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Can information about energy costs affect consumers' choices? Evidence from a field experiment☆☆

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ABSTRACT

Whether consumers are fully informed and attentive when investing in energy efficiency is still hotly debated. We experimentally evaluate the role of imperfect information about or limited attention to energy costs in the demand for energy-consuming household durables in Switzerland. Using in-home visits, we collect unique data on the characteristics of participants' current home appliances and light bulbs. Our intervention exploits this data to provide customized information about the potential of monetary savings from adopting new, comparable, and efficient durables. We find a substantial information treatment effect on the energy efficiency of the newly purchased durables. A larger potential of monetary savings induces larger durables choices responses. These findings provide suggestive evidence that the informational content of our intervention played a significant role in determining the observed durables choices responses.

1. Introduction

Recent research has suggested that, when individuals make purchase decisions, they are not fully informed about some product characteristics, such as health plans' out-of-pocket costs (Abaluck and Gruber, 2011), sales taxes (Chetty et al., 2009) or shipping and handling charges (Brown et al., 2010). Specifically, the literature has proposed imperfect information about or limited attention to energy costs as a prominent explanation for the observation that, even though it appears some

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investments in energy-consuming durables ensure net monetary savings over their lifetime (McKinsey & Company, 2009), households often fail to make these investments (Allcott and Taubinsky, 2015).

There is an ongoing debate in the literature on the explanations for this phenomena, known as the “energy efficiency gap”. These reasons range from the idea that the private net benefits consumers obtain from investments in energy efficiency, as estimated by engineering models, are overstated (Fowlie et al., 2018), to the role various market and behavioral anomalies (Broberg and Kazukauskas, 2015; Gillingham and Palmer, 2014) play. In particular, although some empirical studies find imperfect information leads to underinvestment in energy efficiency (Newell and Siikamäki, 2014; Davis and Metcalf, 2016; Houde, 2018), other recent studies did not find this factor affecting investment decisions (Allcott and Sweeney, 2016; Allcott and Greenstone, 2017; Allcott and Knittel, 2019).

In this paper, we experimentally evaluate the role of imperfect information about or limited attention to the monetary costs of using home appliances and light bulbs in consumers’ investment efficiency.[1] This is an interesting context to study the role of imperfect information in consumers’ choices because of the private and social gains engineering models predict from adopting more efficient durable goods and the substantial empirical evidence that individuals have limited knowledge of electricity prices (Blasch et al., 2018). If they were imperfectly informed, consumers would underestimate (overestimate) the future monetary savings associated with higher energy efficiency, making them systematically biased against (in favor of) more energy efficient products. These biases could potentially reflect in a suboptimal timing of replacing the current household durables with new ones, or in a suboptimal newly purchased energy-consuming durables energy efficiency level. We then ask whether personalized information about the potential monetary savings from adopting energy efficient technologies affects the probability of purchasing new home appliances and light bulbs as well as the energy efficiency level of the newly purchased household durables.[2]

To answer these questions, we conducted a randomized field experiment with customers of two utilities in Switzerland. First, we randomly allocated an initial pool of 40,000, randomly selected, customers between a treatment group (29,000 households) and a control group (11,000 households). We then invited households allocated to the treatment group to take a survey and receive a free in-home visit. We only stated the purpose to be collecting information about their major home appliances’ and lighting’s energy efficiency. Around 460 households agreed to both completing the survey and accepting the baseline in-home visit. During the baseline in-home visits, we collected detailed information on the treatment group participants’ existing home appliances and lighting.[3] This information was used to recover the household durables’ manufacturer-declared electricity consumption for a given utilization level, and construct a measure of the individual household’s monetary savings potential from adopting new, comparable, and efficient appliances and light bulbs. Our approach provides particularly relevant monetary savings potentials because these are obtained based on home appliances that are available on the market and have the same physical characteristics of those currently used by the household. The average treated household has substantial savings potential, corresponding to around 110 and 190 CHF in annual electricity costs, from adopting new home appliances and light bulbs, respectively. We then sent a letter with customized information on the monetary costs of running their existing appliances and individual monetary savings potential to these households. One year after the informational intervention, we conducted a follow-up survey to collect data on post-treatment durables purchase and utilization choices. One year after the recruitment of the treatment group, the same recruitment process was implemented for the customers originally allocated to the control group. Around 180 households agreed to take the same survey and in-home visit, during which they were also simultaneously asked the follow-up questions on their purchase and utilization decisions in the previous year. Further, we asked questions about the appliances replaced in the previous year; we could thus ex-post reconstruct the baseline stock of appliances also for the control group. This design allowed us to obtain unique information on the manufacturers’ declared electricity consumption of the household durables the participants of our experiment purchased, before and after the informational intervention.

The validity of our experimental strategy is supported by several test results. We find no evidence of differential selection in taking the in-home visits between the treatment and control groups, or of substitution bias or selection into the follow-up survey among the treatment group. The standard tests of balance on observables show the treatment assignment was unconfounded. We lend additional credibility to the validity of our experimental design by showing there is no significant difference in the purchase decisions of households in treatment and control groups, before the informational intervention. Estimation of the treatment effects is thus obtained by simply comparing the actual purchase choices of treatment group and control group households in the post-treatment period. Although we find only minor differences between the sample and the national statistics for several individual and household characteristics, the final sample can hardly be representative of the general population considering the selection from the initial invitation to the in-home visits. While this does not affect the internal validity of our study, it represents a potential caveat for the generalizability of our results.

[1] As discussed in Sallee (2014), Caplin and Dean (2015) and Davis and Metcalf (2016), limited knowledge about energy costs may reflect either a rational trade-off between the costs of information acquisition and the expected benefits of learning or forms of irrationality in the individuals’ decision making process.

[2] In this paper, we take electricity consumption of home appliances for a given level of utilization as the main measure of their energy efficiency.

[3] We consider households’ choices related to refrigerators, separate freezers, dishwashers, washing machines, tumble dryers and light bulbs. Together, they accounted for around 50% of households’ electricity consumption in Switzerland in 2017 (data recovered in 2020 from https://www.bulletin.ch/de/news-detail/haushalt-stromverbrauch-gesunken.html (accessed 8 February 2022)).

We find a relevant impact of our intervention. In particular, while the information treatment does not significantly affect the overall probability that households purchase a new home appliance, we find a substantial response in terms of the newly purchased durables' energy efficiency. In particular, based on data obtained by the home appliances manufacturers, we find the intervention induces households to purchase durables that consume on average 14% less electricity for a given level of utilization. Moreover, conditional on the decision of purchasing a new light bulb, the intervention increases the probability that households purchase (at least) one energy efficient light bulb by around 8 percentage points. Because the baseline in-home visit is likely to have been a salient experience for participating households, these results may capture either the effects of information, or salience effects from the in-home visits, or both. To make progress into understanding whether information played a role in determining the response to the intervention, we then exploit data on the individual savings potential from the adoption of new energy-consuming durables (i.e., higher treatment intensity). The results show a larger response in purchase decisions among those households that, ex-ante, had the larger potential of savings from the adoption of efficient energy-consuming durables relative to the initial investment required to attain these savings. Further, we find those households told upgrading would have little savings potential or a relatively high price needed to be paid to attain these savings did not respond to the intervention, even though they were exposed to the same in-home visit. Finally, we find the personalized information treatment induced households to purchase home appliances with lower total lifetime costs, also when we consider individual-specific levels of utilization. Together, these results suggest the information provided through our intervention played a significant role in determining the observed behavioral choices response.

This paper is related to a broad literature that uses information treatments to study the role of limited knowledge in individuals' decision making in a variety of contexts, from social security to the take-up of social benefits (Duflo and Saez, 2003; Chetty and Saez, 2013; Bhargava and Manoli, 2015; Liebman and Luttmer, 2015). We show that providing personalized information about the energy costs of durables can induce a substantial investment efficiency response; this adds to previous studies demonstrating that customized information can improve consumer choices in different settings (Hastings and Weinstein, 2008; Bertrand and Morse, 2011; Kling et al., 2012; Byrne et al., 2018).

We also contribute to a growing body of economic research studying the role of information, certification, labels and inaccurate information on investment in energy efficiency (among others Allcott and Taubinsky 2015; Davis and Metcalf 2016; Houde 2018).[4] Specifically, this is one of the first papers that provides evidence on the role of imperfect information in consumers' choices of household durables purchases by exploiting a field experiment and data on actual purchase decisions. The most prominent studies investigating the role of imperfect information in consumers' misperception of energy efficiency in a similar setting consider only light bulbs (Allcott and Taubinsky, 2015), and those purchases require only small initial investments.[5]

Some recent works (e.g., Fowlie et al. 2018) explain individuals' underinvestment in energy efficiency as a result of an overstatement of the private benefits from energy efficiency investments; we show that investment in some energy efficient durables can yield positive private returns. Our work is especially complementary to Allcott and Knittel (2019) who found in an experimental setting that when providing consumers with information about vehicles fuel economy at the point of sale, there was no evidence American drivers are not informed about fuel costs when making their purchase decisions. In a different setting, we leveraged customized information, delivered at home, regarding potential monetary savings from using more efficient durables compared to existing durables; we show (some) consumers respond to information about energy costs of home appliances and light bulbs.

Previous studies have typically provided consumers with standardized information on energy costs as they are active in the marketplace or in a stated choice setting. In contrast, we exploit an experimental design that uses in-home visits and a customized informational intervention implemented before consumers access the marketplace. These features of our field study are important. First, using in-home visits allows us to compute individual potential monetary savings from investment in energy efficient products (i.e., treatment intensity). Exploiting the heterogeneity in treatment intensity, we can show that our intervention induced households' responses mainly through its informational content. Further, providing information at home before the consumers entered the market allows us to exclude that the intervention induced a durable choice response through enhanced salience of energy costs at the time of purchase.

The remainder of this paper is organized as follows. In Section 2, we sketch a simple conceptual framework to think about the informational intervention's effect. Section 3 describes the customized information treatment and the experimental design. In Section 4 we present the sample characteristics, and Section 5 presents the estimates of the treatment effects on households' durable choices and investment efficiency. Section 6 includes a discussion of the findings and presents our conclusions.

[4] The paper also relates to the recent contribution by d'Adda et al. (2020), who investigated the role of salience of energy costs in consumers' purchase choices of new refrigerators.

