005	0.006	0.007	-0.002	-0.005	-0.004	0.014***	0.005	0.021***
		(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)
	HH: anyone long-term sick or disabled	0.003	0.019**	0.027***	0.003	0.014**	0.015**	-0.001	-0.000	-0.003
		(0.009)	(0.009)	(0.009)	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
	HH: anyone receiving means-tested benefits	-0.028***	-0.032***	-0.012	-0.032***	-0.041***	-0.030***	-0.006	-0.000	0.006
		(0.011)	(0.011)	(0.011)	(0.007)	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)
	HH: anyone retired	0.016	0.005	0.005	0.008	0.016	0.041***	0.028	0.014	0.016
		(0.021)	(0.022)	(0.014)	(0.013)	(0.016)	(0.012)	(0.018)	(0.017)	(0.010)
	HH: anyone unemployed	-0.017	-0.009	0.024	-0.009	-0.000	-0.023	-0.020	0.005	0.009
		(0.027)	(0.025)	(0.023)	(0.015)	(0.018)	(0.019)	(0.020)	(0.019)	(0.016)
Educational attainment of head: GCSE or equivalent	No education	0.026**	-0.006	-0.002	0.008	0.016**	0.023**	0.017**	0.004	-0.008
		(0.010)	(0.010)	(0.012)	(0.006)	(0.008)	(0.011)	(0.009)	(0.008)	(0.009)
	A Levels or equivalent	0.025*	0.009	0.001	-0.003	0.023**	0.016	-0.017	-0.020*	-0.038***
		(0.013)	(0.013)	(0.018)	(0.008)	(0.010)	(0.015)	(0.011)	(0.010)	(0.012)
	Degree	0.021*	-0.006	0.008	0.010	0.010	0.014	-0.063***	-0.057***	-0.045***
		(0.012)	(0.012)	(0.012)	(0.007)	(0.009)	(0.010)	(0.010)	(0.009)	(0.008)
	Education unknown	-0.002	-0.011	0.017	0.027**	-0.010	0.058***	0.018	0.022	-0.030***
		(0.020)	(0.035)	(0.013)	(0.012)	(0.027)	(0.011)	(0.017)	(0.027)	(0.009)

	End terrace	-0.012	0.011	0.002	0.002	-0.004	0.024**	0.010	-0.000	0.047***
		(0.014)	(0.014)	(0.014)	(0.008)	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)
	Mid terrace	-0.048***	-0.030**	-0.055***	0.005	-0.010	-0.008	0.028***	0.008	0.036***
		(0.012)	(0.013)	(0.013)	(0.007)	(0.008)	(0.010)	(0.010)	(0.009)	(0.008)
Dwelling type: semi-detached	Detached	0.023	0.034**	0.029**	0.003	-0.009	0.016	0.014	-0.013	-0.001
		(0.014)	(0.014)	(0.013)	(0.009)	(0.011)	(0.011)	(0.012)	(0.011)	(0.010)
	Bungalow	0.020	0.025*	0.066***	0.029***	0.023**	0.036***	0.023*	0.022*	0.020*
		(0.014)	(0.014)	(0.014)	(0.009)	(0.011)	(0.012)	(0.013)	(0.012)	(0.011)
	Converted flat	-0.207***	-0.132***	-0.218***	-0.053**	-0.047	-0.025	-0.033*	-0.072***	-0.035**
		(0.055)	(0.050)	(0.050)	(0.024)	(0.029)	(0.032)	(0.020)	(0.019)	(0.016)
	Purpose-built flat	-0.081***	-0.064***	-0.063***	-0.021*	-0.022	-0.030*	0.050***	0.021*	0.018
		(0.014)	(0.015)	(0.015)	(0.011)	(0.014)	(0.015)	(0.012)	(0.012)	(0.011)
