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Energy efficiency, information, and the acceptability of rent increases: A survey experiment with tenants☆

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ABSTRACT

This paper studies the role of imperfect information and attentional biases in the context of energy efficiency investments in rented properties and associated split incentives. We design a multiple price list experiment representing owners' decision to replace the central heating appliance, and employ both within-subject information disclosure and between-subject variation in information provision to quantify how tenants trade off energy efficiency and rent increases. Results show that informing tenants of a CHF 1 decrease in energy bills leads to CHF 1.12 in acceptable rent increase on average. Quantile regressions further indicate that the average treatment effect of information reflects heterogeneous changes along the entire distribution of acceptable rent increases. By contrast, information on energy bills variability dampens acceptable rent increase, and information about CO_2 tax payments has no incremental impact on choices. Our results highlight the importance of credible ex-ante estimates of financial savings associated with energy efficiency investments.

1. Introduction

Despite positive private and social returns expected from energy efficiency investments, the adoption of energy efficient technologies is slow, and considerable resources are being directed to policies stimulating take-up (e.g. Allcott and Greenstone, 2012; Gillingham and Palmer, 2014). Considering residential energy consumption, rented dwellings represent a particularly challenging case. If tenants pay for energy bills, property owners have little incentives to invest in energy efficiency of their properties, whereas tenants have little incentives to invest themselves in a property they do not own. The resulting landlord-tenant split incentives constitute a major barrier to the improvement of energy efficiency in the stock of residential buildings (Gillingham et al., 2012; Davis, 2012).[1] Higher up-front investment costs associated with energy efficiency are borne by property owners, whereas tenants benefit from a reduction in the implicit price of energy services. For property owners, generating a positive return on these investments requires increasing rents, although they may encounter difficulties in signaling the value of future energy savings to tenants, leading to information asymmetries as documented in Myers (2020). This makes information a central aspect in tenants' acceptance of rent increases in exchange for lower energy bills.

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[1] In the U.S. about 35% of dwellings are renter-occupied (U.S. Census Bureau, 2019), around 30% in the E.U. (Eurostat, 2017), and in China about 11% (Yang and Chen, 2014). Empirical evidence comparing energy consumption in owner-occupied and rented properties suggests tenants face significantly higher energy bills (see e.g. Bird and Hernandez, 2012; Charlier, 2015; Melvin, 2018).

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In this paper, we study a hypothetical situation in which the owner of a rented property has to replace the central heating appliance, and can either install a standard option (efficiency label B, Council of European Union, 2013) or a more energy efficient one (labeled A^+).[2] Holding the level of comfort fixed across alternatives, we design a stated choice multiple price list (MPL, Andersen et al., 2006; Anderson et al., 2007) in which we expose tenants to a monthly "price" (rent increase) for the efficient technology, starting at zero and then sequentially increasing it. Subjects choose the efficient option until the proposed rent increase is deemed to be too high and the standard replacement option is chosen instead (with no associated rent increase).[3] After a baseline MPL task, which reflects perceived differences derived from mandatory energy efficiency labels, we quantify the impact of alternative informational interventions on tenant's valuation of improved energy efficiency. To do so, we follow Newell and Siikamäki (2014) and Allcott and Taubinsky (2015) and randomly assign subjects to alternative treatments that provide information about financial implications of their choices. We then employ a second MPL task to measure how within-subject information disclosure affects the acceptability of rent increases, and in turn the landlord-tenant split incentives problem. Furthermore, a between-subject comparison across information conditions provides detailed evidence on the role of financial savings information, energy bills variability, and CO_2 tax payments, based on illustrative figures derived from the Swiss context.

Our experimental design is motivated by the need to inform policies that incentivize energy efficiency investments in existing dwellings. Indeed, improving space heating efficiency in the stock of buildings is one of the key measures put forward by many governments in an attempt to reduce environmental externalities associated with fossil fuel consumption. Space heating is thought to offer large potential energy savings (IPCC, 2014) and the U.S., for example, plans to reduce buildings' energy use per square foot by 30% in 2030 relative to 2010 (U.S. Department of Energy, 2015), while China includes the improvement of buildings' energy efficiency in its national energy consumption targets (NDRC, 2017).[4] Importantly, heating systems have a relatively long average lifetime, so that space heating choices represent long-term investments (see Rapson, 2014).[5] Because property owners are "locked-in" a specific technology, evidence contributing to the design of policies targeting energy efficiency investments is crucial.

Previous research has identified a number of market distortions associated with energy efficiency investments (see Gerarden et al., 2017), and growing empirical evidence suggests that imperfect information and attentional biases are significant barriers to energy efficiency improvements (e.g. Allcott and Wozny, 2014; Jacobsen, 2015; Allcott and Knittel, 2019). In a landlord-tenant setting, Myers (2020) provides empirical evidence that tenants are uninformed about energy costs, and in turn that asymmetric information reduces energy efficiency investments. In line with this, in this paper we assess the potential to influence tenants' valuations of energy efficiency with financial information. Our experimental design delivers willingness to pay (WTP) space evidence about how simple efficiency labels are perceived by tenants, and quantifies the incremental impact of specific financial information on their choices. Relative to existing studies, a major contribution of our work is to provide experimentally controlled evidence on the role of information in a landlord-tenant split incentive context.

In particular, our experimental design identifies the impact of information along two important dimensions. First, recent research highlights financial and energy literacy as barriers to energy efficiency investments (see e.g. Brent and Ward, 2018), and emphasizes the importance of financial information in fostering consumers' ability to make rational and efficient choices (as opposed to physical units, see Blasch et al., 2019). Building on these results, we study how illustrative information about financial savings associated with reduced energy consumption affects tenants' acceptance of rent increases. More specifically, a set of experimental conditions informs tenants that choosing option A^+ over B (approximately 30% higher energy efficiency, see Council of European Union, 2013) would reduce energy bills by CHF 40 per month (about USD 42). Within the conditions, we further vary salience of financial savings, thereby adding to the results of Newell and Siikamäki (2014) who study the context of owner-occupied properties. Moreover, because there is ample uncertainty about realizations of future energy bills, which implies that risk averse tenants hold a higher valuation for energy efficiency improvements, for another subset of tenants we couple illustrative financial savings figures to information about variability of energy bills over time.

Second, we test whether salience of CO_2 tax payments incorporated in energy bills has an impact on acceptable rent increases, leveraging the existing CO_2 tax on fossil heating fuels in Switzerland (CHF 84 or USD 87 per ton of CO_2 in 2017, see The Swiss Federal Council, 2012). More specifically, we design a set of conditions where we vary the salience of financial savings and reduced CO_2 expenditures related to their choices, allowing us to examine consumers' responses to tax-inclusive prices as compared to purely financial information. We thereby contribute to a growing literature on the behavioral effect of salience of externality-correcting taxes (see e.g. Li et al., 2014; Houde and Aldy, 2017; Lanz et al., 2018).

Our experimental survey is administered to an online panel of 406 Swiss tenants, the majority of which bears the energy cost of their dwelling separately from monthly rents.[6] Our results indicate that, in the baseline, around 70% of tenants in our sample are willing to accept a rent increase if their landlord replaces their existing heating appliance with an energy efficient option as opposed to a standard one. Quantitatively, average WTP for efficiency grading label A^+ vs. B is CHF 37.51 per month (about CHF 450 or USD 470 per year), roughly 3% of median rents in Switzerland. Providing financial information about expected energy bills associated with each option leads to an average endline WTP estimate of CHF 64.87 per month (about CHF 780 or USD 810 per year), which exceeds financial savings. In particular, informing tenants about CHF 1 in expected energy savings translates into CHF 1.12 in possible rent increases on average, and increasing salience of the information pushes this number to around CHF 1.62. This implies that a large share of our sample holds motives beyond purely financial concerns. By contrast, we find that information about past variability in energy bills dampens acceptable rent increase, and information on CO_2 tax

[2] Our stated preferences MPL is motivated by the difficulty to harness revealed preferences in this setting, as observational data are constrained by supply-side restrictions such as rent control regulations, and a randomized control trial is not practical due to the cost of the interventions we consider. As we discuss in detail below, we take a number of steps to mitigate hypothetical bias and incentivize truthful preference revelation. Nevertheless, our results on the acceptable level of rent increase should be interpreted with caution, and our attention is mainly directed towards between- and within-subjects comparisons quantifying the role of information provision.

[3] Also widely applied, discrete choice experiments allow preference elicitation among multi-attribute alternatives. In a companion paper (Lang et al., 2020), we employ a discrete choice experiment with a sample of home owners and test for the impact of information on preferences for alternative heating replacement options. In rental buildings, however, the multi-dimensional choice of a central heating appliance is made by the landlord, typically without consulting tenants. When studying tenants' willingness to contribute to the appliance's energy efficiency, the MPL procedure offers a more realistic choice setting.

[4] Space heating represents 32% of final residential building energy consumption in 2010, the largest share across end-uses (additional large contributors are cooking and water heating, see IPCC, 2014). The IEA (2011) further reports that 63% of buildings' potential energy savings in 2050 come from the residential sector, with space heating representing 39% of residential buildings' potential energy savings.

[5] A U.S. study by Seiders et al. (2007), for instance, estimates that gas boilers operate for 21 years on average, oil furnaces 15–20 years, and heat pumps 16 years. Most homeowners wait until building components reach the end of their useful life before considering renovation or replacement (Jakob, 2007; Achtnicht and Madlener, 2014).

[6] In Switzerland, tenants commonly pay heating costs for their dwelling separately from their rents, often in the form of down payments. In our sample, only 1% of tenants state that the energy cost is included in their rents, while 85% report paying it separately from their rents. 13% of tenants do not know the billing method (note that this group's WTP estimates are statistically indistinguishable from the remainder of the sample).

payments has no incremental impact on tenants' valuation of energy efficiency. Our results thus suggest a differentiation between financial and pro-social preferences.