[5] While Allcott and Taubinsky (2015) show that providing information about energy costs increases the willingness to pay for energy efficient light bulbs in a stated preferences setting, they do not find significant effects on the actual consumers' behavior of purchase. Rodemeier and Löschel (2020) also analyze the role of information in investment in lighting efficiency. They randomize banners in an online store and find that, while some information (how much efficient lighting saves by percentage) increases investment in efficient lighting, more information (absolute savings) decreases demand for energy efficient light bulbs.

2. Conceptual framework

To describe the potential role of imperfect information about or limited attention to energy costs related to consumers' choices, we sketch a simple model in which a consumer chooses between two energy-consuming durable goods with different energy intensities using a framework similar to Allcott and Greenstone (2012). The problem of the consumer can be thought of as a problem of optimal investment in the presence of limited knowledge on the stream of future costs of operating the durable good.[6] Moreover, we can think of this problem as that of a consumer evaluating the replacement of the durable good currently in use.

In each period, the consumer decides how much capital to invest in a durable good that will provide a flow of utility from a level of utilization (i.e., energy services from the durable good) m in the following periods. The cost of producing these energy services depends on the technology of the good that has been chosen e and the electricity price c^e. Assume only two goods exist in the consumer's choice set, which differ only in their level of energy intensity e^A and e^B, with $e^A < e^B$, and require different initial investments P^A and P^B.[7] In a standard investment model with no market failures or behavioral anomalies in the individuals' decision making process, a consumer would choose to purchase the energy-consuming durable A over B only if:

$$\underbrace{\left(\sum_t \frac{c^e(m_B e_t^B - m_A e_t^A)}{(1+r)^t}\right)}_{\text{actual energy savings}} > \underbrace{P^A - P^B}_{\text{investment}} \quad (1)$$

where r is a constant discount factor. Other factors might influence the *experienced* utility from the purchase of the more energy efficient durable good. On the one hand, the consumer might obtain additional utility θ related, for instance, to the emotional reward from helping the environment or the possibility the more efficient product is also associated with more advanced features. On the other hand, purchasing the more energy efficient durable good may be associated with non-monetary costs γ, depending on the presence of search costs (which may vary depending on the individuals' opportunity cost of time) or market failures such as credit constraints.

Moreover, several market failures and behavioral anomalies, such as imperfect information about or limited attention to energy costs, present bias, or low computational skills can influence the individuals' valuation of the savings from energy efficiency, and then the *perceived* utility from the purchase of the more energy efficient durable good. In the presence of imperfect information about or limited attention to energy costs, the consumer will choose the more efficient durable A only if:

$$\underbrace{\Gamma(\xi)\left(\sum_t \frac{c^e(m_B e_t^B - m_A e_t^A)}{(1+r)^t}\right)}_{\text{perceived energy savings}} + \underbrace{\theta}_{\text{non-monetary benefits}} > \underbrace{P^A - P^B}_{\text{investment}} + \underbrace{\gamma}_{\text{non-monetary costs}} \quad (2)$$

where, as in Allcott et al. (2014), $\Gamma(\xi)$ is the valuation weight in the presence of behavioral and psychological anomalies, and $\xi = (c^e, e^B, e^A, r)$ is the set of parameters determining the gross utility gains from energy efficiency.

Clearly, imperfect information about or limited attention to energy costs might or might not explain under-adoption of energy efficient durables.[8] To isolate the role of imperfect information or limited attention, in this work we exploit an experimental design to provide individuals with customized information on energy costs. We then test the hypothesis that consumers are perfectly informed about and pay attention to the energy costs of home appliances and light bulbs, so that providing some consumers with information will not make them change their behavior of purchase compared to the individuals in the control group, that is:

$\frac{\Delta\Gamma(\xi)}{\Delta\xi} = 0.$

In this setting, any behavioral change induced by an informational intervention that increases the valuation of energy efficiency $\Gamma(\xi)$ through enhanced knowledge and then the *perceived* utility from purchasing a more energy efficient durable is clearly welfare increasing as long as the treatment does not affect investment or non-monetary costs.[9]

3. Informational intervention

We administered the randomized control trial in collaboration with two local utilities in Switzerland: Aziende Industriali di Lugano (AIL) and Stadtwerk Winterthur (SW). AIL serves around 97,000 households in the city of Lugano and some

[6] We consider individuals' limited knowledge as the result of a combination of imperfect information and limited attention. Clearly, this can reflect either irrationality in individuals' decision making or rationally inattentive behavior as in Caplin and Dean (2015).

[7] P^B may reflect scrappage costs when the good B represents the existent durable good.

[8] The latter might indeed simply reflect individuals' preference heterogeneity, present bias (see, e.g., Allcott et al. 2014), or the fact that the investment in the more energy efficient durable goods do not deliver (Fowlie et al., 2018).

[9] More generally, the informational intervention is welfare enhancing if the effect on energy savings is larger than the sum of the effects on investment and non-monetary costs.

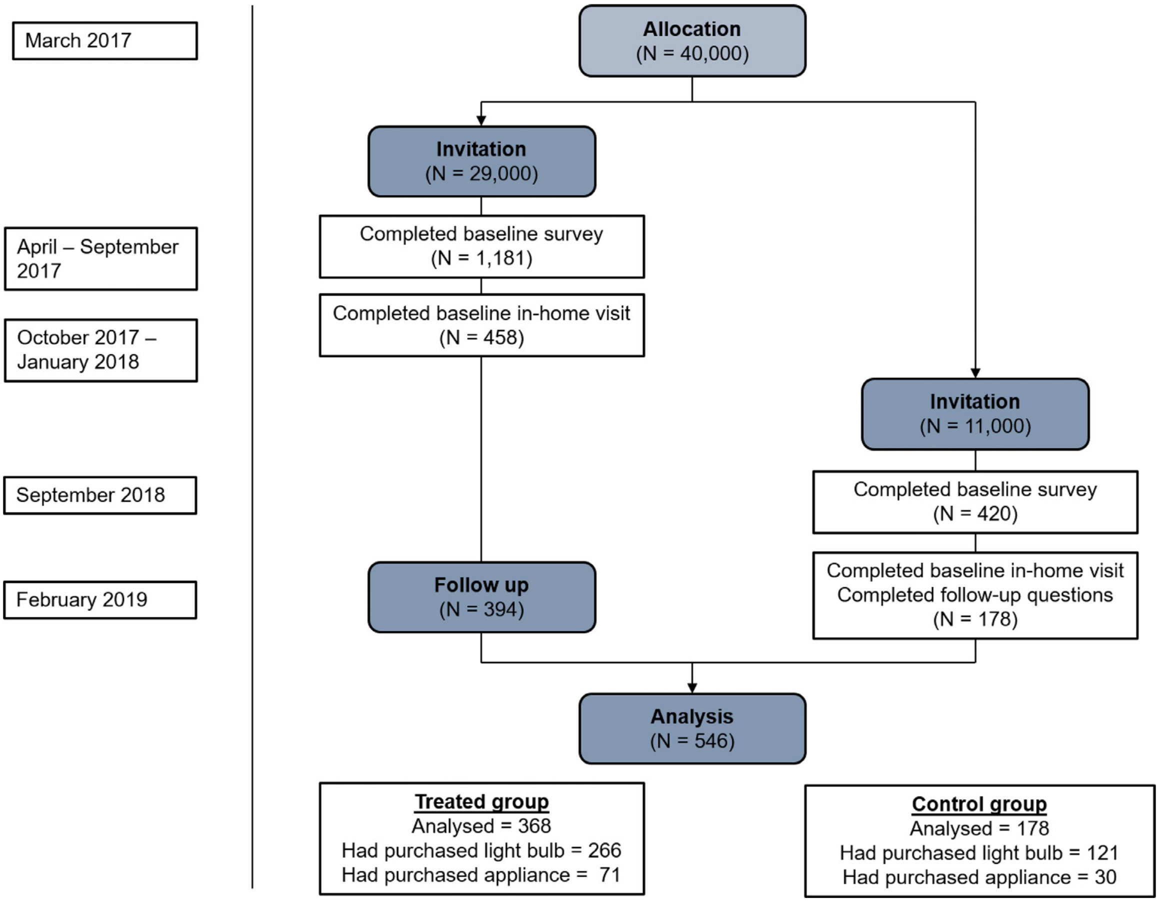


Fig. 1. Experimental design.

surrounding municipalities, and SW serves almost 50,000 households in the city of Winterthur.[10] The goal was to provide a group of households with information about the monetary savings potential they could achieve by purchasing energy efficient durable goods. In this section, we first describe the design of the experiment and its implementation and then the informational content of the intervention.

3.1. Experimental design

The experimental design is sketched in Fig. 1, which presents a summary of the different steps of the experiment. The two utilities agreed to provide the contact information of 40,000 households that were randomly selected among their customers to take part in the experiment (20,000 from AIL and 20,000 from SW). These customers were randomly allocated between the treatment group (29,000 households) and the control group (11,000 households).[11]

Between April 2017 and September 2017, the households allocated to the treatment group received an invitation to take a baseline survey.[12] The baseline survey collected detailed information about the respondents' and their households' socio-economic characteristics, dwelling characteristics, some basic human values (such as altruistic and environmental values), and energy-related knowledge of the participants.[13] The baseline survey was completed by around 4.1% of the households contacted for the treatment group (1181 households).

[10] In Switzerland, the electricity market is not yet open to competition for residential customers. Thus, the two utilities serve the entire population in the respective service area.

[11] The treatment group included 14,000 customers of AIL and 15,000 customers of SW.

[12] The invitation letters sent to the target households assigned to the treatment group in the two regions are included in Appendix E.2. The participation requirements are: (i) the household should have moved into the current residence before January 1, 2017, and (ii) the customer number entered for identification purposes should refer to the principal residence.

[13] The full questionnaire instrument can be found in the H2020 project report under the following link: https://www.penny-project.eu/wp-content/uploads/2017/05/PENNY_D1.3_updated_final.pdf (accessed 8 February 2022)

At the end of the survey, the participants were offered the opportunity to receive a free in-home visit to then obtain information about the energy efficiency of their major home appliances and lighting. We contacted these households to schedule an appointment for the baseline in-home visit to take place between October 2017 and January 2018. Among the households completing the survey, 458 households booked and received the in-home visit. During the baseline in-home visit, the research assistants briefly explained the purpose of the visit (collecting data on the existing home appliances and light bulbs), but did not provide specific information to the participants about the existing appliances or suggestions about how to improve the energy efficiency of the home appliances or lighting.

