LSU | E. J. Ourso College of Business
Department of Economics

DEPARTMENT OF ECONOMICS WORKING PAPER SERIES

Energy Efficiency and Financial Literacy

Daniel A. Brent
Louisiana State University

Michael Ward
Monash University

Working Paper 2017-04
http://faculty.bus.lsu.edu/papers/pap17_04.pdf

Department of Economics
Louisiana State University
Baton Rouge, LA 70803-6306
http://www.bus.lsu.edu/economics/

Energy Efficiency and Financial Literacy

Working Paper

Daniel A. Brent*[1] and Michael Ward[2]

[1]Department of Economics, Louisiana State University
[2]Department of Economics, Monash University

February 2017

Abstract

Recent attention has focused on the role of financial literacy as an explanation for anomalies in consumer choice in a range of settings, such savings, retirement investment, and debt. We contribute to this literature on this by analyzing the link between financial literacy and consumer durables in the context of energy efficiency. Energy efficiency is a compelling setting to assess the role of financial literacy on consumer behavior because purchasing energy durables is a complicated dynamic decision, and there is an extensive literature claiming that consumer investments in energy efficiency are sub-optimal. We augment a standard choice experiment for the purchase of a new hot water system by eliciting data on financial literacy. Financial literacy is an economically important and statistically significant determinant of investment in energy efficiency. A one standard deviation increase in our metric of financial literacy increases the willingness to pay for reduced operating costs by 9%. This result is robust to incorporating incentivized experimentally-elicited individual discount rates and risk aversion, as well as standard controls such as income and education, indicating that financial literacy is not merely a proxy for standard demographic characteristics. We show that financial literacy also makes choices more consistent with standard consumer preferences and increases the probability that respondents select the investments with the lowest lifetime discounted costs. The results establish low financial literacy as a specific mechanism driving low investment in energy efficiency.

Keywords: energy efficiency; financial literacy; energy efficiency gap
JEL Classification Numbers: Q48, D12.

*Corresponding Author: Daniel Brent, *email:* dbrent@lsu.edu. The authors are thankful to the Brotherhood of St. Laurence for funding, and Damian Sullivan for information about the Home Energy Efficiency Upgrade Program.

1 Introduction

Consumers face a host of decisions every day ranging from the choice of milk at the supermarket to allocating savings into a portfolio of retirement investments. Many of these choices are complex and require significant cognitive effort on the part of consumers. Mani et al. (2013) argue that poverty-related concerns use up valuable mental energy, thus depleting the cognitive resources available for a host of consumer decisions, which leads to costly mistakes. Lacking the ability to cope with the complexity of certain decisions is not unique to those in poverty, and a burgeoning research field is devoted to how financial literacy impacts a wide range of economic outcomes. Lusardi and Mitchell (2014) define financial literacy as a combination of cognitive ability and investment in human capital related to understanding financial decisions. Poor financial literacy has been linked to lower rates of financial planning for retirement, increased mortgage default, lower participation in the stock market, and increased likelihood of taking out high-cost loans. While financial literacy is correlated with standard demographics such as education and cognitive ability, a substantial proportion of the variation in financial literacy cannot be explained by observable characteristics. Furthermore, controlling for covariates and correcting for endogeneity has typically increased the impact of financial literacy on economic outcomes. Financial literacy has therefore been an attractive framework to understand how consumers mis-optimize financial decisions. The impact of financial literacy on consumer welfare is immense: simulations by Lusardi et al. (Forthcoming) estimate that half of wealth inequality in the United States can be explained by differences in financial literacy.

Financial literacy research has primarily focused on decisions related to savings, investment, and liabilities. These are clearly important decisions, however, there are choices in many other settings that require the same set of skills and are subject to costly mistakes. One particularly high profile domain where consumers are argued to mis-optimize is investment in energy efficiency. The energy efficiency gap, defined as underinvestment in energy efficiency opportunities that have a negative net present cost, has received significant attention in the literature (Jaffe and Stavins, 1994; Allcott and Greenstone, 2012; Gerarden et al., 2015; Ameli et al., 2015). Underinvestment in energy efficiency is important because, in addition to the private welfare costs of consumer mistakes, there are also significant public welfare costs due to the local and global externalities associated with energy consumption. There has been significant debate regarding the presence and size of the energy efficiency gap. While engineering estimates of the energy efficiency gap may overstate the problem there are several behavioral biases that plausibly drive down investments from the optimal level (Allcott et al., 2014). The biases that cause mistakes are important to the extent that policy interventions can correct consumer errors, and bring investment in energy efficiency closer to the optimal level.

We apply the concepts of financial literacy to analyze potential mistakes in investments in consumer durables. We augment a choice experiment where consumers trade off between upfront costs and operating costs by eliciting data on the respondents' financial literacy. Consumer durables such as cars and large household appliances are important financial decisions with many moving parts that have the potential to overwhelm households. However, the evidence is mixed on the existence and degree of consumer mistakes in energy efficiency investments. For example, Allcott and Wozny (2014) show that vehicle prices do not sufficiently respond to variation in gas prices, indicating that consumers are not paying enough attention to the lifetime fuel cost of automobile ownership. However, Newell and Siikamäki (2014) shows that accounting for individual discount rates, as opposed to assuming conventional discount rates, rationalizes consumer investments in energy efficiency within an expected utility framework. Since financial literacy has been established to drive suboptimal decisions in many important economic decisions, incorporating it into choices about energy efficiency helps clarify whether consumers are systematically under-valuing the benefits of reduced future energy costs.

We make three contributions to the literature. First, to our knowledge, we are the first to model financial literacy as a driver of investments in consumer durables. Second, we explain a novel, yet intuitive, factor in explaining the energy efficiency gap. Lastly, we analyze heterogeneity in the impact of financial literacy by examining the interaction between information and financial literacy and disaggregating financial literacy into specific types of information.

Our results show that higher financial literacy increases the willingness to pay for energy efficiency, suggesting a specific mechanism driving the energy efficiency gap. This result is robust to controlling for individual discount rates, risk aversion, green preferences, and standard demographic characteristics in multiple econometric models. Financial literacy is not strongly correlated with variables such as income and education, indicating that it does not merely serve as a proxy for basic demographics. In fact, including controls such as income and education in our regressions *increases* the impact of financial literacy on the willingness to pay (WTP) for energy efficiency. A one standard deviation increase in our metric of financial literacy increases the WTP for energy savings by roughly 9%.

While increased investment will likely increase social welfare through the reductions of externalities, the energy efficiency gap purports that consumers are missing out on privately beneficial investments. Using a generalized multinomial logit model we find that financial literacy reduces scale heterogeneity, thus decreasing the error component in the random utility model and making choices more consistent with a standard model of consumer preferences. Additionally, we find that financial literacy increases the probability of selecting alternatives with the lowest lifetime costs in net present value over a range of conventional and experimentally elicited discount rates. These findings are robust to controlling for a host of demographic and behavioral parameters.

Our metric of financial literacy relies on questions that elicit generic financial knowledge such as the concept of compound interest as well as information specific to investments in energy efficiency such as the concept of a payback period for more expensive and efficient models. We find that the results are similar when using either generic or energy-specific financial literacy; in fact the results are slightly stronger using the generic questions. This indicates that financial literacy is a proxy for an underlying capacity to make complex decisions that extends beyond the specific context of the questions. The individual questions that produce the largest results are knowledge of inflation and being able to calculate payback periods.

To investigate the interaction between financial literacy and the complexity of the choice environment we provide a randomized treatment where some respondents with a payback period button that calculates the number of years a system will take to recoup the higher fixed cost relative to the cheapest option in the choice set.[1] The payback period information exogenously makes the decision easier for some respondents, potentially moderating the impact of financial literacy. There is weak evidence that the payback period information diminishes the impact of financial literacy, however, this is not robust across specifications. We do not find evidence that the payback period makes choices more consistent.

[1]We chose the payback period as our source of additional information based on personal focus group interviews that asked how consumers make decisions about energy-consuming durables.

While we test one form of information, presenting different information to consumers may prove to be more effective at reducing the effect of financial literacy. Learning how to counter the effect of financial literacy is important because many energy efficiency programs specifically target consumers who have low financial literacy, such as low income and elderly populations. In addition to providing subsidies and advice on the type of energy efficiency investment to make, policies should be designed to simplify the investment decision as much as possible in order to avoid consumer mistakes associated with government interventions.

2 Existing Literature and Policy Context

The energy efficiency gap has received significant attention in the economics literature dating back over 20 years (Jaffe and Stavins, 1994). The concept of the "gap" rests on the claim that consumers fail to make investments in energy efficiency that are both privately beneficial from a financial perspective and also reduce externalities such as local air pollution and global greenhouse gas (GHG) emissions. A major source of tension is that calculations that determine whether investments are privately beneficial often stem from engineering models McKinsey (2009), which may overestimate the impact of energy cost savings or underestimate the costs associated with the investment. Fowlie et al. (2015) show that the U.S. weatherization program substantially overestimates energy savings and the investment costs are significantly higher than energy savings. There have been several recent overview studies that document various explanations of the energy of the energy efficiency gap (Allcott and Greenstone, 2012; Gerarden et al., 2015).[2] Some of the explanations rely on market failures such as imperfect information, split incentives, and capital market failures. Behavioral failures such as myopic consumers, inattentiveness, and status quo bias are another source of justifications for suboptimal investments.

Behavioral explanations assume that consumers suffer from internalities, or the failure to internalize all the appropriate private costs and benefits when making decisions about energy efficiency. Allcott and Sunstein (2015) highlight the problem of internalities and offer recommendations for using behavioral policy to regulate internalities. Many of the heuristics from behavioral economics contribute to the consumer internalities. For example, in the context of energy efficiency present bias leads consumers to focus more on upfront costs as opposed to operating costs. With respect

[2] Fowlie et al. (2015) also provide evidence that energy savings from engineering estimates are likely overstated.

to energy efficiency, Allcott et al. (2014) present a model of internalities that shows these failures are large and important; distortions in the energy markets double the welfare gains from a carbon tax. Identifying internalities has important policy implications; Heutel (2015) shows that Pigouvian taxes are not optimal to address both externalities and internalities such as present bias.

There are several applied studies that document consumers' failures to make energy investment decisions consistent with standard economic models. Attari et al. (2010) show that consumers have poor knowledge about the energy consumption of various activities. Importantly for the energy efficiency decision, consumers underestimate the energy consumption of large appliances. In related research, Jacobsen (2015) shows that consumers do not respond to energy prices when purchasing energy efficient appliances. Thus, consumers are likely unaware of both energy consumption and prices, making informed decisions on energy efficiency investments challenging.

