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Energy efficiency, information, and the acceptability of rent increases: A multiple price list experiment with tenants

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Energy efficiency, information, and the acceptability of rent increases: A multiple price list 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. A set of quantile regressions suggests that information on expected energy bills reduction induces around 30% of tenants to equate financial savings and acceptable rent increase. Around 20% of tenants oppose rent increase and do not respond to information, whereas tenants' valuation in the upper tail of the distribution exceeds financial savings, presumably on account of pro-environmental motives. By contrast, information on energy bills variability dampens acceptable rent increase. Our results highlight the importance of realistic ex-ante estimates of financial savings associated with energy efficiency investments.

Keywords: Market failures; Information; Split incentives; Energy efficiency; Environmental policy; Rented properties; Economic experiments; Multiple price lists.

JEL Codes: Q4; R31; Q5; H23.

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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 properties represent a particularly challenging case. If tenants pay for energy bills, landlords have little incentives to invest in energy efficiency, whereas tenants have little incentive to invest themselves in a property they do not own. The associated 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 the implied reduction in the implicit price of energy services. For property owners, generating a positive return on these investments requires increasing rents, although they may have difficulties to signal the value of future energy savings to the tenants, leading to information asymmetries as documented in Myers (2018). This makes information a central aspect of tenants' acceptance of rent increases in exchange for lower energy bills.

In this paper, we study a 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⁺). Holding the level of comfort fixed across alternatives, we design a multiple price list (MPL) experiment (Andersen et al., 2006; Anderson et al., 2007) in which we systematically vary rent increases associated with the more efficient option. After a baseline MPL task, which reflects perceived differences derived from standard 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, where each treatment combines two sequential information screens. We then employ a second MPL task

¹ In the U.S. about 35% of dwellings are renter-occupied (U.S. Census Bureau, 2016), 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).

to measure how within-subject information disclosure affects the acceptability of rent increases. Furthermore, a between-subject comparison provides forensic evidence across information conditions based on illustrative figures derived from the Swiss context, focusing on financial savings, energy bills variability, and CO₂ tax payments.

Incentivizing energy efficiency investments and addressing investment barriers 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 (National Development and Reform Commission, 2017).² Importantly, heating systems have a relatively long average lifetime, so that space heating choices represent long-term investments (see Rapson, 2014).³ Because property owners are “locked-in” a specific technology, evidence contributing to the design of policies that target energy efficiency investments is important.

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, 2017).⁴ In the landlord-tenant setting, Myers (2018) provides empirical evidence that tenants are uninformed about energy costs, and in turn that asymmetric information reduces efficiency investments. A major contribution of our work is to provide experimentally controlled evidence on the role of information in a landlord-tenant split incentive context. More specifically, our experimental design delivers willingness to pay (WTP) space evidence about how simple efficiency labels are perceived by tenants (see Newell and Siikamäki, 2014, for a related discussion). We then quan-

² 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.

³ 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).

⁴ A related line of research emphasizes financial literacy as a key barrier to energy efficiency investments, see Blasch et al. (2017) and Brent and Ward (2018).

tify the incremental impact of information along three dimensions. First, we provide quantitative information about financial savings associated with reduced energy consumption. In particular, we inform a subset of tenants about the expected reduction in energy bills associated with label A⁺ vs. B (approximately 30% higher energy efficiency, see Council of European Union, 2013), which is set to CHF 40 per month for illustrative purposes (about USD 42). Because there is ample uncertainty about realization of energy bills, for another subset of tenants we introduce information about variability of energy cost over time (together with financial information about energy savings, as above). Finally, we make use of the existing CO₂ tax on fossil heating fuels in Switzerland (CHF 84 or USD 87 per ton of CO₂ in 2017, see Federal Council, 2012) to study how tenants respond to information about reduced CO₂ tax expenditures in relation to their choices. In these treatments, subjects receive information about both financial savings and CO₂ payments, allowing us to contribute to a growing literature on consumers' perception of externality-correcting taxes (Houde and Aldy, 2017; Lanz et al., 2018).

Our experiment is administered to an online panel of Swiss tenants who all individually bear the energy cost of their dwelling separately from their monthly rents. Our results indicate that, in the baseline, around 70% of tenants in our sample are willing to accept 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 endline average WTP estimate of CHF 64.87 per month (about CHF 780 or USD 810 per year). Informing tenants about CHF 1 in expected energy savings thus translates to CHF 1.73 in possible rent increases. We further find that adding information about past variability in energy bills dampens the impact of financial information, so that endline mean WTP only increases by roughly 40% relative to baseline. By contrast, we find that information about CO₂ tax payments has no incremental impact on tenants' valuation of energy efficiency.

