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Energy Use and Appliance Ownership in Ireland

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Abstract: This paper examines household energy use and appliance ownership in Ireland. Logit regression analyses on a large micro-dataset reveal how household characteristics can help explain the ownership of energy using appliances. Using OLS regression models, we explore the factors affecting residential energy demand conditional on appliance ownership. Results suggest that the methods of space and water heating employed by a household are even more important than electrical appliances in explaining domestic energy usage. However, the stock of appliances must be included in such models so that results will not be biased. The methods employed in this paper can be easily adopted for studies of household energy use in other countries where household expenditure survey data are available.

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1. Introduction

Ireland faces the toughest greenhouse gas emissions reduction target in the European Union. A large body of work has been carried out on emissions in the transport and industrial sectors, however, the residential sector has received relatively little attention in Ireland to date. The demand for domestic energy is determined by the number of households and certain household characteristics such as the type of heating system installed and the extent to which they employ energy-using appliances and energy-saving features. This paper investigates, with the use of regression analyses, the determinants of residential energy use in Ireland. It is the most in depth analysis of residential energy use in Ireland to date. Using estimates of the amount of energy used by each household, we model the determinants of energy use from electricity and other fuels while controlling for household characteristics and the household's endowment of energy using appliances. The majority of studies that aim to explain household energy usage fail to control for the stock of appliances. We show that this leads to biased results.

This paper represents an application of existing methods rather than the development of a new methodology. The methods employed in this paper can be easily adopted for studies of household energy use in other countries where data on household expenditures are available.

The paper continues as follows. Section 2 presents the data used in our analysis and section 3 describes our models. In section 4 we discuss the results and compare our findings to those of other similar studies. Section 5 concludes.

2. Data

Since the early 1990s Ireland has experienced rapid economic and demographic change, which in turn has affected domestic energy demand. Between 1990 and 2006 residential energy use in Ireland increased by over 32 per cent (O'Leary et al., 2008).[1] This rise was largely due to the increases in income, population and the housing stock that occurred over the same period.[2] The demand for energy-using appliances increased substantially as Ireland's economy and population grew. Of the nine

appliances studied in this paper the greatest demand increases between 1994 and 2004 were for home computers, dishwashers, tumble dryers, and microwaves. (See Appendix 1). Over the period 1996 to 2006, the average floor space of Irish houses increased by 170 square feet according to data collected for the Permanent TSB/ESRI House Price Index (Duffy, 2009). This is an important consideration for household energy demand because larger houses have higher space-heat requirements and higher heat losses due to their proportionally greater surface area (O'Leary et al., 2008). Unfortunately, we do not have data on actual floor space, but we do control for the number of rooms in the residence.

The dataset used for this study is the anonymised 2004/05 Irish Household Budget Survey (HBS), which is a survey of a representative random sample of all private households in Ireland. Carried out by the Central Statistics Office of Ireland, the main aim of the HBS is to determine household expenditure in order to update the weightings used for the Consumer Price Index. In this cross-sectional micro dataset, detailed information is also provided on income and household facilities. In 2004/05, 6,884 private households participated in the survey. This represented a response rate of 47%.

The questions asked in the HBS are not sufficient to explain every aspect of household energy usage. Such a study would require more extensive details on the efficiency of individual households' appliances and heating and cooking facilities as well as the frequency with which they are used. However, we can examine which household characteristics as well as which appliances, heating and cooking methods significantly influence the amount of energy or electricity used in the home. The survey asks if certain appliances are owned or continuously available for use in the accommodation. The questionnaire also asks if the household has double glazing. We were interested in modelling the presence of double glazing because we wanted to ascertain whether those households that have high energy-using appliances are more or less likely to invest in double glazing. However, we do not know how many windows in the house are double glazed. Unfortunately, the data do not allow us to examine any other energy-saving features which may be present in the home.[3]

Questions about the household's main method of space heating, water heating and cooking are also present. In addition, households are asked to report expenditure on and quantity used of different fuel types in the past year. With these variables we compute estimates of the total energy use from electricity and the total energy use

from fuels other than electricity (we will refer to these henceforth as 'other fuels'). These variables are discussed in more detail in Section 3.

3. Models

This paper reports estimates from a series of models intended to measure the association between various household characteristics and the ownership of energy using appliances and domestic energy usage.

A number of household characteristics are controlled for. We include location (Dublin vs. the rest of the country, urban vs. rural) because we are interested to know if urban and rural dwellers have different preferences. Location variables were found to be important in studies of household energy usage by Druckman and Jackson (2008) and O'Doherty et al. (2008). The age and type of accommodation are also included as explanatory variables. We want to know if older accommodation is more likely to have older, less efficient appliances and whether or not the residents are less likely to own more modern appliances. While we do know the year in which the accommodation was built, we do not know if any refurbishments have taken place. We control for the type of accommodation because it provides a proxy for information on heat loss due to dwelling design and surface area. Druckman and Jackson (2008) and O'Doherty et al. (2008) find that dwelling type is associate with household energy usage. We include the number of rooms as a proxy for the size of the residence. We also control for the number of residents in the household, which is consistent with the literature. Tenure is included in addition because those renting may have a very different set of appliances and, perhaps, a different pattern of energy usage than those who own or are buying their own home. Also, tenure was found to be a significant predictor of appliance ownership by O'Doherty et al. (2008). We look at two different aspects of family composition but for brevity they are listed under the same heading. We want to look at households in which children are present so that we can establish whether children have an impact on the households set of appliances and energy demand versus households comprised of adults only. We also want to see if there are significant differences in energy usage between single parent households (which tend to be relatively vulnerable to poverty and deprivation) and households in which two parents are present. Several characteristics of the household's Chief Economic Supporter (CES) (defined as the person in the household with the highest gross income) are also included: social group, employment status, highest level of education

achieved and age. These variables allow us to examine how energy usage and appliance ownership vary among households where the CES is an unskilled worker or a higher professional, is employed full time or in full time education, has a degree of some sort or just a primary education or is under 25 or over 75, amongst other things. For each categorical explanatory variable there is a reference category, which is, in essence, a baseline against which households with different characteristics may be compared. We also control for the log of household disposable income. According to O'Leary et al. (2008), 49% of household energy expenditures relate to heating and cooking. We therefore thought that it would be important to include methods of space heating, water heating and cooking in the analysis of energy and electricity use. The quarter in which the survey took place is also included as an explanatory variable.

The partial effects reported in our models refer to the average usage of households that have a given appliance, heating or cooking system. As previously mentioned, we do not know the frequency or intensity with which households use the appliances, nor do we know when a household has more than one appliance of a given class. Thus, it is likely that the amount of energy used by each of the appliance types and cooking and heating methods would vary widely.

Modelling access to appliances

The HBS questionnaire asks if appliances are owned or continuously available for use. For brevity, we refer to ownership of appliances. However, we understand that in some instances, especially in rented accommodation, appliances may be available for use rather than owned by the occupants. The dataset we use provides information on a large number of energy using appliances which may be present in a household. We limit our analysis to nine appliances for which there is sufficient variation in ownership to provide interesting results.[4] Nevertheless, this number is large enough for us to ascertain whether any patterns exist among different types of households. The appliances we include are washing machine, dishwasher, refrigerator ("fridge"), deep freezer, fridge-freezer, microwave oven, vacuum cleaner, tumble dryer and home computer. We also carried out an analysis of video player/recorder, portable television, and CD player, however, these items account for only a very small percentage of household electricity/energy usage and were later omitted.