While average treatment effects are important, a policy interest persists in the impact on the tails of the WTP distribution (an ideal informational intervention incentivizes the lowest quantiles to correct their expectations of ex-post benefits upwards). In order to document heterogeneity in how the treatment effect of financial information varies across the distribution of valuations, we report results from a set of quantile regressions. Results show that, while values for mean and median treatment effect estimates are very similar, the average treatment effect reflects heterogeneous changes along the entire WTP distribution. Specifically, we document that the upward shift in WTP reflects an increased frequency of high energy efficiency valuations in particular, with lower quantiles remaining unaffected. In other words, providing tenants with information on expected energy bills reductions results in a WTP distribution that is less (positively) skewed, i.e., with a larger proportion of high valuations.

Our results also complement a small number of studies on tenants' preferences towards energy efficiency investments. Banfi et al. (2008) and Phillips (2012) employ discrete choice experiments to study tenants' preferences towards specific combinations of energy efficiency investments in Switzerland and New Zealand respectively, with mixed results. While Banfi et al. (2008) find that Swiss tenants' valuation of energy efficiency improvements such as window replacement and installing a ventilation system is generally higher than the corresponding investment costs, Phillips (2012) suggests that willingness to accept rent increases in exchange for an energy efficiency improvement of the heating system is economically insignificant. These results show that improved comfort plays an important role in tenants' choices, something we control for in our experimental design, and confirm that tenants may be ill-informed about financial savings associated with their investments. Studying a sample of university tenants in Ireland, Carroll et al. (2016) show that WTP for energy efficiency is substantially higher at the lower end of the energy efficiency distribution, but find no statistically significant WTP for improvements in buildings with energy efficiency grade B or above. Relative to Carroll et al. (2016), our contribution is to consider a replacement decision, thereby isolating the impact of energy efficiency on tenants' valuation of renting services. We also build on Hoppe (2012) and Glumac et al. (2013), who conduct in-depth (case study) analyses of specific renovation projects in the Netherlands, showing that rent increases are an important driver of ex-post acceptability. Our work instead emphasizes the role of ex-ante information for tenants' acceptance of rent increases. We show that obtaining and providing realistic measures of energy savings prior to renovation is an important step to foster the adoption of energy efficient technologies in a split-incentive context (see Fowlie et al., 2018; Burlig et al., 2017; Liang et al., 2018).

The paper proceeds as follows. In Section 2, we present a simple conceptual framework that allows us to identify the impact of information on WTP. Section 3 describes our experimental design, including MPL procedures, and provides the details of alternative informational interventions. Section 4 presents our results. Concluding comments are provided in Section 5.

2. Conceptual framework

Our survey experiment focuses on owners' decisions to *replace* the appliance supplying heat to the central heating system and, in that context, on the choice between a standard and an energy efficient appliance. Our main objectives are then to estimate (i) tenants' acceptance of rent increases in exchange for increased efficiency of their central heating system; and (ii) whether additional information about energy savings and CO_2 taxes affects tenants' WTP. In this section, we first lay out a simple conceptual framework representing tenants' decisions, which allows us to introduce some useful notation. Second, we describe our empirical strategy to quantify the impact of information on observed choices.

2.1. A model of tenants' decisions: Notation

As mentioned above, our identification strategy builds on Allcott and Taubinsky (2015). We consider a set of tenants indexed by i who are consulted for a choice between an efficient heating system (E) and a standard heating system (S). The two alternatives $j \in (E,S)$ are associated with prices p_j, and $p = p_E - p_S$ denotes relative prices. Both alternatives are financed by rents and are thus expressed in monthly outlays.[7] We refer to tenants' utility directly in monetary equivalents in the form of tenants' WTP (in rents), and define tenant i's WTP for selecting j as wtp_{ij}. Accordingly, we denote relative WTP as $wtp_i = wtp_{iE} - wtp_{iS}$. Notionally, a utility maximizing tenant would select E if and only if $wtp_i > p$, that is, the relative surplus from selecting the efficient system is greater than the associated increase in rents.

Given this notation, the objective of this study is to identify wtp_i. In particular, as discussed extensively below, we use a MPL procedure to identify the relative prices at which subjects switch from choosing option E to option S. This is achieved by offering a sequence of t choices between options E and S, where relative prices p^t vary in the form of increased monthly rents. Therefore, if tenant i prefers efficient option E at price p^1, but instead chooses the standard option S at price p^2, then the MPL task reveals that this particular tenant's relative valuation wtp_i lies within the interval $[p^1,p^2]$.

Importantly, wtp_i includes all perceived differences between efficient (E) and standard (S) heating systems. In general, considering different heating systems involves expectations about potential cost savings, non-monetary costs associated with installation, different levels of comfort, differences in lifetime duration of appliances, or social benefits associated with lower energy use, among many other things (see Fowlie et al., 2015). As an attempt to fix subjects' heterogeneous expectations and thereby control for these potential confounders, we frame the experimental survey to focus exclusively on energy efficiency gains as measured by a simple energy label that is encountered in the marketplace.

The narrow focus on energy efficiency implies that wtp_i will reflect expected differences in energy consumption and associated financial savings. In particular, energy consumption directly affects exposure to variations in the price of heating fuels, so that risk aversion might act as a relevant source of heterogeneity in WTP for energy efficiency. In turn, a risk averse tenant may attribute a higher value to a given energy efficiency improvement, as lower energy expenditures reduce exposure to fuel price risk, so that wtp_i includes a component associated with risk reduction. Similarly, heterogeneity in wtp_i may be driven by differences in environmental preferences. In section 3.2, we lay out how we manipulate individual perceptions of heating cost savings, risk considerations, and CO_2 emissions, by means of various informational interventions.

2.2. Identifying the effect of information

In order to quantify how financial and environmental information affect choices, we first elicit wtp_i with a baseline MPL choice task, and then randomly assign tenants to one of several information treatments.

[7] From the tenants' perspective, rents and energy costs are paid each month, so the decision problem is static. We therefore do not consider the role of time preferences. In our experimental setting, we further clarify that selecting the standard appliance as a replacement corresponds to usual maintenance of the property, so that choosing this option would not affect rents.

As we describe in more detail in the next section, these conditions mainly focus on providing information about energy cost savings and CO_2 tax payments. Subsequently, we elicit wtp_i with an endline MPL choice task.

Formally, we denote tenant i's *baseline* WTP as wtp_i^0, and WTP *after* being subject to one of the interventions as wtp_i^1. We refer to the latter as *endline* WTP. We exploit within- and between-subject variation in wtp_i^s, $s \in \{0,1\}$ to identify the impact of information in WTP-space. This is achieved with a set of linear regressions in which the outcome variable is wtp_i^s measured by respective MPL tasks[8]:

$$wtp_i^s = \alpha + \sum_k \beta_k T_{ik} + \epsilon_i \quad (1)$$

where T_{ik} is a set of treatment indicators (i.e., one dummy variable for each treatment condition) and ϵ_i is an error term. The vector of coefficients in β_k represents average treatment effects, and provides direct evidence on how information affects WTP.

Similarly, we study how alternative treatment interventions affect the distribution of tenants' WTP. For this purpose, we employ a set of quantile regressions. Formally, we estimate the (unconditional) quantile function for quantile τ, denoted Q^τ, with the following quantile regression model:

$$Q^\tau(wtp_i^s) = \alpha^\tau + \sum_k \beta_k^\tau T_{ik} + \epsilon_i^\tau \quad (2)$$

where $Q^\tau(wtp_i^s)$ is the τth quantile of wtp_i^s and the vector of coefficients in β_k^τ denotes quantile treatment effects. In other words, β_k^τ provides evidence on the effect of information on the τth quantile of the WTP distribution.

3. Experimental design

In a nutshell, subjects go through the following sequence: (i) a baseline MPL choice task, (ii) random assignment to one of six information treatments plus a control group, and (iii) an endline MPL choice task. In the following, we provide details of the MPL elicitation tasks and informational interventions. We then provide some notes about how we administer the experimental survey. A full set of screenshots of the experimental material is provided in Appendix A.

3.1. Multiple price list procedures

The MPL exercise asks subjects to consider that the current appliance supplying heat to their dwelling needs replacement, and invites them to think about which option would be best suited for their household. We also make them aware that the choice of heating appliance could influence their rents. The owner of the property may choose a "standard" replacement option, which is considered normal maintenance of the property and would therefore not affect monthly rents. Alternatively, the owner may invest in a more energy efficient central heating appliance, and may therefore increase rents to cover higher upfront investment costs.[9]

The choice focuses explicitly on replacing the appliance that supplies heat to the dwelling through the heating system. The two options considered by the owner only differ by a standard energy efficiency label of the form mandated by the European Union, ranging from A^{++} (most efficient) to G (least efficient). To keep it simple, we attribute label A^+ to the efficient appliance and label B to the standard appliance, which corresponds to an approximate 30% improvement in energy efficiency (Council of European Union, 2013).[10] The description of the choice makes clear that both appliances perform equally well, meet general requirements, and are expected to have the same operating life of 15 years. We also emphasize that the installation of the new appliance would necessarily take place in the year of the survey (to mitigate discounting issues), and that other elements of the heating system (such as radiators) would not be affected. As mentioned previously, this relatively narrow focus allows us to abstract from comfort considerations associated with energy efficiency improvements, so that WTP estimates exclusively relate to expected benefits associated with energy efficiency.[11]

As we focus on a single dimension of space heating (the efficiency of the appliance that supplies heat), standard MPL elicitation procedure is particularly well suited. Moreover, MPL choice tasks are easy to explain to respondents, and allow elicitation of robust and relatively precise valuations (see Andersen et al., 2006; Anderson et al., 2007). In order to mitigate possible biases associated with the MPL elicitation format, and foster incentives for truthful preference revelation in a stated preference context, we take the following steps. First, in order to eliminate the risk of subjects feeling inclined to pick a response in the middle of the MPL task (framing effect), we present the choice tasks sequentially, i.e., one MPL choice task per screen. Subjects therefore do not know, a priori, the upper bound used in the experimental survey. Second, to prevent multiple switching sometimes observed in MPLs, the sequence of choices stops whenever the respondent selects the standard appliance.[12] Third, to make sure that respondents fully understand the MPL task, we provide them with an example before they start each sequence. However, we do not display a specific price tag to avoid anchoring effects.

