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Electrical Appliance Ownership and Usage in Ireland

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Abstract: Past research into the determinants of appliance ownership has identified associations with socioeconomic characteristics of households. Few studies have examined the intensity with which different sorts of households use the appliances they have. This paper uses microdata to examine the factors influencing ownership and usage of electrical appliances in Irish households. We also consider the factors influencing the ownership of different cooker types, space and water heating systems and energy saving features. We find that appliance ownership and usage is related to the socio-economic characteristics of the household's chief income earner as well as household characteristics such as the type and age of accommodation, tenure and the number of bedrooms. The number of people living in the household has a positive association with both ownership and usage of electrical appliances. However, it does not increase ownership of energy saving features, with the exception of CFLs. The highest earning households are more likely to own electrical appliances but they do not necessarily use them more often, nor are they more likely to purchase energy saving features.

Key words: Electrical appliance ownership, appliance usage, energy saving features, Ireland

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1. Introduction

Household electricity accounts for 34% of all electricity demanded in Ireland (SEAI, 2010). The average Irish household uses about 4,300 kWh of electricity per year (CSO, 2007). SEAI (2008) estimates that refrigeration is responsible for 11% of household demand while wet appliances such as washing machines account for 9%. Appliances such as DVDs, TVs and kettles account for 13% (SEAI, 2008). The remainder of household electricity use is attributed to lighting (18%), space heating (14%), water heating (23%) and cooking (12%). Irish residential electricity demand almost doubled between 1990 and 2009 (SEAI, 2008) with an increase in the number of households and accommodation size¹. Accompanied by increases in household income, this led to a doubling in the penetration of electrical appliances in Irish households between 1987 and 2004/05 (SEAI, 2008).

The determinants of appliance ownership have been given some attention in Ireland in recent years. O'Doherty *et al.* (2008) find that homes with more energy-saving features are also more likely to have a high number of energy using appliances. Statistically significant household features included location, the type of dwelling and its value. Other important variables were income, the age of the respondent, period of residency, social status and tenure. Leahy and Lyons (2010) study the household characteristics associated with ownership of a fridge-freezer, fridge, washing machine, vacuum cleaner, microwave, tumble dryer, dishwasher, deep freezer and home computer. The socio-economic characteristics of the household reference person proved to be important in explaining ownership as did household characteristics such as tenure, number of rooms, location, type of dwelling and period in which the dwelling was built. Income was statistically significant in all of the models except for the fridge freezer, fridge and home computer. Neither of these papers considers the frequency with which appliances are used.

In fact, the literature on appliance usage is sparse. In a longitudinal study of 72 households, Firth (2008) found that the domestic electricity consumption is driven to a large extent by the use of standby and active (lights and kettles) appliances. Dubin and McFadden (1984) note that expected appliance utilization should be an important factor in the appliance purchasing decision process. The authors jointly model the demand for consumer durables and the derived demand for electricity. However, the determinants of usage were not directly estimated. Yohanis *et al.* (2008) examined the determinants of domestic electricity use in Northern Ireland and found a significant correlation between electricity consumption and floor space as well as a marked seasonal effect. Yamamoto *et al.* (2008) consider decision making in residential electrical appliance usage in Japan. They found that usage depends on the characteristics of the appliance rather than on the efficiency of the appliance or the price of electricity. However, micro data on the intensity of appliance usage was not available to these authors and so the determinants of appliance usage are not examined directly. Tso and Yau

¹ Between 1996 and 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)

(2003) found a significant seasonal effect in their study of domestic usage patterns in Hong Kong, with higher usage patterns found during the summer months.

In the first part of this paper, we update and extend the work on appliance ownership by Leahy and Lyons (2010) and O'Doherty *et al.* (2008). Using more recent and detailed data, we model the determinants of ownership of electrical appliances, cookers, space heating systems and water heaters. This part of the analysis also studies the presence of energy saving features in the home. In the second part of the analysis, we model the determinants of appliance usage. To our knowledge, this is the first paper to model the extent to which different appliances are used in the residential sector. Understanding the characteristics associated with ownership and usage of different types of appliances and the presence of energy saving features should help those wishing to forecast future demand for electricity in the residential sector or to design measures to improve household energy efficiency. The methods employed here can be easily adopted for studies of electrical appliance ownership and usage in other countries where the appropriate data are available.

The paper continues as follows: The data and methods used are described in Section 2. Results are presented in Section 3, and Section 4 provides a discussion and conclusion.

2. Data and Methods

We use socioeconomic survey data that was collected for the purpose of Ireland's Smart Metering Consumer Behaviour Trial in 2009-2010 (CER, 2011). 3815 households provided information about the energy saving features and appliances that were present in their homes. Information about the degree to which appliances are used is also available. In addition, the dataset contains information about the socio-economic characteristics of each household.

2.1. Presence of appliances and energy saving features

In the first part of the analysis we estimate the determinants of appliance ownership and energy saving features. The appliances and energy saving features included in the analysis are outlined in Table 1 below. For each appliance or energy saving feature, we run a logit model in which the dependent variable equals 1 if the particular appliance/energy saving feature is present in the household and 0 if it is not. Respondents were also asked to specify the approximate proportion of double-glazed windows and energy saving lights (CFL) present in the home. To model the determinants of these features, we run ordered logit models in which the dependent variable is a set of categories capturing increasing proportions of these energy saving features. For example, CFL is equal to 0.25 if the respondent indicated that about a quarter of the light bulbs present in the home are energy saving.

Table 1: Appliances and Energy Saving Features

APPLIANCES	COOKERS	WATER HEATING	SPACE HEATING	ENERGY SAVING
Washing machine	Electric	Central heating	Central heating	Lagging jackets
Tumble dryer	Gas	Immersion	Electric heaters	External wall insulation
Dishwasher	Oil	Electric heater	Gas	Attic insulation
Freezer	Solid fuel	Gas	Oil	Space heating timers
Electric shower		Oil	Solid fuel	Water heating timers
Desktop computer		Solid fuel	Renewables	Compact fluorescent lamps (CFLs)
Laptop computer		Renewable		Double glazed windows
Games console				
TV > 21 inches				

We include a range of household and socio-economic characteristics as explanatory variables in the models. The characteristics of the chief income earner (CIE) include education level, employment status, socio-economic status and age. We expect to find that the probability of owning energy saving features will vary with levels of education as the relatively well educated may be more aware of the monetary and environmental benefits of such features. Similarly, well educated CIEs may be less likely to use inefficient heating methods such as electric plug in heaters. As per O’Doherty *et al.* (2008) and Leahy and Lyons (2010), we expect to find that the likelihood of owning certain appliances and energy saving features will vary with the socio-economic status of the CIE. We also control for the age category of the CIE because we feel that the young and old may have different preferences regarding appliances. For example, young CIEs may be more likely to possess games consoles or laptops than their older counterparts. With regard to energy saving features, O’Doherty *et al.* (2008) found that households in which the CIE is aged 40-65 had more energy saving features in their homes than households whose CIE was under 40. However, where the CIE was over 65, the number of energy saving features was significantly lower. In this paper we aim to find out if preferences for energy saving features vary with age.

We include dummy variables for the sex of the CIE and for single parent households. As seen in Leahy and Lyons (2010), single parent households may possess fewer energy-using consumer durables such as dishwashers, since they tend to be at higher risk of fuel poverty or poverty generally than other households (see e.g. Scott *et al.*, 2008 and DCENR, 2011). Alternatively, they may be more likely to invest in items such as laptops or games consoles which are popular amongst children.