To further quantify how the treatment effect of information varies across the distribution of valuation, we report results from a set of quantile regressions. Results show that average treatment effect reflects heterogeneous changes along the entire WTP distribution, even though values for mean and median treatment effect estimates are very similar. Specifically, we document that around 30% of tenants adjust their WTP to bunch around the level of financial

savings provided in our informational intervention (namely CHF 40 per month). Subjects in the lower tail of the WTP distribution are particularly unresponsive to information, with around 20% of subjects accepting no rent increases even after receiving quantitative information on financial savings. Conversely, for subjects in the upper tail of the WTP distribution the impact of information is quantitatively large, so that valuation of energy efficiency is above financial savings, suggesting that a large share of our sample holds motives beyond pure financial concerns. However, given the lack of impact of CO₂ tax information on WTP, our results suggest a differentiation between financial and pro-social preferences in line with the idea of micro-frictions put forward by Houde and Aldy (2017).

These findings 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 windows replacement and installing a ventilation system is generally higher than the corresponding investment costs, Phillips (2012) suggest that willingness to accept rent increases in exchange for an energy efficiency improvement of the heating system is economically insignificant. These results suggest 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. In our work, we emphasize the role of ex-ante information about financial savings for tenants' acceptance of rent increases, demonstrating the importance of obtaining realistic measures of energy savings (see e.g. Fowlie et al., 2017).

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 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 CO₂ 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 overview 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.⁵ We define tenant i 's utility from selecting j as u_{ij} , and denote relative utility as $u_i = u_{iE} - u_{iS}$. Notionally, a utility maximizing tenant would select E if and only if $u_i > p$, that is, 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 u_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.

⁵ From the tenants' perspective, rents and energy costs are paid each month, so the decision problem is static. This implicitly assumes that the cost of appliances is passed on to tenants in a 'fair' manner. 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.

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 u_i lies within the interval $[p^1, p^2]$.

Importantly, u_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, different levels of comfort, differences in lifetime duration of appliances, or social benefits associated with lower energy use, among many other things. As an attempt to fix subjects’ heterogeneous expectations and thereby control for these potential confounders, we frame the experiment to focus exclusively on energy efficiency gains as measured by a simple energy label that is encountered in the marketplace. One implication is that u_i will reflect expected differences in energy consumption, and associated financial savings plus other social impacts of energy use such as environmental costs and benefits.

2.2 Identifying the effect of information

In order to quantify how financial and environmental information affect choices, we first elicit u_i with a baseline MPL choice task, and then randomly assign tenants to one of several information treatments. As we describe in more detail in the next section, these conditions mainly focus on providing information about energy cost savings and CO₂ tax payments. Subsequently, we elicit u_i with an endline MPL choice task.

Formally, we denote tenant i ’s *baseline* utility as u_i^0 , and utility *after* being subject to one of the interventions as u_i^1 . We refer to the latter as *endline* utility. We exploit within and between subject variation in u_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 u_i^s measured by respective MPL tasks:⁶

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

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

⁶ Note that MPL tasks only provide bounds on u_i^s , as measured by the price intervals specified in the sequence of t MPL choices, and an alternative to linear regression is thus to apply an interval data model. With our data, however, we find that results from OLS on mid-point intervals and interval data models yield very similar treatment effects, and therefore prefer an OLS specification.

provides direct evidence on how information affects u_i in monetary equivalent.

Similarly, we study how alternative treatment interventions affect the distribution of tenants' WTP. For this purpose, we employ a set of quantile regressions and estimate the treatment effect along the distribution of baseline WTP with the following regression model:

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

where $Q_\tau(u_i^s)$ is the τ th quantile of u_i^s and the vector of coefficients in $\beta_k(\tau)$ denotes the quantile treatment effects. In other words, $\beta_k(\tau)$ provides evidence on the effect of information on WTP measured at the τ th 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 out 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 administered the experiment. A full set of screenshots of the experimental material is provided in Appendix A.

3.1 Multiple price list procedure

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.

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). Here, 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).⁷ 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, 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.⁸

As we focus on a single dimension of space heating (the efficiency rating 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. In order to mitigate possible biases associated with the MPL elicitation format (see Andersen et al., 2006; Anderson et al., 2007), and foster incentives for truthful preference revelation, we take the following steps.⁹ 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 experiment. Second, to prevent multiple switching sometimes observed in MPL experiments, the sequence of choices stops whenever the respondent selects the standard appliance. 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. Finally, we use cheap talk scripts in

⁷ 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.

⁸ 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.”

⁹ We note that MPL choice tasks have similarities with two widely used contingent valuation formats, namely dichotomous choice and payment card. It follows from the literature (e.g. Johnston et al., 2017) that the first MPL choice is incentive compatible, whereas subsequent choices are not. As we discuss in the text, we follow recent literature on discrete choice experiments, which feature a similar sequence of questions, and use cheap talk scripts notably emphasizing consequentiality of subjects’ choices (e.g. Vossler et al., 2012).

line with the literature on truthful preference revelation (Vossler et al., 2012; Newell and Sikamäki, 2014). Previous work on the topic has shown that a crucial element involves perceived consequentiality of stated choices, and we therefore inform subjects that our results will be used in the formulation of energy policy in Switzerland, and explain that it is in their best interest to answer the questions truthfully.¹⁰ Another insight from the stated preference literature is the use of budget constraint reminders.¹¹ The full text underlying baseline MPL choices is reported in Appendix A, Figures A1 to A5.