The last set of steps is more directly geared towards the hypothetical nature of the choice task.[13] On the one hand, we use a number of scripts in line with the literature on truthful preference revelation (e.g. Vossler et al., 2012; Newell and Siikamäki, 2014). More specifically, previous work on the topic has shown that a crucial element involves perceived consequentiality of stated choices. We therefore inform subjects that their answers will be

[8] Note that MPL tasks only provide bounds on wtp_i^s, as measured by the price intervals specified in the sequence of t MPL choices. An alternative to linear regression using the mid-point of the interval is to apply an interval data model (e.g. Cameron, 1988). With our data, however, we find that OLS and interval data models yield very similar treatment effects, and therefore stick with OLS specifications.

[9] The distribution of efficiency grades among tenants' own heating equipment might influence the choice of acceptable rent increase. However, the impact of subjects' initial endowment on choices is not the focus of this study (to the extent that there are no concerns with sampling, see section 3.3). Much rather, we direct our attention to the role of information in tenants' decision-making by exploiting between- and within-subjects comparisons.

[10] In order to focus exclusively on energy efficiency, we do not mention specific energy technologies. Nevertheless, the standard option with label B corresponds to conventional and comparatively cheap oil boilers, whereas the option labeled A^+ corresponds to either a heat pump appliance or, alternatively, a "package" combining a standard oil boiler coupled with solar panels. Because the choice is framed as a replacement decision, one of the two options would be installed in any case.

[11] The specific text we use is as follows: "Aside from the specific characteristics of the appliances, please assume that they meet your general requirements, perform equally well, and are expected to have the same operating life of 15 years," and "When making your choices, please assume that the change of appliance will necessarily take place in 2017. The selected heating appliance would fully replace your current central heating appliance, but the rest of your heating system, such as the radiators, would not need to be changed." Note that our experimental design does not allow us to test whether we have been successful in disciplining households' expectations.

[12] Multiple switching behavior leads to inconsistent valuations and thus complicates inference, while preventing it imposes structure (strict monotonicity and transitivity) on the subject's responses that is not always justified (Anderson et al., 2007). However, while multiple switching behavior can be at least partly explained by subject's indifference between options (and therefore by weakly rather than strictly convex preferences), enforcing a single switching point has been shown to have no systematic effect on results (Andersen et al., 2006).

[13] We note that MPL choice tasks have similarities with two widely used stated preferences formats, namely dichotomous choice and payment card contingent valuation, although with costs presented sequentially. It follows from the literature (e.g. see Johnston et al., 2017) that the first MPL choice is incentive compatible, whereas subsequent choices are not. Another important result from the stated preference literature is that iterative bidding can potentially lead respondents to anchor their response to their first choice (see Bateman et al., 2001). Because we start with a price of zero, our approach would therefore tend to underestimate tenants' WTP.

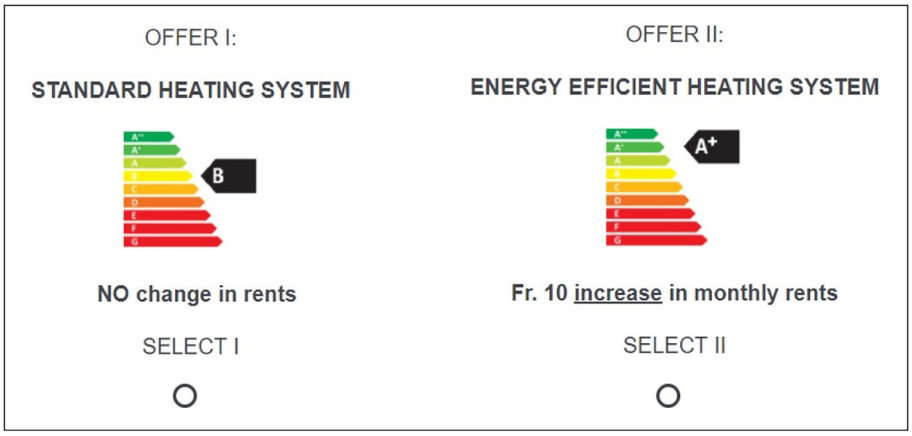

Fig. 1. Baseline multiple price list choice task.

used exclusively by academic research, and explain that it is in their best interest to answer the questions truthfully. On the other hand, following important insights from the stated preference literature (see Johnston et al., 2017), we use a number of budget constraint reminders.[14] The full text underlying MPL choices is reported in Appendix A, Figs. A1 to A5.

Turning to the MPL choice task itself, shown in Fig. 1, we ask subjects to consider a binary choice between a standard and an efficient appliance. At the beginning of the MPL task neither of the two alternatives is associated with a rent increase. Since both options have the same cost (zero) but one is more efficient, we would expect tenants to choose the efficient alternative. After that, the rent associated with the more efficient option increases gradually, with steps along the ladder shown in Table 1. Note that the price levels selected were piloted to ensure that they yield meaningful switch-points for respondents.

3.2. Informational interventions

The baseline MPL sequence ends either when respondents select the standard appliance or when they reach the maximum price level specified. Respondents are then randomly allocated to one of seven conditions, summarized in Table 2. Each condition consists of two consecutive information screens, all of which closely match each other in design, structure, complexity and length. Therefore, only the actual content of the screen should affect the MPL decision (see Figs. A10 to A14).

Following Allcott and Taubinsky (2015) and Allcott and Knittel (2019), we take a number of steps to ensure that information is effectively conveyed to tenants. First, information is displayed both verbally and visually (in the form of a simple figure). Second, to incentivize attention, we announce upfront that each information screen will be followed by a one-question quiz (a simple question about the core information displayed on the screen). Respondents are required to answer the quiz question in order to move forward in the experimental survey (if they do not answer correctly, the correct answer is displayed). In our sample, 76% of respondents answered both quiz questions correctly on first attempt, and 89% gave at least one correct answer.

After being exposed to the two information screens and completing the quiz questions, subjects receive instructions for the second (endline) MPL task. As we discuss below, in some treatments the design of the MPL is modified to reinforce salience of the information provided.

[14] We include two different budget reminders: "Some of the following questions will involve costs to your own household; please give careful consideration to how these costs would affect your financial budget," and "In making your choices, please remember that any money spent on your heating will not be available for other expenses by your household. The only right answer is what you would really choose."

Table 1
Multiple price list payment ladder of rent increases.

Choice task	Rent increase standard heating appliance	Rent increase energy efficient heating appliance
No. 1	0 CHF	0 CHF
No. 2	0 CHF	10 CHF
No. 3	0 CHF	20 CHF
No. 4	0 CHF	30 CHF
No. 5	0 CHF	40 CHF
No. 6	0 CHF	50 CHF
No. 7	0 CHF	75 CHF
No. 8	0 CHF	100 CHF
No. 9	0 CHF	150 CHF
No. 10	0 CHF	200 CHF

Thus, after being exposed to both information screens, respondents either repeat the same MPL task as in the baseline, or a slightly modified version of it. In the following subsections, we discuss our set of treatment conditions in more detail.

3.2.1. Control group (T_{iA})

Treatment group A represents the control intervention. It is designed to provide "placebo information" that should not affect the demand for efficient heating appliances, and thus tenants' acceptance of rent increases. Concretely, in this condition tenants are given information about the age of the Swiss building stock (information screen *Neutral I*, Fig. A10) and the different energy sources used to heat buildings in Switzerland (information screen *Neutral II*, Fig. A11). After the two information screens (and the associated quiz questions), respondents repeat the MPL choice task presented in the baseline.

3.2.2. Information about heating costs (T_{iB}, T_{iC}, T_{iD})

Treatments B and C both provide one information screen about average monthly heating costs associated with each option (information screen *Heating cost*, shown in Fig. A12), and then the neutral information screen on the age of the Swiss building stock (information screen *Neutral I*, Fig. A10). The information about heating costs aims at illustrating the importance of specific financial information for tenants' choices.[15] It is based on an average expenditure of CHF 170 per month

[15] Nonetheless, the empirical analysis relies on subjects perceiving the provided information as credible and trustworthy. Given the ambiguous findings in the literature regarding returns from energy efficiency investments (see e.g. Fowlie et al., 2018; Lang and Lanz, 2020), it is conceivable that some subjects doubt the magnitude of the provided ex-post savings. This would render our informational interventions ineffective in correcting imperfect information bias (the intervention would, however, still raise subjects' attention to the matter). As a result, we potentially underestimate the effect of (more credible) information on tenants' WTP.

Table 2
Overview of informational treatment interventions.

Treatment indicator	Treatment group name	1st information screen	2nd information screen	Endline choice task
T_{iA}	Control	Neutral I	Neutral II	Rent increase (baseline)
T_{iB}	Heating cost	Heating cost	Neutral I	Rent increase (baseline)
T_{iC}	Heating cost salient	Heating cost	Neutral I	Rent increase + Heating cost
T_{iD}	Heating cost variability	Heating cost	Heating cost variability	Rent increase + Heating cost
T_{iE}	CO_2 tax	Heating cost	CO_2 tax	Rent increase (baseline)
T_{iF}	CO_2 tax salient (A^+ lower tax)	Heating cost	CO_2 tax	Rent increase + Heating cost + CO_2 tax (A^+ lower tax)
T_{iG}	CO_2 tax salient (A^+ no tax)	Heating cost	CO_2 tax	Rent increase + Heating cost + CO_2 tax (A^+ no tax)

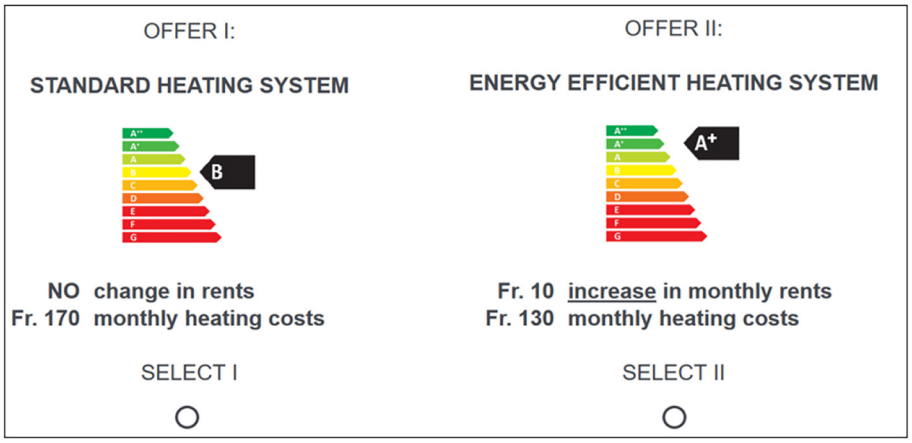

Fig. 2. Endline multiple price list choice task with heating costs.