A new strand of research aims at improving consumers decisions by providing more information at the time of purchase. A common approach is changing the labels on appliances that inform consumers about the operating costs, and relative energy efficiency. Newell and Siikamäki (2014) show that different energy labels have an impact on how much consumers are willing to pay for reduced energy costs in hot water systems. Additionally, once Newell and Siikamäki (2014) incorporate individual discount rates into the analysis consumers appear to make decisions consistent with expected utility theory, whereas using a standard (5%) discount rate implied that consumers undervalued savings from energy efficiency. Davis and Metcalf (Forthcoming) show that incorporating local energy prices into labels improves consumers decisions - while average investment in efficiency stays the same it shifts from low energy cost regions to high cost regions.

A common finding in the broader economics literature is that consumers seem to be making mistakes, either due to behavioral biases or lacking adequate information to make informed decisions. There has been a growth in literature about financial literacy, which describes how consumers lack the basic skills to make many important decisions related to financial planning and retirement. Lusardi and Mitchell (2014) review the literature on financial literacy and highlight the glaring lack of consumer competence in this area. The research on financial literacy has focused on major financial decisions such as debt and retirement planning, but there are parallels with the energy efficiency investments. Both decisions require combining technical information with complex mathematical calculations. Additionally, both financial investments and purchasing large energy durables are environments with a large degree of uncertainty.[3]

2.1 Policy Context

We study the impact of financial literacy and labeling information on investments in energy efficiency in the market for residential hot water systems, henceforth "water-heater". Our study took place in the greater metropolitan area of Melbourne, Australia. According to the Australian government water heaters comprise roughly one quarter of residential energy consumption, making them an important good in aggregate energy demand (Commonwealth of Australia Department of Industry, 2014). A water heater can be classified by two main characteristics: fuel type and tank type. The primary fuel types are gas, electric, and solar. Solar systems generally are supplemented by either gas or electric power. The tank size is differentiated by either storage systems that heat a full tank or instantaneous (instant) systems that only heat up water as it is being used. Instant systems generally are more energy efficient. Water heater are a good product to examine energy efficiency because the primary form of differentiation is through operating costs. While some prefer an instant system since it is less likely to run out of hot water, most consumers focus on upfront and operating costs when making their purchase decisions.

Since water heater are a major component of household energy use, they are a common target of government energy efficiency policies. One such policy in Australia is the Home Energy Efficiency Upgrade Program (henceforth "Efficiency Program"), which provided subsidies for low income home owners to upgrade their hot water system with an energy efficient model. The Efficiency Program was administered by the Brotherhood of St. Laurence, a non-profit organization.[4] There are many similar government policies such as the Weatherization Assistance Program in the United States. Many of these programs are means tested in order to alleviate the burden of high energy bills for low income households. These programs are politically attractive because they not only serve as a distributional policy, but also help reduce environmental externalities. Alleviating behavioral biases that reduce investments in energy efficiency is an additional benefit.

Similar to other programs, the Efficiency Program had expert recommendations regarding the specific investment built into the program. When a consumer inquired about the Efficiency Pro-

[3] While the stock market and portfolio selection has obvious sources of uncertainty, many facets of purchasing energy durables are also subject to uncertainty such as of current and future energy consumption, future energy prices, and how long a household will remain in their home.

[4] The Efficiency Program was funded by the Low Income Energy Efficiency Program, a the Commonwealth of Australia program.

gram, the first step was to conduct a personal visit to learn more about the specific needs of the consumer, provide more information about the program, and offer recommendations for specific systems. The recommendations were generated through software that took inputs about factors related to energy use (e.g. number of occupants, length of shower, etc.) to provide estimates of upfront and operating costs of several systems. Through this process the consumer has a viable choiceset from which to select a water heater. Other programs have similar features that consist of a home energy audit, where an expert offers advice on the types of energy efficiency investments available to the consumer. However, the consumer still makes the final decision and this allows us to assess whether they are choosing water heater that minimize their expected lifetime costs. The Efficiency Program offered lower subsidies for gas systems ($350-500) and higher subsidies for solar systems ($2000-2500).

Table 1 shows a subset of data from the Efficiency Program. Importantly, we have data not only on the water heater that the participant installed, but also the alternative recommended water heaters that were shown to the participant by the Efficiency Program representative. Most participants were shown three or four water heaters. We calculate the lifetime discounted costs, which include both upfront costs and discounted running costs, for a range of discount rates. In the Efficiency Program 46-54% of the participants did not choose the cheapest system from a lifetime cost perspective. The average cost of the mistake was roughly 10% of the lifetime costs of the system. As seen by the last two rows of Table 1 the cost minimizing system generally had lower energy costs than the chosen systems, which is consistent with an energy efficiency gap. These finding are based on a small sample of individuals, and are primarily used to motivate the problem of consumer mistakes in the energy durables market. Even when consumers have substantial assistance from experienced professionals looking out for their best interests they do not make decisions consistent with a standard economic model.

Table 1: Hot Water System Preferences in Subsidy Program

	5%	10%	Mean(IDR)
Avg. lifetime discounted costs (AUD)	3305	3085	2898
Proportion of cost minimization choices	0.54	0.46	0.52
Avg. cost of mistake (AUD)	321	276	263
Energy costs of cost minimizing systems (AUD)	111	114	140
Energy costs of non-cost minimizing systems (AUD)	222	206	192

Note: The table is based on average how water system installations of participants in the the Home Energy Efficiency Upgrade Program in Melbourne Australia. The columns represent different discount rates for calculating the lifetime discounted costs. There were 78 participants who were shown three to four systems. The data in the table are based on their selected choices relative to systems that they were shown, but did not select. The program was ongoing at the time of data collection.

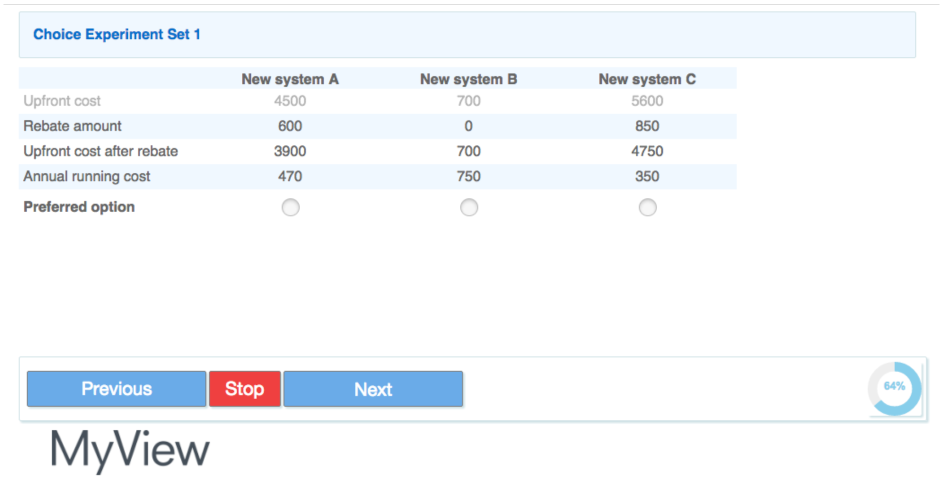
3 Design and Data

3.1 Choiceset Design

Our primary data are generated from a survey conducted during 2015 in the greater metropolitan area of Melbourne, Australia. A professional survey company recruited 1358 respondents from a representative online panel. The primary inclusion criteria was that the respondent owned their home, since they are more likely to be familiar with the water heater purchase decision. Additionally, we oversampled low income households in order to ensure that we were able to generate inference about the population of interest for the Efficiency Program: low income homeowners. The primary component of the survey was a choice experiment about the water heater purchase decision.

We offered a forced choice (no status quo option) among three generic hot water systems. The three attributes in the choiceset were net upfront costs, annual operating costs, and the size of the government subsidy. The respondents were told that all systems were under warranty for ten years. We employed a Bayesian optimal design to select the levels of the attributes. The priors for upfront costs and running costs were adapted from Wasi and Carson (2013). We used diffuse priors for all other parameters. Since we were primarily concerned with the interactions of the preferences for running costs with our financial literacy and other variables we optimized the design to include these interactions. The levels of the attributes were drawn from the distribution of running costs and operating costs from the recommendations that the Efficiency Program provided to their participants. Thus, the levels are realistic for consumers in the Australian market for hot water systems. An example choiceset is shown in Figure 1.

Figure 1: Example Choiceset



Note: This is an example of a choiceset without the payback period. See Figure A.1 in the Appendix for an example of a choiceset with the payback period information.

3.2 Financial Literacy

We elicit financial literacy using three standard questions from the financial literacy literature as shown in Lusardi and Mitchell (2014), and developed by Lusardi and Mitchell (2008) and Mitchell and Lusardi (2011). The first question asks about compound interest, the second is about inflation, and the last question tests the knowledge of volatility of individual stocks versus mutual funds. We augment the three standard questions with three questions about the hot water system purchase decision. The first hot water-specific question is about the cumulative value of operating cost compared to upfront costs. The second question asks the respondent to calculate the payback period for a more energy efficient system relative to a cheaper more energy intensive system. The last question examines the opportunity costs of capital when buying a more expensive system. The full list of financial literacy questions is shown in Figure A.2 in the Appendix.

In addition to financial literacy we also elicit consumers rate of time preferences and risk aversion. Discount rates are estimated using an incentivized choice between $1000 in one month and $1000 +$X in seven months based on Coller and Williams (1999). Respondents make choices between less money soon or more money later for a range of X. For each value of X respondents choose between the $1000, $1000 +$X, or indifference. See Figure A.4 in the Appendix for the complete choice task. We elicit risk based on the risk lottery of Eckel and Grossman (2002). This task asks the respondent to select one of seven different lotteries. All the lotteries have two options, each of which has a 50% chance of being selected. The lotteries sequentially have higher expected payoff and higher variance, and the selection of lottery can be mapped to a coefficient of relative risk aversion (CRRA) from the constant relative risk aversion utility function. See Figure A.6 in the Appendix for the complete choice task.

In order to elicit accurate preference parameters and financial literacy all three behavioral tasks are incentivized. For the discount rate and risk aversion tasks, the participants are informed that one of the respondents will be selected at random, and will receive the payoff from the choice task. The questions in the financial literacy questions were worth 25 panel points for a correct answer and -5 panel points for an incorrect answer in order to discourage random guessing. The respondents could also receive zero panel points for answering "Do not know". The instructions for each task (provided in Figures A.5 A.7 A.3 in the Appendix) explain how the respondents are paid for each behavioral task.

Overall the respondents performed well on the financial literacy questions relative to prior studies, as seen in Table 2. Panel A presents the data summarized Lusardi and Mitchell (2014) from the 2004 HRS Planning Module, and Panel B shows the responses to the same questions in our survey. Except for the first question, where our sample performed substantially better, the answers to common questions are quite similar. The respondents in our sample performed better on each question in terms of correct answers. One key difference is that we incentivized accurate responses, which may have caused respondents to exert more effort when completing the questions. Panel C presents the responses to the water heater-specific questions. Most people understood the basic arithmetic of upfront costs versus running costs. However, the respondents were challenged by more complex questions that involve calculating payback periods and the opportunity cost of capital. Less than half of the respondents answered each of these questions correctly, which highlights the complexity of purchasing energy durables.