Turning to the MPL choice task itself, shown in Figure 1, we ask subjects to consider a binary choice between standard and efficient appliances. In the first MPL choice 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 option. After that, the rent associated with the choice of the more efficient option increases gradually, with steps along the ladder shown in Table 1. Note that the MPL task starts at zero to avoid signaling an experimentally-induced value for WTP, and that the selected price levels were piloted to ensure that they would yield meaningful switch-points for respondents.¹²

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 out 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, in order to make sure that only the actual content of the screen affects the MPL decision (see Figures A10 to A14).

Following Allcott and Taubinsky (2015) and Allcott and Knittel (2017), we take a number of

¹⁰ The exact wording is: “The information that we collect will be used to inform Swiss energy policy, and it is therefore important that your answers reflect your specific situation and your personal tastes.” There is no deception involved, as our results are indeed part of a government-funded project directly feeding into policies at both federal and cantonal levels.

¹¹ 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.”

¹² Another important result highlighted in the contingent valuation literature is that iterative bidding can potentially lead respondents to anchor their response to their first choice (see Bateman et al., 2001). Therefore, because the sequence of MPL prices starts at zero, our approach would therefore tend to underestimate tenants’ WTP.

Figure 1: Baseline multiple price list choice task

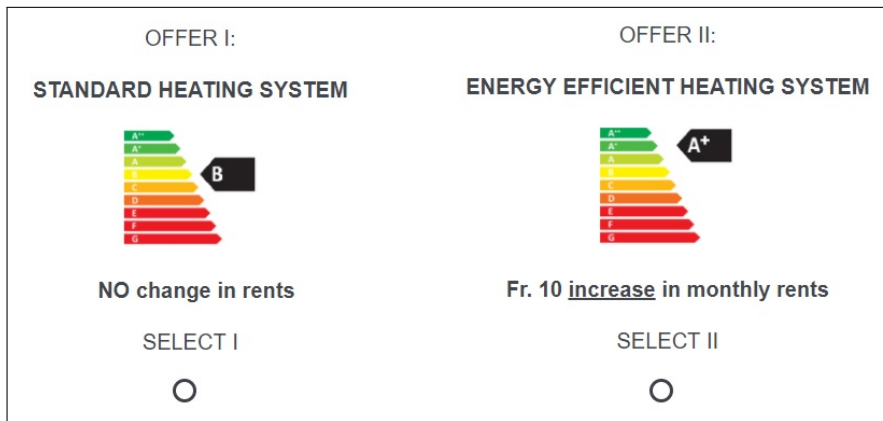


Table 1: Multiple price list payment ladder of rent increases

| 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 |

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 experiment (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 successfully completing the quiz

Table 2: Overview of informational treatment interventions

| Treatment indicator | Treatment group name | 1 st information screen | 2 nd 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) |

questions, subjects receive instructions for endline MPL tasks. As we discuss below, in some treatments the design of the MPL is modified to reinforce salience of the information provided. 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.

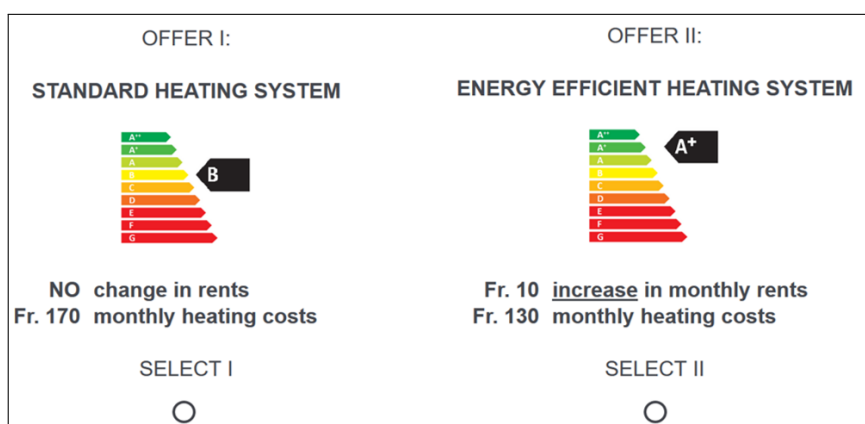
3.2.1 Control group (T_{iA})

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*, Figure A10) and the different energy sources used to heat buildings in Switzerland (information screen *Neutral II*, Figure 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 Figure A12), and then the neutral information screen on the age of the Swiss building stock (information screen *Neutral I*, Figure A10). The information about heating costs aims at illustrating the importance of specific financial information for tenants’ choices. It is based on average expenditures of CHF

Figure 2: Endline multiple price list choice task with heating costs



170 per month for a standard appliance (about USD 178), whereas heating costs associated with the energy efficient alternative amount to CHF 130 per month (about USD 136). As a result, financial savings associated with the efficient alternative represent about 30%, which is consistent with the energy efficiency labels discussed.¹³

The difference between treatments B and C is the design of the endline MPL task. Tenants in treatment B complete the MPL presented in the baseline, just as the control group. This endline WTP 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 Figure 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).