	Dwelling floor area (m^2)	-0.001**	-0.001	-0.001	-0.000	-0.000	-0.000	-0.000	0.000	0.000
		(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Approx. perimeter (m)	0.021**	0.020*	0.011	0.006	0.011	0.007	-0.014*	-0.022***	-0.023***
		(0.010)	(0.012)	(0.011)	(0.005)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)
	Pre-1850	-0.170***	-0.318***	-0.325***	0.016	-0.001	-0.051**	-0.336***	-0.348***	-0.322***
		(0.063)	(0.070)	(0.061)	(0.015)	(0.020)	(0.022)	(0.020)	(0.019)	(0.016)
	1850–1899	-0.234***	-0.230***	-0.257***	-0.013	0.009	-0.039**	-0.238***	-0.252***	-0.245***
		(0.041)	(0.040)	(0.037)	(0.011)	(0.014)	(0.015)	(0.014)	(0.013)	(0.011)
	1900–1918	-0.224***	-0.215***	-0.212***	0.011	0.027*	-0.024	-0.222***	-0.207***	-0.228***
		(0.033)	(0.031)	(0.028)	(0.011)	(0.014)	(0.015)	(0.014)	(0.013)	(0.011)
Year property built: 1965–1974	1919–1944	-0.054***	-0.030**	-0.039***	0.022***	0.033***	0.005	-0.111***	-0.102***	-0.148***
		(0.013)	(0.013)	(0.014)	(0.008)	(0.010)	(0.011)	(0.011)	(0.010)	(0.009)
	1945–1964	0.031***	0.049***	0.059***	0.018**	0.043***	0.020*	-0.027***	-0.026***	-0.057***
		(0.011)	(0.011)	(0.011)	(0.008)	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)
	1975–1980	-0.003	0.004	-0.021	-0.009	0.011	-0.003	-0.009	0.003	-0.018
		(0.014)	(0.014)	(0.015)	(0.011)	(0.013)	(0.015)	(0.013)	(0.013)	(0.012)
	1981–1990	0.119***	0.083***	-0.113***	-0.021**	0.002	-0.031**	0.007	0.009	-0.007
		(0.013)	(0.014)	(0.013)	(0.011)	(0.013)	(0.014)	(0.013)	(0.013)	(0.012)
	Post-1990	0.262***	0.159***	0.060***	0.125***	0.166***	0.145***	0.307***	0.291***	0.190***
		(0.014)	(0.014)	(0.013)	(0.010)	(0.012)	(0.012)	(0.017)	(0.016)	(0.014)

Main heating fuel: gas	Electricity	0.063***	0.031	0.063*	0.030**	0.080***	0.009	0.059***	0.071***	0.037
		(0.022)	(0.029)	(0.038)	(0.014)	(0.021)	(0.030)	(0.017)	(0.020)	(0.023)
	Oil	0.020	0.041*	0.008	0.028**	0.019	-0.008	-0.035*	-0.021	-0.030**
		(0.024)	(0.025)	(0.023)	(0.014)	(0.017)	(0.018)	(0.019)	(0.019)	(0.015)
	Solid fuel	-0.000	-0.027	-0.083**	0.000	-0.028	-0.020	-0.095***	-0.095***	-0.092***
		(0.028)	(0.033)	(0.042)	(0.015)	(0.022)	(0.030)	(0.021)	(0.023)	(0.025)
	Communal heating	0.009	-0.027	-0.069***	0.026	-0.045*	-0.127***	-0.060***	-0.075***	-0.106***
		(0.024)	(0.025)	(0.026)	(0.021)	(0.027)	(0.034)	(0.020)	(0.019)	(0.018)
No central heating	Has central heating	0.031	0.040	0.082**	0.016	0.062***	0.036	0.082***	0.095***	0.071***
		(0.019)	(0.026)	(0.037)	(0.011)	(0.018)	(0.029)	(0.014)	(0.017)	(0.022)
Region: South East	North East	0.015	0.100***	0.171***	0.061***	0.148***	0.223***	-0.072***	-0.079***	0.006