3.3 Data

Summary statistics for demographic, attitudinal, and behavioral variables are presented in Table 3. Roughly 38% of the sample has income above $65,000, which is approximately the median income in Australia at the time of the study. The relatively low income distribution is due to our sampling strategy, where we oversample low income households to be able to appropriately make inferences on low income subsamples to advise the Efficiency Program. Over 33% of the respondents have

Table 2: Financial Literacy Responses

	Correct	Incorrect	DK	Refuse
Panel A: Lusardi & Mitchell (2014)				
Compound Interest	67.1	22.2	9.4	1.3
Inflation	75.2	12.4	9.9	1.5
Stock Risk	52.3	13.2	33.7	0.9
Panel B: Our Survey - Financial Literacy	Correct	Incorrect	DK	Refuse
Compound Interest	85.1	8.9	6	0
Inflation	76.9	14.7	8.5	0
Stock Risk	56.3	8.3	35.3	0
Panel C: Additional Hot Water Questions	Correct	Incorrect	DK	Refuse
Upfront vs. Running Costs	90.4	4	5.7	0
Payback Period	39.7	42.5	17.8	0
Opportunity Cost of Capital	44.7	31.4	23.9	0

Note: Panel A shows data on three financial literacy questions shown in Lusardi and Mitchell (2014). Panel B shows data for the same questions for our sample and Panel C shows the additional context-specific financial literacy questions.

a college degree or higher and 45% are male. Since environmental preferences are important in energy efficiency purchases we also ask whether consumers pay a premium for green power and whether they support a carbon tax.[5] We ask how many times the respondent has purchased a hot water systems for their home to assess the role of experience in energy efficiency decisions. Lastly we present the behavioral parameters. The mean discount rate is 18.8%, which is high compared to conventional parameters, but similar to those elicited in Newell and Siikamäki (2014). The sample is risk relatively risk averse, with no risk loving participants. The financial literacy metric we use in our econometric models is the total earnings. Respondents receive $0.25 for each correct answer, so the maximum earnings is $1.50. The average earnings was a little over $1 with a standard deviation of roughly 30 cents.

[5] Ma and Burton (2016) show that energy efficiency decisions are affected by pro-environmental preferences and warm glow, so we elicit these questions to control for those preferences.

Table 3: **Summary Statistics**

Statistic	N	Mean	St. Dev.	Min	Max
Income > \$65,000	1,176	0.372	0.483	0	1
College Degree	1,166	0.336	0.473	0	1
High School or Less	1,166	0.178	0.382	0	1
Pay for Green Power	1,358	0.105	0.307	0	1
Support Carbon Tax	1,358	0.376	0.485	0	1
Hot Water Systems Purchased	1,358	1.325	1.193	0	11
Discount Rate	1,358	0.188	0.155	0.025	0.500
Risk Aversion (CRRA)	1,358	0.950	0.776	0.000	2.180
Financial Literacy	1,358	1.054	0.313	0.100	1.500

Note: The variables Income, College, Male, Green Power, and Carbon Tax are all represented as indicator variables, and the mean is the fraction equal to one. Discount rates are percents, risk aversion is CRRA, and financial literacy is measured in term of the respondents' earnings in the financial literacy tasks.

4 Econometric Models

Our analysis is framed within the random utility model (RUM) (McFadden, 1974) where consumers choose between a set of discrete alternatives with utility specified as

$$U_{ijt} = Vijt + \epsilon_{ijt}. \tag{1}$$

Equation 1 models the utility that consumer i receives for alternative j in choice occasion t as a deterministic component ($V_{ijt} = X'_{ijt}\beta$) and an unobserved component (ϵ_{ijt}). Selecting the type I extreme value distribution for the unobserved component ϵ_{ijt} leads to the logit family of models. We estimate three types of discrete choice models to analyze the relationship between financial literacy and energy efficiency investments. All three models allow for flexible substitution patterns such that we do not need to assume independence of irrelevant alternative required for the standard multinomial logit model. First, we estimate a mixed logit model (MXL) in willingness to pay (WTP) space to estimate the effect of financial literacy on investments in energy efficiency. We test the robustness of this result by estimating a latent class logit (LCL) model where financial literacy is a predictor of class membership. Lastly we model financial literacy as a driver of scale heterogeneity in a generalized multinomial (GMNL). This tests whether financial literacy affects the "randomness" of choices, where more random choices are less consistent with a model of rational investment in energy efficiency.

4.1 Mixed Logit model in WTP space

Let utility for the purchase a hot water system from the RUM be defined as

$$U_{ijt} = \lambda_i Net_{ijt} + \phi_i Run_{ijt} + \psi_i Sub_{ijt} + \epsilon_{ijt} \tag{2}$$

where Net_{ijt} is the net upfront cost, Run_{ijt} is the annual operating costs and Sub_{ijt} is the size of the subsidy. We use the MXL model developed by Revelt and Train (1998) to incorporate unobserved preference heterogeneity by modeling the attributes as random parameters with continuous distributions. The type I extreme value has variance $\sigma_i^2(\pi^2/6)$, and the model is identified by either normalizing σ_i to a constant or by dividing through all the coefficients by σ_i. Thus in practice $\lambda = \tilde{\lambda}_i/\sigma_i$, $\beta = \tilde{\phi}_i/\sigma_i$, and $\psi = \tilde{\psi}_i/\sigma_i$, and Train and Weeks (2005) term this specification estimation in preference space. If the estimated coefficients are independent this specification assumes the scale term μ_i does not vary by individual, which may not hold in practice. Since WTP normalizes the preference parameters by the cost parameter, in our case λ_i, the individual scale term cancels out. When the goal is to estimate the preference parameters in monetary terms this specification also has attractive features in both interpretation and estimation.[6] Hole and Kolstad (2012) show that in addition to facilitating interpretation, estimation in WTP space in practice can fit the data better and generate more realistic WTP distributions. The model in WTP space is thus

$$U_{ijt} = \lambda_i[Net_{jt} + \delta_i Run_{jt} + \theta_i Sub_{jt}] + \epsilon_{ijt} \tag{3}$$

where $\delta_i = \phi_i/\lambda_i$ and $\theta_i = \psi_i/\lambda_i$. The scale term is incorporated into the coefficient on Net_{ijt} and cancels out of δ_i and θ_i. We estimate heterogeneity in the WTP for energy efficiency by interacting respondent characteristics, including financial literacy, with Run_{ijt}. The choice probabilities of the MXL, where we collapse the deterministic component of utility to $X'\beta$, is specified as

$$P_{ijt} = \int \frac{\exp(X'_{ijt}\beta)}{\sum_{j\in J}\exp(X'_{ijt}\beta)} f(\beta|\mu)d\beta. \tag{4}$$

[6] For example the ratio of two random variables, such as two normally distributed random variables, is not always well defined.

The choice probabilities of the MXL model therefore are weighted averages of the observable component of utility. The weights are determined by the density $f(\beta|\mu)$, where μ are the distributional statistics such as the mean and variance that are estimated from the data. There is no closed form for the parameters in the model and therefore the estimates are approximated through numerical simulation (Train, 2009).

4.2 Latent Class Logit

Whereas the MXL model specifies preference heterogeneity with continuous distributions the LCL model uses a nonparametric specification of heterogeneity by estimating discrete mass at fixed points. Train (2008) shows that this model can be estimated for many classes using an expectation-maximization algorithm. This leads to a model where the choice probabilities are specified as

$$P_{ijt} = \prod_{c=1}^{C} \pi_c \frac{\exp(X'_{ijt}\beta_c)}{\sum_{j \in J} \exp(X'_{ijt}\beta_c)} \tag{5}$$

where β_c is a unique parameter vector for each class c of the total set of classes C, and π_c sums to one. A standard multinomial logit model is used to generate the class membership probabilities as a function of respondent characteristics. In this model we focus on how financial literacy affects the discrete classes as a robustness test for the continuous MXL specification.

4.3 Generalized Multinomial Logit

The concept of scale heterogeneity has received more attention in recent years due in part to the work by Fiebig et al. (2010) that shows the empirical advantages of explicitly modeling scale heterogeneity. The generalized multinomial logit (GMNL) nests scale heterogeneity within a model that includes preference heterogeneity. This can be seen by making the scale term explicit in the standard logit model and then multiplying through

$$U_{ijt} = X'_{ijt}\beta + \epsilon_{ijt}/\sigma_i \tag{6}$$

$$U_{ijt} = X'_{ijt}(\beta\sigma_i) + \epsilon_{ijt} \tag{7}$$

Equation (7) shows the standard scale heterogeneity model, which Fiebig et al. (2010) extends to incorporate both scale and preference heterogeneity. We focus on a special case that Fiebig et al. (2010) call the GMNL-I where σ_i essentially scales up the importance of all the attributes, and thus reduces the relative importance of the error term. The GMNL-I specifies utility as

$$U_{ijt} = X'_{ijt}(\beta\sigma_i + \eta_i) + \epsilon_{ijt} \tag{8}$$

where η_i is a k-dimensional vector specifying preference heterogeneity that is additively separable from scale heterogeneity.[7] In this setting $\sigma_i = exp(\bar{\sigma} + Z'_i\gamma + \tau\epsilon_{0i})$ where $\bar{\sigma}$ is a constant, Z_i are respondent characteristics that influence the scale heterogeneity, and $\epsilon_{0i} \sim N(0, 1)$. Thus, as τ increases so too does the degree of scale heterogeneity, or randomness in the responses. We normalize E[σ_i]=1 in order to identify the model and keep the interpretation of β as the mean parameter vector. In order to maintain the normalization $Z'_i\gamma$ is a decreasing function of τ and thus as E[σ_i] increases the choices are more consistent with the deterministic component of utility. We use financial literacy and other demographics to determine whether financial literacy not only affects the WTP for energy efficiency but makes choices more consistent with the estimated preferences. This addresses whether any impact of financial literacy on the WTP for energy efficiency is simply due to differences in preferences or a model of consumer mistakes.

Another way to consider scale heterogeneity within the decision to purchase a hot water system is the consistency of implicit discount rates. As shown in Wasi and Carson (2013), it is possible to use the coefficients on net upfront costs and running costs (or the WTP which is a combination of these two parameters) to back out an implicit discount rate that rationalizes the choice of any hot water system. If each respondent only made one choice a single discount rate could perfectly rationalize their choice. However, in our setting each respondent completes five choice sets, thus opening up the possibility that a single discount rate cannot perfectly rationalize their choices. Consumers with more weight on the attributes are more consistent with having a single discount rate relative to those with more weight on the error. Therefore, modeling financial literacy as a predictor of scale heterogeneity helps address whether consumers with low financial literacy invest less in energy efficiency, but are also making choices that are less consistent with a standard economic model of preferences.

[7] We also estimate more flexible models that allow interaction between scale and preference heterogeneity. The Appendix describes these models and presents their results.