¹³ Naturally, energy bills are expected to vary across households and over time. The specific numbers we use are representative values that 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.

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*, Figure 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 expect that it should generally decrease attractiveness of the more efficient option, and hence reduce endline WTP. After the second information screen, respondents complete a second MPL task in which energy cost differentials are also reported (Figure 2). Comparing treatments D and C provides evidence about the incremental effect of information on energy cost variability.

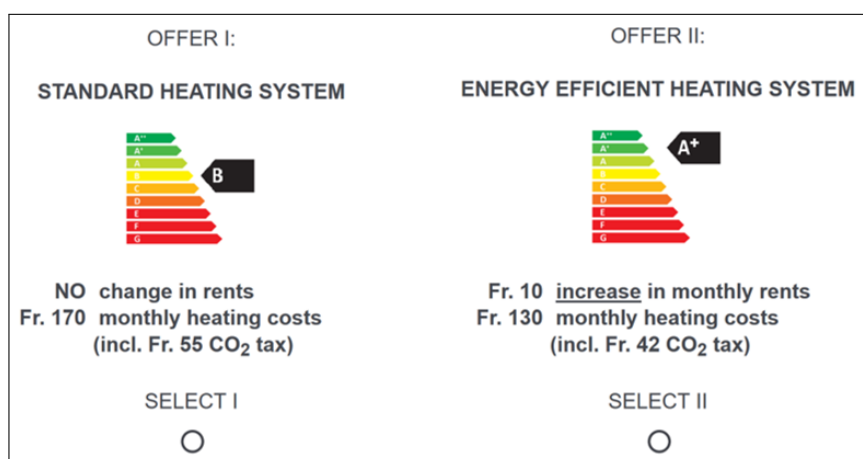
3.2.3 Information about carbon tax payments (T_{iE} , T_{iF} , T_{iG})

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.¹⁴ Subjects in these treatments first face the information screen *Heating cost*, and the second screen provides information about the CO₂ tax in Switzerland and its implications on fossil-based heating costs (information screen *CO₂ tax* is shown in Figure A14). Note that in Switzerland, the tax is paid when heating oil is delivered, so that most tenants receive no details about CO₂ tax payments when they pay their heating bills.

The difference between treatments E, F and G is again driven by whether and how the CO₂ tax information is included in the MPL task. In treatment E, we repeat the baseline MPL design reported in Figure 1, so that comparing treatments B and E provides evidence about whether the CO₂ information screen affects WTP. If environmental motives affect choices, one would expect WTP in Treatment E to be higher than in treatment B. However, because we associate environmental impacts with tax payments, respondents who oppose government interventions in the form of taxes may react negatively to this information (Houde and Aldy, 2017; Lanz et al.,

¹⁴ More precisely, the Swiss carbon tax is imposed on all fossil heating and process fuels (heating oil, natural gas, coal, petroleum coke, etc., see Federal Council, 2012). At the time of the experiment, the tax amounts to CHF 84 (about USD 87) per ton of CO₂, 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 (Federal Council, 2016).

Figure 3: Endline multiple price list choice task with heating costs and CO₂ tax (A⁺ lower tax)



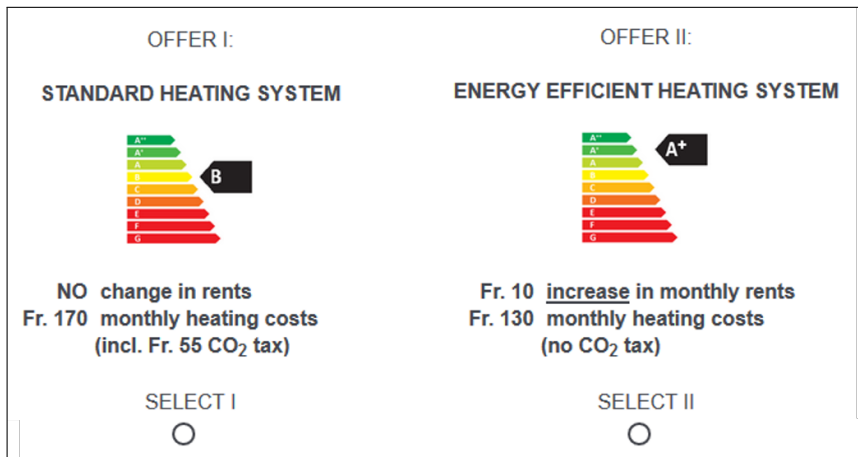
2018).