Each of the appliance ownership models has a dependent variable representing access to a particular appliance (or double glazing). This is set to a value of one when the

appliance (or double glazing) is present in the household, and a value of zero when it is not. For each appliance, we estimate a logit model including all available variables and then, using stepwise deletion of variables, we estimate a more parsimonious model which omits explanatory variables that are not significant. The results of the preferred models are discussed in section 5.

Modelling energy use

The second, and main, part of the analysis involves estimation of OLS regression models to explain average weekly household use of electricity and energy from other fuels, conditional on a range of household characteristics.

We then extend this model by including controls for the stock of appliances and heating and cooking facilities present in the household.

In each case we run two regressions; one modelling electricity use and the other energy use from fuels other than electricity. The dependent variable in the first regression, energyelec, is the estimated energy use from electricity measured in kilowatt hours. We construct this variable using Equation 1 below:

$$energyelec_i = (expenditure^{elec}{}_i / price^{elec}) * (kWh^{elec}/q^{elec}) \quad (1)$$

where $expenditure^{elec}{}_i$ is the average weekly expenditure by household *i* on electricity. This information is contained in the HBS. $Price^{elec}$ is the average unit price of electricity for the period in which the household was interviewed. Price data were obtained from Sustainable Energy Ireland (SEI) (2008). Prices for each fuel type included in the analysis can be found in Appendix 2. kWh_{elec}/q_{elec} is kWh of electricity per unit and is also known as the gross calorific value. It is the amount of heat which is generated from the complete combustion of a given quantity of a fuel. All households face the same gross calorific values. In the case of electricity, the gross calorific value is 1. Gross calorific values for each fuel type used in the analysis are taken from SEI (2009). A list of gross calorific values for each fuel type included in this analysis can be found in Appendix 3.

Energyoth, the dependent variable in the second regression, measures the estimated energy use from fuels other than electricity. It is calculated using Equation 2 below:

$$energyoth_i = \sum (expenditure^f{}_i / price^f) * (kWh/unit^f) \quad (2)$$

where $expenditure^f{}_i$ is the average weekly expenditure by household *i* on fuel type *f*.

The fuels are coal, anthracite, gas, turf, heat oil, paraffin, liquefied petroleum gas (LPG) and wood. This variable is also measured in kilowatt hours. As is the case in the first equation, prices and gross calorific values are not household specific.

Two versions of each OLS model are estimated, the first of which includes all available variables. We then test for joint significance of all variables that appear individually insignificant, generating more parsimonious models. The results of the preferred models are discussed in section 4.

A list of the variables included in the models and some descriptive statistics on them are set out in Appendix 4. Because there are a large number of variables in our sample we were conscious of the possible presence of multicollinearity. Having examined the correlations between individual variables, we are satisfied that multicollinearity is not a problem in the data.[5]

Although our motivation is partly descriptive, we have some prior expectations based on international research as to some of the effects we might expect to observe. Income should have a positive effect on energy usage. In addition, indicators of a household's potential to consume energy should be positively associated with usage: for instance, we expect to find that as the number of occupants increases, so too does energy demand. We presume that the socioeconomic characteristics of the household (proxied by those of its main earner) may also play a role in explaining appliance ownership and energy usage. For example, it is possible that households with higher education levels are more aware of energy saving opportunities or are more environmentally conscious. Thus their households may have a lower demand for energy. Hence, we include variables for the main earner's education level and age, among other things.

We have already noted that many models of household energy usage do not account for the ownership of electrical appliances. In this paper, we can assess if such an omission leads to biased results. A further area of interest is the degree to which methods used for space heating, water heating and cooking influence the demand for household energy. Are methods of heating and cooking more or less important than electrical appliances for household energy demand? The results of these models are presented in the next section.

4. Results

Access to appliances

The results of the appliance models are presented in terms of odds ratios which reflect the odds that a household with a given characteristic will have a certain appliance, relative to a household in the reference category. An odds ratio of 1 indicates that households with that characteristic are equally likely to have the appliance in their home as those in the reference category. An odds ratio greater than 1 indicates a higher probability that the appliance will be present, while a ratio below 1 indicates that the probability is lower.

The results are presented in Table 1. Due to the large number of variables included in the model, we discuss the general pattern of results and the typical relationships that exist between the dependent and independent variables.

[Table 1 about here]

We find that households in urban areas are more likely to have most of the appliances under study than their rural counterparts. The exceptions are fridge and deep freezer, which are more likely to be found in rural homes. It appears that urban dwellers favour the fridge freezer over these items, which could be due to less space being available in the average urban dwelling (note that we have controlled for the number of rooms, but we have no data on the average room size).

As the number of rooms in the accommodation increases so too does the probability of having a washing machine, vacuum cleaner, microwave, tumble dryer, dishwasher, or deep freezer in the household. This may be because the accommodation requires that more time be devoted to housework, and so, such items may help to ease the work load.

The year in which the accommodation was built is associated with different appliances in different ways. The reference category includes dwellings built between 1918 and 1960. Homes built before 1918 are less likely to have fridge freezers or microwaves. This may be because the occupants simply favour the traditional fridge over the fridge freezer or because fridge freezers were not widely available at time of purchase. They may also prefer to use traditional cooking methods over the more modern methods (e.g. microwaving). These households are also less likely to own washing machines, vacuum cleaners or home computers. Homes built after 1991 are

significantly more likely to have fridge freezers compared to those in the reference category. One possible explanation is that as people began to buy a higher number of kitchen appliances, space saving measures were pursued, for example buying fridge freezers rather than two separate appliances. Homes built between 1971 and 1980 are more likely to be equipped with fridges, deep freezers, vacuum cleaners, microwaves or home computers than the reference category. Accommodation built after 2000 is significantly more likely to have a fridge freezer, tumble dryer or dishwasher. This may be due to the lifestyle changes which accompanied the increases in income during the Celtic Tiger period in Ireland. Also, 70% of the accommodation built post 2000 is occupied by a CES aged between 25 and 44. It appears that these households opt for appliances which help to ease the housework requirement.

The likelihood of having a tumble dryer is significantly increased for occupants of bedsitters,[6] converted apartments or apartment blocks compared to those in the reference category (detached houses). This is probably due to the fact that occupants of these households have no garden in which they can line dry their clothes or they may not be able to dry clothes in the accommodation by other means due to space restrictions.

Compared to those who own the accommodation in which they reside, residents of local authority housing are significantly less likely to have vacuum cleaners, tumble dryers, dishwashers, deep freezers or home computers in their homes. The same pattern exists for those renting privately. Tenants, and particularly those in social housing, probably have less access to credit than owner-occupiers. In addition, their planned stay in the property may be short term in nature. These factors could help explain lower acquisition of appliances. However, the supply side is important here too, and it may be that the average local authority or landlord installs fewer appliances than an owner-occupier due to capital spending constraints (for local authorities) or due to a low valuation being placed on such items by the rental market. Data including both property rents and fittings would be required to distinguish between such effects.

Regarding the number of residents, larger households are more likely to have a tumble dryer or dishwasher. Again this may be due to the work load that arises when there are more occupants. The larger the household, the more likely it is that a deep freezer will be present, probably because larger amounts of food need to be stored at any one time. Home computers are also significantly more likely to be in households that are bigger

than the reference category (two person households). This may simply be because there is a higher probability that one will be required by someone in the household. In contrast, one person households are significantly less likely to have appliances of all kinds, apart from refrigerators and vacuum cleaners.

As was previously mentioned, there are two reference groups in the family composition category. We find that households with children are less likely to have a vacuum cleaner, deep freezer or home computer, perhaps because their income must be diverted towards more urgently required items. These households are more likely than adult only households to have tumble dryers and dishwashers. This may be due to the increased workload that is associated with looking after children. Interestingly, the single parent variable is only significant for one appliance. The probability that a dishwasher will be present in a single parent household is significantly reduced, compared to one in which two parents are present.