We later used the information collected during the baseline in-home visits to recover data on the energy consumption of the participants' current appliances for a given level of utilization, or energy efficiency of participants' household durables choices. Further, for each existing home appliance, we collected information about a comparable new appliance that satisfies high energy efficiency standards (energy label A++ and A+++), and is on the market at the time of the baseline in-home visit. The matching between the existing appliances at home and the alternatives on the market was performed based on the physical characteristics (height, width, capacity, and volume) of the appliances. The information was gathered from the online shops of two leading national retailers and one neutral online database for appliances.[14] We used this information to compute the appliance-specific potential of monetary savings households could achieve from the adoption of a new energy efficient appliance. This information was then used to compile the customized report, which was subsequently sent to each household in the treatment group by regular postal mail.[15] In February 2019, one year after the informational intervention, we conducted a follow-up survey and asked participants in the treatment group about their purchase decisions in the previous year.

No customer of the utilities allocated to the control group was contacted in 2017 with reference to the research project. However, in fall 2018, the same recruitment process was implemented for the customers in the control group: they received an invitation letter to take the same baseline survey followed by an invitation to receive the in-home visit.[16] 178 households initially allocated to the control group took the baseline survey and booked and received the baseline in-home visit. During the baseline in-home visit, participants in the control group were also asked about the decisions of purchase of energy-consuming durables and utilization taken in the previous year. In addition, information regarding the appliances that were swapped out was collected, in case a new purchase was made. The in-home visit served then also as a follow-up survey among households in the control group.

For the analysis and in the remainder of the paper, we refer to those households initially allocated to receiving an invitation to take a survey and that complied by accepting the baseline in-home visit and the follow-up survey as the "treatment" group. Similarly, we label the "control" group those households that complied by accepting the in-home visit among those households initially held out. The final experimental sample in the analysis includes information on 368 households in the treatment group and 178 households in the control group.[17]

Before providing additional details on the steps of the randomized field experiment, we highlight our experimental design differs from a traditional randomized controlled trial, due to some constraints dictated by the partner utilities. A traditional experimental design would have recruited all participants at once for the baseline survey and the baseline in-home visit. Then, it would have randomized individual participants into the treatment group or the control group among those who agreed to participate, and either delayed the delivery of the informational content for the control group or sent a less tailored or less informative report to households in the control group. However, the partner utilities dictated that all their customers who received an invitation letter at a given time would then have to receive the same informational report at the same time. In this setting, what we study is therefore the households' durables choices occurring between the baseline in-home visit and the follow-up survey, where the two are collected at different times for the treatment group but simultaneously for the control group, with the baseline being ex-post back-imputed. Because we are collecting data on durable goods, our experimental design allows us to ex-post reconstruct the control group's stock of durable goods that we would have observed if we had conducted the in-home visit at the same time as for the treatment group. In Section 3.3, we discuss the validity of the assumptions we need to take in this context to conclude any differences in the choices between the two groups observed in the post-treatment period come from the informational intervention.

In-home visits We took several steps to implement the in-home visits. Before starting the visits, we held discussions with experts from the utilities and the Swiss association of appliances producers (Fachverband Elektroapparate für Haushalt und Gewerbe Schweiz - FEA) how to identify a feasible and effective way to obtain information related to the appliances' energy efficiency. We concluded that a reliable measurement of the appliances' electricity consumption could be obtained during a short in-home visit by collecting data on the appliances' brand, model number, serial number (on the nameplate), energy label, and dimensions or capacity. We restricted the data collection to the major home appliances (refrigerator, freezer, dishwasher, washing machine, and tumble dryer), which represent the most energy-intensive consuming durable

[14] https://www.topten.ch/ (accessed 8 February 2022)

[15] Additional details on the measurement of durables' electricity consumption are reported in Appendix A.

[16] The invitation letters sent to households allocated to the control group in the two regions are included in Appendix E.2. The same participation requirements used for the treatment group were set for the control group.

[17] Because we could not recruit control group households that had moved between March 2017 and September 2018, we dropped the 26 households who took the follow-up survey and declared they had moved since the baseline in-home visit.

goods in the residential sector. Also, we limited the collection of information about home lighting to the number of halogen, energy saving, and LED light bulbs.

The project participants were divided into groups based on their living area in the city of Winterthur and district of Lugano. Every two weeks, a group of participants was contacted to schedule an appointment at their residence with one of our research assistants. The reservation of each participant's slot for the in-home visit was managed using the online scheduling tool Setmore (one hour slots within the research assistants' stated availability). A reservation notification was sent to the research assistant directly following the participant's reservation.

We hired bachelor's and master's students with backgrounds in economics or engineering at Lugano and Zurich universities as research assistants to conduct the in-home visits. These research assistants were trained about the project goals, expected behavior with the participants during the in-home visits (e.g., giving no advice to participants on purchase decisions to improve the energy efficiency), and the data collection process. They received a training manual with detailed information on the project background, definition of data collection standards, process of scheduling in-home visits, procedures to be implemented during the in-home visit for the data collection, and an explanation of large home appliance and lighting characteristics to be collected. The full training manual is included in Appendix E.4. The research assistants' training included an instruction meeting and pilot in-home visits, which were organized in collaboration with the partner utilities.

During the in-home visit, the research assistants were instructed to briefly explain the purpose of the visit was to collect information on the existing home appliances and light bulbs. Using a tablet and the Epicollect platform, the data collection was carried out using an online survey designed with questions about brand, model, serial number, and energy label of each major appliance, and the number of halogen, energy saving and LED light bulbs in the household. The full survey instrument is included in the training manual in Appendix E.4. We also included the possibility to take photos of the appliances' nameplates directly on the survey. This enabled collecting detailed information on the home appliances households purchased prior to 2018.[18] The in-home visit was also used to collect post-intervention data about the purchase and utilization choices of households allocated in the control group. They were asked about purchases in 2018 and also information about the appliances that were replaced, in case a new purchase was made.[19]

The information collected during the visit was initially stored locally on the tablets provided to the research assistants; then, it was uploaded daily on the servers of the research institute. Each in-home visit lasted between 15 and 30 min, depending on the characteristics of the participants' residence.

Follow-up survey In February 2019, one year after the informational intervention, treatment group participants were invited to take part in a follow-up survey. This follow-up survey was designed to collect detailed information on the home appliances and light bulbs participants had purchased following the information treatment. In particular, regarding the newly purchased home appliances, participants were asked to either: (i) copy the information written on the energy label (when available), (ii) provide us with the appliance model number, or (iii) upload a picture of the nameplate. We obtained precise information on electricity consumption (kWh/year) and energy efficiency class (A+++, A++, ...) of home appliances purchased in 2018, the reason for replacing an existing appliance, and the type of light bulbs purchased in year 2018. Further, we asked respondents how many times per week people in their households used the dishwasher, washing machine, and clothes dryer. The full survey instrument is included in Appendix E.3. All households that received the information treatment were invited to take the follow-up survey, and around 87% of the households that received the invitation completed the follow-up survey.

3.2. Information treatment

Households in the treatment group received an informational intervention, which consisted of two parts: (i) in February 2018, we sent them a letter via regular postal mail with a brief report about the electricity consumption of their current major household appliances (refrigerator, freezer, dishwasher, washing machine, and tumble dryer) and lighting, and the potential monetary savings from the adoption of comparable energy efficient durable goods available on the market; (ii) in June 2018, we sent an email offering them access to a website with similar information to that included in the report sent via regular postal mail. All participants in the treatment group received both the letter and the invitation to access the website.

In both the letter and on the website, we provided participants with customized information about the energy efficiency of each of their current electrical appliances, and the potential monetary savings they could achieve by adopting new, comparable, and more efficient appliances available on the market. We wish to highlight that these are particularly relevant comparisons because they are based on appliances with the same physical characteristics of those the households currently used. To facilitate the participants' understanding of its content, the report also included a brief description of the information included. An example of the full personalized letter sent to the participants is included in Appendix E.

Figure 2 includes an example of the information content for a washing machine included in the letter sent to the participants. The table includes information about the electricity consumption (in kWh) of each existing appliance, the corresponding monetary costs (in CHF), and the annualized operative costs. The appliance-specific information varied depending

[18] We asked households in which year the existing appliances were purchased. However, we only collected information on the type of existing light bulbs (we did not ask about the year of purchase).

[19] The specific information asked about the old appliance varied depending on the appliance type, but it always included size, brand, and year of purchase.

Washing machine

Characteristics of your appliance: Producer: Bosch, Width: 60cm, Height: 90cm, Year of Purchase: 2007

	Your appliance	Alternative appliance on the market (load capacity: 8kg)	
		A++	A+++
Consumption per cycle	1.050 kWh	1.170 kWh	0.470 kWh
Cost of one cycle	0.210 CHF	0.234 CHF	0.094 CHF
Annual operating cost[ii]	46 CHF	51 CHF	21 CHF
Approximate price range of new appliance		725-2309 CHF	440-4099 CHF
Estimate of potential annual savings on operating costs (compared to current appliance)		No savings	25 CHF

[ii] The annual operating costs for the washing machine are estimated using 220 cycles.

- You can save an estimated CHF 25.- per year in electricity costs by replacing your washing machine with a new A+++ appliance.

Fig. 2. Information provision, appliances.

on the type of appliance. We provided information on the annual electricity consumption and corresponding operating costs for refrigerators and freezers, and an estimate of the electricity consumption per cycle and corresponding monetary costs for dishwashers, washing machines, and tumble dryers. The annualized operating costs of dishwashers, washing machines and tumble dryers were computed using the number of cycles hypothesized in the calculation of the European energy labels (280, 220, and 160 cycles per year for dishwashers, washing machines, and clothes dryers, respectively).[20]

In addition, for each current appliance at home, we reported the same information for two comparable alternative appliances available on the market with two levels of efficiency standards (A++ and A+++), and a range of prices at which it was possible to purchase such appliances. Hence, we provided a comparison between the existing appliances and alternative efficient appliances in the market both in terms of energy intensity (i.e., for one unit of output) and for an average level of utilization. Finally, we highlighted the potential monetary savings on the operating costs associated with the purchase of an appliance with energy labels A++ and A+++ compared to the existing appliance using a separate sentence, which read “You can save an estimated CHF [savings potential] per year in electricity costs by replacing your [appliance] with a new A+++ appliance.”