In treatments F and G, respondents see the same information screens *Heating cost* and *CO₂ tax* and, in addition, the endline MPL task integrates financial information about both energy expenditures and CO₂ 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 CO₂ tax payments are positive for both options (they are of course proportionally lower for the efficient appliance as compared to the standard one). An example of the ensuing MPL task is shown in Figure 3. In treatment G, we instead consider an efficient option with no CO₂ tax payments, signaling that it implies no (direct) CO₂ emissions. This alternative corresponds, for example, to a heat pump appliance. The ensuing MPL task is displayed in Figure 4. Because the efficient option in treatment G is free of CO₂ emissions, WTP can presumably be expected to be higher than in treatments F (and C).

3.3 Implementation

Our experiment is fielded as an online survey and administered to a representative panel of Swiss households. Among a sample of around 5,000 survey participants, which also includes property owners, we obtain a randomly selected subsample of 406 tenants that completed our

Figure 4: Endline multiple price list choice task with heating costs and CO₂ tax (A⁺ no tax)



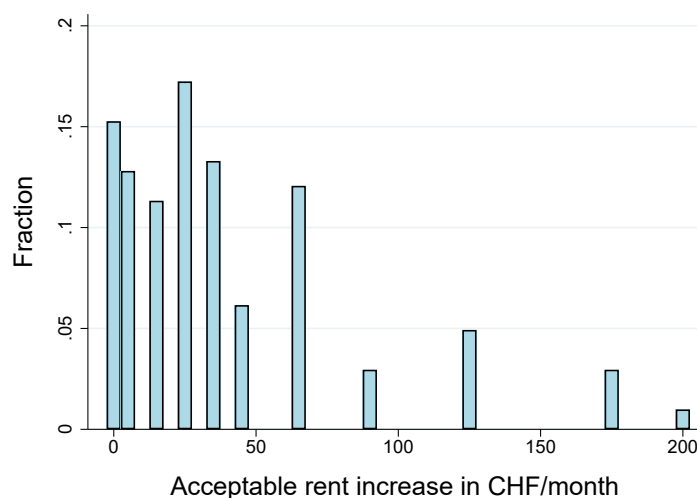
experiment. In Appendix B, we summarize key observable characteristics of our sample.¹⁵ Data collection took place during six weeks in April and May 2017. In Appendix C, we further summarize randomized treatment assignment, showing that treatment groups are balanced on observables.

4 Experimental results

This section reports the main results from the experiment. We first provide evidence on tenants' WTP for efficient heating appliances based on baseline MPL choices. Second, we exploit within and between subject variations to identify the impact of information about energy costs and CO₂ 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.

¹⁵ The experiment is included in the second wave of a large-scale study on energy behavior in Switzerland (Weber et al., 2017), which generates a rolling panel dataset of 5,000 respondents per wave. Subjects are chosen randomly out of the Swiss online access pool managed by the private marketing company Intervista, which holds over 70,000 subscribers. While this means that our sample is not random, in Appendix B we provide evidence that on average our subjects are broadly representative of the underlying population characteristics for a number of key observables. The data also contains detailed information about tenants' characteristics, including risk preferences elicited with separate MPL tasks, and therefore provides rich information about participants in our experiment.

Figure 5: Distribution of baseline WTP (u_i^0)



4.1 Tenants' WTP estimates from baseline choices

Figure 5 shows the distribution of baseline WTP estimates for our sample of 406 tenants, as measured by the mid-point intervals reported in Table 1.¹⁶ Average WTP associated with a central heating appliance of grade A⁺ rather than B is $u_i^0 = \text{CHF } 37.51$ per month. This corresponds to 3.07% of net median rents in Switzerland and 2.76% of net average rents.¹⁷ 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 u_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.

Baseline MPL results also show that around 15% of respondents select the standard heating appliance in the first choice. This means that they select the inefficient appliance even though the more efficient option is provided at no additional cost (i.e. no increase in rents). Another 12.8% of respondents switch from the more efficient option to the standard one in the second MPL question. 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.¹⁸ By contrast, around 72 percent

¹⁶ To be conservative, WTP for the highest value on the list is set at its lower bound, which is CHF 200.

¹⁷ In 2016 monthly median rent in Switzerland amounted to CHF 1322, while average rents were CHF 1220 (Federal Statistical Office, FSO).

¹⁸ By construction, these respondents are attributed a WTP of $u_i^0 = \text{CHF } 5$ per month, or CHF 60 per year.

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

| Treatment | N | Mean | Std.-dev. |
|--|-----|-------|-----------|
| Baseline choices (u_i^0) | 406 | 37.51 | 42.29 |
| Endline choices (u_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).