5 Results

The presentation of the econometric results is structured as follows. First, we show the impact of financial literacy on the WTP for energy efficiency using both MXL and LCL models. Second, we estimate how financial literacy affects scale heterogeneity within a GMNL-I model to test whether increased financial literacy decreases the randomness of choices. Third, to better understand how specific aspects of financial literacy impacts energy efficiency decisions we decompose our aggregate financial literacy metric into questions focusing on generic financial information, water heater-specific information, and each question individually. Lastly, we present several robustness checks.

5.1 Does financial literacy increase the WTP for energy efficiency?

Table 4 presents the results from MXL logit models in WTP space. Since our model is normalized by upfront costs the coefficient on running costs has the interpretation of the willingness to pay to reduce annual running costs by $1 over the life of the water heater.[8] Running costs and the subsidy are modeled as normally distributed random parameters, and the implicit price parameter that incorporates the scale term is lognormally distributed. Our parameter(s) of interest is the coefficient on running costs, and the relevant interactions. We will interchange referring to the running cost parameter, and the associated interactions, as the WTP for energy efficiency and WTP to avoid running or operating costs. In our base model, shown in column (1) of Table 4, consumers are willing to pay $8.8 to avoid an additional dollar of annual running costs. The subsidy is also positive and significant, indicating that respondents consider the subsidy a signal of quality or feel that they are getting a good deal with a highly subsidized model.

Columns (2) - (5) of Table 4 show the impact of financial literacy on the WTP for energy efficiency, sequentially adding more controls and accounting for heterogeneity. Financial literacy increases the WTP for energy efficiency across all models; a result that is consistently significant at the 5% level. Adding additional controls such as rate of time preferences, risk aversion, and demographics increases the magnitude of the effect, indicating that financial literacy is not simply a proxy for discount rates or standard demographic characteristics.[9] This is consistent with results

[8]In the standard model the running cost parameter is negative since consumers prefer lower costs. We transform the coefficients in order to interpret the running cost parameters, and associated interactions, as WTP for energy efficiency.

[9]We actually use the number of times the times the respondent selected options A ($1000 in one month) rather than the actual discount rates since the IDRs require assumptions at the boundaries.

presented by Lusardi and Mitchell (2014) where controlling for demographics or the endogeneity of financial literacy generally increases the magnitude of its effect on economic outcomes. In column (4), which controls for behavioral parameters and demographics, a one standard deviation increase in financial literacy increases the WTP for energy efficiency by 9% over the base coefficient.

The model presented in Column (5) investigates heterogeneity in financial literacy by interacting financial literacy with the payback period dummy.[10] The motivation for this model is that the impact of financial literacy on the WTP for energy efficiency may be a function of the complexity of the choice environment. The coefficient on the payback period dummy is positive and statistically significant at the 10% level indicating that payback period information increases the WTP for energy efficiency. The increased investment in energy efficiency due to the payback period information is primarily driven by respondents with low financial literacy, as seen by the negative and significant coefficient on the triple interaction term between running costs, financial literacy, and payback period (Running*Fin. Lit.*Payback). Another way to interpret the triple interaction is that additional information decreases the importance of financial literacy. When we exogenously increase the information available to the consumer, thereby decreasing the complexity of the decision, the impact of financial literacy decreases.

In addition to the MXL model we also estimate a LCL model where the class membership is driven by financial literacy. All the models assume two unique classes in order to focus the interpretation on the impact of financial literacy on the WTP for energy efficiency. The results, presented in Table 5, are structured as follows: the parameters from Class 1 are in the first panel, the parameters from Class 2 are in the second panel, the predictors of class membership are in the third panel, and model specific information is in the bottom panel. The first column of Table 5 shows the base results of the LCL model. The WTP for energy efficiency for each class, calculated as the ratio of running costs to net upfront costs, is presented in the bottom panel of the table. Two distinct classes appear: Class 1 has a high WTP for energy efficiency, and Class 2 has a low WTP for energy efficiency. Our parameters of interest in the LCL model are the demographics that predict class membership, which are presented in panel labeled "Class 1 Membership Model"

[10]We examine the effect of the payback period in more detail in Table A.1 in the Appendix. Dividing the sample by the presence of the payback period does not generate substantially different results. When interacting the payback period with the main attributes (net upfront costs, running costs, and subsidy) none of the interaction terms are statistically significant. Therefore, we can conclude that adding the information on payback periods does not substantially change preferences for energy efficiency.

Table 4: **Mixed Logit Regressions WTP for Energy Efficiency**

	(1) Base	(2) Fin. Lit.	(3) Behavioral	(4) Demographics	(5) Payback
Random Coefficients					
Running Costs	8.884***	8.596***	8.783***	5.901***	6.044***
	(0.150)	(0.305)	(0.592)	(0.852)	(1.498)
Subsidy	0.177***	0.164***	0.164***	0.181***	0.176***
	(0.018)	(0.013)	(0.014)	(0.026)	(0.031)
Behavioral Interactions (Fixed)					
Running*Fin. Lit.		0.808***	1.226**	1.804***	2.470***
		(0.182)	(0.602)	(0.688)	(0.748)
Running*Discount Rate			-0.137**	-0.181***	-0.139*
			(0.058)	(0.055)	(0.082)
Running*Risk Aversion			-0.394	-0.263	-0.206
			(0.291)	(0.241)	(0.430)
Demographic Interactions (Fixed)					
Running*Green Power				0.888*	1.767***
				(0.463)	(0.618)
Running*Carbon Tax				2.319***	2.850***
				(0.439)	(0.961)
Running*High Income				0.765*	1.217*
				(0.433)	(0.677)
Running*College				1.058**	-0.327
				(0.425)	(0.644)
Running*Low Edu.				0.005	-1.046
				(0.677)	(1.379)
Running*Experience				0.075	-0.216
				(0.096)	(0.250)
Payback Interactions (Fixed)					
Running*Payback					2.258*
					(1.257)
Running*Fin. Lit.*Payback					-2.291**
					(1.105)
Std. Dev.					
Running Costs	7.250***	7.302***	7.489***	7.615***	7.489***
	(0.243)	(0.520)	(0.476)	(0.478)	(0.532)
Subsidy	0.256***	0.215***	0.212***	0.035	0.016
	(0.028)	(0.012)	(0.013)	(0.064)	(0.027)
Net Upfront Costs (LN)	1.315***	1.501***	1.446***	1.064***	1.094***
	(0.118)	(0.167)	(0.138)	(0.148)	(0.180)
Observations	6790	6790	6790	5415	5415
Individuals	1358	1358	1358	1083	1083

Note: These are the results of the mixed logit regressions on the choice of hot water systems. The model is estimated in WTP space, where we normalize all parameters using net upfront costs, which is log-normally distributed to account for unobserved cost sensitivity. Running costs and the subsidy are random parameters using a normal distribution to account for unobserved heterogeneity. All other parameters are fixed coefficients. Standard errors clustered at the respondent level are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

in Table 5.[11] In particular we are interested in the effect of financial literacy on the probability of being in the high WTP class. In all the LCL models financial literacy increases the probability of being in the high WTP class, and the coefficient is consistently statistically significant. In fact, financial literacy is one of the few predictors of being in the high-WTP class along with supporting

[11] LCL models have $k-1$ class membership models where k is the number of classes. Since we only have two classes there is only one set of class membership predictors.

a carbon tax and being above the median income. The payback button and the interaction with financial literacy, are not statistically significant in the LCL model, although the effects work in the same direction as in the MXL model.

Since there are many simultaneous factors that impact the WTP for energy efficiency we plot the individual WTP for each individual in our sample based on the linear combination of the running cost parameter and the interaction terms with the individual covariate values based on the model in column (3) of Table 4. Panel A of Figure 2 superimposes a two-way density of individual WTP and financial literacy on top of a scatter plot of the actual model outputs. The colors and shapes of the points denote the green preferences of the consumers.[12] There is a clear trend towards higher financial literacy and higher WTP for energy efficiency. It is also clear that across the range of financial literacy values those with green preferences are willing to pay more for reduced operating costs. To isolate the role of financial literacy panel B of Figure 2 presents the same graph after removing "green" consumers, defined as those that either pay for green power or support a carbon tax. The same general trend holds, but the WTP values are lower. Respondents with very low WTP are respondents with below average financial literacy.

[12]Green preferences are categorized as three discrete levels: paying for green energy and supporting a carbon tax, either paying for green energy or supporting a carbon tax, and neither paying for green energy nor supporting a carbon tax.

Table 5: **Financial Literacy as a Predictor of Latent Heterogeneity**

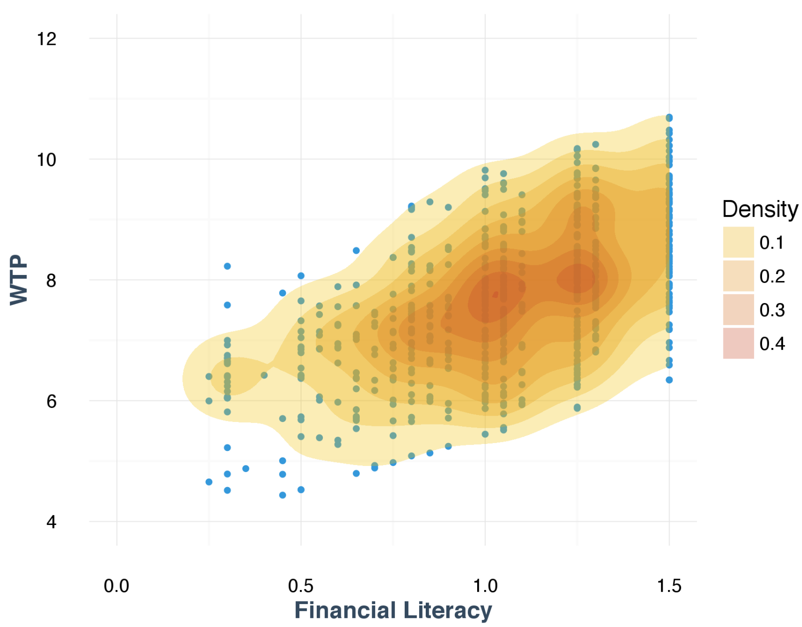
	(1) Base	(2) Fin. Lit.	(3) Behavioral	(4) Demographics	(5) Payback
Class 1 Parameters					
Running Costs	-0.966***	-0.978***	-0.982***	-0.964***	-0.966***
	(0.0422)	(0.0409)	(0.0417)	(0.0422)	(0.0425)
Net Upfront Costs	-0.0883***	-0.0911***	-0.0910***	-0.0936***	-0.0936***
	(0.00502)	(0.00497)	(0.00503)	(0.00506)	(0.00508)
Subsidy	0.0393***	0.0400***	0.0401***	0.0365***	0.0365***
	(0.00278)	(0.00274)	(0.00277)	(0.00286)	(0.00286)
Class 2 Parameters					
Running Costs	-0.251***	-0.231***	-0.239***	-0.113**	-0.116***
	(0.0362)	(0.0370)	(0.0364)	(0.0443)	(0.0442)
Net Upfront Costs	-0.0685***	-0.0654***	-0.0660***	-0.0528***	-0.0531***
	(0.00475)	(0.00491)	(0.00481)	(0.00547)	(0.00545)
Subsidy	-0.00843**	-0.00984***	-0.00923***	-0.00472	-0.00442
	(0.00333)	(0.00342)	(0.00334)	(0.00379)	(0.00379)
Class 1 Membership Model					
Fin. Lit.		0.858***	0.862***	0.883***	1.010***
		(0.197)	(0.198)	(0.236)	(0.335)
Discount Rate			-0.0237	-0.0120	-0.0127
			(0.0159)	(0.0184)	(0.0185)
Risk Aversion			-0.0419	-0.0389	-0.0344
			(0.0819)	(0.0946)	(0.0950)
Green Power				0.428	0.427
				(0.262)	(0.263)
Carbon Price				0.430***	0.429***
				(0.156)	(0.156)
High Income				0.306*	0.310**
				(0.158)	(0.158)
Low Edu.				-0.203	-0.207
				(0.208)	(0.209)
High Edu.				-0.116	-0.115
				(0.171)	(0.172)
Experience				0.0437	0.0423
				(0.0658)	(0.0658)
Payback					0.314
					(0.493)
Fin. Lit.*Payback					-0.242
					(0.459)
Constant	0.161	-0.697***	-0.587**	-0.854***	-1.026**
	(0.104)	(0.220)	(0.240)	(0.306)	(0.409)
Observations	6,790	6,790	6,790	5,415	5,415
Respondents	1,358	1,358	1,358	1,083	1,083
WTP Class 1	10.9	10.7	10.8	10.3	10.3
WTP Class 2	3.7	3.5	3.6	2.1	2.2
Classs 1 Share	0.5	0.5	0.5	0.6	0.6
Log Lik.	-6239.6	-6229.9	-6228.6	-4941.9	-4941.7

