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# Fuel poverty and financial literacy: Evidence from Irish home owners

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**Abstract**

Fuel poverty is a condition that is distressing families in Europe and elsewhere. One of its drivers is low energy efficiency levels. Some research indicates that financial literacy can help achieve higher levels of energy efficiency. We use data from a survey of Irish home owners to analyse how financial literacy can affect the decision making process when adopting measures to reduce the burden imposed by high energy prices. We also analyse the role of financial preferences in current levels of energy efficiency, barriers to accessing energy efficiency retrofit grants and the relationship between fuel poverty and financial literacy. We find only a very weak association between financial literacy and fuel poverty across a set of different metrics. Household income is very strong strongly associated with both fuel poverty and energy effi-ciency. Our findings provide the first empirical evidence of the association between financial literacy and fuel poverty, and that the administrative burden associated with accessing energy efficiency retrofit grants represents a substantial barrier.

# 1 Introduction

Textbook economic theory assumes that individuals can take rational and optimal decisions when facing economic choices. However, empirical research shows that this consistency in choices is correlated with wealth levels, with more affluent individuals more likely to make rational decisions (Choi et al., 2014). Not having enough economic resources to face the cost of living could impede cognitive functions, leading to decision-making errors and myopic behaviour that focuses on immediate consumption rather than in investment decisions (see Shah et al., 2012). Carvalho et al. (2016) analyse decision-making among two groups of low-income individuals: those just before payday and those just after payday. They find that liquidity constraints in the before-payday group correlate with present-biased decisions. This means that this group prioritises immediate consumption rather than long term investments. They also find that the two groups make similarly risky choices, suggesting that scarcity of economic resources does not affect the willingness to take risks. It is possible that there are other hidden barriers preventing households from taking optimal decisions, such as lack of financial literacy. Lusardi and Mitchell (2007) show that financial literacy plays an important role in encouraging workers to engage in retirement planning, leading them to propose that employers could provide seminars to workers to increase the number of workers using retirement plans.

Brent and Ward (2018) show that financial literacy also plays an important role in energy-related investment decisions. When investing in energy efficiency, consumers compare the upfront costs to the stream of discounted value of future savings in their energy expenditure. However, this assumes that consumers are sufficiently familiar with the associated financial instruments to make an informed decision. Both Blasch et al. (2021) and Damigos et al. (2021) confirm that financial literacy can increase the likelihood that households will choose energy efficiency investments with the lowest lifetime cost. An important gap in this growing literature is the mechanism that explains the connection between financial literacy and the investment decision. For example, it is unclear whether financial literacy affects financial preferences such as willingness to pay and expected payback period of investments. Alternatively, some types of households might also be less aware of the potential savings that can be achieved by retrofitting, like show by Chen et al. (2017) for poorer households. In addition, they might assume that certain retrofit programmes do not address their specific vulnerability, or they might misunderstand scheme eligibility conditions. Households may also avoid lengthy application procedures or disruptive arrangements needed for the retrofit (Raissi and Reames, 2020).

There is an increasing number of articles that analyse the role of energy efficiency in tackling fuel poverty. Fuel poverty is a condition in which households are unable to keep their homes warm. Approximately 8% of European households experience this condition (European Commission, 2022a,b). Living with low income levels and facing an increasing burden imposed by high energy prices could lock households in a vicious circle where prioritising present consumption over energy efficiency retrofit investments increases the burden of high energy bills over time.

Increasing energy efficiency is an effective instrument to tackle fuel poverty. Charlier et al. (2019) show that the incidence of fuel poverty is lower for households living in energy-efficient social housing. When designing programmes to improve energy efficiency, regional and spatial inequalities should be considered (Bardazzi et al., 2021). In this regard, Pillai et al. (2021) show that a free energy efficiency retrofit scheme for low-income households has been successful in reducing the number of vulnerable households living in very energy-inefficient dwellings in Ireland. In the US, Bednar and Reames (2020) note that the targeting of households in fuel poverty has serious shortcomings because it does not consider specific vulnerabilities or outcomes achieved.

Since the literature shows that fuel poverty is related to energy efficiency, and that energy efficiency investment decisions are related to financial literacy, one factor contributing to the problem of fuel poverty is that a lack of financial literacy could prevent households from undertaking energy efficiency measures. As mentioned above, one gap in this literature is the link between fuel poverty and financial literacy. In addition, the role of financial preferences of households living with low energy efficiency levels plays in the decision to invest in energy efficiency and other mitigation strategies against high energy prices (such as energy payment method and switching energy supplier) is not sufficiently investigated. In this article, we contribute to the literature on the design of policies to overcome fuel poverty and protect vulnerable households. We contribute to filling the aforementioned gaps in the literature by analysing the barriers faced by low-income groups to engage in energy efficient investments and switching their energy supplier. We also analyse the role of homeowners' time preferences and willingness to pay for retrofit investments in adopting strategies to mitigate the effect of high energy prices. We analyse the role of financial literacy in investment behaviour and in the likelihood of experiencing fuel poverty and having low energy efficiency levels.

Taking up measures to improve energy efficiency and switching energy suppliers are key elements of the European strategy to protect vulnerable households from increased energy prices (EPAH, 2021; European Union, 2020). In addition, the use of direct debit payment for the energy bills is is a potential mitigating factor in the face of high energy costs, as it is generally the cheapest option (Hills, 2011). However, the drivers of these mitigation actions and their association with financial preferences are poorly understood.

The administrative burden associated with enrolling in government programmes can prevent and interrupt households' participation in such programmes (Heinrich, 2016). low-income households can reduce energy consumption when participating in government programmes (Hancevic and Sandoval, 2022). While there are programmes that provide free energy efficiency retrofits to low-income households in Europe, Lades et al. (2021) argue that complex administrative tasks required to access the subsidies can reduce investments in energy-efficient technologies. Relatively little is understood about the perception of administrative burden among low-income homeowners related to applications for energy efficiency retrofit grants specifically.

In addition to the complexity of the administrative process preventing vulnerable households from accessing energy efficiency supports (Friedrichsen et al., 2018), other potential barriers are a lack of awareness of financial support programmes (Hrovatin and Zorić, 2018) or a desire to wait for more convenient moment to undertake such disruptive works (Fawcett, 2014). Similar barriers could also prevent households from switching their energy provider. For example, studies have found that provider switching is correlated with educations levels (He and Reiner, 2017). DellaValle (2019) argues that when individuals face fuel poverty, they are more likely to forego switching energy suppliers because of fear of facing unexpected high bills. DellaValle (2019) also argues that a similar mechanism exists in the decision processes of whether to adopt unknown technologies, and of whether to retrofit. Households facing fuel poverty might may focus on objectives that are closer in time and disregard those that are further in the future, like long term investments in energy efficiency. However, there is no strong empirical evidence of these arguments. We add to the literature by empirically analysing the potential drivers of switching and retrofitting behaviour.