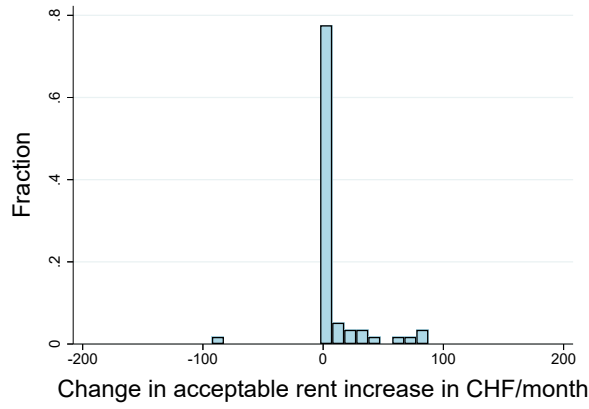
of our sample accept an increase in rents for improved energy efficiency. Both median and mode WTP correspond to the fourth step in the MPL ladder, translating to a WTP of CHF 25 per month for the energy efficient option relative to the standard one.

4.2 The impact of information on tenants' WTP

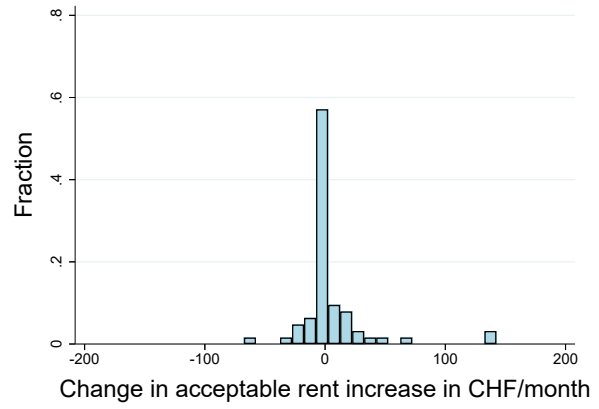
Table 3 tabulates average WTP estimates across baseline MPL choices (before treatment, u_i^0) and endline MPL choices (after treatment, u_i^1). For endline MPL choices, we break down average WTP across treatment conditions. This provides both within and between tenant information about the impact of 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 ($\Delta WTP = u_i^1 - u_i^0$), reported in Figure 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 indicates that the placebo information screens worked as intended, as they have very little effect on WTP for energy efficiency.

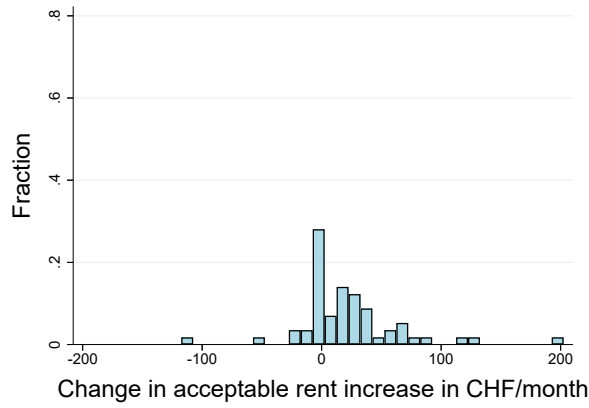
Figure 6: Distributions of the change in acceptable rent increases ($\Delta WTP = u_i^1 - u_i^0$)



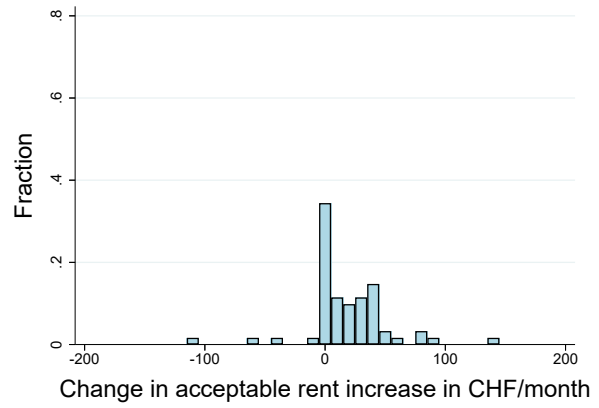
(a) Control (T_{iA})



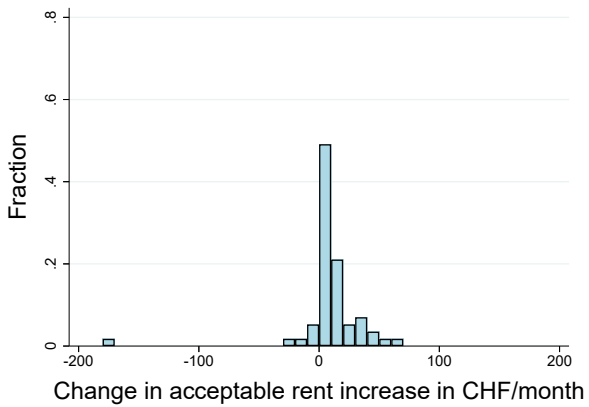
(b) Heating cost (T_{iB})