No clear pattern exists between appliance ownership and the social group of the CES. The reference group here is "employers and managers, higher professional or lower professional". The "non manual" and "manual skilled/semi skilled" social groups are both significantly more likely than the reference group to report having computers in their homes. This may be because they do not have access to a computer at work, unlike those who are employers, managers, higher professionals or lower professionals. 6% of the sample categorise their CES as being an unskilled or agricultural worker. These households are less likely than the reference category to have washing machines, vacuum cleaners or dishwashers.

A household whose CES is employed on a part-time basis is less likely to have a fridge-freezer, deep freezer or home computer than those in the reference group (full time employee). Interestingly, those in the retired category are less likely to have a washing machine but they are significantly more likely to have a computer, probably because they can not access one through place of work.

Lower levels of education are associated with a reduced probability of owning most appliances under study. Households whose CES has only a primary education are less likely to have a fridge-freezer but more likely to have a fridge than those in the reference category (Leaving Certificate).[7] Interestingly, where the CES has a primary degree or a higher degree the odds of having a microwave are reduced relative to households in the reference category. This may be because the relatively well educated favour traditional cooking methods. A similar relationship exists between

education level and the presence of home computers. This could be because those with higher education levels have access to a computer through their place of work and thus, need not privately invest in one.

The age of the CES also plays an important role in predicting whether certain appliances will be present or not. Where the CES is 75 years of age or over, the probability of having most appliances under study is significantly reduced, relative to the 35-44 year old category. Households led by older persons may simply have different preferences regarding appliance ownership. For households whose CES is aged between 25 and 34, the odds of having a vacuum cleaner, tumble dryer, dishwasher, deep freezer or home computer are reduced relative to households where the CES is in the next higher age bracket. Like capital accumulation, acquisition of durable goods such as appliances may have a life cycle component or could simply take place over time as wealth permits. Controlling for the flow of income will not pick this up fully, so age acts as a proxy. In contrast to these appliances, microwave ownership is higher for households with a CES aged 25-34.

The log of household disposable income has the expected effect in most cases. As income rises the probability of having most appliances is increased. The strongest effect is on dishwashers. If household disposable income increases by 10%, the probability of a dishwasher being present in the household increases by 18%. As expected, the log of household disposable income does not play a role in explaining the presence of fridges or fridge freezers. This is probably because demand is already saturated at low income levels: either one or both of these appliances can now be found in 99.64% of Irish homes.

Double Glazing

Over 77% of the sample reported having double glazing somewhere in their home. We include this variable in an attempt to establish whether those respondents who report having energy intensive appliances in the home are more or less likely to have double glazing. We would like to investigate other energy-saving features such as the presence of a lagging jacket or attic insulation, but, unfortunately, the HBS data do not include such items.

The odds of having double glazing are higher for those living in areas outside of the Border, Midland and West region and Dublin. However, when the whole country is taken into account, urban dwellers are more likely to have double glazing than their

rural counterparts. It is more likely that double glazing will be present in accommodation with 6 or more rooms, compared to the reference category (5 rooms). This is probably because larger houses have more space to heat and tend to have a greater degree of heat loss. The more recently built the home, the higher the chance of double glazing being present. In fact, those homes built since 2000 are over nine and a half times more likely to have double glazing than homes built between 1918 and 1960. This can be largely explained by the building control act which made provisions for the conservation of fuel and energy. The act was first passed in 1990 and has been subsequently amended.

Local authority housing and rented accommodation is less likely to have double glazing than those with owner-occupiers, as would be expected. It is often the case that owners do not invest in energy-saving measures unless they are living in the residence themselves. Families with children are more inclined to live in accommodation with double glazing, probably to reduce the impact of draught and noise. The opposite is the case for single parents, although not significantly so. Other significant, but negative, predictors of double glazing are households whose CES is in the "own account workers and farmers" category or is aged 75 or over. The log of household disposable income is highly significant and implies that as income increases, so too does the probability of having double glazing, as would be expected. While the positive relationship to income indicates that double glazing is more prevalent among richer households, its benefits in reducing energy use may be offset by the fact that such households tend also to have larger numbers of energy using appliances, as found in O'Doherty et al. (2008).

Energy use

Controlling for household characteristics, we now explore the factors which help determine domestic use of electricity and other fuels. For each of the explanatory variables, the coefficient of determination in the preferred model did not differ significantly from that of the model with all available variables. The results of the preferred model are presented in Table 2.[8] The standard errors in each case are robust to heteroskedasticity.

Many factors show a statistically significant association with higher or lower energy use from electricity or other fuels, but it is also important to know if each association is economically significant (i.e. large enough to make a material difference to household consumption). To illustrate the level of economic significance, we compare

the estimated partial effects to the total weekly usage of electricity or other fuels for different types of households. Appendix 5 displays weekly electricity use and other fuel use by households with different characteristics. Average weekly electricity usage of all households in the sample is 87.5 kWh, while energy usage from other fuels equals 429 kWh. This amounts to over 26,800 kWh per year which is among the highest in the EU 27.[1] Energy consumption per dwelling in Belgium is approximately the same as that of Ireland while the UK dwellings use approximately 20,000 kWh per year (Odyssee, 2009). French and German dwellings use approximately 18,500 kWh per year and households in the Netherlands use just over 17,000 (Odyssee, 2009).

[Table 2 about here]

The pattern of results for electricity use and other fuel use is somewhat similar. Living in Dublin is associated with higher use of energy from electricity and especially other fuels. The regional variable may be picking up unobserved characteristics of the housing stock. As the number of people living in the household or the number of rooms in the accommodation increases, more electricity and energy from other fuels are used. Both of these effects are in line with expectations.

The year in which the accommodation was built presents some interesting findings. Homes built before 1918 are seen to use 5.96 kWh more electricity per week (7.5% of their weekly electricity use) than those built between 1918 and 1960 (the reference group). This may be because these homes are on average less well insulated, more difficult to heat or generally more inefficient. Central heating may be less common than it is in newer dwellings and occupiers may be using electrical heating and power showers. Homes built more recently than the reference category use significantly less energy from other fuels.

Concerning accommodation types, bedsitters and apartments use less energy from other fuels than detached houses while semi detached/terraced houses use less electricity and other fuels. This can be explained by the fact that apartments generally have a smaller floor space than other types of houses and, thus, are easier to heat. Semi-detached/terraced houses use less of all energy types than detached houses do, but the effect on other fuels is not as strong as that of apartments or bedsitters.

[1]According to Odyssee (2009) energy use per dwelling in Ireland is about 24,000 kWh per year.

Interestingly, those in local authority housing appear to use more energy from other fuels than home owners, but those renting privately or living in rent free accommodation do not. One possible contributing factor is that local authority tenants are probably more likely to receive fuel allowances and free fuel from the state than owners or private renters. Mortgage holders are seen to use 19.6 kWh more energy from other fuels each week (4% of their weekly other fuel use) than those who own their home outright. Tenure was seen to have no effect on electricity use.

Family composition does not affect electricity use or energy use at all while socio economic status and employment status do not affect electricity use. However, a household whose CES is in the manual skilled/semi-skilled employment category uses 34.8 kWh less energy from other fuels each week (8% of their weekly other fuel use). Where the CES is a student or retired or has only primary education the effect on other fuel use is positive. On the other hand those with only a primary education use 6kWh less electricity per week (10% of their weekly electricity use) than those who have completed the Leaving Certificate.