Note: These are the results of the latent class logit regressions on the choice of hot water systems. There are two classes and respondent characteristics are used to model the membership probability into each class. The WTP for each class and the share of Class 1 are in the bottom panel. Standard errors clustered at the respondent level are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

Figure 2: Individual WTP and Financial Literacy

A: Including Green Consumers

B: Excluding Green Consumers



Note: The graphs show a scatter plot of the predicted WTP for energy efficiency and financial literacy along with a two-way density. The predicted WTP values are linear predictions of all interactions with running costs based on the regression presented in column (4) of Table 4. Panel A presents shapes for consumers with different green preferences and Panel B excludes consumers with green preferences.

5.2 Does financial literacy make choices more consistent?

We show from both the MXL and LCL models that financial literacy increases the WTP for energy efficiency. This is an important component in understanding the energy efficiency gap since it links low financial literacy to decreased investment in energy efficiency. However, the energy efficiency gap states that investment is sub-optimally low from an individual welfare perspective, implying that consumers make mistakes. The analysis so far simply shows that less financially literate consumers have lower preferences for operating costs, but their preferences may still be consistent with a standard economic model. We investigate how financial literacy affects the consistency of choices within the RUM by modeling financial literacy as a driver of scale heterogeneity.

Table 6 shows the results of GMNL-I regressions that account for both preference and scale heterogeneity. The model is estimated in preference, as opposed to WTP, space, but the independence assumptions are not needed since we explicitly allow for scale heterogeneity. The focus of these regressions is on the second set of parameters labeled, "Predictors for Scale Heterogeneity", particularly the coefficient on financial literacy.[13] As seen in columns (2) - (5) the coefficient on financial literacy is positive and significant in all specifications. A positive coefficient as a predictor of scale heterogeneity assigns more weight to the vector of parameters and relatively less weight to the random term. The results show that financial literacy makes the choices less random, which is more consistent with a rational consumer preference structure.

[13] The predictors of scale heterogeneity are fixed coefficients in contrast to the primary attributes that are modeled as normal random variables.

Table 6: Impact of Financial Literacy on Scale Heterogeneity

	(1) Base	(2) Fin. Lit.	(3) Behavioral	(4) Demographics	(5) Payback
Random Coefficients					
Running Costs	-0.754***	-0.205***	-0.191***	-0.140***	-0.140***
	(0.0384)	(0.0381)	(0.0388)	(0.0335)	(0.0410)
Net Upfront Costs	-0.0909***	-0.0244***	-0.0228***	-0.0176***	-0.0173***
	(0.00445)	(0.00450)	(0.00457)	(0.00416)	(0.00503)
Subsidy	0.0179***	0.00483***	0.00447***	0.00425***	0.00408***
	(0.00207)	(0.00103)	(0.00104)	(0.00112)	(0.00131)
Predictors for Scale Heterogeneity					
Fin. Lit.		1.192***	1.190***	1.183***	1.181***
		(0.152)	(0.154)	(0.172)	(0.224)
Discount Rate			0.00976	0.00708	0.00615
			(0.0103)	(0.0115)	(0.0105)
Risk Aversion			0.0327	0.0356	0.0365
			(0.0562)	(0.0664)	(0.0611)
Green Power				-0.205	-0.196
				(0.163)	(0.153)
Carbon Price				0.174*	0.213**
				(0.0942)	(0.0906)
High Income				0.249***	0.285***
				(0.0905)	(0.0880)
Low Edu.				-0.00905	-0.0847
				(0.125)	(0.125)
High Edu.				-0.149	-0.179*
				(0.0987)	(0.0975)
Experience				0.0692*	0.0671*
				(0.0390)	(0.0397)
Payback					-0.0926
					(0.395)
Fin. Lit.*Payback					0.0954
					(0.322)
Std. Dev.					
Running Costs	0.617***	0.610***	0.610***	-0.550***	-0.550***
	(0.0358)	(0.0357)	(0.0357)	(0.0290)	(0.0320)
Net Upfront Costs	-0.00204	-0.00621	-0.00662	0.00146	0.0110**
	(0.0106)	(0.00929)	(0.00935)	(0.0112)	(0.00469)
Subsidy	0.0373***	0.0375***	0.0374***	-0.0224***	0.0240***
	(0.00318)	(0.00312)	(0.00312)	(0.00406)	(0.00455)
τ	0.770***	0.591***	0.598***	0.498***	-0.474***
	(0.0879)	(0.131)	(0.125)	(0.110)	(0.0992)
Observations	6,790	6,790	6,790	5,415	5,415
Respondents	1,358	1,358	1,358	1,083	1,083
Log Lik.	-6147.2	-6104.8	-6104.1	-4874.6	-4876.2

Note: These are the results of the generalized multinomial logit on the choice of hot water systems where the γ parameter constrained to one (GMNL-I). All attributes are modeled as normally distributed random coefficients to account for preference heterogeneity. The set of fixed parameters in the Predictors for Scale Heterogeneity models the scale term as a function of respondent characteristics. Standard errors clustered at the respondent level are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

5.3 What type of financial literacy is most important?

Our metric of financial literacy is based on the answers to six questions: three of which are generic questions used in the previous literature on financial decisions (Lusardi and Mitchell, 2014) and three are specific to investments in hot water systems. In this section we disaggregate the financial literacy variable to account for financial information alone, water heater information alone, and each question individually. The specific questions are summarized in Table 2.

Table 7 shows the results of regressions where the financial literacy variable is the earnings from all questions, only the first three questions (Financial) or the last three questions (Hot Water System). All regressions are based on models that also include interactions with demographics - column (4) of Tables 4, 5, and 6. All other coefficients are suppressed to save space. In all models there are no statistically significant differences for the various specifications of financial literacy. In the MXL model the effect of financial literacy on the WTP for energy efficiency is largest when using the generic financial literacy questions and insignificant when using the water heater-specific questions. Generic information also has a larger effect on the probability of being in the high WTP class in the LCL model. The effect of financial literacy on scale heterogeneity is slightly larger for water heater-specific questions than for financial questions.

Next, we replace the earnings from the financial literacy questions with six separate dummies that take on the value of one if the respondent answered the relevant financial literacy question correctly. We again use the specification of column (4) of Tables 4, 5, and 6. The results are presented in Table 8, where the rows are the individual financial literacy dummies and the columns correspond to the MXL, LCL, and GMNL models respectively. Columns (1) and (2) show that the WTP for energy efficiency is primarily driven by understanding inflation (Q2) and the payback period (Q5). Similarly column (3) shows that inflation and payback period are important for making consistent choices along with understanding the opportunity cost of capital. Therefore both generic financial information and energy-specific information are important drivers of investments in energy efficiency. The results need to be interpreted in the context that the correlation between the financial literacy questions is reasonably strong. Figure A.9 shows the correlation between all the financial literacy metrics used in this section.

Table 7: Financial vs. Energy-Specific Literacy

	(1) All Questions	(2) Financial	(3) Hot Water System
MXL: Financial Literacy Interactions			
Running*Fin. Lit.	1.804***	2.273**	2.263
	(0.688)	(0.999)	(3.678)
LCL: Class Membership Model			
Fin. Lit.	0.883***	1.329***	1.056***
	(0.236)	(0.383)	(0.390)
GMNL: Predictors for Scale Heterogeneity			
Fin. Lit.	1.183***	1.474***	1.677***
	(0.172)	(0.278)	(0.265)
Observations	5,415	5,415	5,415
Respondents	1,083	1,083	1,083
LCL: WTP Class 1	10.3	10.4	10.3
LCL: WTP Class 2	2.1	2.3	2.1
LCL: Classs 1 Share	0.6	0.6	0.6

Note: The table presents results from three different models for different specifications of the financial literacy variable. The rows of column (1) correspond to the regressions in column (4) of Tables 4, 5, and 6. All other coefficients are included in the models and are suppressed for space. Column (2) restricts earnings to the first three financial literacy questions and column (3) restricts the earnings to the last three financial literacy questions.

Table 8: Disaggregating Financial Literacy Questions

	(1) WTP for Energy Efficiency	(2) Class 1 Membership Probability	(3) Predictor for Scale Heterogeneity
Fin. Lit. (Q1)	-0.889	-0.036	0.302
	(0.936)	(0.230)	(0.223)
Fin. Lit. (Q2)	1.632***	-0.604**	0.615*
	(0.457)	(0.213)	(0.253)
Fin. Lit. (Q3)	0.374	-0.061	-0.061
	(0.610)	(0.162)	(0.096)
Fin. Lit. (Q4)	0.053	0.203	0.205
	(0.820)	(0.291)	(0.282)
Fin. Lit. (Q5)	1.902***	-0.549***	0.452***
	(0.476)	(0.167)	(0.088)
Fin. Lit. (Q6)	-1.104	0.124	0.206*
	(0.717)	(0.156)	(0.090)
Observations	5,415	5,415	5,415
Respondents	1,083	1,083	1,083
Model	MXL	LCL	GMNL
WTP Class 1		2.0	
WTP Class 2		10.3	
Classs 1 Share		0.43	

Note: The table presents results from three different models for different specifications of the financial literacy variable. The columns correspond to the regressions in column (4) of Tables 4, 5, and 6 respectively replacing the financial literacy variable with the six separate dummies for each question. All other coefficients are included in the models and are suppressed for space.