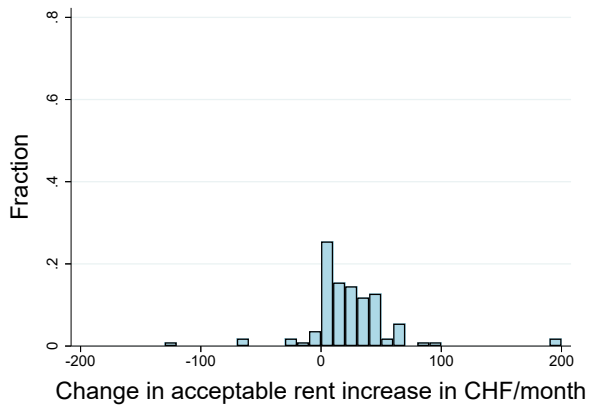
(c) Heating cost salient (T_{iC})



(d) Heating cost variability (T_{iD})



(e) CO₂ tax (T_{iE})



(f) CO₂ tax salient (T_{iF} and T_{iG})

Turning to our informational interventions (T_{iB} - T_{iG}), we find clear evidence that all of them increase tenants' WTP. The largest increase in average WTP 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 tasks (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 (Figure 6, panels b-f),¹⁹ as we find that treatments T_{iB} and T_{iE} feature the largest proportion of respondents with no change in WTP. Note also that, relative to T_{iA} , all distributions are more dispersed and skewed to the right, despite the fact that the mode for all distributions stays $\Delta WTP = 0$.

Inference on these results is reported in Table 4. In column 1, we report OLS regression results for equation (1), which models baseline and endline individual WTP values (u_i^0 and u_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 $\Delta WTP_i = u_i^1 - u_i^0$. Finally, column 3 reports OLS results for a model of endline WTP u_i^1 as a function of treatment dummies, controlling for baseline WTP u_i^0 . Note that regressions in columns 2 and 3 only feature one observation per subject (hence a sample size of 406). Inference for these models is based on heteroskedasticity-robust standard errors.

Estimation results in column 1 confirm that salience of financial information matters: treatments B and E show comparatively small impacts on individual WTP, and these are the only information treatments that do not include financial information in the MPL task directly. Specifically, when information is not included in the MPL task, the difference in WTP between baseline and endline choices is around CHF 7 and not statistically significant. By contrast, treatments in which energy costs are displayed in endline MPL tasks show a highly statistically significant impact on WTP. Treatment C shows the largest WTP increase (about CHF 27 per month, or a 73% increase compared to baseline WTP). Thus, after being informed about financial savings (and introducing this information in the MPL task), WTP for the energy efficient option is CHF 64.87

¹⁹ Note that we find almost no difference between the distributions of treatment groups F and G, and therefore report observations for these two treatments into panel f of Figure 6. More specifically, mean endline WTP of CHF 60.14 for group F and CHF 58.15 for group G, and medians of CHF 45 for both groups.

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

| | (1) WTP (panel) u_i^s | (2) Δ WTP $u_i^1 - u_i^0$ | (3) Endline WTP u_i^1 |
|---|-------------------------------|--|-------------------------------|
| Control (T_{iA}) | 1.201 (5.401) | – | – |
| Heating cost (T_{iB}) | 7.454 (5.889) | -0.528 (4.926) | 1.189 (5.025) |
| Heating cost salient (T_{iC}) | 27.36*** (6.624) | 15.34** (6.541) | 18.08*** (6.282) |
| Heating cost variability (T_{iD}) | 15.81*** (5.224) | 9.935* (5.436) | 11.12** (5.143) |
| CO ₂ tax (T_{iE}) | 6.441 (4.975) | -1.629 (5.085) | 0.110 (4.652) |
| CO ₂ tax salient (A ⁺ lower tax, T_{iF}) | 22.64*** (6.471) | 14.09** (6.208) | 15.95*** (5.853) |
| CO ₂ tax salient (A ⁺ no tax, T_{iG}) | 20.64*** (5.582) | 14.01** (5.844) | 15.38*** (5.638) |
| Baseline WTP (u_i^0) | – | – | 0.747*** (0.0566) |
| Constant | 37.51*** (2.108) | 7.155** (3.229) | 15.14*** (3.412) |
| Observations | 812 | 406 | 406 |
| Adjusted R ² | 0.037 | 0.028 | 0.501 |

Notes: Column (1) reports OLS estimates for a model with two observations per subject (baseline WTP u_i^0 and endline WTP u_i^1). Standard errors are clustered at the respondent-level and reported in parentheses. Column (2) reports OLS estimates for a model of Δ WTP_{*i*} = $u_i^1 - u_i^0$. Column (3) reports OLS results for a model of endline WTP u_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.

per month (CHF 780 per year, see also Table 3). This result parallels earlier findings on the role of financial information for choices reported by Newell and Siikamäki (2014) and Allcott and Taubinsky (2015). Because expected financial savings reported to respondents are set to CHF 40, this upward adjustment following information suggests that financial considerations of energy efficiency only partly determine tenants' WTP.