As the age of the CES increases past 64, electricity use decreases but the age variables are not important predictors of other fuel use. As expected, income is positively associated with electricity use. As the log of household disposable income increases by one unit, electricity use increases by 5.5 kWh per week. Although income has a positive effect on other fuel use, it is not significant. The quarter in which respondents were interviewed sometimes proved significant, with the highest usage in the first quarter of the year. This probably reflects seasonal factors such as external temperature and hours of daylight.

Energy use models including appliance ownership

We repeat the electricity and other fuel use regressions with the inclusion of the appliance ownership, heating and cooking variables. The results of the preferred OLS regressions are presented in Table 3.[9]

[Table 3 about here]

We find that the general pattern of results is similar; however, many of the variables which are statistically significant in the first set of models are not in the second set and vice versa. Also, the magnitude of coefficients tends to vary between the two sets

of models. One interesting finding is that the inclusion of the appliance variables shows that the measured effect of income on electricity use is overstated in the first model. When controls for appliances, heating and cooking methods are introduced the effect of increasing the log of household disposable income by one unit a week results in an increase in electricity use of 3.7 kWh per week instead of 5.5 kWh per week. Similarly, the coefficients on the variables in the age of CES and household composition categories as well as some of the variables in the rooms per accommodation and education level of CES categories are overstated in the first electricity use model. Variables in the location, type of accommodation and household composition categories appear to be overstated in the energy from other fuels models. This pattern also exists for some of the variables in the number of rooms and the age of accommodation categories.

5 out of 9 electrical appliances are statistically significant predictors of electricity use and many of the heating and cooking variables included prove to be important factors in explaining both electricity use and other fuel use. Results show that households with either a fridge-freezer or vacuum cleaner are seen to use between 5 and 6 kWh more electricity per week (6-7% of their weekly electricity use) than households that do not have such appliances. The effect of having a tumble dryer, dishwasher or deep freezer is even stronger at over 9 kWh extra electricity. (These households use on average 99, 104 and 102 kWh of electricity per week respectively). These appliances do not have any significant effect on energy derived from other fuels as would be expected. While the presence of double glazing does not significantly affect electricity use, as one might expect its effect on energy from other fuels is negative. On average, having some double glazing reduces the use of other fuels by 35 kWh per week (8% of weekly other fuel use by households with double glazing).

Also as expected, gas and LPG cookers negatively affect electricity use, while electric space and water heating methods increase it. Electrical space and water heating methods have the opposite effect on other fuels. For example, electric heaters and appliances reduce other fuel use by 205 kWh each week compared to homes which are heated by central heating where other fuel use is 479 kWh per week. However, electricity use is increased by 36 kWh per week. This is 44% of the electricity used by homes with central heating each week. Similarly, homes which are heated using piped gas use 111 kWh less of other fuels than homes being heated by central heating. In addition, it is worth noting that using renewable sources of energy to heat water is

associated with higher use of both electricity and other types of energy. Overall, the coefficients on the cooking, space heating and water heating variables suggest that heating and cooking methods play a larger role in explaining household energy use than electrical appliances.

Comparison with previous studies of household energy demand

In Ireland, the determinants of appliance ownership and energy-saving features were investigated by O'Doherty et al. (2008). Using the National Survey of Housing Quality, which was carried out in 2001 and 2002, the authors employ a Papke-Wooldridge generalised linear modelling (GLM) estimator to examine the characteristics of households that have a large number of energy using appliances and a Poisson count model to analyse those factors affecting the total number of energy-saving features present in a household. This was the first study of its kind in Ireland, however, O'Doherty et al. (2008) did not have data on actual energy use as we do in the present study. The authors find that respondents living in newer, detached homes and home owners are more likely to have a higher number of energy-saving features in their home but they are also more likely to have a higher number of energy-using appliances. With regard to income, O Doherty et al. (2008) find that as income increases by £100, the weighted number of appliances is likely to increase by 0.6%. In the present study we look at the effect of income on individual appliances and find that the greatest impact of an increase in income is on dishwasher ownership. O'Doherty et al. (2008) find that an increase in income has an even bigger effect on the expected number of energy saving features present in the home. While in the present analysis we only study double glazing, we find that an increase in income has a bigger effect on ownership of washing machines, vacuum cleaners, dishwashers and tumble dryers than it does on double glazing.

O'Doherty et al. (2008) also find that households in which children are present have a weighted number of appliances that is about 10% higher than other households. In the present study, we find that that children increase the probability that a number of appliances will be present. The biggest effect is on tumble dryers which are 13% more likely to be in a household where children are present.

Other factors such as the length of time a household has been resident at its current address, respondent age and tenure type were also found to be significant but negatively associated with the weighted number of appliances in a household. With

regard to tenure type, O'Doherty et al. (2008) find the weighted number of appliances is highest in households which are owned by the occupant. The number is 8% lower in local authority and 11% lower in privately rented dwellings. In the present study, we also find that this is the case in rented accommodation for all appliances except fridges, fridge freezers, washing machines and microwaves.

Other studies focus on the importance of income in determining household energy usage. Moll et al. (2005) look at the energy intensity of households with different income levels in the UK and in the Netherlands. They find that in the Netherlands the richest 25% of the population have a household energy requirement that is 60% higher than the poorest quarter of the population. In the UK, the richest 20% of households demand 75% more domestic energy than the poorest 20%. A similar analysis using our data shows that the richest 20% of households use 30% more energy in their homes than the poorest 20% of households. Moll et al. (2005) also show the importance of family size in household energy demand, a finding that is reiterated in our study.

The most important indicator of household energy usage was found to be income in studies of domestic energy use in India by Pachauri (2004) and the Netherlands by Vringer and Blok (1995). Pachauri (2004) found that the expenditure elasticity of energy is 0.67 whereas in the Netherlands it was estimated to be 0.83 using 1990 data (Vringer and Blok, 1995). Using the HBS data for 2004/2005 we find that the household expenditure elasticity is only 0.32 in Ireland.

As stated previously, many studies of household energy usage fail to account for the stock of appliances present in the household. O'Neill and Chen (2002) focus on the demographic determinants of household energy use in the US. Specifically, relationships between per capita energy consumption and house-holder age, household size and several measures of household composition are presented. The household's endowments of appliances, cooking and heating facilities are not taken into account. Similarly, Leth-Petersen (2002) carries out an analysis of domestic electricity and gas demand for Danish households in 1996. Electricity consumption is found to depend on the number of children, the natural log of total household expenditure, the size of the house and the age level but socio economic characteristics of the CES and the stock of appliances are not controlled for. Thus, the contribution of these demographic characteristics to domestic energy use may be overstated. Leth-Peterson (2002) finds that an increase in the log of household expenditure of 1% can

increase electricity use by 10% (if using OLS model) or 30% (if using GMM). Leth-Peteson (2002) also finds that children can increase household electricity use by up to 22%. In our study, however, children do not affect electricity use at all.

One recent contribution is a UK-based study which was carried out by Druckman and Jackson in 2008. The authors find that household energy use and associated carbon emissions are strongly, but not exclusively, related to income levels. They find that the richest 20% of households use 51% more energy in their homes than the poorest 20%. This gap between rich and poor is much larger than that observed in Ireland. The authors do not show the results of regression analysis but they do find that the type of dwelling plays a very important role in household fuel use. Flats, for example, use about 1/3 less energy per year than terraced houses. In Ireland we find that bedsitters use 64% less energy per year than semi-detached or terraced houses while apartments use about 14% less. Druckman and Jackson (2008) find that rural dwellers demand 33% more household energy per year than their inner-city counterparts. However, those living in suburbs use the most energy of all. In Ireland we find that rural households use only about 7% more energy than urban households. However, the urban variable included in our study includes suburban dwellings. Druckman and Jackson (2008) do not study the effect of appliances or heating or cooking methods on household energy demand.