We also control for characteristics of the wider household and the property. It is important to include the type of accommodation as an explanatory variable because we expect to find that apartment dwellers will possess different appliances to those living in detached houses or bungalows. The space available for appliances and the availability of suitable locations for them (e.g. utility rooms, counter space) will vary by type of property, and we do not observe such

characteristics directly. Also, apartment dwellers might have less need to invest in energy saving features like attic insulation because they may be surrounded by other apartments. Unfortunately, we cannot control for the size of the dwelling in which the respondent lives.² However, we do know the number of bedrooms in the accommodation. We would expect to find that the probability of owning certain appliances, especially large items such as TVs > 21 inches and dishwashers will increase with the number of bedrooms as these homes probably have a larger internal area. They may also be more likely to invest in external wall insulation or double glazing than those who live in homes with fewer bedrooms.

The probability of owning appliances and energy saving features is likely to vary by housing tenure. Respondents living in rented accommodation should be less likely to own less essential items such as dishwashers or tumble dryers, which require a relatively high initial investment, especially if they perceive their stay to be short-term. Also landlords may be less likely to invest in these appliances and energy saving features as they do not directly benefit from them. However, landlords may be able to obtain compensation for such investments through higher rents. We also control for the number of people living in the household as we expect that the demand for the services provided by appliances will be higher when there are many people living in the household.

The income level of the household is very important as it affects how much respondents can afford to invest in appliances and energy saving features. O'Doherty *et al.* (2008) and Leahy and Lyons (2010) find income to be significant in determining the ownership of electrical appliances. O'Doherty *et al.* (2008) also find that income strongly influenced the number of energy saving features found in the home.

We control for the year in which the accommodation was built because newer homes may have features such as timers which have become more widely available in recent years. It could also be the case that older homes are less well equipped to cope with a large number of electrical appliances because of the layout of the accommodation or because there are fewer mains plugs.

2.2. Usage of appliances

In the second, more novel, part of the analysis we analyse the determinants of appliance usage. The survey asks respondents to rank the degree to which they use an appliance on a scale of 1 to 4. Units of measurement vary by appliance and are displayed in Appendix A. In this paper we analyse the frequency with which households use washing machines, tumble dryers, dishwashers, electric showers, electric cookers, electric heaters, immersions, TVs > 21 inches, desktop computers, laptop computers and games consoles. Because the dependent variable is ordinal, ranging between 1 and 4 depending on the frequency with which the appliance is used, we use ordered logit models.

When analysing the determinants of appliance usage, we include all of the explanatory variables used in the ownership models along with other respondent characteristics that we feel may

² The questionnaire does contain a question about the size of the accommodation; however, we cannot use this variable because too few respondents specified whether the unit of measurement was in square feet or square metres.

influence the degree to which appliances are used. One such variable is the number of people who are at home during the day. This may be associated with the intensity of use of electrical appliances such as TVs, laptops and electric heaters. We include a dummy variable which describes whether the household has access to the internet or not as this will affect the degree to which laptops and desktop computers are used. It may also pick up some aspect of appliance knowledge as the internet provides access to information about efficient use of appliances.

Questions about the respondent's attitude towards the electricity bill and the environment are also included.³ We expect to find that respondents who are concerned about the environment or who wish to reduce their electricity bill⁴ will use appliances such as tumble dryers or dishwashers less frequently than those who do not show any concern for such issues. Respondents are asked if they ever forego heating on a cold day or if their accommodation is adequately warm. If they respond yes to either of these questions we categorise that household as being fuel-poor (as per Scott *et al.*, 2008). We expect to find that households suffering from fuel poverty use appliances less often than non fuel-poor households. Some descriptive statistics on the explanatory and control variables are set out in Appendix B.

Most of our explanatory variables are categorical and therefore included as dummy variables. This means that we do not impose a functional form on them. For example, we estimate a separate dummy for each age, rather than appliance ownership as a linear function of age. We estimate multivariate models. As many variables are correlated (e.g., age, income, education, family structure), some of the results below are, at first sight, surprising. However, our models show the "pure" effect of, say, age on appliance use – while our intuition is informed by the "convoluted" effect of age with income, education, family and so on.

3. Results

Due to the large number of variables in the models only a selection of the statistically significant results are presented. Full regression results are available here <http://www.esri.ie/UserFiles/publications/WP421/WP421.xlsx>. For each categorical explanatory variable there is a reference category that acts as a baseline against which households with different characteristics may be compared. The reference categories are outlined in Table 2 below. In the case of the logit models, a plus sign indicates that households with a particular characteristic are more likely to own a certain appliance compared to households in the reference category. A minus sign indicates that the probability of ownership is lower for households with that characteristic compared to households in the reference group. With regard to the presence of double glazing and CFLs, a plus

³ Respondents are asked to respond to the following statements: I am interested in changing the way I use electricity if it reduces the bill and I am interested in changing the way I use electricity if it helps the environment. In each case respondents must state whether they strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree.

⁴ These variables are specified as dummy variables in the models. A value of 1 is assigned if respondents either strongly agree or agree to the relevant statements, 0 otherwise.

sign indicates that the number of double glazed windows or CFLs in the accommodation is likely to be higher in households with a certain characteristic compared to households in the reference group. The opposite is the case where a minus sign appears.

Table 2: Reference categories of control variables

CONTROL VARIABLE	REFERENCE CATEGORY
Employment status	Employee
Socio-economic status	DE: Semi and unskilled manual workers, casual workers, those in receipt of state benefits
Age category	Aged 46-55
Level of education	Third Level
Type of accommodation	Semi – detached
Tenure	Owned outright
Number of bedrooms	3 bedrooms
Household Income	€50,000 - €75,000

3.1. Appliance ownership

The results of the logit models that investigate the determinants of electrical appliance ownership are displayed in Table 3A. Results show that dishwashers are more likely to be found in households whose CIE is self employed, working as a carer or retired. It is possible that carers, self employed or retired people invest in dishwashers as a way to reduce the amount of time and effort they must devote to housework. On the other hand, households whose CIE is retired are less likely to own games consoles, likely reflecting differences in preferences. Retired CIEs are also less likely to own electric showers. This may also reflect preferences or may be influenced by safety considerations relating to poor health or restricted mobility.

The socio-economic status of the CIE is not as significant a determinant of appliance ownership as we would have expected. Households with farmer CIEs are less likely to own laptops or games consoles than those with employee CIEs (the reference category). This could be because they spend more time outdoors than their counterparts in other occupations. The age of the CIE proves very important in determining appliance ownership. Households whose CIE is younger than the 45-56 group are more likely to own washing machines but less likely to own freezers. It may be that due to differences in lifestyle; younger adults may not have as much need to store large amounts of food in a freezer. As expected, households whose CIE is older than those in the reference group are less likely to own laptops and games console. The level of education of the CIE also plays a role in explaining the presence of certain appliances. Households whose CIE is educated to lower secondary (“junior cert”) or upper secondary (“leaving cert”) level are more likely to own TVs >21 inches than those with a degree-holding CIE, but they are less likely to own laptops.

Accommodation characteristics are also important. Respondents living in detached houses are more likely to own tumble dryers, dishwashers and freezers than those living in semi-detached houses. This is likely to be due to differences in floor space and suitable locations within the house. Apartment dwellers are more likely to own TVs >21 inches. This might be unexpected given that they

are likely to have less living space than those in the reference group. However, the association between these variables could reflect unobserved variation in socioeconomic characteristics or preferences. The results for those living in bungalows are also somewhat surprising. These respondents are more likely to own tumble dryers and freezers than those in the reference group but less likely to own washing machines. However, a closer examination of the results shows that 98.7% of those who live in bungalows own a washing machine whereas the figure is over 99% for those living in semi-detached houses. So, although the difference is statistically significant, in absolute terms it is small.