The information content related to lighting was organized in two parts, as shown in Fig. 3. First, we provided information about the number of light bulbs at the participant’s home, distinguishing between halogen, energy saving and LED bulbs. We provided an estimate of both the annual electricity consumption for each light bulb and the total electricity consumption for lighting considering the number and efficiency of the existing light bulbs. Second, we provided an estimate of the monetary savings potential from the replacement of the existing halogen bulbs with either energy saving bulbs or LED bulbs. The savings potential was reported both in terms of the annual electricity expenditure for lighting and in total electricity costs in 10 years.[21]

The information provided through the website was similar to that included in the letter sent via regular postal mail. The only difference involved the information about the potential savings coming from installing a new energy efficient dishwasher, washing machine, and tumble dryer, which was based on the intensity of usage the participants selected. The members of the treatment group were contacted via email and invited to access the website; there they could obtain more personalized information about the potential savings from adopting a new appliance. To access the personal information on the website, a participant was required to follow a simple registration procedure using the participant’s customer number.

3.3. Attrition patterns and potential threats

The validity of our experimental strategy for the identification of the information treatment effects relies on some assumptions. Specifically, we need: (i) no differential selection into the baseline survey between treatment and control groups;

[20] Information on the standard number of cycles can be found here: https://www.siemens-home.bsh-group.com/uk/current-energy-label (accessed 8 February 2022)

[21] Total costs of electricity included the cost of light bulbs purchase and was normalized over 10 years to account for the different lifetimes of each light bulb type (assumed to be 2, 10 and 15 years for halogen, energy saving and LED bulbs, respectively).

Lighting

	Halogen	Energy Saving	LED
Total number of light bulbs	29	13	5
Annual cost per light bulb (iv)	8.51 CHF	2.22 CHF	1.11 CHF
Total annual costs	247 CHF	29 CHF	6 CHF
--			
Price of the light bulb	4 CHF	6 CHF	5 CHF
Lifetime	2 years	10 years	15 years
Total cost of one bulb for 10 years	105 CHF	28 CHF	14 CHF
Estimated annual saving in Francs for each Halogen light bulb replaced	-	6.29 CHF	7.40 CHF

(iv) The estimation of the annual electricity consumption for each light bulb has been performed assuming the usage of light bulbs that exhibit similar luminosity (700 lm) and light color (2500 K). This corresponds to a capacity of 46 W for halogen, 12 W for energy saving and 6 W for LED light bulbs. Additionally, it was assumed that every light bulb was used for 1000 hours per year.

- We estimate that you can save approximately CHF 215.- in annual electricity costs by replacing your 29 Halogen light bulbs with LED bulbs!
- If you replace your 29 Halogen bulbs with LED bulbs, you can save approximately CHF 2639.- in total electricity costs for lighting in 10 years!

Fig. 3. Information provision, lighting.

(ii) no differential selection in taking the in-home visits (conditional on taking the survey); (iii) no substitution bias (participants assigned to the control group cannot get substitutes for our information treatment that they are randomized out of receiving); and (iv) no selection among the households in the treatment group into the follow-up survey. Further, to estimate the intervention's effect on utilization, we also need to assume no "experimenter" effects on reporting of actual usage.

To lend support to the experimental setting's credibility, we show that the necessary conditions for the validity of these assumptions are satisfied. First, we observe similar response rates to the baseline survey between the treatment group (4.1%, in 2017) and the control group (3.8%, in 2018). Attrition rates are relatively high between the baseline survey and the take-up of the in-home visit. However, as shown in Column 1 of Table D.1, we find no evidence of differential attrition between treatment and control groups in taking the in-home visits (conditional on having taken the survey).

To check correct implementation of our experimental manipulation, we asked participants whether they remembered having received a report with information about the efficiency of their major appliances and lighting.[22] The recall rate in the treatment group is very high, equal to almost 98%.[23] Only 3 sample members in the control group (out of 181 households receiving the in-home visit) indicated they somehow received an expert report on the energy efficiency of the major home appliances and lighting (i.e. a treatment similar to that provided by our experiment).[24] The high recall rate among members of the treatment group indicates almost complete treatment take-up, while the stark difference in recall rates between the treatment and control groups confirms that the treatment has been implemented correctly.[25]

Further, the results in Column 2 of Table D.1 provide evidence that no selection on observables occurred into the follow-up among the treated group. We submit this evidence should be taken as suggestive of no selection, considering we cannot exclude selection occurred based on unobservable characteristics or that people who installed a new appliance were also more likely to take the follow-up survey. Although this is one potential caveat to our approach, we believe it does not represent an important threat in the specific context. This is because 87% of the treated households responded to the follow-up survey and unobserved characteristics potentially driving selection are also likely correlated with observables characteristics,

[22] The question was asked both to respondents to the follow-up survey in the treatment group (with wording, "Do you remember having received a report via mail with information about the efficiency of your major home appliances and lighting?") and respondents taking the survey conducted by our research assistants during the in-home visit in the control group (with wording, "Has the participant received an expert report on the energy efficiency of the major home appliances and lighting since November 2017?"). The question was asked at the beginning of both surveys.

[23] Among those recalling having received the report, 353 respondents answered "Yes, and I have read the report"; only 5 answered "Yes, but I have not read the report".

[24] To avoid threats to internal validity from substitution bias, we excluded these 3 households from the final (baseline) sample for the analysis and show our findings are broadly unaffected when we add control substitution (i.e., assign these 3 households to the treatment group).

[25] Because of the high recall rate among the treated, the fact that those households that do not recall having received the report still received an in-home visit by one of our research assistants, and because it is possible to be influenced by information without recalling when one received such information, we think the treatment effects on households' choices should not be adjusted using the treatment effect on recall.

which are found to be uncorrelated with the probability to participate in the follow-up survey. Finally, in Section 4.1, we examine the balance of observables between the treatment and control groups. In Section 5.3, we also report results of a test for pre-intervention differences in consumers' choices between the treatment and control group using data about purchase decisions in the years 2014, 2015, and 2016. Together, these results support the internal validity of our experiment.

4. Sample characteristics

To evaluate the effects of the informational intervention, we combined data from the baseline household survey, the in-home visits, and the follow-up survey.[26]

Our final sample consists of 546 households (368 treated and 178 control).[27] In Table D.2 in the Online Appendix, we compare descriptive statistics for our final experimental sample with the corresponding statistics at the national level.[28]

Considering the substantial attrition from the initial invitation to the in-home visits, the participation in the follow-up survey (for the treatment group) and the incentives offered the households to participate, the final sample can hardly be representative of the general population. Interestingly, we find only slight differences between the sample and the national statistics for several individual and household characteristics. The share of female heads of household, the average dwelling size, and the age distribution of the buildings in which the households live are similar to the corresponding national statistics. The experimental sample is slightly older and wealthier with slightly larger households than the Swiss population. The sample respondents are, however, significantly more educated, more likely to own their main residences and more likely to live in single-family houses than the national population.

4.1. Balance

As described in Section 3.1, the target population of the two utilities' customers was originally randomly allocated between the treatment and control groups. However, because the (same) recruitment process occurred in two different time periods (2017 for the treatment group vs 2018 for the control group) and an additional selection (into the follow-up) occurred among individuals in the treatment group, we compare the balance of selected covariates among groups to complement the evidence supporting the validity of the experimental setting provided in Section 3.3. In Table 1, we present a comparison of selected respondents' and households' characteristics between households in the treatment and control groups.[29] These data were collected with baseline surveys (in two different periods for treatment and control groups) before the in-home visits. The time-varying information refers to the same time period, i.e. the year before the baseline survey was conducted among the individuals assigned to the treatment group (2016).[30]

Most of the observables considered differ only marginally across the treatment and control groups. The distribution of household size is similar in the treatment and control samples and averages at around 2.6 residents per dwelling. Households in the treatment and control groups are also balanced with respect to their income levels. The share of households earning less than 6000 CHF per month is around 18%, and around 23% and 19% of the households stated they have a monthly gross income between 6000 and 9000 CHF and between 9000 and 12,000 CHF, respectively.[31] The share of households with a tertiary degree is above 50% and statistically equal between the treatment and control groups. We find a significantly higher share of female participants in the treatment group. Additionally, it appears the respondents in the treatment group were around three years younger on average than those in the control group. Respondents in the treatment and control groups are balanced with respect to the level of advanced financial literacy, status-quo bias, and environmental values. Tenants represent a minority in our sample, and there is an equal ownership rate in both treatment and control groups of around 80%. As tenants often live in multi-family houses, it is not surprising the share of single-family houses is relatively high (around 70%), though not statistically different between the two groups. Further, we find no difference in the age of the buildings in which the treated and control households live.

Even though we observe by chance few variables are statistically different at conventional significance levels between the treatment and control groups, the F-test rejects the joint significance of all observable characteristics included. Hence, we conclude characteristics of the treatment and control groups are similar, and the two groups are balanced on observables. On this basis, we proceed with the assumption that treatment assignment is unconfounded. Nevertheless, we also present results of the treatment effects conditional on a large set of controls in order to not only address possible concerns coming from compositional differences but also increase the precision of treatment effects estimates. As an additional robustness

[26] The information collected during the in-home visits conducted between October 2017 and January 2018 represent the pre-treatment data for the treatment group; the information collected during the in-home visits completed in the fall of 2018 serve as post-treatment data for the control group.

[27] For the control group, 216 households took part in the experiment. However, one utility sent an erroneous reminder to the baseline survey followed by a corrected version; this acted like an additional reminder a few days later, which threatened equal participation across the treatment and control groups. Hence, we decided to exclude people who answered after receiving the corrected version.

[28] We follow Allcott and Knittel (2019) and impute missing covariates with sample means. Table B.1 in the Appendix reports the (low) share of missing values for each covariate in the sample used for the analysis.

[29] A detailed description of the definition of the variables included in Table 1 is in the Appendix.

[30] The survey asks about household income and number of household members for the five previous years. We adjusted the respondents' ages in the control group to consider time of interview effects.

[31] We observe household income in ranges for gross monthly total income.

Table 1
Balance on observables.

	Control	Treatment	*t*-test
female	0.275	0.383	(−2.49)
age	58.161	55.152	(2.68)
household size	2.679	2.619	(0.55)
university	0.534	0.595	(−1.36)
income: 6000 CHF or less	0.175	0.179	(−0.12)
income: 6001–9000 CHF	0.226	0.242	(−0.41)
income: 9001–12000 CHF	0.198	0.179	(0.52)
advanced financial literacy	3.129	3.231	(−1.35)
status-quo index	2.617	2.543	(0.52)
biospheric index	5.591	5.570	(0.23)
tenant	0.197	0.226	(−0.77)
multi-family house	0.292	0.353	(−1.42)
living area (sq. m)	156.348	151.005	(0.86)
building period: 1970–2000	0.339	0.283	(1.36)
building period: after 2000	0.148	0.206	(−1.64)
moved in before 2012	0.180	0.236	(−1.50)
Lugano	0.511	0.378	(2.98)
p-value of *F*-test of joint significance		0.136	
Observations	178	368	546

Notes: The table reports a comparison of selected respondents' and households' characteristics in the treatment and control groups. Mean values by group and the value of the *t*-test for mean comparison are reported. By chance, few variables are statistically different at conventional significance levels between the treatment and control groups, but the *F*-test fails to reject the joint significance of all observable characteristics included. Hence, we conclude characteristics of the treatment and control groups are similar, and the two groups are balanced on observables.

check, we adopt a matching approach. We show our results change only slightly once we control for respondents' and households' characteristics and rely on the matched sample for the analysis.