Fernandez (2001) focuses on the replacement of household appliances. Using a duration model, Fernandez (2001) finds that household characteristics and product features play a significant role in explaining the appliance replacement decision over time. While our study finds that household characteristics help determine the household's stock of appliances, our data do not enable us to investigate appliance replacements or to control for specific features of products.

Dubin and McFadden (1984) jointly model the demand for appliances and the demand for household energy. However, the focus of the paper is on the bias which can result when attempts are made to estimate such models. If specifications ignore the fact that the demand for energy and the demand for appliances are related decisions, then estimates of price and income elasticities will be biased. The authors recommend using an instrumental variable procedure in such instances. Due to the lack of a suitable instrument, such as the availability of a gas supply, we are unable to take account of the endogeneity that can arise between purchase and use of appliances.

5. Conclusions

In this paper we investigated the determinants of domestic ownership of energy-using appliances and double glazing in Ireland by running logit regressions on a large cross-sectional dataset. We also explored the factors affecting the level of domestic energy usage using OLS regression models. We found a high level of statistical and economic significance for many appliance ownership variables in the energy use regressions discussed above. This implies that if one were to model energy use without controlling for the endowment of appliances, the model would be misspecified and could lead to incorrect inferences.

The approach we have adopted should be practicable in any jurisdiction where national expenditure surveys are carried out. Most jurisdictions have such a survey, not least due to the requirement for updating retail price index baskets.

Because the residential sector accounts for such a large proportion of greenhouse gas emissions in Ireland it is important to identify the factors that are driving the demand for domestic energy. Without this knowledge, policies aimed at reducing greenhouse gas emissions from the residential sector cannot be devised or implemented. Thus, the results of this paper can assist with several policy applications. Since appliances make a significant contribution to household energy demand, knowing more about the households that have access to them can help those designing or implementing home energy efficiency campaigns. A secondary benefit is to provide hints as to how this contributor to household energy demand might be expected to change in response to demographic shifts (e.g. for those forecasting domestic energy demand), although panel data would be more suitable for this purpose.

For jurisdictions like Ireland that do not collect information on the efficiency of the household appliance stock or the intensity of use of specific appliances, the coefficients on appliances in the electricity and other energy use models provide rough estimates of the average energy consumption for each type of appliance and heating method. This could be used to cross-check assumptions from engineering-based models used to estimate the effects of proposed policy measures to improve household energy efficiency.

The results are consistent with our expectation that heating and cooking methods are more important contributors to energy use than ownership of individual appliances. This underlines the importance of having efficient cooking and, especially, space and

water heating methods in the home. Nevertheless, when taken together, appliances can make a very significant contribution to a household's electricity demand. Five out of the nine energy-using appliances included in our analysis proved to be statistically significant in the energy use regressions. We also looked at the relationship between the presence of double glazing and energy usage. While double glazing tends to be more prevalent among richer households, any reduction in energy use it may bring about is more than offset by these households' increased electricity usage (due to higher usage or ownership of more appliances).

Our results provide a useful indication of how household characteristics affect ownership of energy-using appliances and, conditional upon such ownership, the amount of energy from electricity and other fuels that is used by households in Ireland. However, our analysis is limited by some shortcomings in the available data. We do not know the intensity or frequency with which appliances, heating or cooking methods are employed. It would be very helpful to have energy ratings for appliances, cookers or heating systems, but these were not available for the sample period.

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[1] By comparison, the rise in the UK over the same period was approximately 12% (Business, Enterprise and Regulatory Reform (BERR), 2008). In Spain the increase in residential energy consumption between 1990 and 2005 was 64%, due largely to the increased demand for air conditioning (Royal Institution of Chartered Surveyors (RICS), 2008).

[2] The average industrial wage more than doubled in real terms over the period 1990-2006 (Dáil Éireann, 1998 and Central Statistics Office, 2007a). The housing stock in 1990 was only 57% of its 2006 level (Department of the Environment, Heritage and Local Government (DoEHLG), 2007) and the population increased by over 21% from its 1990 level (Central Statistics Office, 2007b).

[3] The HBS includes a question on loft insulation, but it does not seem to have been completed by most households.

[4] We do not model whether households have access to cooking or heating facilities, since such facilities are essentially ubiquitous in our sample.

[5] The correlation matrix is available on request from the authors.

[6] A bedsitter is a small flat consisting of only a combined bedroom and sitting room. Sometimes some cooking facilities may also be available. The bathroom and lavatory are usually shared.

[7] An upper secondary level qualification, the Leaving Certificate is the final course in the Irish secondary school system. It is a two year programme in which students must study at least 6 subjects. For the majority of students, English, Irish and Mathematics are compulsory, while

the remaining subjects are optional. Students may opt for tests with varying degrees of difficulty for each subject.

[8]A joint zero restriction on insignificant coefficients was not rejected. Energyelec: F(35, 6811) = 1.27 [0.1355], Energyoth: F(29, 6811) = 1.11 [0.3121].

[9]A joint zero restriction on insignificant coefficients was not rejected. Energyelec: F(43, 6785) = 1.12 [0.2687], Energyoth: F(50, 6785) = 1.15 [0.2204]

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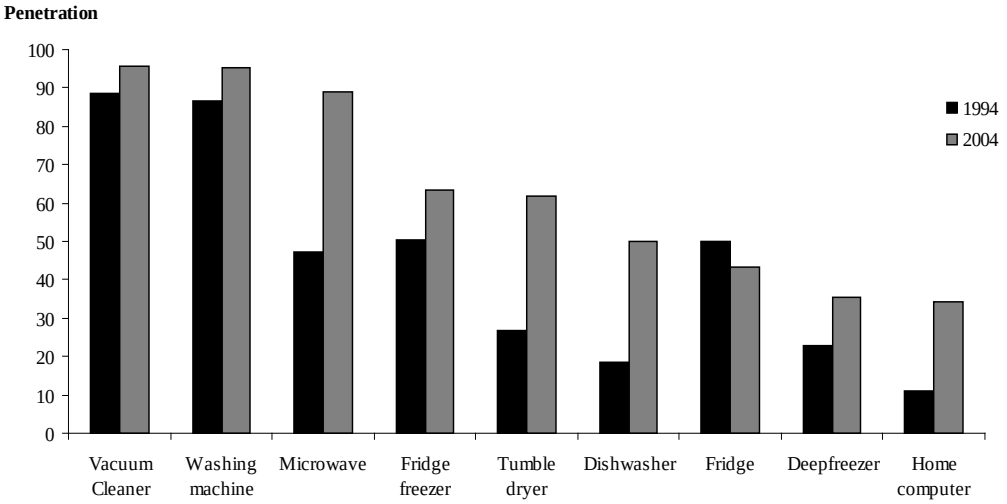
Appendix 1. Appliance ownership in Ireland



Source: CSO, 2009

Appendix 2. Quarterly average fuel price per unit

Fuel Type	Q4 2004	Q1 2005	Q2 2005	Q3 2005	Q4 2005
Coal	258.63	258.63	258.63	280.93	280.93
Anthracite	298.04	298.04	298.04	325.25	325.25
Gas	0.03	0.03	0.03	0.03	0.03
Turf	3.13	3.13	3.00	3.00	3.00
Heatoil	0.48	0.45	0.53	0.58	0.66
Paraffin	0.48	0.45	0.53	0.58	0.66
LPG	0.77	0.77	0.78	0.78	0.82
Wood	0.20	0.20	0.20	0.20	0.21
Electricity	0.14	0.15	0.16	0.16	0.15