As expected, respondents living in rented accommodation are less likely to have washing machines, dishwashers or tumble dryers available to them compared to those who own their homes outright. Mortgage holders are more likely to own dishwashers and TVs > 21 inches than those in the reference category. This probably reflects an unobserved difference in when properties were purchased; many outright owners will have purchased properties with a mortgage but have since paid it off. Households with mortgages are thus likely to have younger members, *ceteris paribus*.

Properties with more than three bedrooms (the reference category) are more likely to own washing machines, tumble dryers, dishwashers, freezers, electric showers, desktop computers and TVs > 21 inches. It may be that respondents living in larger properties have more disposable income or simply more space. As the number of people living in the household increases so too does the probability that all of the appliances considered will be present, except for electric showers. As expected, respondents in the lowest income category are less likely to own most of the appliances considered while the richest group are more likely to own dishwashers, laptops and TVs > 21 inches than those in the reference category. Interestingly, they are less likely to own freezers. This may be because they eat out more often than their poorer counterparts and, thus, have a lower food storage requirement.

Households whose CIE is female are more likely to own dishwashers but less likely to invest in large TVs than households whose CIE is male. The single parent variable is interesting. We find that single parent households are more likely to have games consoles and desktop computers in their homes than their counterparts living in two-parent households. This may be explained by the manner in which single parents choose to entertain their children or it may be because the absent parent provides the children with gifts such as these. The newer the accommodation, the more likely it is that tumble dryers and dishwashers are present. It could be residents of such accommodation availed of loans for the purchase of appliances and home fit-outs in conjunction with their mortgages.

3.2. Cookers and space heaters

Table 3B displays the results of the logit models which investigate the presence of different cookers and space heaters. Results show that oil cookers are more likely to be found in households whose CIE is self-employed, unemployed or retired. The self-employed are also more likely to use electric heaters. This may be because some of those who are self-employed are more prone to work from home and as a result they have a higher demand for flexible heating during the day. Farmers are less likely to use natural gas heating methods than those in the reference group. This is to be expected,

as piped gas is not widely available in rural areas. Farmers, on the other hand, are more likely to use solid fuel. This may be because farm houses contain a larger number of open fires than other types of houses or it could be that low cost solid fuel is available to many farm households.

Households whose CIE has not completed formal education are significantly more likely to use solid fuel cookers. They are less inclined to use gas and solid fuel but more inclined to use oil heating than those in the reference group. It may be that the well educated are better informed about fuel efficiency or more concerned about the environment and so they choose to use gas because it is a relatively clean and economically efficient fuel.

77% of households in the sample have electric cookers in their homes. Such cookers are significantly more likely to be found in homes whose CIE is younger than the 46-55 year old reference group. On the other hand, households whose CIE is aged over 65 are less likely to use solid fuel space heating methods. As expected apartment dwellers are more likely to have gas heating because apartments tend to be found in urban areas where gas is widely available. The same is true for those living in terraced houses. Individuals who live in detached houses are more likely to have oil heating which may be due to the fact that they are often located in rural areas where piped gas is not available. They are also more likely to use solid fuel heating methods than those in the reference group, probably due to the presence of open fires.

Housing tenure is not important in explaining cooker type. However, we find that mortgage holders are significantly more likely to use gas heating and less likely to use oil, solid fuel or renewables than those who own their homes outright. 3 bed-roomed houses are more likely to have oil heating. As we do not control for location, it may be that households with many bedrooms are more likely to be found in rural areas where it is not possible to connect to the gas network.

The relatively poor households in our sample are more likely to use gas cookers while electric cookers are more often found in the richest households. The richest households are significantly less likely to use solid fuel for heating compared to those in the reference group. This is consistent with the negative income elasticity found for coal heating by previous research for Ireland (Scott *et al.*, 2008). Finally, the newer the accommodation the more likely it is that electric cookers and gas heating will be present. Respondents living in these households are significantly less likely to have oil fuelled cookers or to use solid fuel for heating or cooking.

3.3. Water heaters

The determinants of water heater ownership are displayed in Table 3C. Renewable-energy water heaters have become more prevalent in recent years. Results show that they are more common in households where the CIE is self employed or unemployed than in those with an employed CIE. This may be because some of those who are self employed and unemployed are current or ex-members of the building trade who are aware of the grants that are available in this area and are capable of installing such products themselves. Electric water heaters are more likely to be found in the homes of a CIE whose socio-economic status is C1 (supervisory or clerical, junior managerial, administrative or professional) or C2 (skilled manual), while the use of central heating for water heating is preferred by those who are older than 55. Households whose CIE is older than those in the reference category are also less likely to use oil for water heating while the oldest group in our sample are less likely to

use solid fuel. This is consistent with the space heating results displayed in Table 3B, and indeed the two services are often supplied by a common device. Water heating by solid fuels is preferred by households whose CIE has an education level lower than upper secondary level.

The type of accommodation plays a role in explaining the type of water heater a household will use. Central heating is used more often in detached houses while immersions are less likely to be found in apartments or terraced houses. Terraced houses tend to have gas water heating while detached houses and bungalows are significantly less likely to use gas. This variable may be picking up some aspect of household location mentioned previously. Residents of detached houses and bungalows tend to opt for oil, solid fuel or renewable heaters. Also opting for oil or solid fuel heaters are respondents who live in 4 bed-roomed or at least 5 bed-roomed homes.

With regard to housing tenure, mortgage holders are more inclined install central heating, immersions or gas in order to heat their water but they are less likely to use oil or solid fuels compared to those who own their homes outright. Respondents living in newer accommodation are more likely to use gas or oil for water heating while the probability of using a solid fuel heater increases as the number of household members increases.

3.4. Energy saving features

The results of the models that estimate ownership of energy saving features are displayed in Table 3D. Households whose CIE is retired are more likely to have a lagging jacket in their home but less likely to have attic insulation. One possible explanation for this is that the fitting of attic insulation involves a period of mess and disruption that retired people may not be as willing to accept as employees are. CFLs are also less likely to be found in homes where the CIE is retired but they are more likely to be found in the homes of carers. This may be because carers tend to spend a significant amount of time at home and so may feel a greater benefit from the use of CFLs.

Lagging jackets are more likely to be found in homes where the CIE's socio-economic status is AB (managerial, administrative, professional), C1 (supervisory or clerical, junior managerial, administrative or professional) or C2 (skilled manual workers) compared to those in the reference group. Those in higher social classes may be more aware of the monetary savings that can result from such investments. External wall insulation is more likely to be found in homes where the CIE is employed as a professional or as a farmer compared to those in the reference group. This variable may be picking up some effect of the size of the accommodation. It could be that professionals and farmers live in relatively large accommodation that can benefit greatly from external wall insulation. Regarding age, results show that younger CIEs are more inclined to have water heating timers, attic insulation, external wall insulation and double glazing in their homes. This could be due to different attitudes or because these respondents feel that they have more time to benefit from such investments. Households whose CIE is educated to upper secondary level are less likely to have water heating timers, lagging jackets or CFLs in their homes. This is probably because they are less well educated about the monetary and environmental benefits that can result from the use of such items.

External wall insulation is more prevalent in detached houses, while lagging jackets are less common. This may be due to the type of water heating system that is installed. As expected,

respondents who are renting privately are less likely to have external wall insulation or double glazing in their homes while respondents who are renting from the local authority are less likely to have space heating timers, external wall insulation, double glazing and CFLs compared to those who own their own homes. This is because landlords are reluctant to make such investments when they will not reap the monetary benefits. Tenants do not make such investments because their expected length of stay is often short-term. External wall insulation is more likely to be found in homes with more than 3 bedrooms, probably because such accommodation has a larger surface area. As expected, households whose income level is low relative to the reference category are less likely to have invested in space heating timers, water heating timers, double glazing or CFLs. Surprisingly, the probability of having energy saving features in the home is not significantly higher for households whose income levels are above average.