Many fuel poverty studies rely on official surveys from State statistics offices, though the surveys are not specifically designed to analyse fuel poverty or to identify vulnerable households. For this analysis, we design a bespoke survey to elicit information on energy expenditure, financial literacy, dwelling conditions and financial preferences regarding energy efficiency investments. We focus on homeowners, as opposed to rental occupants, because it avoids the case of split incentives across

tenants and landlords (Castellazzi et al., 2018). Having low income levels, facing high energy expenditure, a lack of financial literacy and facing administrative burdens are hidden barriers for the households' adoption of measures to reduce the burden imposed by higher energy prices. The analysis of these barriers has so far escaped the scrutiny of academics and policymakers. Our survey data allows us to measure incidence of fuel poverty and financial literacy, as well as analyse the decision making process of low-income households regarding investment in energy efficiency and fuel provider switching behaviour. We find a weak association between our financial literacy metrics and fuel poverty. Nor do we find strong evidence that financial literacy is associated with financial preferences for the investment. Fuel poverty is the result of different factors that include energy efficiency levels and the willingness to adopt mitigation strategies. We do not find that our metrics for financial literacy are associated with the existing energy efficiency levels. However, income is strongly associated with dwelling energy efficiency. On cost mitigation strategies, we find that paying the electricity bill by direct debit (i.e., automatic bank transfer) is strongly associated with income rather than financial preferences. Regarding the administrative burden, we find that the complexity of works proposed can keep households from requesting grants for the energy efficiency retrofit, with the incidence of this barrier homogeneously distributed across income levels.

The remainder of this article is structured as follows. Section 2 outlines the survey and data collection, and the methodological approach for data analysis. Section 3 presents the analytical results, while sections 4 discusses policy implications. Section 5 presents some final conclusions.

# 2 Data and methods

## 2.1 Data

The data for this study were collected in a telephone survey of 900 Irish homeowners in late 2021 and early 2022. The survey included a total of 48 questions. In addition to home ownership status, the survey elicited information on socioeconomic characteristics, characteristics of the dwelling itself, as well as some information on the respondents' financial attitudes and behaviour. Since the purpose of this study is to investigate the issue of fuel poverty, the survey also included questions on fuel and energy expenditure, as well as questions on the subjective level of warmth and comfort experienced in the home. Finally, several questions asked about the respondents' attitudes towards, and history with energy efficiency retrofits and the available government grants to finance them.

While the original sample was of 900 units, a total of 864 homes are included in the analysis. Observations excluded during data cleaning were primarily due to item non-responses on critical questions within the survey. Table 1 reports summary statistics for the variables of interest, where among the categorical variable a value of 1 indicates the presence, and the value of 0 indicates the absence, of the item in question. The reported mean of these variables represents the share of respondents for which the variable equals one. The dependent variables utilised in our econometric analysis are included in the first section of the table.

To analyse the patterns of fuel poverty in our sample, we elicit three subjective measures and one expenditure based metric of fuel poverty. The three subjective measures all reflect the prevalence of a specific potential symptom of fuel poverty, namely the frequency of being cold at home; having to forgo spending on other necessities of daily life in order to pay one's energy bills; as well as a subjective assessment of the level of warmth or comfort within the home. The variable "Forgone Necessities" takes a value of 1 if the respondent reports that they have to forgo spending on other necessities in favor of paying energy bills, at least occasionally. Respondents are classified as "Not

being able to keep [their home] warm" if they report being able to afford a warm home either sometimes or never rather than always. The expenditure based measure indicates households that have per capita income of less than 60% of the sample median income, but above median energy costs. Subjective measures are standard metrics used in the Survey on Income and Living Conditions (SILC) survey (Watson and Maître, 2015). The expenditure based metric has been widely used in the literature (Tovar Reaños and Lynch, 2022).

Since we are interested in the impact that specific socioeconomic and other characteristics have on respondents' financial decision making, we elicit information on three specific aspects. Firstly, "Prefer long term return" indicates whether they prefer a larger long term cash reward of between €1100 in three years and €550 in one year or a smaller over an immediate cash reward of €500. Secondly, we elicit how high their willingness to pay for a hypothetical energy efficiency investment is, by asking how much they would be willing to spend for an improvement to their home that would save them €100 every year in energy bills for the next 20 years. The answer choices provided were "€100–€200", "€300–€400", "€500–€600" and "More than €600". Thirdly, the variable "Time Expectation" reflects how long respondents expect to have to wait until they break even on an energy efficiency investment. Finally, we ask whether they have recently switched their energy provider, which tends to lead to reduced energy costs (He and Reiner, 2017). The questions on financial preferences outlined above are adapted from Newell and Siikamäki (2015).

Only one third of respondents report having switched their energy provider in the past 24 months. Survey participants were also asked whether they have in the past investigated undertaking an energy efficiency retrofit, with 45% of homeowners responding affirmatively. Finally, since we are interested in the link between fuel poverty and energy efficiency, we also ask respondents details of their home's energy performance certificate, termed a Building Efficiency Rating (BER). Unfortunately, this question elicited an item non-response in many instances, indicating either that many homeowners are unaware of their home's energy efficiency level or that the dwelling does not have a BER rating. Since the year 2009, a BER certificate is compulsory for all homes being sold or offered for rent but properties with longstanding occupants would not necessarily have a need for BER assessment. Although the BER rating system uses seven different ratings, the variable in our data set only takes five distinct values, because all ratings of E or worse are combined into a single category.[1]

Our survey targeted homeowners in Ireland but we over-sampled across the three lowest income categories to ensure sufficient observations of fuel poor households for our analysis. We use weights to calibrate our sample with the income distribution of the Survey on Income and Living Conditions (SILC) data of 2020.

Table 1: Summary Statistics

| | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| ***Dependent Variable*** | | | | | |
| Not able to keep warm | 0.15 | 0.36 | 0 | 1 | 900 |
| Forgone Necessities | 0.08 | 0.27 | 0 | 1 | 900 |
| Sometimes or often cold | 0.19 | 0.39 | 0 | 1 | 900 |

[1] A Building Energy Rating (BER) is provided in $kWh/m^2$ per year when a certificate is issued. However, it is also expressed in letter format. We structured the options for the answer of this question in letters to reduce the burden on respondents. We amalgamated the three lowest categories due to the how share of respondents (just 5% across the three categories), which may reflect the fact that the lowest BER ratings are more prevalent in non-owner occupier tenure categories.

Table 1: Summary Statistics (cont'd)

| | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| Low Inc. & High Exp. | 0.11 | 0.32 | 0 | 1 | 900 |
| Bank Account | 0.87 | 0.34 | 0 | 1 | 900 |
| Debit Card | 0.83 | 0.38 | 0 | 1 | 900 |
| Banking App | 0.58 | 0.49 | 0 | 1 | 900 |
| Loan | 0.19 | 0.39 | 0 | 1 | 900 |
| Pay by direct debit | 0.80 | 0.40 | 0 | 1 | 900 |
| Switched Provider | 0.33 | 0.47 | 0 | 1 | 890 |
| Retrofit Investigated | 0.45 | 0.50 | 0 | 1 | 899 |
| *Energy Efficiency Rating (BER)* | | | | | |
| E or worse | 0.05 | 0.22 | 0 | 1 | 900 |
| D | 0.07 | 0.25 | 0 | 1 | 900 |
| C | 0.15 | 0.36 | 0 | 1 | 900 |
| B | 0.11 | 0.31 | 0 | 1 | 900 |
| A | 0.07 | 0.26 | 0 | 1 | 900 |
| None | 0.55 | 0.50 | 0 | 1 | 900 |
| *Reasons to forgo financial support* | | | | | |
| Afraid of Complexity | 0.32 | 0.47 | 0 | 1 | 351 |
| Prefer other offer | 0.25 | 0.43 | 0 | 1 | 351 |
| See no benefit | 0.27 | 0.44 | 0 | 1 | 351 |
| Timing not right | 0.28 | 0.45 | 0 | 1 | 351 |
| | | | | | |
| ***Socioeconomic Characteristics*** | | | | | |
| Female | 0.52 | 0.50 | 0 | 1 | 900 |
| Age | 57.90 | 14.36 | 21 | 75 | 900 |
| HH members under 18 | 0.32 | 0.47 | 0 | 1 | 900 |
| HH members aged 18-34 | 0.31 | 0.46 | 0 | 1 | 900 |
| HH members over 64 | 0.26 | 0.44 | 0 | 1 | 900 |
| Household Size | 3.04 | 1.56 | 1 | 12 | 900 |
| *Location* | | | | | |
| City (50k+ inhabitants) | 0.21 | 0.41 | 0 | 1 | 898 |
| Town (1,5k to 50k) | 0.32 | 0.47 | 0 | 1 | 898 |
| Village (¡ 1,5k) | 0.47 | 0.50 | 0 | 1 | 898 |
| *Annual Household Income (in €)* | | | | | |
| under 15k | 0.10 | 0.30 | 0 | 1 | 882 |
| 15k-25k | 0.13 | 0.34 | 0 | 1 | 882 |
| 25k-35k | 0.20 | 0.40 | 0 | 1 | 882 |
| 35k-50k | 0.18 | 0.39 | 0 | 1 | 882 |
| 50k-75k | 0.21 | 0.41 | 0 | 1 | 882 |
| 75k-100k | 0.10 | 0.30 | 0 | 1 | 882 |
| above 100k | 0.08 | 0.27 | 0 | 1 | 882 |
| *Willingness to Pay* | | | | | |
| €100-€299 | 0.23 | 0.42 | 0 | 1 | 900 |
| €300-€499 | 0.19 | 0.40 | 0 | 1 | 900 |
| €500-€600 | 0.21 | 0.41 | 0 | 1 | 900 |
| more than €600 | 0.37 | 0.48 | 0 | 1 | 900 |
| *Time Expectation* | | | | | |
| <1 year | 0.23 | 0.42 | 0.00 | 1.00 | 826 |