4.2. Energy-related knowledge in the baseline

The baseline household survey included a set of specific questions designed to assess the respondents' level of energy-related knowledge. The first question aims at eliciting the knowledge level about the operating cost of large household appliances. More specifically, we asked the respondents the approximate cost of operating a washing machine with a load of 5 kg at 60 °C. The second question asked the respondents the approximate savings in electricity costs of an LED bulb compared to a halogen bulb. The third question asked the respondents to indicate the marginal electricity price (the cost in CHF of 1 kWh).

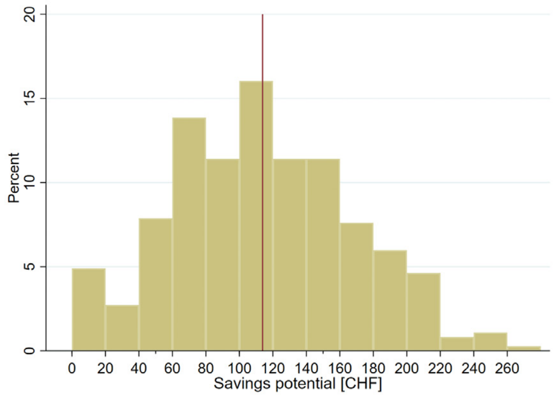
Figure D.1 in the Appendix presents a summary of the answers to the three questions related to this type of energy-related literacy and indicates that it was generally low before the treatment. Only around 20% of the respondents in our pooled sample were aware of the monetary costs of that washing cycle. The remaining respondents either stated they could not quantify the cost or they assessed it incorrectly. Only about half of the sample knew the approximate energy savings potential associated with using a LED light bulb compared to a conventional halogen bulb. Additionally, the majority of the respondents did not know the approximate electricity price or indicated a wrong value. Only around one fourth assessed their electricity price correctly.

4.3. Potential of monetary savings

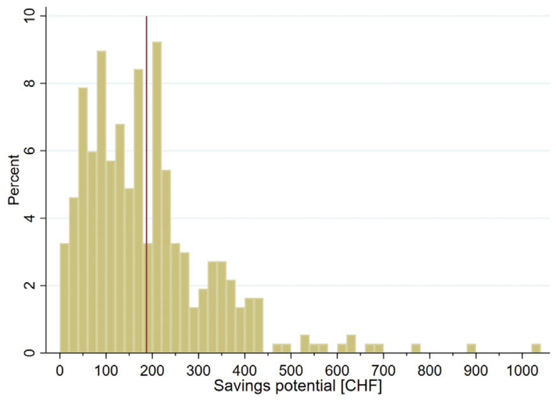
As described in Section 3.1, we provided households allocated to the treatment group with information on their existing large electrical appliances and lighting through a letter and access to a website. In particular, we informed participants about the potential electricity cost reductions associated with the replacement of the existing devices with new energy efficient ones. The following subsection aims at visualizing the range of these potential monetary savings.

Regarding the appliances, participants also received information on the potential yearly monetary cost reduction from using the most efficient A+++ alternatives on the market compared to their existing appliances.[32] By definition of our savings potential measure, this is then equal to zero if the household was already using an appliance with the highest energy efficiency standard. The total savings potential of all appliances owned in the pre-treatment period for the sample of treated households that completed the follow-up survey is presented in Fig. 4a. We estimated the total savings potential to be over

[32] Due to systematic price differences between the two utilities considered, we based our calculations on 18.5 Rp./kWh for AIL and 20 Rp./kWh for SW.



(a) Home appliances



(b) Lighting

Fig. 4. Potential of yearly monetary savings for the treated group.

110 CHF of annual electricity costs on average if all existing appliances were replaced by the most efficient alternative on the market at that time. Additionally, the potential monetary savings distribution exhibits substantial variation, implying significant electricity expense reductions may be achieved by replacing very inefficient appliances. For example, replacing the most inefficient refrigerators, freezers, and tumble dryers is estimated to lead to a decrease in annual energy costs of more than 100 CHF. The savings potential distribution we report deviates from that presented in Levinson and Sager (2020) mainly due to the different approach to measuring savings potential. In fact, while they calculated the cost differences within automobile models that have been released both as gas and hybrid versions, we compare the household appliance currently used (often several years old) to the most efficient and comparable alternative (with same physical dimensions) currently offered on the market. Moreover, our diagram relies on the standard assumption on utilization that is used to compute the energy consumption on the EU energy label; their measure considers individual intensity of utilization.

As indicated in Fig. 4b, potential monetary savings are even higher related to lighting. Under the assumptions taken to compute the yearly electricity consumption of each type of light bulb, replacing one halogen with one LED light bulb is estimated to lower electricity consumption by 40 kWh.[33] Based on regional electricity prices and the number of halogen bulbs installed, households were estimated to possibly reduce annual lighting energy costs by almost 190 CHF on average if all energy inefficient light bulbs were replaced by LED bulbs.

5. Empirical results

The intervention provides information about the monetary savings potential participants could achieve in their electricity bills by purchasing new energy efficient durable goods. We aim to estimate the impact of this informational intervention on households' actual decisions regarding energy-using durable goods investments.

[33] In order to calculate this potential, we relied on data for halogen and LED light bulbs that exhibit similar luminosity (700 lm) and light color (2500 K) values. This corresponds to a capacity of 46 W for halogen and 6 W for LED light bulbs. Additionally, it was assumed that every light bulb was used for 1000 h per year.

Table 2
Information treatment effect: probability of purchase of new energy-consuming durable goods.

	Appliances				Light bulbs	
	Purchase		Replacement		Purchase	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.0248	0.0278	0.0253	0.0320	0.0425	0.0802
	(0.0358)	(0.0355)	(0.0215)	(0.0215)	(0.0410)	(0.0393)
Controls	No	Yes	No	Yes	No	Yes
Observations	546	546	546	546	546	546
Dependent variable mean control	0.169	0.169	0.034	0.034	0.680	0.680

Notes: Estimated marginal effect of the treatment indicator from the Probit model are reported. The dependent variable in Columns (1) and (2) is a binary indicator for households that have purchased at least one new home appliance between November 2017 and December 2018. The dependent variable in Columns (3) and (4) is a binary indicator for households that have replaced at least one home appliance between November 2017 and December 2018 even though the old appliance was not defective. The dependent variable in Columns (5) and (6) is a binary indicator for households that have purchased at least one light bulb between November 2017 and December 2018. Regression models in Columns (2), (4), and (6) control for the respondent's gender, age, income, education, values, financial literacy, and status quo bias as well as for a set of building and household characteristics (ownership status, household and dwelling size, building period, moving-in year, and utility service area). Standard errors are reported in parentheses.

The balance analysis in Section 4 indicated no systematic differences between the treatment and control groups; therefore, the experimental design allows us to estimate the impact of the information treatment by simply regressing the outcome of interest on a treatment indicator by using data from the post-treatment period. However, because we do find some individual characteristics are unbalanced between the treatment and control groups, we identify the impact of the information provision under the conditional independence assumption, that is there are no unobservable differences between participants in the treatment and control groups, conditional on a set of covariates. We have shown the common support condition to be amply satisfied in our setting.

We then estimate the following equation:

$$Y_i = \beta D_i + \delta X_i + \epsilon_i \tag{3}$$

where Y_i is an indicator of energy-consuming durable goods choices that can be both dichotomous or continuous, D_i is a treatment indicator and X_i is a set of respondents' and households' characteristics. The controls include each respondent's gender, age, income, education, financial literacy, status-quo bias, and environmental values as well as for a set of household and building characteristics (ownership status, household and dwelling size, building period, moving-in year, and utility service area).[34] Including the set of observable characteristics also aims to improve the precision of the estimated treatment effects. The coefficient of main interest β indicates the reduced form impact of the informational intervention on households' choices. In particular, in our main empirical analysis we wish to estimate the information treatment effect on: (i) the probability of purchasing new energy-consuming durable goods; (ii) the level of energy efficiency of the newly purchased durable goods, conditional on the purchase decision, and (iii) the intensity of utilization.[35] Equation (3) is estimated using a Probit model when the outcome variable is binary and using OLS with robust standard errors when the outcome variable is continuous. As a robustness check, in Appendix C we also report results obtained using a Logit model for binary outcome variables. Further, Appendix C reports a description and the results of the matching approach that we adopt to address potential concerns about the small compositional differences between treatment and control groups shown in Table 1.

5.1. Probability of purchasing new energy-consuming durable goods

To address the question of whether the information treatment had an impact on the probability of purchase of new energy-consuming durable goods, we use data from two survey questions asking households if they purchased a new appliance or a new light bulb, respectively, between November 2017 and December 2018.[36] Table 2 reports the marginal effects of the intervention on the probability to purchase at least one new home appliance (Columns 1 and 2) or replace an appliance when it was not defective (Columns 3 and 4). Columns (2) and (4) report results obtained including the set of controls. Columns 5 and 6 present the marginal effects of the treatment on the probability to purchase at least one new light bulb.

[34] Details on the definition of the covariates included in the regression models are reported in the Appendix.

[35] We consider the level of utilization of dishwashers, washing machines, and tumble dryers.

[36] The exact phrasing of the question asking about the purchase of the new appliances was the following: *"Since November 2017, have you, or any other person living with you, purchased one or more new home appliances (fridge, separate freezer, dishwasher, washing machine, clothes dryer)?"*. Similarly, we also asked: *"Between November 2017 and December 2018, have you, or any other persons living with you, purchased any light bulbs?"*. Because the follow-up survey had been carried out in February 2019, we also asked respondents to report the month of purchase and then used this information to exclude purchases made in January and February 2019.