The year in which the accommodation was built is important in explaining the presence of space heating timers, external wall insulation and double glazing. These items are more likely to be found in newer homes, which is to be expected given that installation is much easier during the building process than it is at a later stage. Leahy and Lyons (2010) find that children increased the probability that double glazing would be present in a household. We find this result for single parent households. This may be because the warmth and noise minimisation benefits of double glazing become more valuable when there are children in the household. We also find this result for households whose CIE is female, perhaps because females feel the cold more than males (Mozaffarieh *et al.*, 2010).

3.5. Appliance usage

Table 4 displays the results of the ordered logit models which estimate the determinants of appliance usage. As was the case with the ownership models, each categorical explanatory variable has a reference category against which households are compared. A plus sign indicates that households with a certain characteristic use an appliance more often than households in the reference category. The opposite is the case where a minus sign is found.

Results show that households in which the CIE is self employed use electric heaters, immersion, desktop computers and laptops significantly more often than households in which the CIE is an employee. This may be because the self-employed CIEs in our sample tend to work from home. Interestingly, households in which the CIE is a carer use desktop computers more often than households whose CIE is an employee. This could be because employees are more likely to have access to computers through their place of work. Another interesting finding is that households in which the CIE is unemployed but not seeking work use tumble dryers more often than those in the reference group. Unlike other unemployed people, it may be that this group includes some relatively wealthy individuals who do not need to work and who are not concerned about the relatively high cost of running tumble dryers.

The most interesting results from the socio-economic category relate to farmers. Farmers are less inclined to use all of the appliances considered in this paper relative to the reference category (employees). It may be that people in farm households spend more of their time outdoors and, in so doing, devote less time on activities that result in appliance use, or it could be that their appliances

tend to be of higher average capacity (perhaps made possible by more spacious properties) and thus need to be run less often. The data do not allow us to identify differences in capacity.

The level of education of the CIE is important in determining usage of large TVs. Households whose CIE is educated only to primary, lower secondary or upper secondary level use TVs >21 inches significantly more often than households whose CIE has a third level qualification. This may be an indication that the relatively well educated spend their leisure time in a different fashion to their less well educated peers.⁵

Results also indicate that appliance usage varies with age. Households whose CIE is aged 26-35 and 36-45 use electric cookers, desktop computers and games consoles less often than those in the 46-55 year old reference group. We had expected to find the opposite result for games consoles. Perhaps it is the children in the households of the 46-55 year olds who are using the games consoles. It may be that there are fewer children or younger children in the households of younger adults, thus, resulting in decreased games console usage. Or it may be that the respondents of households in which the CIE is younger spend more time pursuing activities outside of the home. It is also the case that households whose CIE is older than those in the reference group use desktop computers significantly less often than their younger counterparts.

The type of accommodation is important in explaining dishwasher usage. Apartment dwellers use dishwashers significantly more often than those living in semi-detached houses while the opposite is true for respondents living in detached houses or bungalows. It is unlikely that apartment dwellers accumulate a larger amount of dirty dishes per person, but it may be that crockery and cutlery storage space is limited. This is less likely to be the case in semi-detached or detached houses. Additionally, residents of detached houses and bungalows use desktop computers significantly less often than those in the reference group. There are many reasons why this may be the case. One reason could be that detached houses and bungalows are more likely to be found in rural locations where the residents prefer to engage in outdoor activities. Residents of local authority housing use electric cookers, immersions, large TVs, desktop computers, laptop computers and games consoles significantly more often than respondents who are living in their own homes. It is somewhat surprising that this is the case given that respondents who are renting from local authorities generally have lower levels of disposable income.

With regard to the number of bedrooms, residents of 2 bed-roomed homes use electric heaters less often than respondents living in 3 bed-roomed homes. In this case, the number of bedrooms may be acting as a proxy for the size of the house. If so, the result is intuitive as smaller homes are easier to heat.

An interesting result is that the highest earning households in our sample do not use washing machines and dishwashers as often as households earning between €50,000 and €75,000 per year. It could be that those in the highest income category frequent laundrettes and restaurants more

⁵ The dataset also reveals that households whose CIE has a third level qualification spend relatively little time watching TVs < 21 inches.

often than members of other households, and so their need to use these appliances is reduced. Or, it may be that they are more frugal with regard to efficient appliance usage.

As the number of household members increases so too does the usage level of every appliance considered in this paper, apart from electric heaters. In the usage models we also control for the number of people who are at home during the day. Interestingly, as the number of people who are at home during the day increases, appliance usage does not appear to increase, except in the case of games consoles. Households whose CIE is female use washing machines, dishwashers, electric showers, electric cookers and immersions significantly more often than households whose CIE is male. The results for single parent households indicate that the presence of children in a household may be the reason for increased usage of dishwashers and electric cookers. Single parent households also use games consoles significantly more often than two parent households. It may be that time restricted single parents allow their children to engage in activities such as the use of games consoles that do not require a high level of adult supervision or it may be two parent households are just more likely to engage in other forms of entertainment.

In the usage models we include a variable which indicates whether the household suffers from fuel poverty or not. We had expected to find that fuel-poor households would make a conscious effort to reduce their electricity bills by decreasing appliance usage. However, we find that fuel-poor households use dishwashers significantly more often than non fuel-poor households. Since dishwashers are luxury items which are relatively expensive to run, it appears that some forms of appliance usage may contribute to fuel poverty rather than be deterred by it. Laptop usage is also significantly higher in these households.

As expected, respondents claiming that they would like to reduce their electricity bills use washing machines, tumble dryers and immersions significantly less often than other respondents. However, respondents who wish to help the environment use electric showers, electric heaters and immersions significantly more often than other respondents. This could reflect a positive association between income levels and both environmental awareness and appliance use, if our income variable is not fully capturing the effect of being better off.

As stated earlier, access to the internet may act as a proxy for the degree of knowledge respondents have about efficient use of appliances. This theory is reinforced by the finding that respondents who have access to the internet at home use washing machines and tumble dryers less often than respondents who do not have internet access in the home. Not surprisingly, increased use of the internet is also associated with increased use of desktop and laptop computers.

4. Discussion and Conclusion

We have examined the factors affecting ownership of electrical appliances, cooker types, space and water heating systems as well as energy saving features in Irish households. We find that ownership is explained by the socio-economic characteristics of the household's chief income earner as well as household characteristics such as type and age of accommodation, tenure, the number of bedrooms, the number of household members and income.

People purchase appliances for different reasons. Some appliances offer convenience, others comfort, others entertainment. Results show that dishwashers are prevalent in households where CIEs are self employed, working as a carer or retired. These households opt for appliances which help reduce the amount of time and effort that must be devoted to housework. Results also show that young respondents have different preferences with regard to appliances compared to their older counterparts. This is evident from the fact that younger adults appear to eat out or buy smaller quantities of food on regular basis rather than storing food in a freezer. Results indicate that lifestyle and expenditure patterns also vary by educational attainment, with large TV sets being more prevalent in households where the CIE has a relatively low level of education. As expected, respondents in the lowest income category are less likely to own most of the appliances considered while the richest group are more likely to own dishwashers, laptops and TVs > 21 inches than those in the reference category. The richest households are less likely to own freezers. This may be because they eat out more frequently than those on lower incomes. As the number of people living in the household increases so too does the probability that all of the appliances considered will be present, with the exception of electric showers.

With regard to space heating, the self-employed are more likely to use electric heaters than those who are employed, perhaps because they spent more time at home during the day. As expected, gas heating is popular amongst apartment dwellers, probably because apartments tend to be located in urban areas where connections to the natural gas network are available. The same is true for those living in terraced houses. Oil heating is more popular for residents of detached houses. An interesting result in relation to water heaters is that renewable water heating systems are more likely to be found in households where the CIE is self employed or unemployed compared to households where the CIE is an employee. This may be due to the fact that many of the unemployed and self-employed are current or former members of the building trade.