(about USD 178) for a standard appliance and CHF 130 per month (about USD 136) for the energy efficient alternative. As a result, financial savings associated with the efficient alternative represent about 30%, which is consistent with the energy efficiency labels discussed.[16]

Treatments B and C differ in how the endline MPL task is designed. In particular, tenants in treatment B complete the MPL presented in the baseline, just as those in the control group. Thus endline WTP from treatment B allows us to measure the effect of our information screen about heating costs on tenants' WTP. Conditional on respondents not having been fully aware of financial savings associated with energy efficiency, we expect treatment B to increase endline WTP as compared to baseline WTP. We label this treatment "*Heating cost*."

By contrast, tenants in treatment C face an endline MPL task which explicitly includes the estimate of heating costs associated with each option. This modified MPL task is shown in Fig. 2. Reminding tenants about heating costs *during* MPL choices increases salience of financial implications of energy efficiency, and should therefore reinforce the informational intervention. Treatment C, labeled "*Heating cost salient*," therefore provides further evidence about the importance of heating cost information for the acceptability of rent increases in exchange for energy efficiency improvements. This format is close to U.S. energy labels for water heating appliances discussed in Newell and Siikamäki (2014), and if salience matters endline WTP is expected to be higher in treatment C than in treatment B ($T_{iB}<T_{iC}$).

In treatment D, respondents first get to see the information screen *Heating cost*, and in the second screen we provide information about heating cost variability (information screen *Heating cost variability*, Fig. A13). This second screen illustrates how heating costs may vary over time for reasons unrelated to technology choice, and we therefore label treatment D as "*Heating cost variability*." This sequence of information screens, while maintaining the cost advantage of the energy efficient option, provides historical evidence that heating cost savings are in fact uncertain. We explain this to subjects by means of past energy costs associated with an oil based heating appliance (a comparatively inexpensive heating source with visible price volatility).[17] After the second information screen, respondents complete a second MPL task in which energy cost differentials are also reported (Fig. 2). Comparing treatments D and C provides evidence about the incremental effect of information on energy cost variability, and we expect that this treatment should generally decrease attractiveness of the more efficient option ($T_{iC}>T_{iD}$).

3.2.3. Information about carbon tax payments (T_{iE}, T_{iF}, T_{iG})

Treatments E, F and G all focus on environmental impacts of energy efficiency choices, which we achieve by providing information about the carbon tax levied on heating fuels in Switzerland.[18] Subjects in these treatments first face the information screen *Heating cost*, and the second screen provides information about the CO_2 tax in Switzerland and its implications on fossil-based heating costs (information screen

[16] Naturally, energy bills are expected to vary across households and over time. The specific numbers we use mainly support our objective of quantifying how information on financial savings affects tenants' decisions. We come back to the issue of cost variability when we discuss treatment D below.

[17] We frame the information as a risk that energy bills may not decline as much as expected, mainly because growing evidence suggests engineering projections tend to be overoptimistic (e.g. Fowlie et al., 2015).

[18] More precisely, the Swiss carbon tax is imposed on all fossil heating and process fuels (heating oil, natural gas, coal, petroleum coke, etc., see The The Swiss Federal Council, 2012). At the time of the survey, the tax amounts to CHF 84 (about USD 87) per ton of CO_2, and carbon tax payments are indicated on fossil heating fuels invoices (in addition to the VAT amount). Importantly, the tax is set to increase over time, so that the cost associated with fossil-based central heating appliances can be expected to increase as well (The Swiss Federal Council, 2016).

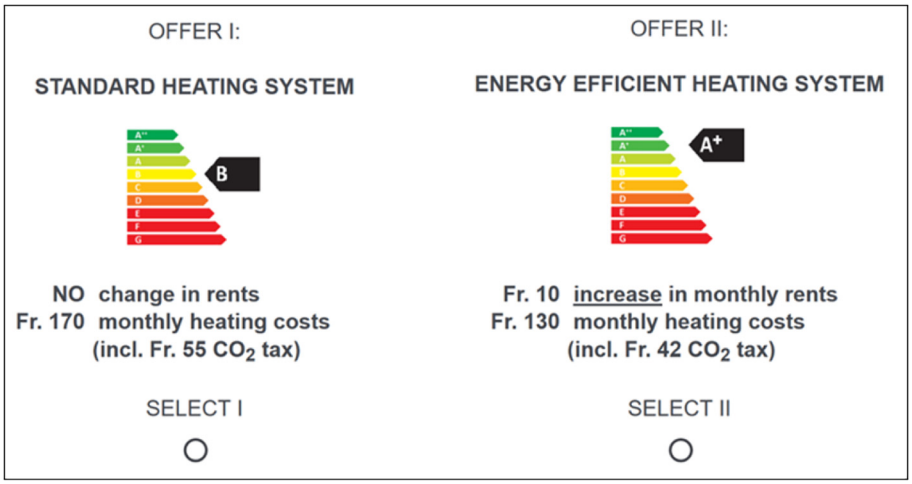

Fig. 3. Endline multiple price list choice task with heating costs and CO_2 tax (A^+ lower tax).

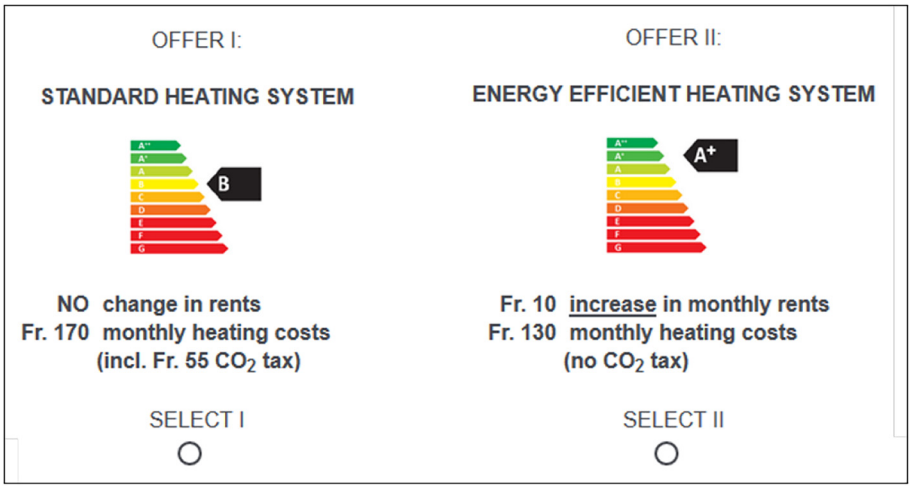

Fig. 4. Endline multiple price list choice task with heating costs and CO_2 tax (A^+ no tax).

CO_2 tax is shown in Fig. A14). Note that in Switzerland, the tax is paid when heating oil is delivered, so that most tenants receive no details about CO_2 tax payments when they pay their heating bills.

The difference between treatments E, F and G is again driven by whether and how the CO_2 tax information is included in the MPL task. In treatment E, we repeat the baseline MPL design reported in Fig. 1, so that comparing treatments B and E provides evidence about whether the CO_2 information screen affects WTP. If environmental motives affect choices, one would expect WTP in treatment E to be higher than in treatment B ($T_{iE}>T_{iD}$). However, if respondents oppose government interventions in the form of taxes, they may react negatively to this information (Perino et al., 2014; Lanz et al., 2018).

In treatments F and G, respondents see the same information screens *Heating cost* and *CO_2 tax* and, in addition, the endline MPL task integrates financial information about both energy expenditures and CO_2 tax payments. In treatment F we consider a situation in which the more efficient option still uses oil (e.g. an oil boiler coupled with solar panels), so that CO_2 tax payments are positive for both options (they are of course proportionally lower for the efficient appliance). An example of the ensuing MPL task is shown in Fig. 3. In treatment G, we instead consider an efficient option with no CO_2 tax payments, signaling that it implies no (direct) CO_2 emissions. This alternative corresponds, for example, to a heat pump appliance. The ensuing MPL task is displayed in Fig. 4. Because the efficient option in treatment G is free of CO_2 emissions, WTP of respondents with pro-environmental motives is expected to be higher than in treatments F ($T_{iF}>T_{iG}$).

3.3. Implementation

Our survey experiment is fielded as an online survey scripted with Qualtrics and administered in April and May 2017 as part of a wider study on energy behavior in Switzerland (Weber et al., 2017). Survey participants are drawn from an online subject pool managed by the private marketing company Intervista, which holds over 90,000 self-subscribers. As per other projects managed by the company, participants are invited via email and they are compensated for their time with vouchers (the equivalent of CHF 6 for completion of the present survey).[19] Among a sample of 5015 participants to the study, a subsample of 406 tenants is randomly selected and completes our survey.

Relying on a panel of self-subscribers implies that our sample is not random. However, in terms of observable characteristics of participating tenants (see Table B1 of Appendix B), our sample is in line with figures

[19] The e-mail invitation is neutral and reads as follows: "Dear Sir or Madam, we have the pleasure to invite you to participate in a new Intervista survey. With a click to the link below you can access the survey directly. If you are part of the target group and complete the survey integrally, you will receive 60 bonus points. Answering the survey will take about 30 min of your time. We wish you a lot of fun answering this survey! Kind regards, your Intervista team." The response rate is approximately one third.