5.4 Robustness

We perform several robustness checks to ensure the validity of the results. One concern with using stated data is that financial literacy might be simply picking up the effort exerted on the survey. While we do not observe effort directly we can observe the time each respondent spent completing the survey. Higher measures of financial literacy are correlated with more time spent on the survey. The median survey time was 22 minutes and a one standard deviation increase in financial literacy is associated with taking additional 2 minutes on the survey. While very long survey times can be indicative of respondents taking a break and coming back to the survey, respondents who completed the survey very quickly may not have given it their full attention. Therefore we curtail the sample by dropping respondents in the the bottom 1st and 5th percentiles of survey time. The results for the MXL, LCL, and GMNL models are presented in Table 9.[14] The results for all three models are consistent even after dropping respondents who answered the survey very quickly, suggesting that financial literacy is not just a proxy for effort exerted on the survey.

As an alternative to evaluating scale heterogeneity as a proxy for consistent preferences we also evaluate whether consumers are making optimal choices in an expected utility framework by calculating the discounted lifetime costs of each system. Similar to Newell and Siikamäki (2014) we assume that a hot water system lasts for 13 years.[15] Next, we create an indicator variable for each choice set that specifies whether the respondent selected the water heater with the lowest lifetime costs - the "optimal choice" - based on a range of discount rates. We then model the binary decision for optimal choices as a function of respondent characteristics in a linear probability probability model.

In these models the dependent variables is a dummy equal to one if the respondent selected the lowest-cost option based on the assumed discount rate. We use this dummy variable as our dependent variable in a linear probability model that regresses the optimal choice dummy on financial literacy payback period and a set of demographic controls. We calculate the discounted lifetime costs for four separate discount rates: 5%, 10%, the mean of the all the IDRs, and the

[14]Similar to Tables 7 and 8 we use the model with demographics (column (4) of Tables 4, 5, and 6) while suppressing all variables except financial literacy to save space.

[15]Although our survey states that the water heater are under warranty for 10 years 30% of our sample owns a water heater over 10 years old. Additionally, we inform them that, "A hot water system a large purchase for a household that will impact energy bills for 10 years or more".

Table 9: Robustness to Time Spent on Survey

(a) WTP for Energy Efficiency: Mixed Logit in WTP Space

	(1) Base	(2) 1st	(3) 5th
Financial Literacy Interactions			
Running*Fin. Lit.	1.804***	1.844**	1.710**
	(0.688)	(0.938)	(0.706)
Observations	5,415	5,390	5,195
Individuals	1,083	1,078	1,039

(b) WTP for Energy Efficiency: Latent Class Logit

	(1) Base	(2) 1st	(3) 5th
Class 1 Membership Model			
Fin. Lit.	0.883***	-0.813***	-0.692***
	(0.236)	(0.239)	(0.251)
Observations	5,415	5,390	5,195
Respondents	1,083	1,078	1,039
WTP Class 1	10.3	2.1	2.2
WTP Class 2	2.1	10.3	10.2
Classs 1 Share	0.6	0.4	0.4

(c) Scale Heterogeneity: GMNL

	(1) Base	(2) 1st	(3) 5th
Predictors for Scale Heterogeneity			
Fin. Lit.	1.183***	1.193***	1.076***
	(0.172)	(0.174)	(0.173)
Observations	5,415	5,390	5,195
Respondents	1,083	1,078	1,039

Note: The first column in each panel presents the regressions displayed in in column (4) of Tables 4, 5, and 6 respectively. The second and third columns restrict the sample to respondents that were above the 1st and 5th percentile in the time it took to complete the survey.

respondent's IDR.[16] Respondents select the optimal water heater at a rate of 39-42% depending on the discount rate - a relatively poor rate given that completely random selection would yield a rate of 33% since their are three alternatives.[17] When using the individual discount rates we also explore removing respondents who were always indifferent in the discount rate task or were at the high or low extremes that correspond to very low (2.5%) or high (50%) discount rates.

Table 10 shows the results of the linear probability model regressions with robust standard errors clustered at the respondent level. For standard discount rates financial literacy increases the

[16] We take a different approach compared to Newell and Siikamäki (2014) who use the individual discount rates to parameterize running costs in terms of discounted operating costs. Our main reason for using the individual discount rates as a control variables is that discount rates are measured with error. For example Harrison et al. (2002) and Andersen et al. (2008) use a full sample of respondents to estimate population level discount rates using a structural model.

[17] Respondents select the optimal choice 42% using the 5% discount rate, 41% with the 10% discount rate, 40% with the IDR, and 39% with the mean of the IDRs.

probability of selecting the cheapest water heater by roughly 4 percentage points, and the effect is statistically significant at the 10% level. The magnitude is similar using the IDRs (Column (4)), but the effect is not statistically significant. Since there is noise in estimating the IDR, column (5) uses the IDR to calculate the optimal choice and removes all respondents who were always indifferent, and thus assigned the median IDR. In this model financial literacy increases the optimal choice by almost 5 percentage points and the results are statistically significant at the 5% level. Column (6) uses the IDR while removing individuals who were either indifferent or at the extremes - due to either always choosing money now or always choosing money later - the magnitude of the financial literacy coefficient increases to 6.5%.

The payback period has significant positive effects using standard discount rates and the mean of the IDRs, but the effects are smaller and insignificant when using individual discount rates. Most other effects are insignificant, though in several specifications green preferences decrease the probability of selecting the optimal choice. However, these consumers likely place higher value on the public good components of reduced energy consumption, and thus the coefficients on green power and carbon price should not be interpreted as green consumers making mistakes.

Lastly, we estimate more flexible GMNL models that allow interactions between scale and preference heterogeneity. These correspond to the GMNL and GMNL-II models of Fiebig et al. (2010). Tables A.2 and A.3 in the Appendix show that the results are robust to more flexible specifications of the GMNL model.

Table 10: Optimal Choice Regressions - Linear Probability

	5%	10%	Mean(IDR)	IDR	IDR	IDR
	(1)	(2)	(3)	(4)	(5)	(6)
Fin. Lit.	0.042*	0.043*	0.039*	0.032	0.045*	0.065**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.024)	(0.031)
Payback	0.032**	0.027**	0.025*	0.011	0.011	−0.012
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.018)
Risk Aversion	0.003	0.009	0.010	0.015*	0.019*	0.016
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.013)
Green Power	−0.026	−0.026	−0.026	−0.065***	−0.074***	−0.051*
	(0.022)	(0.022)	(0.021)	(0.021)	(0.022)	(0.029)
Carbon Price	0.011	0.003	−0.005	−0.021	−0.020	−0.020
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.019)
High Income	0.046***	0.024*	−0.008	0.007	0.004	0.011
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.019)
College	0.001	0.006	0.009	0.024	0.029*	0.035*
	(0.015)	(0.015)	(0.015)	(0.015)	(0.017)	(0.021)
Low Edu.	−0.011	−0.007	0.002	0.009	0.014	0.015
	(0.019)	(0.019)	(0.018)	(0.018)	(0.021)	(0.027)
Experience	−0.004	−0.001	0.001	0.005	0.005	0.011
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.008)
Respondents	1,111	1,111	1,111	1,111	887	569
Observations	5,555	5,555	5,555	5,555	4,860	2,845
Adjusted R^2	0.005	0.003	0.002	0.004	0.006	0.006

6 Conclusion

Financial literacy is a mix of cognitive ability and investment in human capital that is shown to have a major impact on many important financial decisions Lusardi and Mitchell (2014). We contribute to this growing literature be analyzing whether financial literacy plays a role in the investment of energy durables. Energy efficiency is a particularly compelling setting to assess the role of consumer mistakes because many studies find that consumers do not make privately beneficial investments in energy efficiency. We show that financial literacy is a driver for selecting the level of energy efficiency of hot water systems in a stated preference setting. In our preferred specification a one standard deviation financial literacy increases the WTP for energy efficiency by 9%. We also show that financial literacy reduces scale heterogeneity, thus making choices more consistent with a standard model of consumer preferences. The results are robust to a host of modeling specifications and sample restrictions. Both generic financial literacy and energy efficiency-specific knowledge generate similar results. The findings indicate that cognitive abilities are an important driver of investments in energy efficiency, with important private and public welfare implications.

The fact that financial literacy elicited in multiple domains generates the similar results provides evidence for a model of consumers with a lack of capacity to make optimal choices in a variety of settings. While making selecting the wrong water heater may not be as damaging as mis-allocating retirement savings, it conveys important information about the way that consumers make decisions. If financial literacy is an explanation for making mistakes with respect to all consumer durables the cumulative welfare effects may be substantial. The broader the extent of markets affected by financial literacy the greater the returns to investments in policies that improve society's overall level of financial literacy.

Our results open up several exciting opportunities for future research regarding the role of financial literacy in consumer behavior. While financial literacy may provide a broad signal of poor decision, making it may be possible to hone in on more specific mechanisms such as low numeracy, or behavioral biases such as improperly discounting future and/or uncertain costs. Additionally, it will be valuable to test the effect of financial literacy on purchases of consumer in a revealed preference setting. Lastly, understanding the role of financial literacy may help to design energy efficiency policy. Since many energy efficiency programs target disadvantaged communities that may have lower levels of financial literacy it is important that participants are presented with the information necessary to make privately beneficial decisions about investments in energy efficiency.

References

Allcott, Hunt and Cass R Sunstein, "Regulating Internalities," *Journal of Policy Analysis and Management*, 2015, *34* (3), 698–705.

_ **and Michael Greenstone**, "Is There an Energy Efficiency Gap?," *Journal of Economic Perspectives*, 2012, *26* (1), 3–28.

_ **and Nathan Wozny**, "Gasoline prices, fuel economy, and the energy paradox," *Review of Economics and Statistics*, 2014, *96* (5), 779–795.

_ **, Sendhil Mullainathan, and Dmitry Taubinsky**, "Energy policy with externalities and internalities," *Journal of Public Economics*, apr 2014, *112*, 72–88.

Ameli, Nadia, Nicola Brandt et al., "What Impedes Household Investment in Energy Efficiency and Renewable Energy?," *International Review of Environmental and Resource Economics*, 2015, *8* (1), 101–138.

Andersen, Steffen, Glenn W. Harrison, Morten I. Lau, and E. Elisabet Rutström, "Eliciting Risk and Time Preferences," *Econometrica*, 2008, *76* (3), 583–618.

Attari, Shahzeen Z, Michael L DeKay, Cliff I Davidson, and Wändi Bruine De Bruin, "Public perceptions of energy consumption and savings," *Proceedings of the National Academy of sciences*, 2010, *107* (37), 16054–16059.

Coller, Maribeth and Melonie B. Williams, "Eliciting Individual Discount Rates," *Experimental Economics*, 1999, *127*, 107–127.

Commonwealth of Australia Department of Industry, "Product Profile: Solar Water Heaters," Technical Report 2014.