Where energy saving features are concerned, external wall insulation is favoured by residents of detached houses and bungalows. Water heating timers, attic insulation, external wall insulation and double glazing are favoured by households in which the CIE is relatively young, perhaps because the perceived benefit is larger amongst younger adults. Respondents whose CIE was educated to upper secondary level are less likely to have water heating timers, lagging jackets or CFLs in their homes. Thus, there is a need to increase awareness amongst these respondents about the monetary and environmental benefits that can result from the use of such items. Also, if people were aware of the expected payback period, uncertainty would be reduced and they may be more likely to invest.

Tenure plays a very important role in explaining the presence of energy saving features. Renters are less likely to have external wall insulation or double glazing in their homes while local authority residents are less likely to possess space heating timers, external wall insulation, double glazing or CFLs compared to those who own their own homes. Tenants are unlikely to make such investments as residency is only temporary. This highlights the role that minimum standards may have for raising the energy efficiency of rented accommodation. At present there is no requirement for landlords in Ireland to provide any of the energy saving features considered in this paper, although since the start of 2009 there has been a requirement for those renting accommodation to provide a building energy rating certificate. Results also show that space heating timers, external wall insulation and double glazing are more likely to be found in newer homes because installation is much easier during

the building process than it is at a later stage. Double glazing is popular in households where the CIE is female or a single parent, perhaps because females and single parents greatly value the warmth and noise minimisation benefits provided by double glazed windows.

As expected, households whose income level is low relative to the reference category are less likely to have invested in space heating timers, water heating timers or double glazing. However, the probability of having energy saving features in the home is not significantly higher for households whose income levels are above average. Given that many energy saving features require substantial capital investments we had expected to find that they would be more prevalent in higher earning households. This highlights the need for increased awareness about the benefits of energy saving features. The benefits are not only monetary in nature but also create environmental benefits by reducing greenhouse gas emissions. There are also health benefits because better insulation can help prevent drafts and condensation.

The most novel contribution of this paper is to quantify factors associated with higher or lower frequency of appliance usage. Results indicate that lifestyle factors strongly influence the degree to which appliances are used. For example, farmers use all appliances less often than those in the employees, while low levels of education are associated with watching more TV. Households in which the CIE is a carer or is self employed use home computers more often than employees. Apartment dwellers use dishwashers significantly more often than those living in semi-detached houses while the opposite is true for respondents living in detached houses or bungalows. Somewhat surprising is the fact that the highest earning households use washing machines and dishwashers significantly less often than residents of households in the €50,000-€75,000 income category. Perhaps richer people frequent laundrettes and restaurants more regularly, thus, reducing their need to use these appliances. Or, it could be that high earners are motivated by money and, thus, make bigger efforts to reduce their bills.

As the number of household members increases so too does the usage level of every appliance, apart from electric heaters. However, having more people at home during the day only has a positive effect on use of games consoles. Households whose CIE is female use washing machines, dishwashers, electric showers, electric cookers and immersions significantly more often than households whose CIE is male. Single parent households use games consoles significantly more often than two parent households. This indicates that single parent households have different entertainment behaviour than two parent households.

We also controlled for the fact that some households may suffer from fuel poverty. We had expected this to have a negative effect on the amount of appliances usage. However, we find that fuel-poor households use dishwashers significantly more often than those who are not fuel-poor. The direction of causation here does not seem to run in the expected direction. Again, this highlights the need for increased awareness amongst households of the financial and environmental benefits associated with efficient appliance usage.

Also highlighted in this paper is the fact that residents of local authority housing have higher appliance usage levels than their counterparts who are home owners. People who are provided with local authority housing in Ireland are often in receipt of a free gas or electricity allowance, and it may be that such allowances encourage recipients to be less mindful about efficient appliance usage. The

design of such “in kind” allowances could be made more consistent with the objective of encouraging efficient behaviour, for example by ensuring that most households bear at least some cost for their marginal use of fuel so they have an incentive to reduce usage (Conniffe, D., 2000).

We have focused on the factors associated with the frequency of use of domestic appliances, but further research would be useful into how frequency of use maps into energy demand. Also, we have used a cross-sectional dataset, which limits the extent to which one can establish patterns of causation. If panel data were available with a long enough time dimension to identify changes in household circumstances and other exogenous factors, this would offer a better chance of firmly establishing causal links.

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References

Central Statistics Office (CSO) Ireland, 2007. Household Budget Survey 2004/2005. <http://www.cso.ie/releasespublications/documents/housing/hbsfinal/webcomplete.pdf>. [Accessed 21st July 2011]

Commission for Energy Regulation (CER), 2011. Smart Metering Cost-Benefit Analysis and Trials Findings Reports. Commission for Energy Regulation. <http://www.cer.ie/en/information-centre-reports-and-publications.aspx?article=5dd4bce4-ebd8-475e-b78d-da24e4ff7339&mode=author>. [Accessed 17th June 2011].

Conniffe, D., 2000. The Free Electricity Allowance and the Engel Curve. *The Economic and Social Review*. 31(2), 173-186.

Department of Communications, Energy and Natural Resources [DCENR], 2011. Warmer Homes, a Strategy for Affordable Energy in Ireland. <http://www.dcenr.gov.ie/NR/ronlyres/53F3AC25-22F8-4E94-AB73-352F417971D7/0/AffordableEnergyStrategyFINAL.pdf>

Dubin, J.A, McFadden, D.L., 1984. An Econometric Analysis of Residential Electric Appliance Holdings and Consumption. *Econometrica*. 52, 345-362.

Duffy D. 2009; verbal communication

Firth, S., Lomas, K., Wright, A., Wall, R., 2008. Identifying trends in the use of domestic appliances from household electricity consumption measurements. *Energy and Buildings*. 40, 926-936.

Leahy, E., Lyons, S., 2010. Energy use and appliance ownership in Ireland. *Energy Policy*. 38(8), 4265-4279.

Mozaffarieh, M., Fontana Gasio, P., Schötzau, A., Orgül, S., Flammer, J., Kräuchi, K., 2010. Thermal discomfort with cold extremities in relation to age, gender, and body mass index in a random sample of a Swiss urban population. *Population Health Metrics*. 8(17), 1-5.

O'Doherty, J., Lyons, S., Tol, R.S.J., 2008. Energy-using appliances and energy-saving features: Determinants of ownership in Ireland, *Applied Energy*. 85(7), 650-662.

Scott, S., Lyons, S., Keane, C., McCarthy, D., Tol, R.S.J., 2008. Fuel Poverty in Ireland: Extent, Affected Groups and Policy Issues, ESRI Working Paper 262.

Sustainable Energy Authority of Ireland (SEAI), 2008. Energy in the Residential Sector 2008 Report. http://www.seai.ie/News_Events/Press_Releases/Energy_in_the_Residential_Sector_FNL.pdf. [Accessed 20th July 2011]

Sustainable Energy Authority of Ireland (SEAI), 2010. Energy Balance 2009. http://www.seai.ie/Publications/Statistics_Publications/Energy_Balance/Previous_Energy_Balances/Energy_Balances_1990-2009.pdf. [Accessed 20th July 2011]

Tso, G.K.F., Yau, K.K.W., 2003. A study of domestic energy usage patterns in Hong Kong. *Energy*. 28, 1671-1682.

Yamamoto, Y., Suzuki, A., Fuwa, Y., Sato, T., 2008. Decision-making in electrical appliance use in the home. *Energy Policy*. 36(5), 1679-1686.