Source: SEI, 2008

Appendix 3. Gross calorific value (kWh/unit) by fuel type

Fuel Type	Gross Calorific Value
Coal	8267.2
Anthracite	8735.2
Gas	1
Turf	67
Heat oil	10.55
Paraffin	5.78
LPG	7.09
Wood	4.8
Electricity	1

Source: SEI, 2009

Appendix 4. Descriptive statistics for variables used in regressions (dependent variables are in italics)

Variable	Mean	Std. Dev.
energyelec (Estimated energy use from electricity: kWh/week)	83.36	62.92
energyoth (Estimated energy use from other fuels: kWh/week)	419.31	392.75
Location of household	**Mean**	
Border, Midland and West (REF)		
South West, South East, Mid West, Mid East excluding Dublin	40.1%	
Dublin	30.4%	
Rural (REF)		
Urban	69.8%	
Number of rooms in accommodation		
I roomed house	0.2%	
2 roomed house	0.4%	
3 roomed house	3.4%	
4 roomed house	9.5%	
5 roomed house (REF)		
6 roomed house	27.9%	
7 roomed house	17.8%	
8 or more rooms in house	10.8%	
Period in which accommodation was built		
House built pre 1918	12.7%	
House built between 1918 and 1960 (REF)		
House built between 1961 and 1970	8.4%	
House built between 1971 and 1980	18.5%	
House built between 1981 and 1990	16.6%	
House built between 1991 and 2000	17.4%	
Post 2000	5.9%	
Type of accommodation		
Bedsitter	0.2%	
Converted apartment	1.0%	
Apartment block big or small	1.7%	
Detached house (REF)		
Semi-detached house	48.6%	
Other	0.5%	

Tenure	
Owned outright (REF)	
Rented from local authority	7.2%
Rented privately or rent free	11.0%
Mortgage holder	33.1%
Household composition	
1 person household	26.2%
2 person household (REF)	
3 person household	16.7%
4 person household	16.4%
5 person household	9.5%
6 person household	3.5%
7 person household	1.0%
8 or more people per household	0.4%
Family composition	
No children in household	
Family with children	18.8%
Two parent household	
Single parent	1.7%
Social group of Chief Economic Supporter (CES)	
Employers and Managers, Higher Professional, Lower Professional (REF)	
Non Manual	14.8%
Manual skilled and Semi-skilled	18.6%
Unskilled and Agricultural workers	6.7%
Own account workers and farmers	10.2%
All others gainfully occupied and unknown	16.7%
Employment status of CES	
Full time Employee (REF)	
Part time Employee	7.7%
Unemployed	2.3%
Retired	15.7%
Student	1.7%
Other	13.7%
Education level of CES	
No formal education	0.4%
Primary education	21.0%
Junior Cert/O level	21.1%
Leaving Cert/A level (REF)	
Sub degree	11.5%
Primary degree	11.3%
Higher degree	7.6%
Missing education observations	1.7%
Age of CES	
0-14	0.0%
15-24	4.8%
25-34	15.0%
35-44 (REF)	
45-54	20.2%
55-64	15.6%
65-74	13.2%
75+	9.4%
Income	
Log of household disposable income	645.2%
Period in which interview took place	
Q4 2004	11.0%

Q1 2005	23.5%
Q2 2005 (REF)	
Q3 2005	21.1%
Q4 2005	19.9%
Electrical Appliances	
Washing Machine	95.3%
Dishwasher	50.1%
Fridge	43.4%
Deep freezer	35.4%
Vacuum Cleaner	95.5%
Tumble Dryer	61.7%
Home computer	34.3%
Double Glazing	76.0%
Fridge freezer	63.4%
Microwave	86.0%
Cooking Methods	
Electric cooker (REF)	
Gas or LPG cooker	27.2%
Solid fuel cooker	3.1%
Oil fired cooker	1.6%
Combined methods or other cooking methods	2.6%
Heating Methods	
Space heating by central heating (REF)	
Space heating by open fire	2.6%
Space heating by solid fuel heater or cooker	1.4%
Electric heaters and appliances	2.5%
Space heating by piped gas	0.2%
Space heating by LPG paraffin or other	0.3%
Water heating by central heating (REF)	
Water heating by solid fuel (fire/cooker/stove)	16.2%
Water heating by electric means, e.g. immersion	10.2%
Water heating by gas boiler	6.6%
Water heating by renewable energy	0.0%
Water heating by other methods or no water heating	1.5%

Appendix 5. Average electricity use and other fuel use by households with different characteristics

	Electricity use		Other fuel use	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Location of household				
Border, Midland and West (REF)	86	61	456	445
South West, South East, Mid West, Mid East excluding Dublin	87	62	385	359
Dublin	90	67	466	396
Rural (REF)	91	63	427	362
Urban	86	63	430	416
Number of rooms in accommodation				
1	34	17	87	93
2	40	28	102	128
3	55	50	200	268
4	63	53	364	384
5 (REF)	74	52	417	427
6	90	71	429	374
7	103	61	461	376
8 or more	117	64	517	421
Period in which accommodation was built				
Pre 1918	79	72	409	375
Between 1918 and 1960 (REF)	87	63	429	398
Between 1961 and 1970	76	49	436	403
Between 1971 and 1980	95	64	447	432
Between 1981 and 1990	96	60	418	351
Between 1991 and 2000	97	70	413	383
Post 2000	93	56	430	380
Type of accommodation				
Bedsitter	38	15	60	84
Converted apartment	62	44	256	387
Apartment block big or small	76	54	155	252
Detached house (REF)	94	62	448	416
Semi-detached house	81	65	420	376
Other	69	69	442	504
Tenure				
Owned outright (REF)	79	64	429	415
Rented from local authority	77	58	465	415
Rented privately or rent free	79	65	293	351
Mortgage holder	103	60	460	376
Household composition				
1 person household	46	41	321	327
2 person household (REF)	75	53	425	385
3 person household	95	54	461	398
4 person household	107	71	448	338
5 person household	124	69	500	522
6 person household	127	61	518	514
7 person household	136	55	528	395
8 or more people per household	146	80	464	373
Family composition				
No children in household (REF)	81	60	417	398
Family with children	107	70	466	397

	Electricity use		Other fuel use	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Two parent household (REF)	88	63	429	399
Single parent	86	65	425	389
Social group of Chief Economic Supporter (CES)				
Employers and Managers, Higher Professional, Lower Professional (REF)	87	63	429	398
Non Manual	85	54	424	388
Manual skilled/Semi-skilled	88	55	417	330
Unskilled and Agricultural workers	79	57	462	610
Own account workers and farmers	94	86	424	351
All others gainfully occupied and unknown	64	63	388	414
Employment status of CES				
Full time Employee (REF)	87	63	429	398
Part time Employee	88	59	436	341
Unemployed	80	49	406	812
Retired	52	46	420	393
Student	81	54	224	251
Other	63	62	409	418
Education level of CES				
No formal education	55	32	429	332
Primary education	61	55	441	483
Junior Cert/O level	89	58	427	368
Leaving Cert/A level (REF)	93	60	411	342
Sub degree	100	78	445	363
Primary degree	99	61	442	424
Higher degree	95	66	453	448
Missing education observations	81	54	221	249
Age of CES				
0-14	78	17	666	221
15-24	88	51	378	436
25-34	89	54	397	370
35-44 (REF)	102	63	450	380
45-54	106	71	450	365
55-64	90	62	452	495
65-74	52	45	401	328
75+	40	45	403	457
Period in which interview took place				
Q4 2004	84	55	443	499
Q1 2005	96	76	510	426
Q2 2005 (REF)	90	59	452	386
Q3 2005	84	68	356	306
Q4 2005	81	51	386	393
Electrical appliances				
Fridge freezer	89	64	435	409
Fridge	89	64	428	390
Washing Machine	89	63	433	397
Vacuum Cleaner	89	63	431	385
Microwave	91	61	435	391
Tumble Dryer	99	65	446	409
Dishwasher	104	62	458	381
Deep freezer	102	64	447	378
Home computer	100	61	439	360
Energy saving measures				