In the control group, around 17% of the households reported purchasing at least one new home appliance in the year before the in-home visit, but only 3.4% of the households in the control group did so when the appliance was not broken. Despite the positive coefficient associated with the treatment indicator in all estimated models, we cannot reject the null of no effect of our informational intervention on the probability to purchase a new home appliance or to replace an appliance that was still working. However, the standard errors in columns (1) to (4) are quite large. To understand whether we should think of these estimates as precise zeros, we compare our estimated treatment effect to the variation of our dependent variable, as Allcott and Knittel (2019) did. The standard deviation of the dummy indicating whether a household purchased a new appliance or not is 0.3886, and the upper 95% confidence interval of the treatment effect is 0.0973. Hence, we can exclude that the treatment increased the probability to purchase a new appliance on average by more than 0.0973/0.3886=0.25 standard deviations.

As shown in Table 2 (Column 6), we do find instead some evidence the information treatment increases the probability of purchasing new light bulbs. Specifically, using our preferred specification that includes the set of covariates, we find that providing households with information about how much money they can save from using LED bulbs instead of conventional halogen bulbs increases the probability that households purchase any type of new light bulbs by around 8 percentage points. This effect is substantial, provided that the share of participants purchasing at least one new light bulb in the control group is around 68%.[37]

As shown in Tables C.1 and C.3 to C.5 in Appendix C, the estimates of the treatment effects on the probability of new durable goods purchases are largely unaffected when we adopt a Logit model instead of a Probit model or a matching approach.

5.2. *Efficiency of the newly purchased energy-consuming durable goods*

In testing whether the informational intervention had an impact on the type of the newly purchased energy-consuming durable goods, we separately analyze the treatment effects on the purchases of new home appliances and light bulbs. Among the final experimental sample of 546 households, 101 households purchased at least one new home appliance between November 2017 and February 2019.[38] Furthermore, 387 households reported purchasing at least one new light bulb.

First, we investigate whether the information provision affected the households' choice regarding the energy efficiency of the newly purchased home appliances. We use two indicators of energy efficiency: (i) the average annual electricity consumed by the newly purchased home appliances for a given level of utilization (i.e., an indicator of energy intensity);[39] (ii) the EU energy label, an indicator of the durables' energy efficiency that takes into account capacity/size.

Table 3 reports the estimated treatment effects on the average annual electricity consumption of the newly purchased appliances. In particular, Columns (1) and (2) present results for the log of average electricity consumption of the newly purchased appliances, excluding and including the set of controls, respectively. Column (1) shows the information treatment decreased the average electricity consumption of the home appliances consumers purchase by around 14%, significant at the 1% level. Adding the set of covariates changes the point estimates little: the effect remains significant at the 5% significance level. The estimates of the treatment effects on the average annual electricity consumption of the newly purchased appliances tend to become larger (in the range between −0.18% and −0.23%) when we employ alternative matching estimators (see Table C.6).[40]

This result may reflect both a higher energy efficiency of the new appliances or the fact that due to the informational intervention, households chose to save on their electricity bill by purchasing smaller appliances.[41] To gain more insights about how the information treatment changed the purchasing behavior of treated households, we also consider its effect on the EU energy label. In Columns (3) and (4), we use as the dependent variable a binary indicator equal to one if (all) the new household appliances purchased by the household were labelled A+++, as defined by the EU energy label, and zero otherwise. We find the intervention induced a large increase in the probability to buy A+++ appliances. When we include the set of control variables, the results show that the treatment increased the probability for households to purchase A+++ appliances by around 27 percentage points. Also in this case, our findings are confirmed when we use a Logit model for estimation or adopt a matching approach (see Columns (1) and (2) of Table C.2 and Table C.7).

[37] Results reported in Table D.5 show our results about the information treatment effects on the probability of purchasing new energy-consuming durable goods are unaffected when we add control substitution.

[38] We conducted the follow-up survey with the participants in the treatment group that provided us with their purchase decisions only in February 2019, but we collected this information in the control group from mid-October 2018 to mid-January 2019. In order to account for potential technological changes in January and February 2019 we include yearly dummies in our regressions. We conducted our analysis after dropping the 2019 purchases also, but our main results persist.

[39] For refrigerators and freezers, we simply take the yearly electricity consumption as reported by the producers. For dishwashers, washing machines, and clothes dryers, we take the electricity consumption per (typical) cycle of use as reported by the producers and multiply it by the number of cycles hypothesized in the calculation of the European energy labels (280, 220, and 160 cycles per year for dishwashers, washing machines, and clothes dryers, respectively).

[40] The matching procedure also addresses the potential concern that the subgroup of the treated households who purchased an appliance or a light bulb may include households who bought them because they were treated.

[41] The electricity consumed by the home appliances indeed depends on the intensity of utilization, their energy intensity, and their volume/capacity.

Table 3
Information treatment effect: energy-efficiency of newly purchased durable goods.

	Appliances				Light bulbs			
	El cons *(Log Avg)*		A++		LED		Only halogen	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	−0.143	−0.143	0.373	0.266	0.0778	0.0826	−0.0559	−0.0537
	(0.0544)	(0.0693)	(0.0830)	(0.101)	(0.0280)	(0.0284)	(0.0256)	(0.0259)
Year Dummies	Yes	Yes	Yes	Yes	No	No	No	No
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	101	101	101	101	387	387	387	387
Dependent variable mean control	5.398	5.398	0.267	0.267	0.860	0.860	0.107	0.107

Notes: OLS estimates of the treatment effects are reported in Columns (1) and (2); the estimated marginal effect of the treatment indicator from the Probit model are reported Columns (3) to (8). The dependent variable in Columns (1) and (2) is the log of average annual electricity consumption of the newly purchased home appliances. The dependent variable in Columns (3) and (4) is a binary indicator for households that have purchased only A+++ appliances between November 2017 and December 2018. The dependent variable in Columns (5) and (6) is an indicator for whether the household has purchased at least one energy efficient (LED) bulb between November 2017 and December 2018. The dependent variable in Columns (7) and (8) is an indicator for whether all the light bulbs purchased by the household in the period considered are energy inefficient (halogen bulbs). Regression models in Columns (2), (4), (6), and (8) control for the respondent's gender, age, income, education, values, financial literacy, and status quo bias and for a set of building and household characteristics (ownership status, household and dwelling size, building period, moving-in year, and utility service area). Robust standard errors are reported in parentheses.

These results provide evidence that the decrease in electricity consumption of the newly purchased appliances is mainly driven by an increase in their energy efficiency. Further, these results allow us to conclude the informational intervention had a positive impact on the utility households derive from using the newly purchased home appliances for a same level of utilization (i.e., the *actual energy savings* in Eq. (1) are positive).[42]

We are also interested in investigating the impact of the information treatment on households' decisions regarding the efficiency of the newly purchased light bulbs, conditional on the purchase decision. As shown in Section 4.3, replacing halogen light bulbs with efficient LED bulbs allows households to achieve the most substantial savings in electricity costs. We use two indicators for the efficiency of the newly purchased light bulbs: (i) an indicator for whether the household has purchased at least one energy efficient (LED) bulb between November 2017 and December 2018; and (ii) an indicator for whether all the light bulbs purchased by the household in the period considered are energy inefficient (halogen bulbs).

The estimates of the treatment effects on the energy efficiency of the newly purchased light bulbs are presented in Columns (5) to (8) of Table 3. We find a relevant impact of the information treatment on the probability to purchase efficient light (LED) bulbs (Columns 5 and 6). Receiving information about the monetary savings associated with the purchase of energy efficient light bulbs increases the probability to purchase an energy efficient light bulb by around 7.8 percentage points, significant at the 1% level. The point estimate for the marginal effect increases little when adding covariates to the regression (8.3 percentage points). In the control group, when taking the decision to purchase a new light bulb, around 85% of participants have purchased at least one energy efficient (LED) bulb.

As shown in Columns (7) and (8) of Table 3, the information treatment has a sizable impact on the probability for the households to purchase only halogen bulbs. The information treatment reduces the probability consumers purchase only halogen bulbs by around 6 percentage points (5.6 and 5.4 percentage points when excluding and adding the controls, respectively), significant at the 5% level.[43] These results show the information treatment affected the decisions of households that, prior to the treatment, lacked sophistication in the decision-making process concerning investment in energy efficiency (households that were only purchasing inefficient halogen bulbs).

These results complement the findings in Allcott and Taubinsky (2015), who have shown providing information on energy costs increases respondents' willingness-to-pay for LED bulbs in an online stated-choice experiment.[44]

5.3. Falsification test

As discussed in Section 3, the validity of our empirical strategy crucially relies on the absence of unobservable differences between the treatment and control groups (i.e., the treatment assignment was random, conditional on observables, and the

[42] Our findings about the treatment effects on the efficiency of the newly purchased energy-consuming household durable goods are largely unaffected when we add control substitution (see Table D.6).

[43] Results in Tables C.8 and C.9 also confirm these results are robust for using a logit model for estimation or as a matching approach.

[44] Allcott and Taubinsky (2015) did not find significant effects on consumers' purchase decisions regarding light bulbs when they exploited a field experiment implemented in retail stores.

attrition process was the same between the treatment and control groups). A necessary condition for our empirical strategy's validity is before the intervention, there were no differences in the durable goods purchase decisions of the two groups of households.

To support the credibility of the identifying assumption, we exploit the information collected during the in-home visits about the year of purchase and electricity consumption of the existing home appliances. Controlling for covariates, we regress the log average electricity consumption of the home appliances purchased in the year 2016 on the treatment indicator.[45] The results presented in Column (2) of Table D.12 show there is no significant difference in the electricity consumption of appliances purchased by households in the control and treatment groups, in the year before the intervention. We also find no difference in the probability to purchase A+++ appliances (results in Column 5 of Table D.12) between treatment and control groups in the year before the informational intervention. The results of no difference between the durable goods choices of the treatment and control groups are confirmed when we use data also for the years 2014 and 2015, which are reported in Columns (3) and (6).

Because we cannot reject that, in the pre-treatment period, the two groups made the same investment choices, these results provide further credibility to the validity of the treatment's unconfoundedness assumption, and then to the interpretation of our estimates as causal effects of the informational intervention.

5.4. Personalized information and heterogeneous durable goods choices response

We have shown the informational intervention induced, on average, an energy-consuming household durable goods choice response. However, one might wonder whether our treatment indeed induced these behavioral changes through enhanced knowledge about energy costs, or through other channels. For instance, the intervention might have acted as a sort of "advertisement" for new energy efficient products. Further, the baseline in-home visit is likely to have been a salient experience for the households, possibly inducing them to think about their large appliances, for example, making them more aware of their vintage. In both these cases, households would be responding to the letter they received regardless of its informational content. In contrast, larger responses of households to greater potential monetary savings from the adoption of new technologies (i.e., treatment intensity) would be consistent with information playing a role in determining households' durables choice responses.