Yohanis, Y.G., Mondol, J.D., Wright, A., Norton, B., 2008. Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use. *Energy and Buildings*. 40, 1053-1059.

TABLE 3A. ELECTRICAL APPLIANCE OWNERSHIP (RC: REFERENCE CATEGORY)

	Washing machine	Tumble dryer	Dish-washer	Freezer	Electric shower	Desktop computer	Laptop computer	Games console	TV > 21 inches
Employment status									
Employee (RC)									
Self-employed with employees	-	--	++						-
Self-employed without employees					---				
Unemployed seeking work									
Unemployed not seeking work									
Retired			++		-			---	
Carer			+			++			
Socio-economic status									
AB	-								
C1									
C2								--	
DE (RC)									
F							--	--	
Age category									
Aged 18-25						-			
Aged 26-35	+			---		---			
Aged 36-45	+			--		---	---		
Aged 46-55 (RC)									
Aged 56-65							--	---	
Aged over 65							---	---	
Level of education									
No formal education								-	-
Primary education						-	--		
Lower Secondary (Junior Certificate)					+				++
Upper Secondary (Leaving Certificate)							--		+++
Third level (RC)									
Type of accommodation									
Apartment					---				+
Semi-detached (RC)									
Detached		+	+++	++					
Terraced									
Bungalow	-	+		+			-		-
Tenure									
Renting Privately	--		--			+		++	
Renting from local auth.		--	---						
Owned outright (RC)									
Mortgage holder			++	--					+++
Other tenure									
Number of bedrooms									
1 bedroom									--
2 bedrooms		---	--						
3 bedrooms (RC)									
4 bedrooms	++	+++	+++	++	++	+++			++
At least 5 bedrooms		+++	+++	+++		+++			++
Household income									
< €15,000		---	---	---	--	---	---		
€15,000 - €30,000		--	---						
€30,000 - €50,000									++
€50,000 - €75,000 (RC)									
> €75,000			+++	--			+++		+
Other									
Female CIE			+++						---
Number of household members	+	+++	+++	+++		+++	+++	+++	+++

	Washing machine	Tumble dryer	Dish-washer	Freezer	Electric shower	Desktop computer	Laptop computer	Games console	TV > 21 inches
Year accommodation built		+	+++				---		
Single parent household	---					+		+++	
Number of observations	1125	1793	1793	1793	1793	1788	1788	1773	1781
LR chi2	50.77	283.76	335.14	180.28	106.61	236.09	311.11	822.64	167.19
Prob > chi2	0.0103	0	0	0	0	0	0	0	0
Log likelihood	-70.99	-918.39	-866.99	-1152.05	-1021.87	-1116.57	-1031.57	-790.57	-544.12
Pseudo R2	0.26	0.13	0.16	0.07	0.05	0.1	0.13	0.34	0.13

Key: “-“=negative and significant at the 10% level; “- -“=negative and significant at the 5% level; “- - -“=negative and significant at the 1% level; “+“=positive and significant at the 10% level; “+ +“=positive and significant at the 5% level; “+ + +“=positive and significant at the 1% level

TABLE 3B. OWNERSHIP OF COOKERS AND SPACE HEATING TYPES (RC: REFERENCE CATEGORY)

	Electric cooker	Gas cooker	Oil cooker	Solidfuel cooker	Central heating	Electric heat	Gas heat	Oil heat	Solid fuel heat	Renewable heat
Employment status										
Employee (RC)										
Self-employed with employees		++	++			++				
Self-employed, no employees			++			++			--	
Unemployed seeking work			++				-			
Unemployed not seeking work									++	
Retired			+++							
Carer										
Socio-economic status of CIE										
AB										
C1										
C2										
DE (RC)										
F: Farmers							-		+++	
Age of CIE										
Aged 18-25										
Aged 26-35	+		+							
Aged 36-45	+									
Aged 46-55 (RC)										
Aged 56-65										
Aged over 65							+		-	
Level of education of CIE										
No formal education				+++						
Primary education										
Lower Secondary										
Upper Secondary							--	++	--	
Third level (RC)										
Type of accommodation										
Apartment							++	--		
Semi-detached (RC)										
Detached			++				---	+++	+++	
Terraced							+++	--		
Bungalow			+++	++			---	+++	+++	
Tenure										
Renting Privately										
Renting from local auth.										
Owned outright (RC)										
Mortgage holder							+++	---	--	--
Other tenure										
Number of bedrooms										
1 bedroom								-		
2 bedrooms										
3 bedrooms (RC)										
4 bedrooms							---	+++		
At least 5 bedrooms								++		
Household income										
< €15,000	---	+			+					
€15,000 - €30,000	--	+	++	++			--		+	
€30,000 - €50,000										
€50,000 - €75,000 (RC)										
> €75,000	+								---	

	Electric cooker	Gas cooker	Oil cooker	Solidfuel cooker	Central heating	Electric heat	Gas heat	Oil heat	Solid fuel heat	Renew-able heat
Other										
Female CIE										-
Number in household						---				
Year accommodation built	++		---	---			++		---	
Single parent household					+	+			-	
Other										
Number of observations	1786	1794	1652	1231	1763	1520	1794	1794	1794	1101
LR chi2	70.7	49.99	72.76	70.96	26.62	68.6	465.66	399.6	215.88	37.69
Prob > chi2	0.0007	0.0922	0	0	0.8447	0.0004	0	0	0	0.0647
Log likelihood	-860.86	-946.53	-159.31	-94.35	-287.46	-171.90	-921.15	-1011.29	-876.58	-60.49
Pseudo R2	0.04	0.03	0.19	0.27	0.04	0.17	0.20	0.17	0.11	0.24

Key: “-“=negative and significant at the 10% level; “- -“=negative and significant at the 5% level; “- - -“=negative and significant at the 1% level; “+“=positive and significant at the 10% level; “++“=positive and significant at the 5% level; “+++“=positive and significant at the 1% level

TABLE 3C. OWNERSHIP OF WATER HEATERS (RC: REFERENCE CATEGORY)

	Central heating	Immersion	Electric heat	Gas heat	Oil heat	Solid fuel heat	Renewable heat
Employment status of CIE							
Employee (RC)							
Self-employed with employees							+++
Self-employed, no employees						-	++
Unemployed seeking work				-	+++	---	++
Unemployed not seeking work							
Retired						-	
Carer							
Socio-economic status of CIE							
AB						-	
C1			+				
C2			+				
DE (RC)							
F							
Age of CIE							
Aged 18-25							
Aged 26-35							
Aged 36-45							
Aged 46-55 (RC)							
Aged 56-65	+++				--		
Aged over 65	++				-	-	
Level of education of CIE							
No formal education						+++	
Primary education		---				+++	
Lower secondary						++	
Upper secondary				-	++		
Third level (RC)							
Type of accommodation							
Apartment		-			--		
Semi-detached (RC)							
Detached	+			---	+++	+++	++
Terraced		--		++			
Bungalow				---	+++	+++	+++
Tenure							
Renting Privately					+		
Renting from local authority		+					
Owned outright (RC)							
Mortgage holder	+++	+		+	---	---	
Other tenure							
Number of bedrooms							
1 bedroom							
2 bedrooms							
3 bedrooms (RC)							
4 bedrooms				--	+++	+	
At least 5 bedrooms					+	++	
Household income							
< €15,000							
€15,000 - €30,000						++	
€30,000 - €50,000	-	++					
€50,000 - €75,000 (RC)							
> €75,000		+		+++		---	
Other							
Female CIE							---