Table 1: Summary Statistics (cont'd)

| | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| 1-5 years | 0.64 | 0.48 | 0.00 | 1.00 | 826 |
| 6-10 years | 0.13 | 0.34 | 0.00 | 1.00 | 826 |
| Prefer long term return | 0.55 | 0.50 | 0 | 1 | 860 |
| | | | | | |
| ***Dwelling Characteristics*** | | | | | |
| Damaged Structure | 0.11 | 0.49 | 0 | 1 | 900 |
| *Building Date* | | | | | |
| before 1940 | 0.15 | 0.35 | 0.00 | 1 | 889 |
| 1940-1979 | 0.29 | 0.45 | 0.00 | 1 | 889 |
| 1980-2005 | 0.41 | 0.49 | 0.00 | 1 | 889 |
| 2006-2021 | 0.16 | 0.37 | 0.00 | 1 | 889 |
| *Dwelling Type* | | | | | |
| Detached | 0.60 | 0.49 | 0.00 | 1 | 900 |
| Semi-detached | 0.37 | 0.48 | 0.00 | 1 | 900 |
| Apartment | 0.03 | 0.17 | 0.00 | 1 | 900 |
| *Heating Source* | | | | | |
| Electricity | 0.10 | 0.30 | 0.00 | 1 | 900 |
| Diesel, Gas oil, or kerosene | 0.61 | 0.49 | 0.00 | 1 | 900 |
| LPG or natural gas | 0.17 | 0.38 | 0.00 | 1 | 900 |
| Wood, coal, or peat | 0.11 | 0.31 | 0.00 | 1 | 900 |
| Other heating source | 0.02 | 0.13 | 0.00 | 1 | 900 |

Several questions captured information related to homeowners' hesitations with accessing financial support to improve energy efficiency. Respondents reporting having completed a energy efficiency retrofit in the past without State financial supports were asked for their views on the role specific factors played in not accessing State financial supports.

Finally, the survey elicited information on socioeconomic and dwelling characteristics, such as the respondents age, the size and composition of the household, the household's income, the building's age and location, as well as whether there were any major structural damage or quality deficiencies in the building. Since our research interest is the prevalence and drivers of fuel poverty, we are particularly interested in respondents' typical monthly fuel and electricity costs.[2]

The survey included questions to gauge respondents' familiarity with specific financial instruments to investigate the link between financial literacy and energy efficiency investment behaviour. The survey includes four questions on what kinds of financial services respondents use. As table 1 shows, 87% of our survey participants have an account with a bank or credit union, 83% possess a debit card, 58% use a mobile or internet app to access their account, and 19% have an outstanding car or other type of personal loan (excluding mortgages). Financial literacy has been measured in the literature in a multitude of ways but no consensus on the best approach. We utilise standard questions developed by the OECD (OECD, 2011).

As the dependent variables in our analysis are binary, we use probabilistic logistic models for estimation. Our model is defined as follows:

[2]For electricity costs, the cost ranges are 1) €0–60, 2) €61–90, 3) €91–120, 4) €121–150 and 5) Above €150. For fuel costs, the ranges are 1) €0–40, 2) €41–60, 3) €61–80, 4) €81–100 and 5) Above €100.

$$y^* = \beta' X + \upsilon \tag{1}$$

where $y^*$ is the (latent) continuous outcome, which is only observed in its discrete form $y$. $X$ is a set of building-specific variables and household characteristics, $\beta$ is a set of parameters to be estimated, and $\upsilon$ is the error component (Greene, 2003). In the case of the binary outcome, y=1 if $y^* \geq 0$ and 0 otherwise. The probability of observing the outcome variable given the household and building characteristics, and the estimated parameters is given by the following expression:

$$\Pr(y|\beta, x_n) = \frac{\exp(\beta' x_n)}{1 + \exp(\beta' x_n)}, \tag{2}$$

In all tables containing regression results, these are reported as odds ratios. An odds ratio below one indicates that a respondent with the characteristic in question has a lower likelihood to be for the dependent variable to be one than the reference category. An odds ratio of more than one indicates a higher likelihood than for the reference category. An odds ratio of exactly one would indicate that the odds of the dependent variable being one are exactly the same for the category in question and for the reference category. In the case of binary explanatory variables, the 'reference category' are those respondents for which the variable is zero.

# 3 Results

## 3.1 Fuel Poverty and financial literacy

We first analyse the relation between fuel poverty and financial literacy. The first three columns of table 2 show the results from three different logistic regression specifications, using three self-reported indicators of fuel poverty. In the first column, the dependent variable is a dummy that equals one if the respondent reports being unable to afford to keep the home warm for some or all the time. In the second column, the dependent variable is a dummy which equals one if the respondent reports having to forgo other necessities to be able to pay the heating bill. In the third column, the dependent variable is a dummy that equals one if people report feeling cold in their homes at least occasionally.

The results show that our metrics for financial literacy are mostly statistically insignificant. Only having a debit card seems to have a negative relation with fuel poverty across three of the analysed metrics. Consequently, we do not see a strong relation between financial literacy and fuel poverty. We also do not find a clear relationship between energy efficiency (as measured by the BER variable) and fuel poverty. However, poor dwelling quality is strongly and consistently associated with fuel poverty across all the fuel poverty metrics.

While some other socioeconomic and dwelling characteristics are statistically significant, these relationships are not consistent across all measures and therefore are of less interest for our research question.