		(0.016)	(0.017)	(0.017)	(0.010)	(0.013)	(0.015)	(0.014)	(0.014)	(0.013)
	Yorkshire and Humber	0.007	0.049***	0.075***	0.058***	0.089***	0.145***	-0.033***	0.002	0.055***
		(0.014)	(0.014)	(0.014)	(0.009)	(0.011)	(0.012)	(0.012)	(0.011)	(0.010)
	North West	-0.049***	-0.002	0.054***	0.036***	0.091***	0.156***	-0.026**	-0.002	0.029***
		(0.013)	(0.013)	(0.013)	(0.008)	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)
	East Midlands	0.013	0.089***	0.051***	0.039***	0.068***	0.095***	0.010	0.005	0.022**
		(0.015)	(0.015)	(0.015)	(0.009)	(0.011)	(0.013)	(0.013)	(0.012)	(0.011)
	West Midlands	-0.073***	-0.042***	-0.002	0.039***	0.084***	0.125***	-0.055***	-0.029**	-0.009
		(0.015)	(0.015)	(0.015)	(0.009)	(0.011)	(0.013)	(0.012)	(0.012)	(0.011)
	South West	-0.032**	-0.051***	0.007	0.012	0.038***	0.117***	0.055***	0.024**	0.018*
		(0.014)	(0.014)	(0.014)	(0.009)	(0.011)	(0.013)	(0.012)	(0.012)	(0.011)
	Eastern	0.025*	0.067***	-0.012	0.017*	0.010	0.058***	0.006	-0.016	-0.010
		(0.014)	(0.014)	(0.014)	(0.009)	(0.011)	(0.013)	(0.012)	(0.012)	(0.010)
	London	-0.073***	-0.121***	-0.122***	-0.022**	-0.074***	-0.015	-0.073***	-0.092***	-0.097***
		(0.017)	(0.017)	(0.017)	(0.011)	(0.014)	(0.015)	(0.012)	(0.012)	(0.010)

Area type: suburban-residential	City centre	-0.046*	-0.028	-0.015	-0.011	-0.009	0.011	-0.052***	-0.032*	-0.040***
		(0.026)	(0.028)	(0.027)	(0.017)	(0.021)	(0.024)	(0.018)	(0.017)	(0.015)
	Urban	-0.043***	-0.059***	-0.015	0.003	0.002	-0.011	-0.014*	-0.010	-0.004
		(0.011)	(0.011)	(0.012)	(0.006)	(0.008)	(0.010)	(0.008)	(0.008)	(0.007)
	Rural-residential	0.007	0.014	-0.013	0.008	0.013	0.013	0.050***	0.033***	0.030***
		(0.011)	(0.012)	(0.012)	(0.007)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)
	Village	-0.009	0.016	-0.042**	0.013	-0.015	-0.003	0.014	0.025	0.021
		(0.020)	(0.022)	(0.021)	(0.012)	(0.015)	(0.017)	(0.016)	(0.016)	(0.014)
	Rural	-0.087***	-0.056*	-0.014	-0.029*	-0.033	-0.013	0.034	-0.045**	0.025
		(0.031)	(0.033)	(0.030)	(0.016)	(0.021)	(0.022)	(0.021)	(0.021)	(0.017)
	Pseudo R^2	0.070	0.073	0.079	0.069	0.085	0.081	0.105	0.118	0.151
	Mean of dep. variable	0.387	0.475	0.539	0.129	0.221	0.315	0.568	0.662	0.756
	No. of observations	16,567	16,610	16,954	20,943	20,323	20,550	24,081	23,499	23,642

Note: standard errors in parentheses. * = significant at 10% level; **= 5% level; *** = 1% level. Moving intentions are not asked from 2008 onwards. Dwelling perimeter is the square root of the floor area variable.