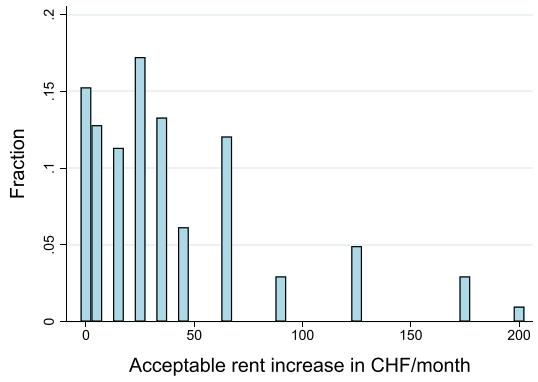

Fig. 5. Distribution of baseline WTP (wtp_i^0).

from the Federal Statistical Office on the Swiss population for gender (53% women in our sample compared to 50% in Switzerland, FSO, 2017), high-education groups (47% of our sample completed tertiary education against 43% in the general population, FSO, 2019a), average age (43 years in our sample compared to 42 years in Switzerland, FSO, 2018a), income (CHF 6000–8999 compared to CHF 7566 in Switzerland, FSO, 2018b), and dwelling size (92m^2 compared to 99m^2 in Switzerland, FSO, 2019b). The proportion of households living in multifamily houses and using oil as a heating fuel are also close to population figures (respectively 84% vs. 77%, FSO, 2019b, and 37% vs. 39%, FSO, 2019b).[20] In Table B2, Appendix B, we further summarize randomized treatment assignment across conditions. The average number of participant per condition is 58, and differences across subsamples are due to the fact that a small number of tenants dropped out of the experimental survey. Note that we find some small differences in baseline WTP across treatment groups, although Wald tests indicate that the differences are statistically insignificant.[21]

4. Experimental results

This section reports the main results from the survey experiment. We first provide evidence on tenants' WTP for efficient heating appliances based on baseline MPL choices. Second, we exploit within- and between-subjects variations to identify the impact of information about energy costs and CO_2 tax payments on subjects' WTP. Third, we employ a set of quantile regressions to discuss the effect of information on the distribution of tenants' WTP.

4.1. Tenants' WTP estimates from baseline choices

Fig. 5 shows the distribution of baseline WTP estimates for our sample of 406 tenants, as measured by the mid-point intervals reported in Table 1.[22] Average WTP associated with a central heating appliance of grade A$^+$ rather than B is wtp_i^0= CHF 37.51 per month. This corresponds to 3.07% of net median rents in Switzerland and 2.76% of net average rents.[23] Since in the baseline MPL task tenants have not received information about heating bills reductions and rely exclusively on labels (as they would in the marketplace), our estimate of wtp_i^0 includes both expectations about reductions in energy bills as well as other expected impacts (such as environmental benefits). We come back to this below.

[20] The second most prevalent heating source in our sample as well as in the general population is natural gas (with 19% vs. 21% respectively, FSO, 2019b). Our sample also covers households heating with district heat (7%), electricity (7%), wood (6%), and heat pump (5%). 17% of tenants do not know the source.

[21] In particular, we fail to reject the hypothesis that T_{iA}=T_{iC}, the largest difference in baseline WTP across groups, with a p-value of 0.2.

[22] To be conservative, WTP for the highest value on the list is set at its lower bound, which is CHF 200.

[23] In 2016, monthly median rent in Switzerland amounted to CHF 1322, while average rents were CHF 1220 (FSO, 2018).

Table 3
Descriptive results of WTP across baseline/endline choices and treatments.

Treatment	N	Mean	Std.-dev.
Baseline choices (wtp_i^0)	406	37.51	42.29
Endline choices (wtp_i^1):			
Control (T_{iA})	58	38.71	43.55
Heating cost (T_{iB})	63	44.96	48.99
Heating cost salient (T_{iC})	57	64.87	51.74
Heating cost variability (T_{iD})	61	53.32	41.59
CO_2 tax (T_{iE})	57	43.95	38.72
CO_2 tax salient (T_{iF}, A$^+$ lower tax)	52	60.14	48.92
CO_2 tax salient (T_{iG}, A$^+$ no tax)	58	58.15	42.54

Notes: All WTP estimates are measured in in CHF per month (2017 exchange rate: CHF 1 = USD 1.04).

Baseline MPL results also show that around 15% of respondents select the standard heating appliance in the first choice (i.e., no increase in rents). In other words, these tenants choose the inefficient appliance even though the more efficient option is provided at no additional cost. Another 12.8% of respondents switch from the more efficient option to the standard one in the second MPL question.[24] One interpretation is that these tenants value energy efficiency in principle, but refuse to pay (much) for it in the form of an increase in rents.[25] The remaining 72% of our sample accept an increase in rents for improved energy efficiency. Both median and mode WTP correspond to the fourth step in the MPL ladder, translating to a WTP of CHF 25 per month for the energy efficient option relative to the standard one.

4.2. The impact of information on tenants' WTP

Table 3 tabulates average WTP estimates across baseline MPL choices (before treatment, wtp_i^0) and endline MPL choices (after treatment, wtp_i^1). For endline MPL choices, we break down average WTP across treatment conditions. This provides both within- and between-tenant information about the impact of information on WTP.

As average WTP from baseline MPL choices is discussed above, here we focus on endline choices for each treatment group. Starting with the control intervention (T_{iA}), as expected we find a very modest difference compared to average baseline WTP. Individual-level distribution of WTP changes ($\Delta WTP = wtp_i^1 - wtp_i^0$), reported in Fig. 6 panel (a), further shows that almost 80% of respondents switched at the same MPL payment level, while only a small number increased WTP (for one respondent, WTP declined from around CHF 90 per month to zero). This is an indication that the placebo information screens worked as intended, as they have very little effect on WTP for energy efficiency. We will get back to this below.

Turning to the set of informational interventions T_{iB} to T_{iG}, we find clear evidence that all of them lead to an increase in the average valuation of energy efficiency. The largest increase is observed for treatments that provide information about financial implications of both options *and* also make the impact on energy bills salient in the endline MPL task (i.e. T_{iC}, T_{iD}, T_{iF} and T_{iG}). By contrast, in treatments that provide expected financial savings through an information screen but not in the endline MPL task (T_{iB} and T_{iE}), the change in average WTP is smaller. This is confirmed by looking at individual changes in WTP (Fig. 6, panels b-f),[26] as we find that treatments T_{iB} and T_{iE} feature the largest proportion of respondents with no change in WTP.

[24] By construction, these respondents are attributed a WTP of wtp_i^0= CHF 5 per month, or CHF 60 per year.

[25] An alternative interpretation is that tenants value energy efficiency but simply do not trust the accuracy of the official energy efficiency labels. See also footnote 3.2.2.

[26] Note that we find almost no difference between the distributions of treatment groups F and G, and therefore report observations for these two treatments together in panel (f) of Figure 6. For completeness, for group F endline WTP is CHF 60.14 on average, CHF 58.15 for group G, and the median for both groups is CHF 45.

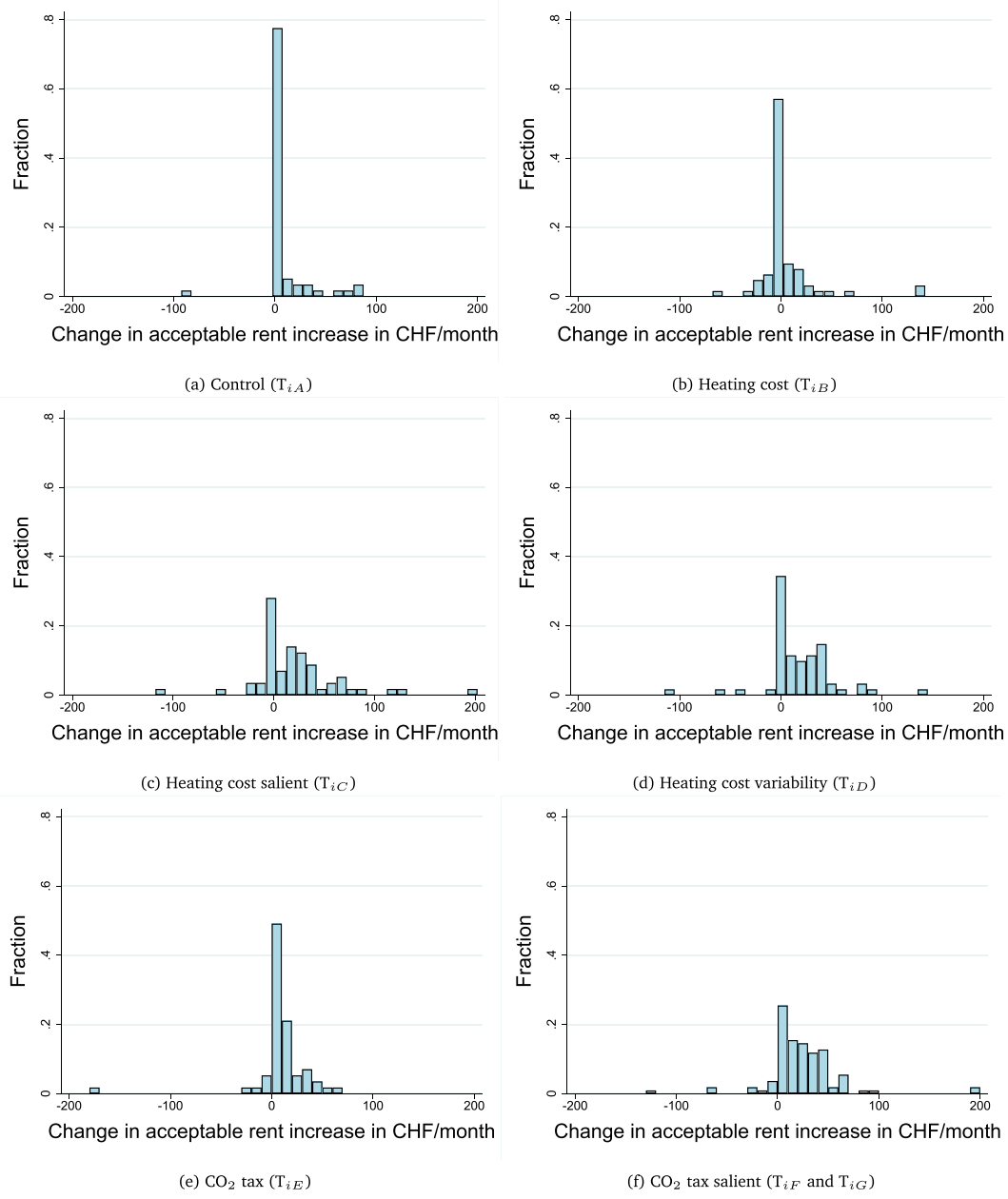

Fig. 6. Distributions of the change in acceptable rent increases (ΔWTP=$wtp_i^1 - wtp_i^0$).