In addition to the self-reported fuel poverty metrics analysed in table 2, we also consider an expenditure based metric for fuel poverty. The fourth column of table 2 shows the results of a logistic regression of the same household and dwelling characteristics used in the first three columns against a binary dependent variable equal to one if the respondent reports both a per capita income that is smaller than 60% of the median reported per capita income and an energy expenditure of more

Table 2: Fuel Poverty and financial literacy: several metrics

| | (1) Not able afford keep home warm | | (2) Forgone Necessities to pay bills | | (3) Sometimes or often home is cold | | (4) Low Income High fuel expenditure | |
|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. |
| *Building Characteristics:* | | | | | | | | |
| Poor building conditions | 4.09*** | (1.24) | 3.06*** | (1.21) | 3.66*** | (1.00) | 0.76 | (0.32) |
| BER (ref: E–G) | | | | | | | | |
| D | 0.36 | (0.23) | 0.40 | (0.31) | 0.20*** | (0.12) | 0.61 | (0.60) |
| C | 0.51 | (0.23) | 0.30 | (0.23) | 0.29*** | (0.13) | 0.40 | (0.32) |
| B | 0.34* | (0.21) | 1.03 | (0.71) | 0.20*** | (0.11) | 3.44 | (3.25) |
| A | 0.16** | (0.12) | 0.35 | (0.28) | 0.09*** | (0.06) | 1.14 | (1.02) |
| None | 0.42** | (0.17) | 0.70 | (0.41) | 0.29*** | (0.12) | 1.56 | (1.06) |
| *Socioeconomic Characteristics:* | | | | | | | | |
| Female | 1.27 | (0.30) | 1.71* | (0.54) | 1.07 | (0.22) | 1.00 | (0.31) |
| Age of the Head (ref: 18-34) | | | | | | | | |
| 35-54 | 0.84 | (0.53) | 1.44 | (0.85) | 1.14 | (0.71) | 0.07*** | (0.05) |
| 55+ | 0.78 | (0.50) | 0.41 | (0.26) | 1.23 | (0.78) | 0.13*** | (0.09) |
| HH members under 18 | 0.69** | (0.11) | 0.90 | (0.13) | 1.03 | (0.12) | 1.08 | (0.36) |
| HH members aged 18-34 | 1.35** | (0.16) | 0.99 | (0.16) | 1.51*** | (0.16) | 1.10 | (0.23) |
| HH members aged 35-64 | 0.81 | (0.17) | 0.83 | (0.19) | 0.89 | (0.14) | 0.77 | (0.18) |
| HH members 65+ | 0.86 | (0.24) | 0.45 | (0.23) | 0.65 | (0.20) | 1.84** | (0.55) |
| Income (ref: under 15k) | | | | | | | | |
| 15k-25k | 0.70 | (0.23) | 0.27*** | (0.14) | 0.64 | (0.22) | 0.39*** | (0.13) |
| 25k-35k | 0.33*** | (0.11) | 0.52 | (0.21) | 0.80 | (0.26) | 0.03*** | (0.01) |
| 35k-50k | 0.29*** | (0.11) | 0.28*** | (0.13) | 0.62 | (0.22) | [omitted] | |
| 50k-75k | 0.20*** | (0.08) | 0.05*** | (0.04) | 0.37*** | (0.14) | [omitted] | |
| 75k-100k | 0.26*** | (0.12) | 0.20*** | (0.12) | 0.43* | (0.19) | [omitted] | |
| above 100k | 0.04*** | (0.05) | 0.11*** | (0.09) | 0.28** | (0.15) | [omitted] | |
| *Financial Characteristics:* | | | | | | | | |
| Pay by direct debit | 0.87 | (0.24) | 0.57 | (0.20) | 0.75 | (0.18) | 0.93 | (0.30) |
| Bank Account | 0.84 | (0.29) | 0.63 | (0.26) | 1.00 | (0.33) | 0.65 | (0.29) |
| Debit card | 0.40*** | (0.12) | 0.30*** | (0.12) | 0.59* | (0.17) | 1.39 | (0.50) |
| Banking App | 1.27 | (0.34) | 1.67 | (0.65) | 1.30 | (0.32) | 0.94 | (0.30) |
| Financial loan | 1.68 | (0.53) | 1.48 | (0.62) | 1.09 | (0.32) | 0.51 | (0.25) |
| Constant | 2.40 | (2.06) | 1.90 | (1.71) | 1.32 | (1.13) | 13.17** | (14.62) |
| N | 881 | | 881 | | 881 | | 380 | |

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The dependent variables are dummies that take a value of one if the condition in question is fulfilled 'often' or 'sometimes'.

than the median expenditure at the same time, and zero otherwise.[3] Households with low incomes and high energy expenditures are especially at risk of falling into fuel poverty. In this column, the four highest income categories are omitted, because none of the respondents that fulfill the criteria for the dependent variable are located in these categories, making it impossible to calculate an odds ratio. The regression results provide little additional insight. Both the building quality and BER variables are statistically insignificant. Working age cohorts (age 35-55) are less likely to fall into this fuel poverty metric. However, only in the case of this metric do we see that households with older members, aged 65 and above, are more likely to fall into fuel poverty. Households with a person aged 65+ are 1.8 times more likely to fall into fuel poverty than households with only people aged below 65.

To check to what extend all four dependent variables capture the same phenomenon, we calculate the pairwise correlations between each of them, which are displayed in table 3. We find that the correlation coefficient between the subjective measures of reported fuel poverty symptoms are much stronger than the correlation between the subjective measures and the expenditure based one. The weak correlation between the expenditure based measure and the subjective fuel poverty indicators suggests that targeting based on income and energy expenditure alone might not be enough to tackle a multidimensional problem like fuel poverty.

Fuel poverty is a multidimensional issue and low energy efficiency levels have been identified as an important driver of fuel poverty (Tovar Reaños and Lynch, 2022). To analyse how low energy efficiency standards in a building are related to financial literacy and income levels, table 4 shows the result of a logistic regression using an indicator of low energy efficiency (defined as a BER of "C" or worse) of the building as the dependent variable. Since this dependent variable is based on the Building Energy Rating (BER), the sample is limited to those respondents that knew their BER at the time of the survey. This effectively creates a sub-sample of households that have either purchased or received grant support for an energy efficiency retrofit in last 15 years or so (as there was no other reason to have a BER assessment otherwise). We find that low energy efficiency levels are not associated with any of the financial literacy metrics, but that there is a strong association with income, with odds ratios less than one across all income categories versus the reference category of less than €15,000. However, the odds ratio estimates on the income variables vary between 0.11 and 0.36 with no clear gradient as income increases, indicating that there is no clear trend across income levels and that we cannot conclude that the likelihood of low energy efficiency declines as income increases.

Table 3: Correlations between Indicators of Fuel Poverty

| | Not able afford keep home warm | Forgone Necessities to pay bills | Sometimes or often cold home | Low income & high fuel expenditure |
|---|---|---|---|---|
| Not able afford keep home warm | 1 | | | |
| Forgone Necessities to pay bills | 0.303*** | 1 | | |
| Sometimes or often cold home | 0.453*** | 0.242*** | 1 | |
| Low income & high fuel expenditure | 0.130*** | 0.0941*** | 0.0607* | 1 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[3]The exact thresholds are less than €25,515 for the annual income and above €112 for the monthly energy expenditure.

To further investigate prior evidence that financial literacy increases the likelihood of adopting energy efficiency technologies (Blasch et al., 2021), we test whether our metrics for revealed financial literacy are associated with financial preferences for the investment. Table 5 shows the results of four regressions, each of which has a different one of our dummy variables indicating whether or not a respondent uses a particular financial service as the dependent variable. Previous work by Brent and Ward (2018) finds that the metric for financial literacy used in their analysis was weakly correlated with income. The correlation we observe in table 5 is in line with this finding. The correlation tends to get stronger for medium and high income levels. We see only a weak relation between our metrics for financial literacy and financial preferences. We do not see a consistent relationship between the odds of using the four financial and preferring a larger future payout over an immediate smaller one, or between the services and the level of willingness to pay for an energy efficiency investment that saves €100 annually for the next 20 years. However, we do find that all financial services, except the use of a banking app, are more likely to be used by respondents that expect to have to wait more than six years for an energy efficiency investment to turn profitable.