	Electricity use		Other fuel use	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Double Glazing	91	63	425	368
Cooking methods				
Electric cooker (REF)	92	66	404	396
Gas or LPG cooker	78	55	481	409
Solid fuel cooker	71	53	470	357
Oil fired cooker	98	75	442	286
Combined methods or other cooking methods	82	54	488	398
Heating methods				
Space heating by central heating (REF)	82	66	479	433
Space heating by open fire	70	65	410	831
Space heating by Solid fuel heater or cooker	61	53	485	528
Electric heaters and appliances	103	76	84	181
Space heating by piped gas	46	60	252	176
Space heating by LPG paraffin or other	43	50	192	224
Water heating by central heating (REF)	89	63	429	372
Water heating by solid fuel (fire/cooker/stove)	80	60	496	480
Water heating by electric means, e.g. immersion	90	71	267	362
Water heating by gas boiler	83	57	544	373
Water heating by renewable energy	148	.	836	.
Water heating by other methods or no water heating	59	48	476	617

Table 1. Logit regression results for determinants of appliance ownership (results are presented as odds ratios)

	Fridge Freezer	Fridge	Washing Machine	Vacuum Cleaner	Microwave	Tumble Dryer	Dishwasher	Deep Freezer	Home Computer	Double Glazing
Location of household										
Border, Midland and West (REF)										
South West, South East, Mid West, Mid East excluding Dublin	0.691***	1.53***					1.23***	1.6***		1.35***
Dublin	0.779***	1.17**				0.542***				
Rural (REF)										
Urban	1.24***	0.789***	1.83***	1.52**	1.31***	1.25***	1.31***	0.762***	1.13**	1.25***
Number of rooms in accommodation										
1			0.17***							
2			0.151***	0.283**						
3	0.374***	2.34***	0.172***	0.258***	0.318***	0.43***	0.343***			
4	0.817**		0.594***	0.562***	0.659***	0.739***	0.439***		0.722***	
5 (REF)										
6			1.77**	1.81***	1.39***	1.24***	1.48***	1.4***		1.44***
7			4.02***	2.74***	1.89***	1.72***	2.77***	1.64***		1.86***
8 or more	0.721***	1.59***	3.37**	2.73***	1.95***	2.11***	4.01***	2.48***		1.86***
Period in which accommodation was built										
Pre 1918	0.865*	1.26***	0.512***	0.646***	0.566***				0.787***	0.656***
Between 1918 and 1960 (REF)										
Between 1961 and 1970							1.27**			1.35***
Between 1971 and 1980		1.14**		2.09***	1.27**			1.2***	1.15**	
Between 1981 and 1990							1.3***			
Between 1991 and 2000	1.17**			1.93***			1.46***			3.58***
Post 2000	1.33**					1.57***	2.86***			9.55***
Type of accommodation										
Bedsitter						3.67**				
Converted apartment				2.53**		1.93**				
Apartment block						2.3***				
Detached house (REF)										
Semi-detached/terraced	1.48***	0.686***		1.79***	1.32***		0.76***	0.672***		

	Fridge Freezer	Fridge	Washing Machine	Vacuum Cleaner	Microwave	Tumble Dryer	Dishwasher	Deep Freezer	Home Computer	Double Glazing
Other	2.45**	0.394**								0.0941***
Tenure										
Home owner (REF)										
Rented from local authority				0.443***		0.684***	0.411***	0.669***	0.618***	0.484***
Rented privately or rent free				0.598**		0.484***	0.394***	0.535***	0.733***	0.494***
Mortgage holder	1.17***		3.08***		1.32***		1.45***	0.822***		
Household composition										
1 person household	0.782***		0.26***		0.625***	0.659***	0.543***	0.567***	0.633***	
2 person household (REF)										
3 person household						1.29***		1.47***	1.58***	0.842**
4 person household						1.46***		1.48***	1.61***	
5 person household						1.87***	1.49***	1.61***	1.9***	
6 person household						1.98***	1.6***	2.28***	1.81***	
7 person household						3.14**			3.51***	
8 or more people per household				0.271**	0.396**					
Family composition										
No children in household (REF)										
Family with children				0.64**		1.32***	1.24**	0.847**	0.797***	1.44***
Two parent household (REF)										
Single parent household							0.564***			
Social group of CES										
Employers and Managers, Higher Professional or Lower Professional (REF)										
Non Manual							0.809**		1.31***	
Manual skilled/Semi-skilled							0.764***		1.21**	
Unskilled and Agricultural workers		1.3***	0.564**	0.46***			0.624***			
Own account workers and farmers					0.671***				0.729***	0.657***
All others gainfully occupied and unknown										
Employment status of CES										
Full time Employee (REF)										
Part time Employee	0.828**									

	Fridge Freezer	Fridge	Washing Machine	Vacuum Cleaner	Microwave	Tumble Dryer	Dishwasher	Deep Freezer	Home Computer	Double Glazing
Unemployed								0.592**	0.538***	
Retired			0.661**						1.62***	
Student										
Other				0.601***					0.675***	
Education level of CES										
No formal education	0.304**		0.162***	0.169***	0.368**					
Primary education	0.718***	1.27***	0.637***	0.344***	0.79**	0.761***	0.619***		0.548***	
Junior Cert/O level										
Leaving Cert/A level (REF)										
Sub degree										
Primary degree					0.586***	0.732***			0.846*	
Higher degree					0.455***				0.601***	
Missing education observations										
Age of CES										
0-14										
15-24				0.255***	1.59**				0.686***	
25-34		0.824***		0.423***	1.36**	0.839**	0.779***	0.841**	0.821**	
35-44 (REF)										
45-54									1.4***	
55-64							1.27***			
65-74									0.614***	
75+			0.638***		0.525***	0.637***	0.479***	0.698***	0.228***	0.652***
Income										
Log of household disposable income			1.63***	1.62***	1.26***	1.45***	1.83***	1.12**		1.38***
Period in which interview took place										
Q4 2004	0.836**	1.22**								
Q1 2005					0.808**			0.84***		
Q2 2005 (REF)										
Q3 2005										
Q4 2005										1.18**

*=significant at the 10% level; **=significant at the 5% level; ***=significant at the 1% level

Table 2. OLS regression results for determinants of electricity use and energy use from other fuels omitting appliance ownership