Inference on these results is reported in Table 4. In column 1, we report OLS regression results for eq. (1), which models baseline and endline individual WTP values (wtp_i^0 and wtp_i^1, respectively) as a function of treatment dummies and a constant term (the latter captures average baseline WTP). We therefore have two observations per respondent, and cluster standard-errors at the respondent level. Column 2 reports OLS results for the *change* in individual WTP, so that the dependent variable is $\Delta WTP_i = wtp_i^1 - wtp_i^0$. Finally, column 3 reports OLS results for a model of endline WTP (wtp_i^1) as a function of treatment dummies, controlling for baseline WTP (wtp_i^0). Note that regressions in columns 2 and 3 only feature one observation per subject, and inference for these models is based on heteroskedasticity-robust standard errors.

Estimation results in column 1 confirm that salience of financial information significantly affect the valuation of energy efficiency. More specifically, treatments B and E that do not include financial information in the MPL task show comparatively small treatment effects. For these conditions, the difference in WTP between baseline and endline choices is around CHF 7 and not statistically significantly different from zero. By contrast, when energy costs are displayed in endline MPL tasks, information has a positive and highly statistically significant impact on WTP. Treatment C, which informs tenants about financial savings *and* introduces this information in the MPL task, shows an increase of WTP of about CHF 27 per month, a 73% increase compared to baseline WTP. This result parallels earlier findings on the role of financial information for choices reported by Newell and Siikamäki (2014) and Allcott and Taubinsky (2015). Moreover, because financial savings information provided to respondents is set to CHF 40 per month, whereas endline WTP in treatment C is higher at CHF 64.87 per month on average (CHF 780 per year, see also Table 3), financial considerations of energy efficiency only partly determine tenants' WTP.

Results for treatment D shows that information about energy cost variability dampens the impact of information on financial savings.

Table 4
Average treatment effect of information on tenants' WTP.

	(1)	(2)	(3)
	WTP (panel)	Δ WTP	Endline WTP
	wtp_i^s	$wtp_i^1 - wtp_i^0$	wtp_i^1
Control (T_{iA})	1.20	–	–
	(5.40)		
Heating cost (T_{iB})	7.45	−0.53	1.19
	(5.89)	(4.93)	(5.03)
Heating cost salient (T_{iC})	27.36 ***	15.34 **	18.08 ***
	(6.62)	(6.54)	(6.28)
Heating cost variability (T_{iD})	15.81 ***	9.94 *	11.12 **
	(5.22)	(5.44)	(5.14)
CO_2 tax (T_{iE})	6.44	−1.63	0.11
	(4.98)	(5.09)	(4.65)
CO_2 tax salient (A^+ lower tax, T_{iF})	22.64 ***	14.09 **	15.95 ***
	(6.47)	(6.21)	(5.85)
CO_2 tax salient (A^+ no tax, T_{iG})	20.64 ***	14.01 **	15.38 ***
	(5.58)	(5.84)	(5.64)
Baseline WTP (wtp_i^0)	–	–	0.75 ***
			(0.06)
Constant	37.51 ***	7.16 **	15.14 ***
	(2.11)	(3.23)	(3.41)
Observations	812	406	406
Adjusted R^2	0.04	0.03	0.50

Notes: Column (1) reports OLS estimates for a model with two observations per subject (baseline WTP wtp_i^0 and endline WTP wtp_i^1). Standard errors are clustered at the respondent-level and reported in parentheses. Column (2) reports OLS estimates for a model of $\Delta WTP_i = wtp_i^1 - wtp_i^0$. Column (3) reports OLS results for a model of endline WTP wtp_i^1. For models reported in columns (2) and (3), we report heteroskedasticity-robust standard errors in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Uncertainty about future energy savings thus reduces WTP.[27] We also find little evidence that additional information on CO_2 tax payments affects decisions by tenants, and in turn WTP. Specifically, T_{iB} and T_{iE} provide very similar average treatment effect estimates (both treatments do not include financial savings in the MPL task), and treatment effects for T_{iF} and T_{iG} are close in magnitude to T_{iC}.[28] Given our previous interpretation that tenants hold more than financial motives when choosing energy efficient appliances, insensitivity to CO_2 tax information may reflect a negative perception of environmental taxes, as already discussed in Perino et al. (2014) and Lanz et al. (2018).

Alternative models reported in columns 2 and 3 show similar results, with a few exceptions. First, OLS regression on ΔWTP (column 2) shows that within treatment changes in WTP are around CHF 15 for treatments C, F, and G. This number is lower as compared to column 1 because within-subject change in WTP for treatment group A (as represented by the constant in column 2) amounts to CHF 7.16. This is due to the fact that average baseline WTP differs slightly across treatment groups (see Table B2), and focusing on within-subject WTP estimation allows us to control for this discrepancy.[29] Second, OLS regression on endline WTP controlling for baseline WTP (column 3) shows that the coefficient for baseline WTP (wtp_i^0) is statistically significant, positive, and smaller than one as one would expect. This illustrates the fact that baseline WTP plays a large though not the sole role in determining endline WTP. Coefficient estimates for treatments B and E again provide sharp evidence that simply providing tenants with information on heating cost savings and CO_2 tax payments prior to investment decisions has a limited impact on WTP, highlighting the importance of making information salient for decisions.

4.3. Heterogeneous treatment effects: Quantile regressions

In this section we study the treatment effect of information across all deciles of the WTP distribution (eq. 2). In order to isolate the marginal impact of information on WTP, we code our treatment dummies according to their information content: (i) *Heating cost screen* equals one if the treatment includes the information screen *Heating cost* (i.e., all treatments except T_{iA}); (ii) *Cost MPL task* equals one if the endline MPL task includes heating costs (i.e. T_{iC}, T_{iD}, T_{iF}, and T_{iG}); (iii) *Cost variability screen* equals one if the treatment includes the information screen *Heating cost variability* (i.e. T_{iD}); (iv) *CO_2 tax screen* equals one if the treatment includes the CO_2 tax screen (i.e. T_{iE}, T_{iF}, and T_{iG}); and (v) *CO_2 tax MPL task* equals one if the endline MPL task includes CO_2 tax payments (i.e. T_{iF} and T_{iG}).[30] This allows us to decompose treatment effects into specific informational components, and thereby identify key drivers of WTP changes.

Estimation results are reported in Table 5. For comparison purposes, column 1 reports OLS estimates of average treatment effects for our dummy-coded specification. Columns 2–10 then report regression results for each decile of the WTP distribution. The dependent variable is individual WTP measured in baseline and endline MPL tasks (wtp_i^0, wtp_i^1, see Table 4, column 1), which allows us to exploit both within- and between-subject variations. Because we observe two outcomes for each tenant, we cluster standard errors at the subject level.

OLS results in column 1 confirm that the key element of our informational intervention is salience of heating cost differentials between efficient and standard appliances (*Cost MPL task*). Quantitatively, we find that this feature alone increases tenants' WTP by CHF 19.91 per month on average. This corresponds to a 53% increase compared to baseline estimates. Importantly, *Heating cost screen* also has a positive impact on WTP, although the average treatment effect is smaller (around CHF 7) and not statistically significantly different from zero.

Quantile regression results for individual deciles reveal that the average treatment effect associated with salience of financial savings (*Cost MPL task*) is driven by heterogeneous effects along the entire WTP distribution. In particular, results reported in columns 2 and 3 show that treatment interventions are ineffective in shifting the lower tail of the WTP distribution. This part of the distribution does not respond to information. Moreover, we find statistically significant treatment effects in five out of nine decile regressions. The third, fourth and fifth decile (columns 4, 5 and 6) adjust WTP with reference to the provided information about financial cost savings. The treatment effect of financial information *declines* across these deciles, and implies that endline WTP for these respondents bunches around CHF 45. This is very close to expected financial cost savings highlighted in the experimental intervention (these respondents select the energy efficient option for a level of CHF 40, and the standard option at CHF 50). Finally, the upper tail increases WTP substantially.[31]

In a nutshell, salient information on financial savings leads to an upward shift in WTP of the middle and upper part of the distribution, without an accompanying shift of the lowest quantiles. These conclusions are further illustrated in Fig. 7, which plots the distribution of baseline WTP and endline WTP for subjects exposed to treatment component

[27] Interestingly, this information screen has the lowest rate of correct answers to the quiz question (63.93%, $N = 61$), suggesting that this information is also more difficult to comprehend for respondents.

[28] Wald tests fail to reject equality of coefficients for T_{iB} and T_{iE} (p-value = 0.84), and the same is true for the coefficients of T_{iC}, T_{iF} and T_{iG} (p-value = 0.87 for T_{iC}=T_{iF}; p-value = 0.99 for T_{iF}=T_{iG}; p-value = 0.86 for T_{iC}=T_{iG}).

[29] Wald tests for column 2 again fail to reject equality for the coefficients of T_{iB} and T_{iE} (p-value = 0.90), as well as for the coefficients of T_{iC}, T_{iF} and T_{iG} (p-value = 0.62 for T_{iC}=T_{iF}; p-value = 0.82 for T_{iF}=T_{iG}; p-value = 0.45 for T_{iC}=T_{iG}).