Table 4: Low energy efficiency

| | Low BER | |
|---|---|---|
| | Odds Ratio | Std. error |
| *Building Characteristics:* | | |
| Poor building conditions | 1.97 | (1.16) |
| Year build (ref: pre 1940) | | |
| 1940-1979 | 0.66 | (0.35) |
| 1980-2005 | 0.32** | (0.15) |
| 2006-2021 | 0.08*** | (0.04) |
| Building type (ref: Detached) | | |
| Semi-detached | 0.93 | (0.31) |
| Apartment | 3.53 | (3.00) |
| Heating fuel (ref: Electricity) | | |
| Diesel, Gas oil, or kerosene | 3.83*** | (1.63) |
| LPG or natural gas | 4.18*** | (2.08) |
| Wood, coal, or peat | 3.65* | (2.55) |
| Other heating source | 1.00 | (0.00) |
| *Socioeconomic Characteristics:* | | |
| Female | 0.70 | (0.18) |
| Age of the Head (ref: 18-34) | | |
| 35-54 | 0.94 | (0.46) |
| 55+ | 1.01 | (0.50) |
| HH members under 18 | 0.94 | (0.15) |
| HH members aged 18-34 | 1.04 | (0.18) |
| HH members aged 35-64 | 1.26 | (0.30) |
| HH members over 64 | 1.01 | (0.40) |
| Income (ref: under 15k) | | |
| 15k-25k | 0.27** | (0.18) |
| 25k-35k | 0.36* | (0.22) |
| 35k-50k | 0.30** | (0.17) |
| 50k-75k | 0.28** | (0.16) |
| 75k-100k | 0.17*** | (0.10) |
| above 100k | 0.11*** | (0.07) |
| *Financial Characteristics:* | | |
| Bank Account | 0.96 | (0.39) |
| Debit card | 0.79 | (0.34) |
| Banking App | 1.55 | (0.48) |
| Financial loan | 0.87 | (0.27) |
| Intercept | 5.88** | (5.31) |
| N | 382 | |

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Low BER: Any BER worse than B

Table 5: Financial Literacy, Socioeconomic Characteristics and Financial Preferences

| | (1) Bank Account | | (2) Debit card | | (3) Banking App | | (4) Financial loan | |
|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. |
| Poor building conditions | 1.37 | (0.52) | 1.21 | (0.41) | 1.59 | (0.49) | 0.89 | (0.30) |
| *Socioeconomic Characteristics:* | | | | | | | | |
| Female | 0.94 | (0.24) | 1.04 | (0.23) | 1.21 | (0.22) | 1.13 | (0.25) |
| Age of the Head (ref: 18-34) | | | | | | | | |
| 35-54 | 0.24* | (0.20) | 0.87 | (0.54) | 0.48 | (0.23) | 0.80 | (0.43) |
| 55+ | 0.32 | (0.28) | 0.69 | (0.44) | 0.37** | (0.17) | 0.43 | (0.23) |
| HH members under 18 | 0.79* | (0.11) | 1.06 | (0.15) | 1.03 | (0.10) | 1.23* | (0.13) |
| HH members aged 18-34 | 0.76* | (0.11) | 0.97 | (0.12) | 0.93 | (0.11) | 1.07 | (0.13) |
| HH members aged 35-64 | 1.06 | (0.21) | 0.62*** | (0.11) | 0.95 | (0.14) | 1.12 | (0.20) |
| HH members 65+ | 0.77 | (0.21) | 0.72 | (0.17) | 0.83 | (0.16) | 0.68 | (0.23) |
| Income (ref: under 15k) | | | | | | | | |
| 15–25k | 1.34 | (0.58) | 0.95 | (0.35) | 0.96 | (0.31) | 2.16 | (1.30) |
| 25–35k | 1.18 | (0.48) | 1.29 | (0.45) | 1.14 | (0.34) | 3.08** | (1.71) |
| 35–50k | 1.84 | (0.82) | 2.73** | (1.10) | 2.84*** | (0.90) | 3.41** | (1.96) |
| 50–75k | 3.19** | (1.52) | 2.82*** | (1.10) | 3.50*** | (1.12) | 3.82** | (2.10) |
| 75–100k | 2.72* | (1.45) | 3.24** | (1.61) | 5.29*** | (2.04) | 4.63*** | (2.73) |
| 100k+ | 19.65*** | (22.46) | 4.82*** | (2.92) | 7.48*** | (3.50) | 3.34* | (2.09) |
| *Financial Characteristics:* | | | | | | | | |
| Prefer long term return | 0.97 | (0.26) | 1.06 | (0.25) | 1.26 | (0.23) | 0.85 | (0.19) |
| Willigness to pay (ref: €100-€299) | | | | | | | | |
| €300-€499 | 0.89 | (0.32) | 0.95 | (0.31) | 1.11 | (0.29) | 0.62 | (0.22) |
| €500-€600 | 2.50** | (1.10) | 1.24 | (0.41) | 1.37 | (0.37) | 0.66 | (0.24) |
| more than €600 | 1.21 | (0.39) | 1.25 | (0.37) | 1.26 | (0.29) | 1.20 | (0.36) |
| Time expectation (ref: 1 year) | | | | | | | | |
| 1-5 years | 2.34*** | (0.65) | 1.19 | (0.31) | 1.38 | (0.30) | 1.06 | (0.28) |
| 6-10 years | 3.55*** | (1.64) | 1.43 | (0.57) | 1.79* | (0.55) | 2.13** | (0.72) |
| Intercept | 8.63** | (7.85) | 4.33** | (3.15) | 0.97 | (0.55) | 0.10*** | (0.09) |
| N | 788 | | 788 | | 788 | | 788 | |

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
All dependent variables are dummies that take the value of one if the respondent uses the financial service in question.

### 3.2 Other mitigation strategies and financial preferences

We now move to analyse the pattern of cost mitigation strategies among households. Table 6 presents the results of three regressions in which the dependent variable is a binary variable indicating whether the respondent reports using direct debit, i.e., automatic bank transfer, as a payment method (first two columns), has switched their gas or electricity supplier in the previous 24 months (middle columns), or whether they have investigated retrofitting their home in the past. All three of these strategies are likely to lead to reduced energy costs. The likelihood of using direct debit is higher for respondents with high income and lower for those in poor standard buildings (i.e., damp, etc.). The key results from table 6 are that households that have either switched energy provider or considered an energy efficiency retrofit (i.e., both non-retrofit cost saving activities) are approximately 1.5 times more likely to have an appetite for long term versus immediate investment returns. Note that the coefficient for the variable "6–10 years" suggests that respondents who expect to have to wait a long time to for an energy efficiency investment to turn profitable are 2.4 times more likely to switch energy provider (more than the 1–5 years cohort). This could indicate such households prefer short run actions (i.e. switching would bring immediate benefits) rather that engaging in long term investments.

For the retrofit investigation, we find that two of the financial preferences variables are statistically significant. Respondents preferring a long term return are more likely to investigate a retrofit. The same is true for those that are willing to pay more than €600 for the hypothetical energy efficiency investment.

### 3.3 Barriers to accessing energy efficiency supports

In this section, we investigate the role various factors play in (not) accessing financial supports for energy efficiency retrofit grants among homeowners that completed a retrofit in the prior 10 years. This analysis will shed light on the extent to which administrative burden may be a potential barrier to accessing energy efficiency retrofit grants among some homeowner cohorts. Table 7 displays four logistic regressions. In each one, a different potential reason for not receiving a grant for the retrofit is used as the dependent variable. The sample is limited to those respondents that have undertaken a retrofit but opted not to utilise grant funding.