Davis, Lucas W. and Gilbert E. Metcalf, "Does Better Information Lead to Better Choices? Evidence from Energy-Efficiency Labels," *Journal of the Association of Environmental and Resource Economists*, Forthcoming.

Eckel, Catherine C. and Philip J. Grossman, "Sex differences and statistical stereotyping in attitudes toward financial risk," *Evolution and Human Behavior*, 2002, *23*, 281–295.

Fiebig, Denzil G, Michael P Keane, Jordan Louviere, and Nada Wasi, "The generalized multinomial logit model: accounting for scale and coefficient heterogeneity," *Marketing Science*, 2010, *29* (3), 393–421.

Fowlie, Meredith, Michael Greenstone, and Catherine Wolfram, "Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program," *NBER Working Paper Series*, 2015, *21331.*

Gerarden, By Todd, Richard G Newell, and Robert N Stavins, "Deconstructing the Energy-Efficiency Gap : Conceptual Frameworks and Evidence," *American Economic Review*, 2015, *105* (5), 183–186.

Harrison, Glenn W, Morten I. Lau, and Melonie B. Williams, "Estimating Individual Discount Rates in Denmark: A Field Experiment," *American Economic Review*, 2002, *92* (5), 1606–1617.

Heutel, Garth, "Optimal policy instruments for externality-producing durable goods under present bias," *Journal of Environmental Economics and Management*, 2015, *72*, 54–70.

Hole, Arne Risa and Julie Riise Kolstad, "Mixed logit estimation of willingness to pay distributions: a comparison of models in preference and WTP space using data from a health-related choice experiment," *Empirical Economics*, 2012, *42* (2), 445–469.

Jacobsen, Grant D., "Do energy prices influence investment in energy efficiency? Evidence from energy star appliances," *Journal of Environmental Economics and Management*, 2015, *74*, 94–106.

Jaffe, Adam B. and Robert N. Stavins, "The energy-efficiency gap What does it mean?," *Energy Policy*, 1994, *22* (10), 804–810.

Lusardi, Annamaria and Olivia S Mitchell, "Planning and Financial Literacy: How Do Women Fare?," *The American Economic Review*, 2008, *98* (2), 413–417.

_ and _ , "The Economic Imortance of Financial Literacy: Theory and Evidence," *Journal of Economic Literature*, 2014, *52* (1), 5–44.

_ , Pierre-Carl Michaud, and Olivia S. Mitchell, "Optimal Financial Knowledge and Wealth Inequality," *Journal of Political Economy*, Forthcoming.

Ma, Chunbo and Michael Burton, "Warm glow from green power: Evidence from Australian electricity consumers," *Journal of Environmental Economics and Management*, 2016, *78*, 106–120.

Mani, Anandi, Sendhil Mullainathan, Eldar Shafir, and Jiaying Zhao, "Poverty impedes cognitive function," *Science*, 2013, *341* (6149), 976–980.

McFadden, Daniel, "Conditional logit analysis of qualitative choice behavior," in P. Zarembka, ed., *Frontiers in Econometrics*, New York: Academic Press, 1974, pp. 105–142.

McKinsey, July, "Unlocking energy efficiency in the US economy," Technical Report, Technical Report, McKinsey & Company 2009.

Mitchell, Olivia S and Annamaria Lusardi, *Financial literacy: Implications for retirement security and the financial marketplace*, Oxford University Press, 2011.

Newell, Richard G and Juha Siikamäki, "Nudging Energy Efficiency Behavior: The Role of Information Labels," *Journal of the Association of Environmental and Resource Economists*, 2014, *1* (4), 555–598.

Revelt, David and Kenneth Train, "Mixed logit with repeated choices: households' choices of appliance efficiency level," *Review of Economics and Statistics*, 1998, *80* (4), 647–657.

Train, Kenneth, *Discrete choice methods with simulation*, Cambridge university press, 2009.

_ and Melvyn Weeks, "Discrete choice models in preference space and willingness-to-pay space," in R. Scarpa and A. Albernin, eds., *Applications of simulation methods in environmental and resource economics*, Springer, 2005, pp. 1–16.

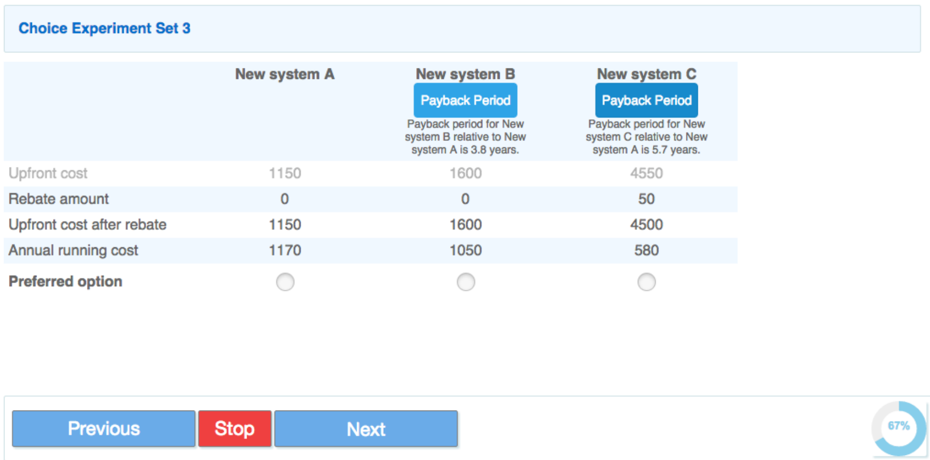
Train, Kenneth E, "EM algorithms for nonparametric estimation of mixing distributions," *Journal of Choice Modelling*, 2008, *1* (1), 40–69.

Wasi, Nada and Richard T. Carson, "The influence of rebate programs on the demand for water heaters: The case of New South Wales," *Energy Economics*, nov 2013, *40*, 645–656.

Appendix

A Survey and Preference Elicitation

Figure A.1: Example Choiceset with Payback Information



Note: This is an example of a choiceset that includes the payback period, with the payback information revealed.

Figure A.2: Financial Literacy Elicitation

Suppose you had $100 in a free savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow:

Please select one answer

- More than $102
- Exactly $102
- Less than $102
- Do not know

Suppose that the interest rate on your free savings account was 1% per year and inflation was 2% per year. After 1 year, with the money in this account would you be able to buy:

Please select one answer

- More than today
- Exactly the same as today
- Less than today
- Do not know

Do you think that the following statement is true or false? "Buying a single company stock usually provides a safer return than a stock mutual fund."

Please select one answer

- True
- False
- Do not know

A hot water system has an upfront cost of $1500 and annual running costs of $400. If the hot water system lasts 10 years which costs are larger in total dollar terms over the full 10 years?

Please select one answer

- Upfront cost
- Running costs
- Do not know

Hot water system A that has an upfront cost of $1500 and annual running costs of $400. Hot water system B has an upfront cost of $3500 and annual running costs of $200. How long will it take to pay back the extra upfront costs of system B through savings in running costs? Assume a 0% interest rate for this question.

Please select one answer

- 1-2 years
- 3-4 years
- 5-6 years
- 7-8 years
- 9-10 years
- More than 10 years
- Do not know

You have $5000 dollars in your savings account. You need to purchase a hot water system, and all the remaining money will purchase a risk-free government bond that earns 10% interest per year. Hot water system A that has an upfront cost of $1500 and annual running costs of $400. Hot water system B has an upfront cost of $3500 and annual running costs of $200. Which system should you buy in order to earn the most money possible after accounting for purchasing the system, running costs, and interest payments?

Please select one answer

- System A
- System B
- Do not know

Note: The first three questions are standard financial literacy questions as shown in Lusardi and Mitchell (2014). We developed the last three questions, which are specific to purchasing energy durables, on our own.

Figure A.3: Financial Literacy Instructions

Instructions for Task 3

- The final task asks factual questions about several investment decisions.
- In all the prior tasks there were no correct or incorrect answers, but in this task there are correct answers.
- These questions are intended to be straightforward; there are no hidden tricks.

Kindly note that standard panel reward scheme will apply for the survey and **additional token** will be provided based on the following:

How you will be paid:

- Please assume for this task that 100 Panel Points = $1
- You will earn 25c in panel points for each correct answer.
- Please select the "Don't know" option if you do not know how to answer the question.
- In order to discourage completely random guessing we will pay 5c in panel points if you select the "Don't know" option.
- The total number of panel points you can earn will range from 0-150. You will earn zero if you answer all questions incorrectly, and you will earn 150 panel points if you answer all answers correctly.

Note: These are the instructions that preceded the financial task.

Figure A.4: Individual Discount Rate Elicitation

Task 1

Please select one answer per row

	Credit A (in 1 month)	Credit B (in 7 months)	Decision		
			I prefer A	I prefer B	I am indifferent
1	$1,000	$1,010			
2	$1,000	$1,025			
3	$1,000	$1,038			
4	$1,000	$1,051			
5	$1,000	$1,064			
6	$1,000	$1,077			
7	$1,000	$1,091			
8	$1,000	$1,104			
9	$1,000	$1,132			
10	$1,000	$1,160			
11	$1,000	$1,217			
12	$1,000	$1,278			

Note: This is the task to elicit individual discount rates, as first developed by Coller and Williams (1999).

Figure A.5: Individual Discount Rate Elicitation Instructions

Instructions for Task 1

- This task will ask you to make decision about having money now or money later.
- On the next screen you will be asked whether you prefer $1000 in one month or some amount more than $1000 in seven months. You will be given several such options where we gradually increase the amount of extra money you receive in seven months.
- For each row choose whether you prefer the $1000 now (Choice A) or the $1000 plus some extra (Choice B) in seven months, or indicate that you are indifferent between the two options.

How you will be paid:

- We will randomly choose one respondent who will earn money based on their decision.
- If you are selected the money will be mailed to you either in one month or seven months.
- To determine your earnings we will randomly choose a number from 1-12 with equal probability that selects which of the 12 decision rows will determine your payoff.

Note: These are the instructions that preceded the individual discount rate task.

Figure A.6: Risk Aversion Elicitation

Task2

Lottery	Outcome A (50%)	Outcome B (50%)	Decision Select exactly one row
Lottery 1	$300	$300	○
Lottery 2	$250	$375	○
Lottery 3	$200	$475	○
Lottery 4	$150	$600	○
Lottery 5	$100	$725	○
Lottery 6	$50	$800	○
Lottery 7	$0	$850	○

Note: This is the task to elicit risk aversion, as first developed by Eckel and Grossman (2002).

Figure A.7: Risk Aversion Elicitation Instructions

Instructions for Task 2

- Task 2 will help us understand your attitudes towards risky decisions.
- In this part of the study you will select from among seven different lotteries the one lottery you would like to play. The seven different lotteries are listed on the next screen. You must select one and only one of these lotteries. Each lottery has two possible monetary rewards that are equally likely. If you are selected your compensation for this part of the study will be determined by: 1) which of the seven lotteries you select; and 2) which of the two possible rewards are drawn.