[30] As mentioned in footnote 12, results for treatment groups F and G are very similar, and we therefore lump these together without affecting our results.

[31] Quantile coefficients provide information about effects on distributions, not individuals. In 8, we document correlations between observable tenant characteristics and WTP, and also seek to identify heterogeneous treatment effects using a set of interaction terms. OLS regression results show that interaction terms have the expected signs, but are statistically insignificant except for the effect of having a university degree, which has a positive impact on baseline WTP but influences the treatment effect negatively. Nevertheless, these results suggest that heterogeneity in the impact of information is mostly driven by unobserved characteristics.

Table 5
Quantile treatment effect of information on tenants' WTP.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)	WTP (panel)
	wtp_i^s	(10th quantile)	(20th quantile)	(30th quantile)	(40th quantile)	(50th quantile)	(60th quantile)	(70th quantile)	(80th quantile)	(90th quantile)
Control	1.20	0	0	0	−10 ***	0	0	−10	0	37.50 ***
	(5.34)	(3.02)	(4.19)	(6.60)	(2.98)	(2.61)	(3.14)	(7.96)	(15.91)	(11.86)
Heating cost screen	7.45	5	10	0	0	0	0	17.50 **	0	37.50 **
	(5.89)	(4.92)	(6.77)	(7.09)	(2.62)	(2.59)	(3.19)	(7.58)	(4.49)	(16.89)
Cost MPL task	19.91 **	0	10	30 ***	20 ***	20 ***	27.50 **	0	62.50 ***	0
	(9.19)	(7.90)	(28.37)	(8.84)	(4.74)	(4.66)	(10.91)	(10.79)	(6.15)	(16.38)
Cost variability screen	−11.55	0	0	−10	−10 **	0	0	0	−37.50 ***	0
	(8.65)	(8.79)	(28.44)	(8.85)	(4.97)	(6.16)	(11.77)	(10.62)	(8.79)	(8.03)
CO_2 tax screen	−1.01	0	0	10	10 **	10 **	10 *	0	0	−37.50 **
	(8.00)	(7.08)	(11.38)	(19.04)	(4.58)	(4.52)	(5.28)	(7.59)	(6.48)	(18.94)
CO_2 tax MPL task	−4.77	10	0	−20	−10	−10	−10	0	−37.50 ***	37.50 *
	(11.37)	(14.38)	(31.03)	(21.51)	(6.88)	(6.79)	(12.19)	(12.54)	(9.07)	(22.56)
Constant	37.51 ***	0	5 ***	15 ***	25 ***	25 ***	35 ***	45 ***	62.50 ***	87.50 ***
	(2.11)	(1.12)	(1.44)	(4.18)	(1.27)	(1.25)	(1.30)	(6.66)	(2.45)	(10.44)
Observations	812	812	812	812	812	812	812	812	812	812
(Pseudo) R^2	0.04	0.01	0.05	0.05	0.05	0.05	0.05	0.04	0.03	0.03

Notes: Dependent variable is baseline WTP wtp_i^0 and endline WTP wtp_i^1. Column 1 reports OLS estimates. Column 2–10 report regression results for each decile of the WTP distribution. Standard errors are clustered at the respondent-level and reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Cost MPL task. The graph confirms that the treatment leads to a large majority of tenants adjusting their WTP in response to the CHF 40 information provided. It also shows that part of the distribution remains in place.

Taken together, our results suggest that financial information affects WTP for a large majority of our sample, and that the estimated average treatment effect is not driven by the tails of the distribution. Moreover, the treatment effect on median WTP is very close to the treatment effect on average WTP. However, providing information does not push the full distribution of tenants above the illustrative CHF 40 threshold, possibly on account of individual social and environmental motives. Finally, we note that the lack of average treatment effect for other interventions appears across deciles, with no clear-cut impact.

5. Discussion and conclusion

In this paper, we have applied a MPL procedure on a sample of 406 Swiss tenants in order to estimate their valuation of improved energy efficiency of their space heating system. We find that tenants' WTP for an efficiency upgrade from B to A^+ is statistically and economically significant, and that information about financial implications plays a crucial role in the acceptability of such measure. We also find that financial information has to be made salient, clearly associating it with the decision at hand, whereas providing information on CO_2 tax payments has virtually no impact on tenants' valuation of energy efficiency improvements.

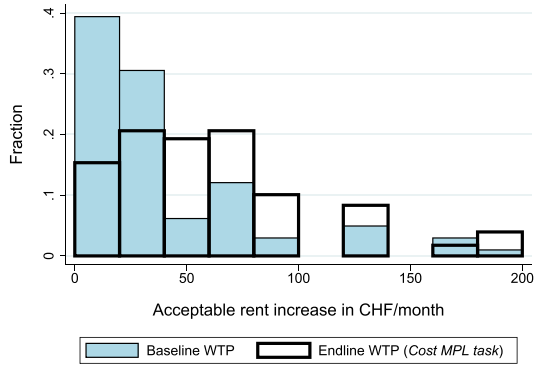

Fig. 7. Distribution of tenants' WTP before and after treatment.

From a policy perspective, our results have important implications. The fact that tenants are willing to support part of the additional investment cost imposed on property owners by paying higher rents could be leveraged to promote energy efficiency investments in rented properties. However, our work suggests that providing tenants with realistic and credible information about financial implications of energy efficiency investment is a necessary first step to make rent increase acceptable. In this sense, it is not sufficient to incentivize property owners to renovate. Rather, they should also be encouraged to communicate with their tenants about the financial implications of renovations. Empirical research on the realizations of energy savings, which requires a credible counterfactual, is only burgeoning (see Fowlie et al., 2018; Burlig et al., 2017; Liang et al., 2018).

Finally, our results also confirm the more conventional view that informational interventions can substantially improve attitudes towards energy efficiency. Our results show that even in a country where the majority of tenants lives in multifamily housing without separate meters, salience of financial savings associated with energy efficiency is critical, and this has implications for the design of energy efficiency labels (see also Newell and Siikamäki, 2014). Moreover, we show that the average treatment effect of information reflects heterogeneous changes along the entire distribution of acceptable rent increases. Identifying the specific drivers of the observed heterogeneity is left for further research.

Data availability statement

The Swiss Household Energy Demand Survey (SHEDS) has been developed as part of the research agenda of the Competence Center for Research in Energy, Society, and Transition (SCCER CREST; details on http://www.sccer-crest.ch). It is designed to collect a comprehensive description of the Swiss households' energy-related behaviors, their longitudinal changes and the existing potentials for future energy demand reduction. SHEDS data can be made available to researchers under some conditions. Details on the procedure to access the data are provided on https://www.sccer-crest.ch/research/swiss-household-energy-demand-survey-sheds/.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2020.105007.

References

Achtnicht, M., Madlener, R., 2014. Factors influencing German house owners' preferences on energy retrofits. Energy Policy 68, 254–263. https://doi.org/10.1016/j.enpol.2014.01.006.

Allcott, H., Greenstone, M., 2012. Is there an energy efficiency gap? J. Econ. Perspect. 26, 3–28. https://doi.org/10.1257/jep.26.1.3.

Allcott, H., Knittel, C., 2019. Are consumers poorly informed about fuel economy? Evidence from two experiments. Am. Econ. J. Econ. Pol. 11, 1–37. https://doi.org/10.1257/pol.20170019.

Allcott, H., Taubinsky, D., 2015. Evaluating behaviorally motivated policy: experimental evidence from the lightbulb market. Am. Econ. Rev. 105, 2501–2538. https://doi.org/10.1257/aer.20131564.

Allcott, H., Wozny, N., 2014. Gasoline prices, fuel economy, and the energy paradox. Rev. Econ. Stat. 95 (5), 779–795. https://doi.org/10.1162/REST_a_00419.

Andersen, S., Harrison, G.W., Lau, M.I., Rutström, E.E., 2006. Elicitation using multiple price list formats. Exp. Econ. 9, 383–405. https://doi.org/10.1007/s10683-006-7055-6.

Anderson, S., Harrison, G.W., Lau, M.I., Rutstrom, E.E., 2007. Valuation using multiple price list formats. Appl. Econ. 39, 675–682. https://doi.org/10.1080/00036840500462046.

Banfi, S., Farsi, M., Filippini, M., Jakob, M., 2008. Willingness to pay for energy-saving measures in residential buildings. Energy Econ. 30, 503–516. https://doi.org/10.1016/j.eneco.2006.06.001.

Bateman, I.J., Langford, I.H., Jones, A.P., Kerr, G.N., 2001. Bound and path effects in double and triple bounded dichotomous choice contingent valuation. Resour. Energy Econ. 23, 191–213. https://doi.org/10.1016/S0928-7655(00)00044-0.

Bird, S., Hernandez, D., 2012. Policy options for the split incentive: increasing energy efficiency for low-income renters. Energy Policy 48, 506–514. https://doi.org/10.1016/j.enpol.2012.05.053.

Blasch, J., Filippini, M., Kumar, N., 2019. Boundedly rational consumers, energy and investment literacy, and the display of information on household appliances. Resour. Energy Econ. 56, 39–58. https://doi.org/10.1016/j.reseneeco.2017.06.001.

Brent, D., Ward, M., 2018. Energy efficiency and financial literacy. J. Environ. Econ. Manag. 90, 181–216. https://doi.org/10.1016/j.jeem.2018.05.004.

Burlig, F., Knittel, C., Rapson, D., Reguant, M., Wolfram, C., 2017. Machine Learning from Schools About Energy Efficiency. https://doi.org/10.3386/w23908 (NBER Working Paper No. 23908).

Cameron, T., 1988. A new paradigm for valuing non-market goods using referendum data: maximum likelihood estimation by censored logistic regression. J. Environ. Econ. Manag. 15, 355–379. https://doi.org/10.1016/0095-0696(88)90008-3.

Carroll, J., Aravena, C., Denny, E., 2016. Low energy efficiency in rental properties: asymmetric information or low willingness-to-pay? Energy Policy 96, 617–629. https://doi.org/10.1016/j.enpol.2016.06.019.