In almost all specifications, the likelihood to agree that the factor in question was a reason not to use a grant is lower for at least one of the higher income bands, compared to the reference category of less than €15,000 in annual income. The association is strongest in the first column, where being afraid of the complexity of the kinds of retrofits eligible for state support is the dependent variable, and all higher income categories show a statistically significant and negative association. There are few other statistically significant relationships with socioeconomic characteristics.

In the second regression, the dependent variable equals one if respondents report not opting for funding because they had a better offer outside the funding system. Contractors operating outside the grant scheme do so to avoid technical inspection and higher compliance costs. The third regression represents households that believe that recommended retrofit works are not (sufficiently) beneficial, whereas the fourth regression relates to where the timing of the retrofit works were deemed not ideal to undertake disruptive works. Compared to the lowest income category, all income classes were less likely to indicate retrofit complexity as the reason for not undertaking a retrofit. There is no similarly clear systematic indicator of households that are likely to opt for a retrofit without accessing grant aid (to subvert higher technical compliance standards). Similarly there is no systematic indicator that particular households are either disillusioned with or do not

Table 6: Mitigation measures against high energy prices

| | (1) Electricity direct payment | | (2) Switching energy supplier | | (3) Retrofit Investigation | |
|---|---|---|---|---|---|---|
| | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. |
| Poor building conditions | 0.45*** | (0.13) | 0.88 | (0.24) | 0.98 | (0.26) |
| *Socioeconomic Characteristics:* | | | | | | |
| Female | 0.89 | (0.19) | 0.76 | (0.14) | 1.13 | (0.19) |
| Age of the Head (ref: 18-34) | | | | | | |
| 35-54 | 0.56 | (0.34) | 0.61 | (0.25) | 1.10 | (0.48) |
| 55+ | 0.32* | (0.20) | 0.46* | (0.19) | 0.95 | (0.41) |
| HH members under 18 | 1.00 | (0.14) | 1.19* | (0.12) | 1.04 | (0.10) |
| HH members aged 18-34 | 0.83 | (0.10) | 1.03 | (0.10) | 1.02 | (0.10) |
| HH members aged 35-64 | 0.82 | (0.14) | 1.03 | (0.14) | 0.88 | (0.12) |
| HH members over 64 | 1.05 | (0.26) | 0.93 | (0.19) | 1.11 | (0.22) |
| Income (ref: under 15k) | | | | | | |
| 15k-25k | 1.75* | (0.60) | 0.62 | (0.22) | 0.95 | (0.31) |
| 25k-35k | 2.59*** | (0.87) | 0.73 | (0.25) | 0.87 | (0.27) |
| 35k-50k | 2.33** | (0.82) | 1.13 | (0.38) | 1.52 | (0.47) |
| 50k-75k | 3.12*** | (1.08) | 1.19 | (0.40) | 1.51 | (0.47) |
| 75k-100k | 3.43*** | (1.49) | 1.65 | (0.62) | 1.52 | (0.54) |
| above 100k | 31.12*** | (32.81) | 1.41 | (0.60) | 3.11*** | (1.18) |
| *Financial Characteristics:* | | | | | | |
| Prefer long term return | 1.22 | (0.27) | 1.51** | (0.28) | 1.42** | (0.24) |
| Willigness to pay (ref: €100-€299) | | | | | | |
| €300-€499 | 1.31 | (0.44) | 1.00 | (0.29) | 0.84 | (0.22) |
| €500-€600 | 0.88 | (0.28) | 1.78** | (0.50) | 1.29 | (0.33) |
| more than €600 | 0.99 | (0.27) | 1.43 | (0.37) | 1.72** | (0.40) |
| Time expectation (ref: 1 year) | | | | | | |
| 1-5 years | 0.89 | (0.23) | 1.68** | (0.39) | 1.29 | (0.27) |
| 6-10 years | 0.92 | (0.34) | 2.40*** | (0.73) | 1.02 | (0.30) |
| Intercept | 6.30*** | (4.32) | 0.37* | (0.21) | 0.33** | (0.19) |
| N | 788 | | 780 | | 787 | |

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The dependent variables are dummies that take a value of one under the following conditions:
Electricity Direct Payment: Uses direct debit as the payment option for electricity bills.
Switching Energy Supplier: Has switched energy supplier in the past 24 month.
Retrofit Investigation: Has investigated a retrofit in the past.

perceive the benefits of retrofit works. Disruption associated with retrofit works is less likely to be given as the reason for not undertaking a retrofit among households in high income categories. This would potentially suggest that they have resources to minimise the impact of disruption. However, the odds are broadly similar across income cohorts above €35,000 i.e., the odds are not lower for the very affluent.

Table 7: Drivers of forgoing government assistance

| | (1) Complexity of works | | (2) Cheaper options without grant | | (3) No expected benefits | | (4) Bad timing/ too disruptive | |
|---|---|---|---|---|---|---|---|---|
| | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. | Odds ratio | Std. Err. |
| *Buillding Characteristics:* | | | | | | | | |
| BER (ref: E–G) | | | | | | | | |
| D | 0.43 | (0.33) | 0.44 | (0.39) | 0.57 | (0.47) | 0.79 | (0.65) |
| C | 0.54 | (0.37) | 1.81 | (1.33) | 1.25 | (0.91) | 0.65 | (0.48) |
| B | 0.80 | (0.56) | 2.44 | (1.79) | 2.54 | (1.84) | 1.19 | (0.88) |
| A | 1.95 | (1.70) | 6.02* | (5.95) | 3.45 | (3.35) | 3.09 | (2.83) |
| None | 0.50 | (0.32) | 0.71 | (0.48) | 0.69 | (0.46) | 1.03 | (0.69) |
| Poor building conditions | 0.66 | (0.30) | 0.43* | (0.22) | 0.86 | (0.39) | 0.97 | (0.42) |
| Year build (ref: pre 1940) | | | | | | | | |
| 1940-1979 | 2.27* | (0.95) | 1.62 | (0.69) | 1.09 | (0.46) | 1.60 | (0.68) |
| 1980-2005 | 1.51 | (0.62) | 0.71 | (0.30) | 0.92 | (0.37) | 1.20 | (0.49) |
| 2006-2021 | 1.32 | (0.76) | 0.15*** | (0.11) | 0.24** | (0.17) | 1.15 | (0.67) |
| Building type (ref: Detached) | | | | | | | | |
| Semi-detached | 0.86 | (0.26) | 0.60 | (0.20) | 0.69 | (0.22) | 0.94 | (0.28) |
| Apartment | 0.38 | (0.44) | 1.00 | (0.00) | 1.00 | (0.00) | 1.96 | (1.58) |
| Heating fuel (ref: Electricity) | | | | | | | | |
| Diesel, Gas oil, or kerosene | 1.88 | (0.92) | 1.08 | (0.55) | 1.46 | (0.78) | 0.89 | (0.40) |
| LPG or natural gas | 1.92 | (1.06) | 0.95 | (0.55) | 2.26 | (1.34) | 1.67 | (0.87) |
| Wood, coal, or peat | 1.38 | (0.88) | 0.88 | (0.57) | 0.89 | (0.62) | 0.25* | (0.19) |
| Other heating source | 1.00 | (0.00) | 0.49 | (0.68) | 0.64 | (0.88) | 0.54 | (0.75) |
| *Socioeconomic Characteristics:* | | | | | | | | |
| Female | 0.90 | (0.23) | 0.00 | 0.91 | (0.25) | 0.00 | 0.77 | (0.21) |
| Age of the Head (ref: 18-34) | | | | | | | | |
| 35-54 | 10.91** | (12.61) | 0.97 | (0.73) | 0.86 | (0.64) | 0.90 | (0.32) |
| 55+ | 10.58** | (12.29) | 0.46 | (0.34) | 0.75 | (0.56) | 1.00 | (0.00) |
| HH members under 18 | 1.18 | (0.20) | 1.02 | (0.17) | 1.07 | (0.18) | 0.96 | (0.16) |
| HH members aged 18-34 | 1.48** | (0.23) | 1.44** | (0.24) | 1.43** | (0.23) | 1.06 | (0.17) |
| HH members aged 35-64 | 0.66* | (0.15) | 1.05 | (0.24) | 1.08 | (0.23) | 1.32 | (0.27) |
| HH members over 64 | 1.01 | (0.32) | 1.26 | (0.42) | 1.28 | (0.41) | 1.52 | (0.48) |
| Income (ref: under 15k) | | | | | | | | |
| 15k-25k | 0.17*** | (0.10) | 0.66 | (0.39) | 0.61 | (0.34) | 0.49 | (0.27) |
| 25k-35k | 0.25** | (0.14) | 0.37* | (0.22) | 0.43 | (0.23) | 0.44 | (0.24) |
| 35k-50k | 0.18*** | (0.10) | 0.40 | (0.24) | 0.32** | (0.18) | 0.41 | (0.23) |
| 50k-75k | 0.28** | (0.15) | 0.23** | (0.14) | 0.23*** | (0.13) | 0.36* | (0.19) |
| 75k-100k | 0.21** | (0.14) | 0.33 | (0.24) | 0.26* | (0.18) | 0.36 | (0.24) |
| above 100k | 0.09*** | (0.06) | 0.54 | (0.35) | 0.13*** | (0.09) | 0.20** | (0.14) |
| Intercept | 0.14 | (0.21) | 1.46 | (1.84) | 0.99 | (1.25) | 0.77 | (0.76) |
| N | 335 | | 330 | | 330 | | 327 | |