	Energyelec		Energyoth	
	Coef.	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
Location of household				
Border, Midland and West (REF)				
South West, South East, Mid West, Mid East excluding Dublin			-57.9***	11.3
Dublin	3.78**	1.88	36***	13.9
Rural (REF)				
Urban	2.95*	1.72		
Number of rooms in accommodation				
1	-21.7***	5.83	-161**	74.8
2			-226***	44.4
3			-142***	22.8
4				
5 (REF)				
6	6.53***	1.75		
7	11.1***	2.04		
8 or more	17.9***	2.52	53.8***	15.8
Period in which accommodation was built				
Pre 1918	5.96***	2.3		
Between 1918 and 1960 (REF)				
Between 1961 and 1970				
Between 1971 and 1980	4.9***	1.84	-18.4	14.7
Between 1981 and 1990			-50.8***	13.1
Between 1991 and 2000			-48.1***	13.6
Post 2000			-40.7**	19.5
Type of accommodation				
Bedsitter			-152*	78.3
Converted apartment				
Apartment block big or small			-163***	26.4
Detached house (REF)				
Semi-detached house	-6.71***	1.71	-35.4***	10.4
Other				
Tenure				
Owned outright (REF)				
Rented from local authority			82.8***	21.5
Rented privately or rent free			-82.4***	15.9
Mortgage holder			19.6*	11.8
Household composition				
1 person household	-17.1***	1.73	-94.1***	13.4
2 person household (REF)				
3 person household	13.6***	2.08	43.5***	14.3
4 person household	22.7***	2.62	28.5**	13.4
5 person household	36.7***	3.09	72.4***	22.7

	Energyelec		Energyoth	
	Coef.	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
6 person household	39.3***	3.81	96.2***	30.5
7 person household	49.2***	5.92	81.9*	41.9
8 or more people per household	59.5***	12.5		
Family composition				
No children in household (REF)				
Family with children				
Two parent household (REF)				
Single parent				
Social group of Chief Economic Supporter (CES)				
Employers and Managers, Higher Professional, Lower Professional (REF)				
Non Manual				
Manual skilled/Semi-skilled			-34.8***	11
Unskilled and Agricultural workers				
Own account workers and farmers				
All others gainfully occupied and unknown				
Employment status of CES				
Full time Employee (REF)				
Part time Employee				
Unemployed				
Retired			28.3*	15.3
Student			141***	38.1
Other				
Education level of CES				
No formal education				
Primary education	-6.25***	1.89	54.7***	15.9
Junior Cert/O level			13.7	11.9
Leaving Cert/A level (REF)				
Sub degree			18	13.6
Primary degree				
Higher degree				
Missing education observations	-1.51	6.2	-248***	30.6
Age of CES				
0-14				
15-24				
25-34				
35-44 (REF)				
45-54	8.13***	2.12		
55-64	9.02***	2.51		
65-74	-14***	2.35		
75+	-19.9***	2.71		
Income				
Log of household disposable income	5.51***	1.32	8.32	8.31
Period in which interview took place				
Q4 2004	-4.82**	2.07		

	Energyelec		Energyoth	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Q1 2005	5.8***	2.13	56.4***	13.6
Q2 2005 (REF)				
Q3 2005	-8.56***	2.03	-106***	11.7
Q4 2005	-10.3***	1.68	-67.8***	13.4

*=significant at the 10% level; **=significant at the 5% level; ***=significant at the 1% level

Table 3. OLS regression results for determinants of electricity use and energy use from other fuels including appliance ownership

	Energyelec		Energyoth	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Location of household				
Border, Midland and West (REF)				
South West, South East, Mid West, Mid East excluding Dublin			-51.8***	11.2
Dublin	5.47***	1.86	26.4*	14.2
Rural (REF)				
Urban				
Number of rooms in accommodation				
1	-30.7***	8.38	-189***	29.9
2	-18.7**	8.39	-145***	47
3			-130***	20.8
4				
5 (REF)				
6	4.93***	1.75		
7	7.24***	2.01		
8 or more	13.7***	2.47	50.6***	15.7
Period in which accommodation was built				
Pre 1918	5.34**	2.27		
Between 1918 and 1960 (REF)				
Between 1961 and 1970	-4.85**	1.92		
Between 1971 and 1980				
Between 1981 and 1990			-32.5***	11.9
Between 1991 and 2000			-25.1**	11.8
Post 2000	-7.11***	2.59		
Type of accommodation				
Bedsitter				
Converted apartment	-10.1**	5.04		
Apartment block big or small			-101***	24.3
Detached house (REF)				
Semi-detached/terraced	-5.61***	1.61	-31.5***	10.4
Other				
Tenure				
Home owner (REF)				
Rented from local authority			67.1***	20.5
Rented privately or rent free			-71.7***	15.1
Mortgage holder				
Household composition				
1 person household	-14.5***	1.72	-90.3***	13.4

	Energyelec		Energyoth	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
2 person household (REF)				
3 person household	11.9***	2.04	35.8***	14
4 person household	21.2***	2.53	22.8*	12.9
5 person household	33.9***	3	64.9***	22
6 person household	35.5***	3.8	93.8***	29.8
7 person household	49.1***	5.8		
8 or more people per household	59.3***	12.7		
Family composition				
No children in household (REF)				
Family with children				
Two parent household (REF)				
Single parent household	9.11**	4.42		
Social group of Chief Economic Supporter (CES)				
Employers and Managers, Higher Professional, Lower Professional (REF)				
Non Manual				
Manual skilled/Semi-skilled			-36***	10.6
Unskilled and Agricultural workers				
Own account workers and farmers				
All others gainfully occupied and unknown				
Employment status of CES				
Full time Employee (REF)				
Part time Employee				
Unemployed				
Retired	-2.99	2.07	31.1**	14.8
Student			175***	41.1
Other				
Education level of CES				
No formal education				
Primary education			38.2***	14.8
Junior Cert/O level				
Leaving Cert/A level (REF)				
Sub degree			17.9	13.1
Primary degree				
Higher degree				
Missing education observations	-1.83	5.79	-275***	33.8
Age of CES				
0-14	2.46	4.41		
15-24				
25-34				
35-44 (REF)				
45-54	7.42***	2.07		
55-64	8.49***	2.4		
65-74	-12.7***	2.59		
75+	-17.2***	2.86		
Income				
Log of household disposable income	3.67***	1.29	12.7	7.92
Period in which interview took place				
Q4 2004	-4.57**	2.04		
Q1 2005	5.64***	2.07	58.7***	13.4
Q2 2005 (REF)				
Q3 2005	-9.1***	1.98	-106***	11.6

	Energyelec		Energyoth	
	Coef.	Robust Std. Err.	Coef.	Robust Std. Err.
Q4 2005	-12.3***	1.65	-63***	13.3
Electrical appliances				
Fridge-freezer	5.91***	1.67		
Fridge				
Washing Machine				
Vacuum Cleaner	5.43*	3.14		
Microwave				
Tumble Dryer	9.27***	1.52		
Dishwasher	9.25***	1.7		
Deep freezer	9.92***	1.83		
Home computer				
Energy saving measures				
Double Glazing			-35.1***	12.7
Cooking methods				
Electric cooker (REF)				
Gas or LPG cooker	-10.1***	1.45	54.3***	11.1
Solid fuel cooker	-15.1***	2.79		
Oil fired cooker				
Combined methods or other cooking methods	-10.2***	3.43		
Heating methods				
Space heating by central heating (REF)				
Space heating by open fire	5.65	4.33		
Space heating by solid fuel heater or cooker				
Electric heaters and appliances	36.2***	5.62	-205***	20.5
Space heating by piped gas			-111**	49.3
Space heating by LPG paraffin or other				
Water heating by central heating (REF)				
Water heating by solid fuel (fire/cooker/stove)			53.1***	14.8
Water heating by electric means, e.g. immersion	10.9***	2.83	-74.3***	16.7
Water heating by gas boiler			77***	20.3
Water heating by renewable energy	21.6***	4.86	311***	36.4
Water heating by other methods or no water heating	-12.3***	3.76		

*=significant at the 10% level; **=significant at the 5% level; ***=significant at the 1% level

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