Charlier, D., 2015. Energy efficiency investments in the context of split incentives among French households. Energy Policy 87 (C), 465–479. https://doi.org/10.1016/j.enpol.2015.09.005.

Council of European Union, 2013. Commission Delegated Regulation (EU) no 811/2013. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0811 (Brussels, Belgium).

Davis, L., 2012. Evaluating the slow adoption of energy efficient investments: Are renters less likely to have energy efficient appliances? In: Fullerton, D., Wolfram, C. (Eds.), The Design and Implementation of U.S. Climate Policy, University of Chicago Press, USA, pp. 301–316

Eurostat, Europe in Figures: Housing Statistics, 2017. http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics#Tenure_status, Luxembourg, Luxembourg.

Fowlie, M., Greenstone, M., Wolfram, C., 2015. Are the non-monetary costs of energy efficiency investments large? Understanding low take-up of a free energy efficiency program. Am. Econ. Rev. 105, 201–204. https://doi.org/10.1257/aer.p20151011.

Fowlie, M., Greenstone, M., Wolfram, C., 2018. Do energy efficiency investments deliver? Evidence from the weatherization assistance program. Q. J. Econ. 133, 1597–1644. https://doi.org/10.1093/qje/qjy005.

FSO, Die Bevoelkerung der Schweiz 2017, 2017. https://www.bfs.admin.ch/bfs/en/home/statistics/population/effectif-change/population.assetdetail.6606496.html, Federal Statistical Office (FSO), Neuchâtel, Switzerland.

FSO, 2018. Construction and Housing Dataset. https://www.bfs.admin.ch/bfs/en/home/statistics/construction-housing.html (Federal Statistical Office (FSO), Neuchâtel, Switzerland).

FSO, 2018a. Durchschnittsalter der staendigen Wohnbevoelkerung nach Staatsangehoerigkeitskategorie, Geschlecht und Kanton, 2010–2017. Federal Statistical Office (FSO), Neuchâtel, Switzerland https://www.bfs.admin.ch/bfs/en/home/statistics/catalogues-databases/tables.assetdetail.6046558.html.

FSO, 2018b. Haushaltseinkommen und -ausgaben saemtlicher Haushalte nach Jahr. https://www.bfs.admin.ch/bfs/en/home/statistics/economic-social-situation-population/income-consumption-wealth/household-budget.assetdetail.6506527.html (Bern, Switzerland).

FSO, 2019a. Bildungsstand der Bevoelkerung - Daten des Indikators. Federal Statistical Office (FSO), Neuchâtel, Switzerland https://www.bfs.admin.ch/bfs/de/home/statistiken/bildung-wissenschaft/bildungsindikatoren/themen/wirkung/bildungsstand.assetdetail.7886035.html.

FSO, 2019b. Construction and Housing. Federal Statistical Office (FSO), Neuchâtel, Switzerland https://www.bfs.admin.ch/bfs/de/home/statistiken/bau-wohnungswesen.html.

Gerarden, T.D., Newell, R.G., Stavins, R.N., 2017. Assessing the energy-efficiency gap. J. Econ. Lit. 55, 1486–1525. https://doi.org/10.1257/jel.20161360.

Gillingham, K., Palmer, K., 2014. Bridging the energy efficiency gap: policy insights from economic theory and empirical evidence. Rev. Environ. Econ. Policy 8, 18–38. https://doi.org/10.1093/reep/ret021.

Gillingham, K., Harding, M., Rapson, D., 2012. Split incentives in residential energy consumption. Energy J. 33 (2), 37–62. https://doi.org/10.5547/01956574.33.2.3.

Glumac, B., Reuvekamp, S., Han, Q., Schaefer, W., 2013. Tenant participation in sustainable renovation projects: using AHP and case studies. J. Energy Technol. Policy 3, 16.

Hoppe, T., 2012. Adoption of innovative energy systems in social housing: lessons from eight large-scale renovation projects in the Netherlands. Energy Policy 51, 791–801. https://doi.org/10.1016/j.enpol.2012.09.026.

Houde, S., Aldy, J.E., 2017. The Efficiency Consequences of Heterogeneous Behavioral Responses to Energy Fiscal Policies. https://doi.org/10.3386/w24103 (NBER Working Paper No. 17282).

IEA, 2011. Technology Roadmap Energy-Efficient Buildings: Heating and Cooling Equipment. International Energy Agency (IEA), Paris, France https://sustainable.stanford.edu/sites/default/files/IEA_buildings_roadmap.pdf.

IPCC, 2014. AR5 Climate Change 2014: Mitigation of Climate Change. Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA https://www.ipcc.ch/report/ar5/wg3/.

Jacobsen, G.D., 2015. Do energy prices influence investment in energy efficiency? Evidence from energy star appliances. J. Environ. Econ. Manag. 74, 94–106. https://doi.org/10.1016/j.jeem.2015.09.004.

Jakob, M., 2007. The Drivers of and Barriers to Energy Efficiency in Renovation Decisions of Single-Family Home-Owners (Center for Energy Policy and Economics, CEPE Working Paper No. 56).

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C.A., 2017. Contemporary guidance for stated preference studies. J. Assoc. Environ. Resour. Econ. 4, 319–405. https://doi.org/10.1086/691697.

Lang, G., Lanz, B., 2020. Climate Policy Without a Price Signal: Evidence on the Implicit Carbon Price of Energy Efficiency in Buildings. http://ceepr.mit.edu/publications/working-papers/720.

Lang, G., Farsi, M., Lanz, B., Weber, S., 2020. Energy Efficiency and Heating Technology Investments: Manipulating Financial Information in a Discrete Choice Experiment. https://ideas.repec.org/p/irn/wpaper/20-07.html.

Lanz, B., Wurlod, J.-D., Panzone, L., Swanson, T., 2018. The behavioral effect of pigovian regulation: evidence from a field experiment. J. Environ. Econ. Manag. 87, 190–205. https://doi.org/10.1016/j.jeem.2017.06.005.

Li, S., Linn, J., Muehlegger, E., 2014. Gasoline taxes and consumer behavior. Am. Econ. J. Econ. Pol. 6, 302–342. https://doi.org/10.1257/pol.6.4.302.

Liang, J., Qui, Y., James, T., Ruddell, B., Dalrymple, M., Earl, S., Castelazo, A., 2018. Do energy retrofits work? Evidence from commercial and residential buildings in Phoenix. J. Environ. Econ. Manag. 92, 726–743. https://doi.org/10.1016/j.jeem.2017.09.001.

Melvin, J., 2018. The split incentives energy efficiency problem: evidence of underinvestment by landlords. Energy Policy 115, 342–352. https://doi.org/10.1016/j.enpol.2017.11.069.

Myers, E., 2020. Asymmetric information in residential rental markets: implications for the energy efficiency gap. J. Public Econ. 190, 104251. https://doi.org/10.1016/j.jpubeco.2020.104251.

NDRC, 2017. 13th Five-year Plan for Economic and Social Developmentof the Peoples Republic of China (2016–2020). National Development and Reform Commission (NDRC), Beijing, China https://www.greengrowthknowledge.org/national-documents/13th-five-year-plan-economic-and-social-development-peoples-republic-china.

Newell, R.G., Siikamäki, J., 2014. Nudging energy efficiency behavior: the role of information labels. J. Assoc. Environ. Resour. Econ. 1, 555–598. https://doi.org/10.1086/679281.

Perino, G., Panzone, L., Swanson, T., 2014. Motivation crowding in real consumption decisions: who is messing with my groceries? Econ. Inq. 57 (2). https://doi.org/10.1111/ecin.12024 592–560.

Phillips, Y., 2012. Landlords versus tenants: information asymmetry and mismatched preferences for home energy efficiency. Energy Policy 45, 112–121. https://doi.org/10.1016/j.enpol.2012.01.067.

Rapson, D., 2014. Durable goods and long-run electricity demand: evidence from air conditioner purchase behavior. J. Environ. Econ. Manag. 68 (1), 141–160. https://doi.org/10.1016/j.jeem.2014.04.003.

Seiders, D., Ahluwalia, G., Melman, S., Quint, R., Chaluvadi, A., Liang, M., Silverberg, A., Bechler, C., 2007. Study of Life Expectancy of Home Components. https://www.interstatebrick.com/sites/default/files/library/nahb20study20of20life20expectancy20of20home20components.pdf (National Association of Home Builders and Bank of America Home Equity).

The Swiss Federal Council, 2012. Ordinance on the Reduction of CO2 Emissions (CO2 ordinance). https://www.admin.ch/opc/en/classified-compilation/20120090/index.html (Bern, Switzerland).

The Swiss Federal Council, 2016. Imposition of the CO2 Levy on Heating and Process Fuels. https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy/co2-levy/imposition-of-the-co2-levy-on-thermal-fuels.html.

U.S. Census Bureau, 2019. Owner/renter (tenure): Demographic Characteristics for Occupied Housing Units. https://data.census.gov/cedsci/all?q=Owner%2FRenter%20%28Tenure%29 (Suitland, MD, USA).

U.S. Department of Energy, 2015. 2016–2020 Strategic Plan and Implementing Framework. Office of Energy Efficiency and Renewable Energy, Washington, D. C., USA https://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf.

Vossler, C., Doyon, M., Rondeau, D., 2012. Truth in consequentiality: theory and field evidence on discrete choice experiments. Am. Econ. J. Microecon. 4 (4), 145–171. https://doi.org/10.1257/mic.4.4.145.

Weber, S., Burger, P., Farsi, M., Martinez-Cruz, A.L., Puntiroli, M., Schubert, I., Volland, B., et al., 2017. Swiss Household Energy Demand Survey (SHEDS): Objectives, Design, and Implementation. https://www.sccer-crest.ch/fileadmin/FILES/Research/Weber_Burger_et_al_2017_SHEDS_Official_description.pdf SCCER CREST Working Paper WP2 - 2017/04.

Yang, Z., Chen, J., 2014. Housing Affordability and Housing Policy in Urban China. Springer Science & Business Media, The Netherlands.