Monetary savings potential and households' responses In particular, we hypothesize larger monetary savings potiential from replacing existing durable goods with new ones would induce households to replace existing appliances with greater probability following the information treatment. Further, we also hypothesize households who are told there would be no savings potential from upgrading or they have to pay a high price to attain this savings potential (i.e., receiving a "do nothing" nudge) indeed do not respond to the intervention.

To test these hypotheses, we exploit the household-specific potential of monetary savings from adopting more energy efficient home appliances and light bulbs reported in the letter we sent to treated households. We then estimate the following equation for the probability of purchasing a new durable good or replacing a new home appliance when this was not broken:

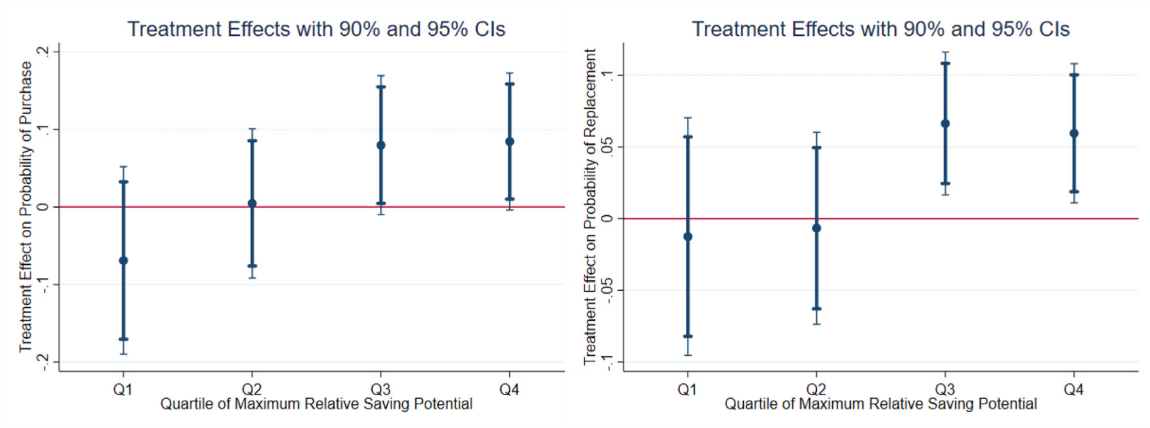
$$Y_i = \sum_{j=2}^{4} \gamma_j Q_{j,i} * D_i + \beta D_i + \delta X_i + \epsilon_i \tag{4}$$

where $Q_{j,i}$ $(j = 2, 3, 4)$ are quartiles of measures of "treatment intensity" and the other variables are as in Eq. (3). For home appliances, we consider four alternative measures of treatment intensity: (i) the monetary savings potential (in CHF) averaged across those for all appliances indicated in the letter; (ii) the highest monetary savings potential from purchasing a new energy efficient appliance among those indicated in the letter; (iii) the ratio of average monetary savings potential to new appliance price; (iv) the ratio of highest monetary savings potential to new appliance price.[46] Because the vintage of the existing appliances is correlated with the savings potential and is likely to drive the desire, or need, to upgrade, the set of controls X now also includes quartiles of the distribution of average age of the existing appliances when we use (i) or (iii) as measures of treatment intensity or quartiles of the distribution of the highest age of an appliance among the existing appliances when we adopt (ii) or (iv). When we estimate Eq. (4) for the probability to replace a light bulb, we use the individual monetary savings potential (in CHF) from replacing all halogen bulbs with LED bulbs reported in the letter as a measure of treatment intensity.[47] We then control for the total number of light bulbs at home. The coefficient β indicates now the effect of the intervention among households belonging to the first quartile of the measure of treatment intensity. We interpret β as indicative of the upgrading response of those households that received the equivalent of a "do nothing"

[45] We do not consider households' choices of purchase in the "transition" year 2017 because the treatment group started to fill in the baseline survey in April 2017 and received the first in-home visits in October 2017.

[46] To compute (iii) and (iv), we use the average price of a new energy efficient appliance, between the upper and lower range limits of prices reported in the letter received by the participants.

[47] Notice all participants received uniform information for the price of a new LED bulb.



(a) Probability of Purchase (b) Probability of Replacement

Fig. 5. Appliances: Heterogeneous Treatment Effects by Maximum Relative Savings Potential

message in the letter.[48] γ_j indicates the additional effect of the intervention among households belonging to quartile j of the distribution of treatment intensity.

The results, reported in Table D.4 in Appendix D, show for households in upper quartiles of the distribution of treatment intensity the informational intervention induced an increase in the probability to replace existing home appliances with new ones. This finding is confirmed using alternative measures of treatment intensity.[49] Moreover, we find those households informed of little savings potential from upgrading or they had to pay a high price to attain the savings potential (i.e., the "do nothing" nudge) did not respond to the intervention, even though they also received the potentially salient in-home visit. Figure 5 reports a graphical depiction of the treatment effects by quartiles of our preferred measure of treatment intensity that considers the ratio of highest monetary savings potential to new appliance price (measure iv). It shows no significant effect on both probability of purchase (panel a) and probability of replacement when the appliance is not broken (panel b), among households who were informed to have a small savings potential to required investment ratio. The intervention instead increased the probability that households purchase a new appliance (replace an appliance when not broken) by about 8 (6) percentage points among households with above median savings potential to required investment ratio. Similarly, larger potential of savings indicated in the information letter induced a larger response of households in terms of purchasing new light bulbs (see Column 9 of Table D.4).

Overall, these results show the informational content of our intervention mattered in determining households' durables choice responses. However, we cannot exclude that salience effects from the baseline in-home visit induced a parallel shift in the upgrading response to the intervention across the distribution of savings potential (implying we would have observed negative responses among those households that received the "do nothing" message in the absence of the baseline in-home visit), or that salience effects from the baseline in-home visit interacted with the information treatment intensity, as measured by the savings potential.

Heterogeneous effects by age of existing appliances Because older appliances tend to be less energy efficient due to technological improvements over time, our measures of treatment intensity are correlated with the vintage of the existing appliances. We then wish to explore whether our intervention induced an increase in the probability to purchase a new appliance when the existing appliances were relatively older. We estimate two versions of Eq. (4) using alternative measures of appliances vintage to define quartiles Q_{jj}. In the first, we consider the distribution of the average age of the existing appliances; in the second, we use the distribution of the highest age of existing appliances.[50] The results of this analysis are reported in Table D.7 in Appendix B. As expected, we find the probability of purchasing a new appliance significantly increases with the vintage of existing appliances in the absence of the intervention. However, the results show the intervention did not increase the probability of purchasing a new appliance differently across the distribution of appliances' vintage. We interpret this result as consistent with the idea households responded to the information content of the letters, which highlighted the monetary savings potential and not the age of the existing appliances.

[48] The average values of the measures of treatment intensity in the first quartile are 15 CHF, 23 CHF, 0.009 and 0.014, respectively for measures (i), (ii), (iii) and (iv).

[49] An exception is the result we obtain considering measure (i), reported in Columns (1) and (2) of Table D.4. The coefficients associated with the interaction of treatment and 4th quartile of savings potential are positive, and economically large, but in this case not statistically significant.

[50] Importantly, although appliances vintage and savings potential are correlated, there is substantial variation in the monetary savings potential, for a given level of appliances' vintage due to the energy efficiency of the existing appliances. As an example, we report the distribution of average savings potential by average age of the refrigerators in Figure D.2 in Appendix D

Pre-treatment informedness and households' responses To better isolate the mechanism behind the observed behavioral response to our intervention, we explore whether the results are mostly driven by households who were, in the vein of Byrne et al. (2018), ex-ante misinformed. As described in Section 4.2, in the baseline survey, we asked participants about their knowledge of the energy costs of operating a washing machine and the savings potential from adopting LED bulbs instead of halogen bulbs. We estimate Eq. (3) for the probability to purchase a new appliance (a new light bulb) interacting the treatment indicator with a dummy variable taking value one if the respondent correctly answered the question on the energy costs of operating a washing machine (the savings from adopting a LED bulb), and zero otherwise.[51] The results are reported in Table D.8. We find positive point estimates for the effect of the intervention among households who were misinformed according to our definition, and negative point estimates for the effect among those who answered the survey question correctly before the information was provided for both appliances and light bulbs. Although the heterogeneity is economically large, we fail to reject the null of no differential response between levels of pre-treatment knowledge.

5.5. The value of the informational intervention for consumers

To gain more insights into whether households' responses to the informational intervention have been consistent with rational decision making (i.e., a minimization of the total costs for obtaining a flow of utility from using the durable goods), we compare the net present values of the investments undertaken by households in treatment and control groups. This is important because more energy efficient products are often associated with higher purchase prices and it may be then optimal (from a private perspective) for households to purchase less energy efficient durable goods.

Using the notation defined in Section 2, the impact of the informational intervention at the individual level on the lifetime costs NPV_i of home appliance j can be written as:[52]

$$NPV_{i,j}^T - NPV_{i,j}^C = P_{i,j}^C \underbrace{\tau^P}_{\text{TE: prices}} + Lc^e m_{i,j}^C e_{i,j}^C \left[(1 + \underbrace{\tau^e}_{\text{TE: energy intensity}})(1 + \underbrace{\tau_m}_{\text{TE: utilization}}) - 1 \right] \tag{5}$$

Equation (5) highlights that the overall monetary value of the informational intervention for treated households depends on the combination of the treatment effect on appliances' purchase prices τ^P, energy intensity τ^e (i.e., electricity consumed by the purchased appliances to produce one unit of output), and utilization τ^m.[53] In general, higher purchase prices of the more energy efficient appliances may (at least in part) compensate for the monetary savings from greater energy efficiency.[54] Further, the possible presence of a rebound effect may also decrease the reduction in energy costs from utilizing the durable goods with higher energy efficiency.[55]

We compute the lifetime costs of each home appliance j, purchased by household i, as $NPV_{i,j} = P_{i,j} + Lc^e m_{i,j} e_{i,j}$ assuming a lifetime $L = 15$ years and a constant electricity price $c^e = 0.20$ CHF/kWh. We collect market prices P for each appliance purchased by households in the experimental sample in 2018.[56] To highlight the importance of allowing for changes in the behavior of utilization for gauging the overall value of the informational intervention, we report results for constant levels of utilization $m_{i,j}^T = m_{i,j}^C$, for all i, j, as well as using household-specific intensity of utilization for each appliance.[57] We estimate Eq. (3) for log purchase prices and log total lifetime costs (with and without household-specific appliances utilization).