Note: Standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The dependent variables are dummies that take a value of one under the following conditions:
All dependent variables are dummies that equal one if the respondent said they agree when presented with a statement claiming that the respective reason was a factor in their decision not to use a grant to finance their retrofit.

# 4 Discussion

The existing literature confirms the role of financial literacy in the uptake of more efficient technologies, mostly concentrating on the adoption of appliances rather than the adoption of energy efficiency retrofit solutions. We do not find strong evidence that our metrics for financial literacy has an important role in the energy efficiency levels. Most of the existing literature finds that households with financial literacy are more likely make optimal decisions regarding energy efficiency investments. However, the channel from which this knowledge can motivate the adoption of energy efficiency measures is unclear. We also do not find strong empirical evidence that financial literacy affects financial preferences for the uptake of retrofits, or fuel poverty. Consequently, more research is needed in this regard.

We find that the existing levels of energy efficiency of Irish homeowners are more closely associated with income levels than by our metrics of financial literacy. We also find that these metrics do not have a strong association with several fuel poverty metrics. Previous research shows that financial literacy was not strongly correlated with income (Brent and Ward, 2018). However, we find that financial literacy more strongly associated with income levels than with financial preferences. More research is needed to investigate whether this relationship is causal.

The literature shows that it is important to identify individuals who are most in need of financial education and find the most cost-efficient ways to improve that education (Lusardi and Mitchell, 2014). In this line, the OECD has developed some strategies to improve financial education at workplace (OECD, 2022). They highlight that understanding the audience, designing of appropriate delivery mechanisms and content, incentivising participation, evaluating outcomes and learning from the experiences of others are key in this process.

The adoption of energy cost mitigation measures, such as switching of one's energy supplier, or the adoption of energy efficiency measures are key strategies in the European strategy to tackle fuel poverty. However, these policies can be undermined if low-income households face barriers that are not perceived by policy makers. Our results show that income is an important indicator of using direct debit to settle energy bills, but not associated with income.

One important potential barrier to a more widespread adoption of energy efficiency improvement is the administrative burden regarding the applications for energy efficiency retrofit grants. Our results show that the lowest income households are more likely than most other income groups to struggle more with the complexity of the bureaucratic procedures, to report that the conditions under which the grants are offered do not suit them, and to see no benefit in retrofits recommended by the government. Current European programmes that provide free retrofits to low income households deal also with the technical aspects of the investment with the intention of reducing the burden on vulnerable households[4]. Heinrich et al. (2022) provides case studies for the USA in which time of processing applications, simplification of processes, implementation of technology, mapping of public expenditure have reduced the administrative burden of accessing public resources.

Providing financial education to vulnerable households is relied upon by policymakers to increase homeowners' investment in energy efficiency and reduce fuel poverty. Where there are programs that offer free retrofit to vulnerable households, some households withdraw from the application process (Pillai et al., 2021). We show that the administrative burdens exist in these contexts and needs to be addressed.

In several countries, social inclusion is a central objective of their financial literacy strategy. Some research shows that this could also be a strategy to reduce income poverty (Wang et al.,

[4]This scheme in Ireland is called the Better Energy Warmer Homes Scheme.

2022). Given the strong connection between fuel poverty and income in or results, promoting financial literacy to tackle income poverty could also indirectly tackle fuel poverty. Despite its importance, it has not been included in any European strategy to tackle fuel poverty. In Ireland, rural families, households with low incomes and older households are experiencing larger cost of living increases due to higher inflation (Lydon, 2022). This level of inflation has been heavily influenced by energy prices. Consequently, it is important to design short run strategies to protect vulnerable households within a broader view in which strategies such as financial education and simplified access to grants are included to increase the number of retrofits. Part of this strategy is a coordinated work between the government and the society. In this regard, Ramsden (2020) show that charities in the UK have been very effective in assisting households to adopt measures to protect themselves against high energy prices.

# 5 Conclusions

We survey homeowners in Ireland to investigate the decision-making process of vulnerable households to adopt measures to reduce the burden imposed by high energy prices and reduce energy demand. We contribute to the emerging literature on the role of financial literacy and the uptake of energy efficiency measures.

We find that fuel poverty is weakly associated with our metrics of financial literacy. Neither do we find strong evidence of the association between energy efficiency uptake and financial literacy. However, income plays a strong role in fuel poverty and energy efficiency levels.

When compared with the lowest income group, almost all other income groups are less likely to report having to forgo spending on other necessities. The same relationship exists with regards to the frequency of reporting a cold home and the level of discomfort felt at home, although it does not hold across all higher income groups for these variables.

Finally, we find that households in the lowest income group and those with older household heads are more likely to cite administrative complexity as a reason for not accessing retrofit grants. This provides some evidence of administrative burden weighing particularly on this group of households. Overall, our results suggest that most of the potential barriers to retrofitting are experienced by the lowest income cohort. If education for financial literacy, which is itself only weakly related with some symptoms of fuel poverty, plays a role in a country's fuel poverty strategy, it might be especially important for low-income households.

# References


Bardazzi, R., Bortolotti, L., and Pazienza, M. G. (2021). To eat and not to heat? energy poverty and income inequality in italian regions. *Energy Research & Social Science*, 73:101946. https://doi.org/10.1016/j.erss.2021.101946.

Bednar, D. and Reames, T. (2020). Recognition of and response to energy poverty in the united states. *Nature Energy 5*, page 432–439. https://doi.org/10.1038/s41560-020-0582-0.

Blasch, J., Boogen, N., Daminato, C., and Filippini, M. (2021). Empower the consumer! Energy-related financial literacy and its implications for economic decision making. *Economics of Energy & Environmental Policy*, 10(2):149–181. https://doi.org/10.1016/j.jebo.2022.02.014.