	Central heating	Immersion	Electric heat	Gas heat	Oil heat	Solid fuel heat	Renewable heat
Number in household						+++	
Year accommodation built				++	++	---	
Single parent household							
Number of observations	1756	1794	1638	1749	1794	1794	1336
LR chi2	48.88	62.58	23.45	349.98	215.82	212.61	56.05
Prob > chi2	0.0597	0.0073	0.8636	0	0	0	0.0008
Log likelihood	-672.3	-1187.35	-134.00	-861.40	-1111.40	-601.52	-133.98
Pseudo R2	0.04	0.03	0.08	0.17	0.09	0.15	0.17

Key: “-“=negative and significant at the 10% level; “- -“=negative and significant at the 5% level; “- - -“=negative and significant at the 1% level; “+“=positive and significant at the 10% level; “++“=positive and significant at the 5% level; “+++“=positive and significant at the 1% level

TABLE 3D. PRESENCE OF ENERGY SAVING FEATURES HEATERS (RC: REFERENCE CATEGORY)

	Space heating timer	Water heating timer	Lagging jacket	Attic insul.	Ext.wall insulation	Double glazing	CFLs
Employment status of CIE							
Employee (RC)							
Self-employed with employees		+				--	
Self-employed, no employees				-			
Unemployed seeking work		+				++	
Unemployed not seeking work							
Retired			++	---			-
Carer							++
Socio-economic status of CIE							
AB			+	-	++		
C1			++	-			
C2	--		+				
DE (RC)							
F					+++		
Age of CIE							
Aged 18-25		++					
Aged 26-35				+++		++	
Aged 36-45		+++		++	++	++	
Aged 46-55 (RC)							
Aged 56-65					---		
Aged over 65					---		
Level of education of CIE							
No formal education							
Primary education							
Lower secondary			--				
Upper secondary		---	-				-
Third level (RC)							
Type of accommodation							
Apartment			--				
Semi-detached (RC)							
Detached			--	+	+++		
Terraced						-	
Bungalow			---		+++		
Tenure							
Renting Privately					-	-	
Renting from local authority	-				-	-	--
Owned outright (RC)							
Mortgage holder	+					++	--
Other tenure							
Number of bedrooms							
1 bedroom	--						
2 bedrooms						-	
3 bedrooms (RC)							
4 bedrooms					+++		
At least 5 bedrooms					+++		
Household income							
< €15,000	---					--	
€15,000 - €30,000	---	--				---	-
€30,000 - €50,000							
€50,000 - €75,000 (RC)							
> €75,000					-		

	Space heating timer	Water heating timer	Lagging jacket	Attic insul.	Ext.wall insulation	Double glazing	CFLs
Other							
Female CIE		-			---	++	
Number in household	---						+
Year accommodation built	+++				+++	+++	
Single parent household						+	
Number of observations							
Number of observations	1794	1794	1778	1794	1794	1795	1795
LR chi2	137.3	69.45	80.99	118.26	406.37	230.95	51.14
Prob > chi2	0	0	0	0	0	0	0.09
Log likelihood	-641.03	-1205.16	-728.72	-1124.74	-971.42	-901.84	-2829.22
Pseudo R2	0.10	0.03	0.05	0.05	0.17	0.11	0.01

Key: “-“=negative and significant at the 10% level; “- -“=negative and significant at the 5% level; “- - -“=negative and significant at the 1% level; “+“=positive and significant at the 10% level; “++“=positive and significant at the 5% level; “+++“=positive and significant at the 1% level

TABLE 4. DETERMINANTS OF APPLIANCE USAGE HEATERS (RC: REFERENCE CATEGORY)

	Washing machine	Tumble dryer	Dish-washer	Electric shower	Electric cooker	Electric heater	Immersion	TV>21 inches	Desktop computer	Laptop computer	Games console
Employment Status of CIE											
Employee (RC)											
Self-employed with employees							+		+++		
Self-employed, no employees						+	+	-		++	
Unemployed seeking work											
Unemployed not Seeking work		+									
Retired					++						
Carer		+							++		
Socio-economic status of CIE											
AB											
C1						-					
C2											
DE (RC)											
F: Farmers	--			--		-	--	--		--	
Age of CIE											
Aged 18-25											
Aged 26-35			-		---	-		--	---		---
Aged 36-45				--	-		--		-	-	--
Aged 46-55 (RC)											
Aged 56-65									-		
Aged over 65									--		
Level of education of CIE											
No formal education											
Primary education							-	+++			
Lower secondary		-					-	+++			++
Upper secondary					++			+++	-		
Third level (RC)											
Type of accommodation											
Apartment			+		---						
Semi-detached (RC)											
Detached			--	---					--		
Terraced											
Bungalow			--						---		
Tenure											
Renting Privately		+						--			
Renting from local authority					+++		++	++	+++	++	+
Owned outright (RC)											
Mortgage holder		++									
Other tenure											
Number of bedrooms											
1 bedroom											
2 bedrooms	-					-				-	
3 bedrooms (RC)											
4 bedrooms											
At least 5 bedrooms			+	--							
Household income											
< €15,000	---			-							
€15,000 - €30,000											
€30,000 - €50,000					+						

	Washing machine	Tumble dryer	Dish-washer	Electric shower	Electric cooker	Electric heater	Immersion	TV>21 inches	Desktop computer	Laptop computer	Games console
€50,000 - €75,000 (RC)											
> €75,000	---		-					-		++	
Other											
Female CIE	+++		+	++	+++		+++				
Number in household	+++	+++	+++	+++	+++	---	++	+++	+++	+++	+++
Year accommodation built								+++		--	
Single parent household			+++		++						++
Suffers from fuel poverty			+							++	
Number at home during day					-			-			+
Like to reduce bill	-	---					-				
Like to help the environment				+		+	+				
Internet at home	-	---							+++	+++	
Number of observations											
Number of observations	1775	1295	1320	1279	1435	539	1448	1588	960	1109	732
LR chi2	685.4	162.83	364.76	216.41	232.9	64.77	93.02	233.71	153.07	119.08	87.95
Prob > chi2	0	0	0	0	0	0.0175	0	0	0	0	0
Log Likelihood	-1476.96	-724.93	-906.87	-1597.94	-1570.51	-349.86	-1419.53	-1752	-1098.09	-1284.85	-660.56
Pseudo R2	0.19	0.10	0.17	0.06	0.07	0.08	0.03	0.06	0.07	0.04	0.06

Key: “-“=negative and significant at the 10% level; “- -“=negative and significant at the 5% level; “- - -“=negative and significant at the 1% level; “+“=positive and significant at the 10% level; “++“=positive and significant at the 5% level; “+++“=positive and significant at the 1% level

APPENDIX A: FREQUENCY OF APPLIANCE USAGE

WASHING MACHINE

- 1: Less than 1 load a day typically
- 2: 1 load typically
- 3: 2 to 3 loads
- 4: More than 3 loads

TUMBLE DRYER

- 1: Less than 1 load a day typically
- 2: 1 load typically
- 3: 2-3 loads
- 4: More than 3 loads

DISHWASHER

- 1: Less than 1 load a day typically
- 2: 1 load typically
- 3: 2-3 loads
- 4: More than 3 loads

ELECTRIC SHOWER

- 1: Less than 5 minutes
- 2: 5-10 minutes
- 3: 10-20 minutes
- 4: Over 20 minutes

ELECTRIC COOKER

- 1: Less than 30 minutes
- 2: 30-60 minutes
- 3: 1-2 hours
- 4: Over 2 hours

ELECTRIC HEATER

- 1: Less than 30 minutes
- 2: 30-60 minutes
- 3: 1-2 hours
- 4: Over 2 hours

IMMERSION

- 1: Less than 30 minutes
- 2: 30-60 minutes
- 3: 1-2 hours
- 4: Over 2 hours

TV > 21 INCHES

- 1: Less than 1 hour a day or a few hours a week typically
- 2: 1-3 hours per day typically
- 3: 3-5 hours per day typically
- 4: More than 5 hours per day typically