The estimates of the treatment effects on purchase prices (Columns 1 and 2) and total lifetime costs (Columns 3 to 6) are reported in Table 4. We find a negative effect of the informational intervention on purchase prices, with treated households

[51] It is worth pointing out our indicator for pre-treatment level of knowledge of operating a washing machine may be a poor proxy for the overall level of knowledge about the energy costs of other appliances. Further, to make informed decisions about upgrading, households also require knowledge about the energy costs of the energy efficient home appliances available in the market and their prices. In other words, the indicator we can build based on our survey questions is likely measuring misinformation with substantial measurement error.

[52] This formulation assumes discount rates equal to zero.

[53] Clearly, this general formulation applies to energy-consuming durable goods of which households can adjust utilization (dishwashers, washing machines and tumble dryers). $\tau^m = 0$ is assumed throughout the paper for refrigerators and freezers.

[54] Previous studies have addressed the related question of how consumers value energy efficiency by estimating the so-called undervaluation ratio (see, e.g., Allcott and Wozny 2014 and Gillingham et al. 2021). If we regress the purchase price of newly purchased appliances in the post-treatment period on their projected energy costs (assuming an average lifetime of 15 years), we find a negative, though insignificant, coefficient associated to energy costs. Interestingly, the point estimate (-0.38) is close to estimates of undervaluation in the literature (in particular in the range of estimates in Gillingham et al. 2021), suggesting substantial undervaluation of energy costs. We wish to stress, however, we cannot credibly address the endogeneity of energy costs in this context; therefore we need to be cautious in the interpretation of this result as an estimate of the degree of undervaluation.

[55] While the decreased energy costs may induce a rebound effect, a reduction in the misperception of energy costs may induce a decrease in utilization for those who were ex-ante underestimating the energy costs. To provide suggestive evidence about the households' utilization response, we analyze the self-reported information collected after the intervention on the number of times households typically used dishwashers, washing machines, and tumble dryers. A description of this analysis, its discussion, and the results we obtained are reported in Appendix D.1. Overall, we find treated households report lower levels of appliance utilization; this also occurred among households who did not purchase a new appliance.

[56] As list prices commonly include unrealistically high mark-ups, we obtained our prices from the Swiss price comparison website toppreise.ch. This website collects offers from several retailers and records the lowest market price at different points in time. We took the average between the lowest offer at the beginning and at the end of 2018 as market price.

[57] The calculation of lifetime costs that assumes constant utilization uses the number of cycles hypothesized in the calculation of the European energy labels (280, 220, and 160 cycles per year for dishwashers, washing machines, and clothes dryers, respectively).

Table 4
Information treatment effects: home appliances prices and NPVs.

	log(Price)		log(NPV)			
			Individual usage		Standardized usage	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	−0.117 (0.110)	−0.267 (0.143)	−0.137 (0.0911)	−0.206 (0.106)	−0.101 (0.0751)	−0.181 (0.0937)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
Observations	98	98	95	95	98	98
Dependent variable mean control	7.069	7.069	7.506	7.506	7.525	7.525

Notes: OLS estimates of the treatment effects are reported. the dependent variable in Columns (1) and (2) is a measure of the average market price in a given time period. The dependent variable in Columns (3) and (4) is the total lifetime cost considering individual intensities of utilization. The dependent variable in Columns (5) and (6) is the total lifetime cost, assuming a standardized intensity of utilization as suggested by the EU energy label. We assume a lifetime of 15 years for the appliances and a 0% discount rate for the calculation of the lifetime cost. Regression models in Columns (2), (4), (6), and (8) control for the respondent's gender, age, income, education, values, financial literacy, and status quo bias and for a set of building and household characteristics (ownership status, household and dwelling size, building period, moving-in year, and utility service area). Robust standard errors are reported in parentheses.

spending around 25% less for the new appliances. This result is interesting in that it shows treated households could buy new more energy efficient appliances (see results presented in Section 5.2) without higher initial investments. Coherently, we find our intervention reduced the overall lifetime costs of home appliances, as shown in Columns 4 and 6. The treatment effect on lifetime costs is slightly larger when we consider household-specific utilization, suggesting the importance of considering the endogeneity of individuals' utilization choices when evaluating the overall impact of behavioral intervention aimed at affecting choices of purchasing new durable goods.

These results provide evidence that investment in energy efficient appliances can yield private benefits and are consistent with an enhanced rationality (i.e., cost minimization for the production of consumption goods) of households following the informational intervention. To conclude the information provision has increased private welfare, one also needs to consider possible heterogeneity in attention or search costs between the treatment and control groups. Because we find a lower bound for the gross private benefits equal to around 50 CHF, households in the treatment group had to pay more than 50 CHF worth attention costs for the information treatment not to be private welfare increasing.[58]

6. Discussion and conclusion

In this paper, we have presented experimental evidence on the role of individuals' imperfect information about or inattention to energy costs on their durables choices. Exploiting unique data on the energy efficiency of home appliances and light bulbs each household in the sample owns, the intervention provided customized information about the potential monetary savings each household could achieve on its electricity bill by adopting new, comparable, energy efficient durable goods.

We document a relevant impact of our informational intervention on households' decisions. First, treated households purchased new home appliances and light bulbs that are substantially more energy efficient. Second, we show the intervention induced households to purchase home appliances with lower total lifetime costs. This result suggests the information treatment triggered purchase decisions associated with positive private financial returns. We also find a larger durables choice response to the intervention among those households that were associated with greater treatment intensity (i.e., the potential of monetary savings from the purchase of new efficient durables), conditional on appliances vintage. In contrast, we find no durables choice responses from households who were told they have nothing to gain from upgrading. Because the information treatment was not provided on the marketplace at the time of the purchase decision, but prior to the time of purchase, we can also exclude that the intervention acted through enhanced salience of energy costs. Together, these results provide suggestive evidence that the informational content of our intervention played a relevant role in determining the observed behavioral response. However, two remarks are worth making. First, the evidence treated households respond more when they were informed to have larger savings potential from upgrading suggests information plays a role, but it does not necessarily indicate there is a behavioral anomaly. Second, we neither can exclude that salience effects from the in-home visit interacted with the information treatment intensity, nor precisely estimate to what extent the results are driven

[58] This lower bound for the gross private benefits is computed using the results in Column (6) of Table 4 and the average probability for a household to purchase a new appliance of 0.17. It represents a lower bound for the gross private benefits because it assumes zero effect on the NPVs of investment in new home appliances after the first year after the treatment, and it does not consider the treatment effects on total costs for lighting.

by households who were ex-ante misinformed. We therefore wish to be cautious in interpreting our results as conclusive regarding the importance of information as the primary mechanism underlying the observed effects of our intervention.

Our findings are important because they show customized information can significantly improve consumers' choices not only in the health, education, and finance sectors (Hastings and Weinstein, 2008; Bertrand and Morse, 2011; Kling et al., 2012) but also in the energy sector. Moreover, they complement findings of previous studies showing investment in energy efficient home renovations in the US do not deliver (Fowlie et al., 2018), and American drivers are informed about fuel costs when buying a new vehicle (Allcott and Knittel, 2019). Investment in home appliances differs from that in home retrofits and vehicles in at least two important aspects. First, while Fowlie et al. (2018) show the upfront investment costs of home improvements are about twice the actual energy savings in the United States, we show investment in energy efficient home appliances allows a reduction in their total lifetime costs under the assumptions the manufacturers' measurements of energy consumption are accurate and there is no systematic measurement error in utilization. Second, the home appliances market is very different from the vehicles market. On the one hand, consumers are likely to value a vehicle's characteristics other than its energy costs significantly more than they do in the case of home appliances. On the other hand, automotive advertising expenditure is much larger than the advertising spending in the household appliance industry.[59] Finally, our findings complement those in Allcott and Taubinsky (2015), providing experimental evidence on the role of imperfect information in consumers' actual choices of light bulbs.

To discuss the welfare implications of our intervention, it is first worth pointing out our measures of savings potential differ from the engineering projections previously found to be overstating true savings (e.g., in Fowlie et al. 2018). Most importantly, our measures of savings potential rely on the standardized electricity consumption of the home durables for a given level of utilization as declared by their producers and stated on the European Energy Label, rather than engineering projections.[60] Further, to compute the savings potential, we make the same assumptions on the utilization level for both the existing appliances and the new appliances on the market. This was pointed out to the participants in the information letter they received. Finally, we show in Table 4 that treated households buy appliances that are cheaper than those purchased by the control group, despite being more efficient (as shown in Table 3). Hence, the treatment would not be welfare enhancing from a private perspective if the true savings from upgrading were systematically lower than those we computed ex-ante only for appliances purchased by the treatment group.

Our results show an informational intervention on the energy costs of home appliances and light bulbs can induce a substantial behavioral choice response when it is personalized to the households' existing stock of durables and is provided with a letter that is available to households before they access the marketplace. They thus inform policy makers that informational campaigns that provide personalized information can increase the adoption of energy efficient durables and help reach the goals of energy conservation. One potential caveat to our findings is they rely on a sample that self-selected into taking the in-home visits and, even though it has only slight differences with the general population in terms of observable characteristics, can hardly be representative. Future research is needed to test the effectiveness of personalized information on durables energy costs in other contexts. Building on the findings in this paper, an important avenue for future research would be investigating the most efficient ways to deliver this customized information treatment in a cost-effective, scalable manner. Finally, more research is needed to understand to what extent individuals' limited knowledge about energy costs results from rational considerations or limitations in their decision making process.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.jebo.2022.02.014.

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[59] Automotive advertising expenditure (18 billion dollars) was around 20 times larger than the advertising spending in the household appliance industry (900 million dollars) in the US market in 2018.

[60] The engineering saving projections in Fowlie et al. (2018) are based on a computer-based audit tool (National Energy Audit Tool, NEAT) that calculates energy savings based on information about the house structure, heating and cooling systems, appliances, insulation, ventilation, etc. In contrast, the electricity consumption of refrigerating appliances is, for example, determined by a standard test over a period of 24 h and subsequently scaled to the annual value (European Commission, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32010R1060 (accessed 8 February 2022)). If anything, our measure of savings potential from upgrading may be underestimating the true saving from upgrading due to the fact old appliances tend to become less efficient as they age (see for instance Hueppe et al. 2020).

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