Brent, D. A. and Ward, M. B. (2018). Energy efficiency and financial literacy. *Journal of Environmental Economics and Management*, 90:181–216. https://doi.org/10.1016/j.jeem.2018.05.004.

Carvalho, L. S., Meier, S., and Wang, S. W. (2016). Poverty and Economic Decision-Making: Evidence from Changes in Financial Resources at Payday. *American Economic Review*, 106(2):260–84. https://doi.org/10.1257/aer.20140481.

Castellazzi, L., Bertoldi, P., and Economidou, M. (2018). Overcoming the split incentive barrier in the building sector: Unlocking the energy efficiency potential in the rental & multifamily sectors. https://doi.org/10.2790/912494.

Charlier, D., Legendre, B., and Risch, A. (2019). Fuel poverty in residential housing: providing financial support versus combatting substandard housing. *Applied Economics*, 51(49):5369–5387. https://doi.org/10.1080/00036846.2019.1613501.

Chen, C., Xu, X., and Day, J. K. (2017). Thermal comfort or money saving? exploring intentions to conserve energy among low-income households in the united states. *Energy Research & Social Science*, 26:61–71. https://doi.org/10.1016/j.erss.2017.01.009.

Choi, S., Kariv, S., Müller, W., and Silverman, D. (2014). Who Is (More) Rational? *American Economic Review*, 104(6):1518–50. https://www.aeaweb.org/articles?id=10.1257/aer.104.6.1518.

Damigos, D., Kontogianni, A., Tourkolias, C., and Skourtos, M. (2021). Dissecting subjective discount rates and investment literacy for energy-efficient investments. *Energy Efficiency*, 14(3):1–20. https://doi.org/10.1007/s12053-021-09941-4.

DellaValle, N. (2019). People's decisions matter: understanding and addressing energy poverty with behavioral economics. *Energy and Buildings*, 204:109515. https://doi.org/10.1016/j.enbuild.2019.109515.

EPAH (2021). EPAH Report: Tackling energy poverty through local actions – Inspiring cases from across Europe. Energy Poverty Advisory Hub of the European Comission. https://energy-poverty.ec.europa.eu/system/files/2022-02/EPAH_inspiring%20cases%20from%20across%20Europe_report_EN.pdf.

European Commission (2022a). Energy poverty in the EU. https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty_en.

European Commission (2022b). EU energy poverty advisory hub. https://energy-poverty.ec.europa.eu/index_en.

European Union (2020). Commission Recommendation (EU) 2020/1563 of 14 October 2020 on energy poverty. *Official Journal of the European Union*, 63(L 357):35–41. http://data.europa.eu/eli/reco/2020/1563/oj.

Fawcett, T. (2014). Exploring the time dimension of low carbon retrofit: owner-occupied housing. *Building Research & Information*, 42(4):477–488. https://doi.org/10.1080/09613218.2013.804769.

Friedrichsen, J., König, T., and Schmacker, R. (2018). Social image concerns and welfare take-up. *Journal of Public Economics*, 168:174–192. https://doi.org/10.1016/j.jpubeco.2018.10.008.

Greene, W. H. (2003). *Econometric Analysis*. Pearson Education India.

Hancevic, P. I. and Sandoval, H. H. (2022). Low-income energy efficiency programs and energy consumption. *Journal of Environmental Economics and Management*, 113:102656. https://doi.org/10.1016/j.jeem.2022.102656.

He, X. and Reiner, D. (2017). Why consumers switch energy suppliers: The role of individual attitudes. *The Energy Journal*, 38(6):25–54. https://www.jstor.org/stable/26534389.

Heinrich, C. J. (2016). The bite of administrative burden: A theoretical and empirical investigation. *Journal of Public Administration Research and Theory: J-PART*, 26(3):403–420. http://www.jstor.org/stable/44165122.

Heinrich, C. J., Camacho, S., Henderson, S. C., Hernández, M., and Joshi, E. (2022). Consequences of administrative burden for social safety nets that support the healthy development of children. *Journal of Policy Analysis and Management*, 41(1):11–44. https://doi.org/10.1002/pam.22324.

Hills, J. (2011). Fuel Poverty: The Problem and its Measurement. CASEreport, 69, Department for Energy and Climate Change, London, UK.

Hrovatin, N. and Zorić, J. (2018). Determinants of energy-efficient home retrofits in slovenia: The role of information sources. *Energy and Buildings*, 180:42–50. https://doi.org/10.1016/j.enbuild.2018.09.029.

Lades, L. K., Peter Clinch, J., and Kelly, J. A. (2021). Maybe tomorrow: How burdens and biases impede energy-efficiency investments. *Energy Research & Social Science*, 78:102154. https://doi.org/10.1016/j.erss.2021.102154.

Lusardi, A. and Mitchell, O. S. (2007). Baby boomer retirement security: The roles of planning, financial literacy, and housing wealth. *Journal of Monetary Economics*, 54(1):205–224. https://doi.org/10.1016/j.jmoneco.2006.12.001.

Lusardi, A. and Mitchell, O. S. (2014). The Economic Importance of Financial Literacy: Theory and Evidence. *Journal of Economic Literature*, 52(1):5–44. https://doi.org/10.1257/jel.52.1.5.

Lydon, R. (2022). Household characteristics, Irish inflation and the cost of living. Economic Letters 1/EL/22, Central Bank of Ireland.

Newell, R. G. and Siikamäki, J. (2015). Individual time preferences and energy efficiency. *American Economic Review*, 105(5):196–200. https://www.aeaweb.org/articles?id=10.1257/aer.p20151010.

OECD (2011). *Measuring Financial Literacy: Core Questionnaire*. OECD, Paris. https://www.oecd.org/finance/financial-education/49319977.pdf.

OECD (2022). Policy handbook on financial education in the workplace. *OECD Business and Finance Policy Papers*, No.07. https://doi.org/https://doi.org/10.1787/b211112e-en.

Pillai, A., Tovar Reaños, M., and Curtis, J. (2021). An examination of energy efficiency retrofit scheme applications by low-income households in Ireland. *Heliyon*, 7(10):e08205. https://doi.org/10.1016/j.heliyon.2021.e08205.

Raissi, S. and Reames, T. G. (2020). "If we had a little more flexibility." Perceptions of programmatic challenges and opportunities implementing government-funded low-income energy efficiency programs. *Energy Policy*, 147:111880. https://doi.org/10.1016/j.enpol.2020.111880.

Ramsden, S. (2020). Tackling fuel poverty through household advice and support: Exploring the impacts of a charity-led project in a disadvantaged city in the united kingdom. *Energy Research & Social Science*, 70:101786. https://doi.org/10.1016/j.erss.2020.101786.

Shah, A. K., Mullainathan, S., and Shafir, E. (2012). Some Consequences of Having Too Little. *Science*, 338(6107):682–685. https://doi.org/10.1126/science.1222426.

Tovar Reaños, M. A. and Lynch, M. A. (2022). Are fuel poverty metrics fit for purpose? an assessment using behavioural microsimulation. *Sustainable Cities and Society*, 81:103817. https://doi.org/10.1016/j.scs.2022.103817.

Wang, S., Cao, P., and Huang, S. (2022). Household financial literacy and relative poverty: An analysis of the psychology. *Frontiers in Psychology*, 13. https://doi.org/10.3389/fpsyg.2022.898486.

Watson, D. and Maître, B. (2015). Is fuel poverty in ireland a distinct type of deprivation. *The Economic and Social Review, Vol. 46, No. 2, Summer, 2015, pp. 267-291.*