How you will be paid:

- We will randomly choose one respondent who will earn money based on their decision. The selection of a respondent will be separate from Task 1.
- If you are selected we will base your payment on your preferred lottery.
- For example: if are chosen and you select Lottery 4 and Outcome A occurs, you will be paid $150. If Outcome B occurs, you will be paid $600.
- For every lottery each event has a 50% chance of occurring.

Note: These are the instructions that preceded the risk aversion task.

B Payback Period Regressions

Table A.1: Mixed Logit Regressions - Payback Period

	(1) Base	(2) No Payback	(3) Yes Payback	(4) Payback Interaction
Random Coefficients				
Running Costs	8.884***	8.548***	9.163***	8.808***
	(0.150)	(0.423)	(0.258)	(0.289)
Subsidy	0.177***	0.201***	0.160***	0.182***
	(0.018)	(0.037)	(0.018)	(0.022)
Payback Interactions (Fixed)				
Running*Payback				-0.105
				(0.553)
Subsidy*Payback				-0.039
				(0.040)
Net*Payback				0.024
				(0.067)
Std. Dev				
Running Costs	7.250***	6.936***	6.788***	7.154***
	(0.243)	(0.600)	(0.323)	(0.375)
Subsidy	0.256***	0.241***	0.311***	0.257***
	(0.028)	(0.071)	(0.023)	(0.031)
Net Upfront Costs (LN)	1.315***	0.752***	1.641***	1.323***
	(0.118)	(0.189)	(0.000)	(0.136)
LL	-6,090.663	-2,510.056	-3,569.26	-6,090.247
BIC	12,240.86	5,074.306	7,194.875	12,269.79
AIC	12,193.33	5,032.111	7,150.519	12,198.49
Observations	6,790	2,790	4,000	6,790
Individuals	1,358	558	800	1,358

These are the results of the mixed logit regressions on the choice of hot water systems. The model is estimated in WTP space, where we normalize all parameters using net upfront costs, which is log-normally distributed to account for unobserved cost sensitivity. Running costs and the subsidy are random parameters using a normal distribution to account for unobserved heterogeneity. Standard errors clustered at the respondent level are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

C Robustness for Scale Heterogeneity

Table A.2: Impact of Financial Literacy on Scale Heterogeneity - GMNL

	(1) Base	(2) Fin. Lit.	(3) Behavioral	(4) Demographics	(5) Payback
Random Coefficients					
Running Costs	-1.671***	-0.540***	-0.513***	-0.115***	-0.124***
	(0.291)	(0.146)	(0.147)	(0.0326)	(0.0445)
Net Upfront Costs	-0.187***	-0.0600***	-0.0571***	-0.0142***	-0.0152***
	(0.0332)	(0.0163)	(0.0164)	(0.00405)	(0.00553)
Subsidy	0.0280***	0.00902***	0.00853***	0.00331***	0.00356**
	(0.00512)	(0.00264)	(0.00271)	(0.00105)	(0.00143)
Predictors for Scale Heterogeneity					
Fin. Lit.		1.084***	1.094***	1.377***	1.305***
		(0.228)	(0.230)	(0.219)	(0.294)
Discount Rate			-0.00438	0.00488	0.00491
			(0.0152)	(0.0122)	(0.0121)
Risk Aversion			0.0723	0.0264	0.0255
			(0.0807)	(0.0821)	(0.0820)
Green Power				-0.246	-0.245
				(0.209)	(0.210)
Carbon Price				0.173	0.172
				(0.105)	(0.105)
High Income				0.342***	0.344***
				(0.128)	(0.128)
Low Edu.				-0.0432	-0.0441
				(0.141)	(0.142)
High Edu.				-0.143	-0.142
				(0.124)	(0.125)
Experience				0.0758	0.0753
				(0.0468)	(0.0465)
Payback					-0.146
					(0.484)
Fin. Lit.*Payback					0.144
					(0.399)
Std. Dev.					
Running Costs	1.251***	0.440***	0.420***	0.470***	0.473***
	(0.229)	(0.0959)	(0.0979)	(0.0862)	(0.0891)
Net Upfront Costs	0.0665***	0.0218***	0.0209***	-0.00119	-0.00103
	(0.0154)	(0.00473)	(0.00476)	(0.00835)	(0.00877)
Subsidy	0.0452**	0.0147***	0.0139***	-0.0207***	-0.0209***
	(0.0222)	(0.00330)	(0.00330)	(0.00521)	(0.00531)
τ	1.383***	1.389***	1.398***	0.591***	0.587***
	(0.183)	(0.245)	(0.233)	(0.157)	(0.156)
γ	0.00212	0.143	0.141	0.961***	0.959***
	(0.0604)	(0.128)	(0.136)	(0.0471)	(0.0497)
Observations	6,790	6,790	6,790	5,415	5,415
Respondents	1,358	1,358	1,358	1,083	1,083
Log Lik.	-6106.1	-6085.1	-6084.5	-4869.6	-4869.5

Note: These are the results of the generalized multinomial logit on the choice of hot water systems. All attributes are modeled as normally distributed random coefficients to account for preference heterogeneity. The set of fixed parameters in the Predictors for Scale Heterogeneity models the scale term as a function of respondent characteristics. Standard errors clustered at the respondent level are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table A.3: **Impact of Financial Literacy on Scale Heterogeneity - GMNL-II**

	(1) Base	(2) Fin. Lit.	(3) Behavioral	(4) Demographics	(5) Payback
Random Coefficients					
Running Costs	-1.671***	-0.588***	-0.555***	-0.302***	-0.246***
	(0.286)	(0.130)	(0.132)	(0.0744)	(0.0761)
Net Upfront Costs	-0.187***	-0.0654***	-0.0617***	-0.0359***	-0.0293***
	(0.0319)	(0.0147)	(0.0146)	(0.00892)	(0.00909)
Subsidy	0.0280***	0.00964***	0.00903***	0.00714***	0.00584***
	(0.00509)	(0.00257)	(0.00269)	(0.00218)	(0.00208)
Predictors for Scale Heterogeneity					
Fin. Lit.		0.988***	1.004***	0.943***	1.130***
		(0.244)	(0.222)	(0.207)	(0.273)
Discount Rate			-0.00426	-0.00774	-0.0242
			(0.0145)	(0.0130)	(0.0182)
Risk Aversion			0.0752	-0.0169	-0.0226
			(0.0763)	(0.0758)	(0.106)
Green Power				-0.402**	-0.393**
				(0.171)	(0.173)
Carbon Price				0.0998	0.105
				(0.106)	(0.105)
High Income				0.365***	0.354***
				(0.127)	(0.124)
Low Edu.				-0.0660	-0.0759
				(0.145)	(0.142)
High Edu.				-0.0629	-0.0663
				(0.124)	(0.123)
Experience				0.0755	0.0702
				(0.0559)	(0.0530)
Payback					0.307
					(0.450)
Fin. Lit.*Payback					-0.394
					(0.370)
Discount Rate*Payback					0.0348
					(0.0255)
Risk Aversion*Payback					0.00423
					(0.148)
Std. Dev.					
Running Costs	1.251***	0.435***	0.412***	0.251***	0.205***
	(0.226)	(0.0982)	(0.0995)	(0.0639)	(0.0641)
Net Upfront Costs	0.0666***	0.0228***	0.0215***	0.00118	0.000864
	(0.0149)	(0.00576)	(0.00598)	(0.00164)	(0.00124)
Subsidy	0.0454**	0.0146*	0.0137**	0.00597***	0.00498***
	(0.0187)	(0.00863)	(0.00616)	(0.00215)	(0.00188)
τ	1.381***	1.332***	1.345***	0.918***	0.904***
	(0.160)	(0.289)	(0.241)	(0.215)	(0.208)
Observations	6,790	6,790	6,790	5,415	5,415
Respondents	1,358	1,358	1,358	1,083	1,083
Log Lik.	-6106.1	-6085.9	-6085.3	-4883.1	-4881.3

Note: These are the results of the generalized multinomial logit on the choice of hot water systems where the γ parameter constrained to zero (GMNL-II). All attributes are modeled as normally distributed random coefficients to account for preference heterogeneity. The set of fixed parameters in the Predictors for Scale Heterogeneity models the scale term as a function of respondent characteristics. Standard errors clustered at the respondent level are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

D Additional material

Figure A.8: Correlations between Financial Literacy and Demographics

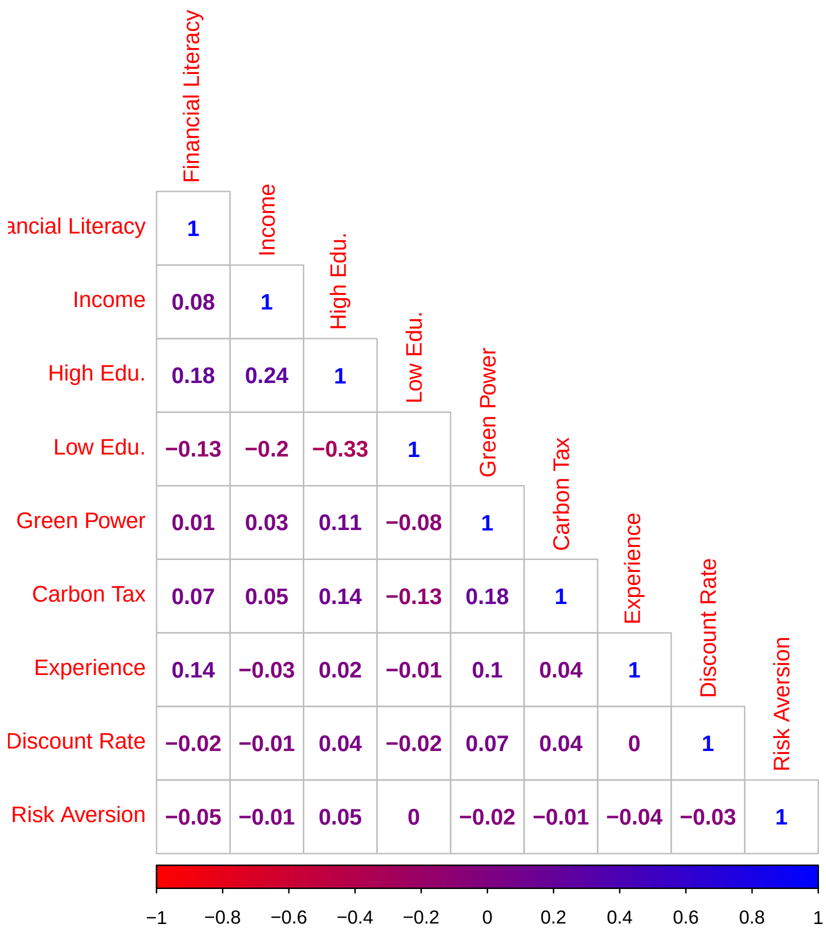


Figure A.9: Correlations between Financial Literacy Metrics