DESKTOP COMPUTERS

- 1: Less than 1 hour a day or a few hours a week typically
- 2: 1-3 hours per day typically
- 3: 3-5 hours per day typically
- 4: More than 5 hours per day typically

LAPTOP COMPUTERS

- 1: Less than 1 hour a day or a few hours a week typically
- 2: 1-3 hours per day typically

- 3: 3-5 hours per day typically

- 4: More than 5 hours per day typically

GAMES CONSOLES

- 1: Less than 1 hour a day or a few hours a week typically
- 2: 1-3 hours per day typically
- 3: 3-5 hours per day typically
- 4: More than 5 hours per day typically

APPENDIX B.1 DESCRIPTIVE STATISTICS: DEPENDENT VARIABLES

	OBS	MEAN	STD. DEV.	MIN	MAX
Appliances					
Washing machine	3804	0.987	0.113	0	1
Tumble dryer	3804	0.694	0.461	0	1
Dishwasher	3804	0.689	0.463	0	1
Freezer	3804	0.505	0.5	0	1
Electric shower	3804	0.698	0.459	0	1
Desktop computer	3795	0.486	0.5	0	1
Laptop computer	3795	0.551	0.497	0	1
Games console	3795	0.348	0.477	0	1
TV > 21 inches	3795	0.854	0.353	0	1
Cooker type					
Electric cooker	3804	0.767	0.423	0	1
Gas cooker	3810	0.253	0.435	0	1
Oil cooker	3810	0.0226	0.149	0	1
Solid fuel cooker	3810	0.0207	0.143	0	1
Space heating					
Central heating	3810	0.0425	0.202	0	1
Electric heaters	3810	0.0312	0.174	0	1
Gas	3810	0.333	0.471	0	1
Oil	3810	0.58	0.494	0	1
Solid fuel	3810	0.248	0.432	0	1
Renewables	3810	0.00604	0.0775	0	1
Water heating					
Central heating	3810	0.129	0.335	0	1
Immersion	3810	0.561	0.496	0	1
Electric heater	3810	0.015	0.121	0	1
Gas	3810	0.26	0.438	0	1
Oil	3810	0.398	0.49	0	1
Solid fuel	3810	0.149	0.356	0	1
Renewables	3810	0.0155	0.123	0	1
Energy saving features					
Space heating timer	3810	0.824	0.381	0	1
Water heating timer	3810	0.444	0.497	0	1
Lagging jacket	3810	0.841	0.366	0	1
Attic insulation	3810	0.361	0.48	0	1
External wall insulation	3810	0.596	0.491	0	1
CFLs	3810	0.46	0.354	0	1
Double glazing	3810	0.89	0.287	0	1
Usage variables					
Washing machine	3755	1.59	0.756	1	4
Tumble dryer	2639	1.24	0.547	1	4
Dishwasher	2621	1.45	0.577	1	4
Electric shower	2654	2.3	0.959	1	4
Electric cooker	2918	2.17	0.81	1	4
Electric heater	1143	1.41	0.855	1	4
Immersion	2958	1.59	0.946	1	4
TV >21 inches	3240	3.13	0.855	1	4
Desktop computer	1846	1.91	1.03	1	4
Laptop computer	2091	1.96	0.972	1	4
Games console	1322	1.57	0.787	1	4

APPENDIX B.2 DESCRIPTIVE STATISTICS: CONTROL VARIABLES

	OBS	MEAN	STD. DEV.	MIN	MAX
Employment Status of CIE					
Employee (RC)	3810	0.481	0.5	0	1
Self-employed with employees	3810	0.0554	0.229	0	1
Self-employed without employees	3810	0.0703	0.256	0	1
Unemployed seeking work	3810	0.0472	0.212	0	1
Unemployed not seeking work	3810	0.0352	0.184	0	1
Retired	3810	0.302	0.459	0	1
Carer	3810	0.00892	0.0941	0	1
Socio-economic status of CIE					
AB: Managerial, administrative, professional	3810	0.158	0.365	0	1
C1: Supervisory or clerical, junior managerial, administrative or professional	3810	0.273	0.446	0	1
C2: Skilled manual workers	3810	0.167	0.373	0	1
DE: Semi and unskilled manual workers, casual workers, those in receipt of state benefits (RC)	3810	0.365	0.481	0	1
F: Farmers	3810	0.0268	0.161	0	1
Age of CIE					
Aged 18-25	3810	0.00367	0.0605	0	1
Aged 26-35	3810	0.101	0.301	0	1
Aged 36-45	3810	0.218	0.413	0	1
Aged 46-55 (RC)	3810	0.243	0.429	0	1
Aged 56-65	3810	0.208	0.406	0	1
Aged over 65	3810	0.222	0.416	0	1
Level of education of CIE					
No formal education	3810	0.0118	0.108	0	1
Primary education	3810	0.11	0.314	0	1
Junior Certificate	3810	0.167	0.373	0	1
Leaving Certificate	3810	0.279	0.448	0	1
Third level (RC)	3810	0.383	0.486	0	1
Type of accommodation					
Apartment	3810	0.0171	0.13	0	1
Semi-detached (RC)	3810	0.323	0.468	0	1
Detached	3810	0.264	0.441	0	1
Terraced	3810	0.138	0.345	0	1
Bungalow	3810	0.258	0.438	0	1
Tenure					
Renting Privately	3810	0.0126	0.112	0	1
Renting from local authority	3810	0.0472	0.212	0	1
Owned outright (RC)	3810	0.522	0.5	0	1
Mortgage holder	3810	0.415	0.493	0	1
Other tenure	3810	0.00262	0.0512	0	1
Number of bedrooms					
1 bedroom	3810	0.00866	0.0927	0	1
2 bedrooms	3810	0.0745	0.263	0	1
3 bedrooms (RC)	3810	0.44	0.496	0	1
4 bedrooms	3810	0.363	0.481	0	1
At least 5 bedrooms	3810	0.112	0.316	0	1
Household income					

< €15,000	1799	0.0878	0.283	0	1
€15,000 - €30,000	1799	0.141	0.348	0	1
€30,000 - €50,000	1799	0.24	0.427	0	1
€50,000 - €75,000 (RC)	3810	0.158	0.365	0	1
> €75,000	1799	0.197	0.398	0	1
Other					
Female CIE	3810	0.487	0.5	0	1
Number of household members	3810	2.61	1.7	0	12
Year in which accommodation was built	3804	1970	34.9	1700	2008
Single parent household	3810	0.0391	0.194	0	1
Suffers from fuel poverty	3810	0.0457	0.209	0	1
Number of household members at home during the day	3810	3.54	4.03	0	16
Like to reduce bill	3810	0.953	0.212	0	1
Like to help the environment	3810	0.932	0.252	0	1
Internet at home	3810	0.709	0.454	0	1

Year	Number	Title/Author(s) ESRI Authors/Co-authors <i>Italicised</i>
2012	420	Trade, Energy, and Carbon Dioxide: An Analysis for the Two Economies of Ireland <i>Marie Hyland, Anne Jennings and Richard S.J. Tol</i>
	419	To Convergence and Beyond? Human Capital, Economic Adjustment and a Return to Growth <i>John FitzGerald</i>
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	410	“One Dummy Won’t Get it: The Impact of Training Programme Type and Duration on the Employment Chances of the Unemployed in Ireland” <i>Seamus McGuinness, Philip J. O’Connell and Elish Kelly</i>
	409	Carrots without Sticks: The Impacts of Job Search Assistance in a Regime with Minimal Monitoring and Sanctions <i>Seamus McGuinness, Philip J. O’Connell and Elish Kelly</i>

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