As expected, results for treatment D show that information about energy cost variability dampens the impact of information on financial savings. Uncertainty about future energy savings thus reduces WTP.²⁰ We also find little evidence that additional information on CO₂ tax

²⁰ Interestingly, this information screen has the lowest rate of correct answers to the quiz question (63.93%, N=61), suggesting that this information is more difficult to comprehend for respondents.

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} . Given our previous interpretation that tenants hold more than financial motives when choosing energy efficient appliances, insensitivity to CO₂ tax information can be surprising. This could be driven by our association of CO₂ emissions with environmental tax payments, as previous work has suggested negative behavioral effects associated with environmental taxes (see Houde and Aldy, 2017, and references therein).

Estimation results reported in columns 2 and 3 show similar results, with a few exceptions. First, OLS regression on Δ WTP (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 the 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 Appendix C), and this is controlled for if we focus on within-subject WTP estimation. Second, OLS regression on endline WTP controlling for baseline WTP (column 3) shows that the coefficient for baseline WTP (u_i^0) is statistically significant, positive, and smaller one as one would expect. This illustrates the fact that baseline WTP plays a large though not the sole role in determining endline WTP. Treatments B and E again provide sharp evidence that simply providing tenants with information on heating cost savings and CO₂ tax payments prior to investment decisions has a limited impact on WTP.

4.3 Heterogeneous treatment effects: Quantile regressions

In this section we study the treatment effect of information across all deciles of the WTP (u_i^s) distribution. 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) *CO₂ tax screen* equals one if the treatment includes the CO₂ tax screen (i.e. T_{iE} , T_{iF} , and T_{iG}); and (v) *CO₂ tax MPL task* equals one if the endline MPL task

includes CO₂ tax payments (i.e. T_{iF} and T_{iG}).²¹ This allows us to decompose treatment effects into specific informational components, and thereby identify key drivers of WTP.

Estimation results are reported in Table 5. In column 1, we report 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 (u_i^0 , u_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.²²

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 marginal effects along the entire WTP distribution. In particular, we find statistically significant treatment effects in five out of nine decile regressions, with several important implications. First, respondents in the lower deciles of the distribution do not respond to information. Around 20% of tenants oppose the choice of a more efficient appliance. Second, respondents in the third, fourth and fifth decile (columns 4, 5 and 6) all adjust WTP in light of the information about financial cost savings. The treatment effect of financial information *declines* across these deciles, and implies that endline WTP for these respondents is around CHF 45, which is very close to expected financial cost savings highlighted in the information provided.²³ Therefore, around 30% of tenants in our sample align their WTP in response to information on energy cost savings. Finally, respondents

²¹ As mentioned in footnote 19, results for treatment groups F and G are very similar, and we therefore lump these together without affecting our results.

²² In Appendix D, we employ a similar specification to 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.

²³ This can be seen by summing the treatment effect estimate and the constant term. In particular, it implies that these respondents selected the energy efficient option for a level of CHF 40, and the standard option at CHF 50.

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

| | (1) WTP (panel) u_i^0 | (2) WTP (panel) (10th quantile) | (3) WTP (panel) (20th quantile) | (4) WTP (panel) (30th quantile) | (5) WTP (panel) (40th quantile) | (6) WTP (panel) (50th quantile) | (7) WTP (panel) (60th quantile) | (8) WTP (panel) (70th quantile) | (9) WTP (panel) (80th quantile) | (10) WTP (panel) (90th quantile) |
|------------------------------|-------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|--|
| Control | 1.201 (5.398) | 0 (3.018) | 0 (4.187) | 0 (6.601) | -10*** (2.975) | 0 (2.614) | 0 (3.138) | -10 (7.961) | 0 (15.91) | 37.50*** (11.86) |
| Heating cost screen | 7.454 (5.885) | 5 (4.921) | 10 (6.768) | 0 (7.087) | 0 (2.624) | 0 (2.593) | 0 (3.193) | 17.50** (7.579) | 0 (4.493) | 37.50** (16.89) |
| Cost MPL task | 19.91** (9.190) | 0 (7.897) | 10 (28.37) | 30*** (8.835) | 20*** (4.744) | 20*** (4.662) | 27.50** (10.91) | 0 (10.79) | 62.50*** (6.145) | 0 (16.38) |
| Cost variability screen | -11.55 (8.647) | 0 (8.792) | 0 (28.44) | -10 (8.846) | -10** (4.972) | 0 (6.162) | 0 (11.77) | 0 (10.62) | -37.50*** (8.794) | 0 (8.031) |
| CO ₂ tax screen | -1.013 (7.997) | 0 (7.075) | 0 (11.38) | 10 (19.04) | 10** (4.583) | 10** (4.523) | 10* (5.284) | 0 (7.588) | 0 (6.475) | -37.50** (18.94) |
| CO ₂ tax MPL task | -4.765 (11.37) | 10 (14.38) | 0 (31.03) | -20 (21.51) | -10 (6.879) | -10 (6.793) | -10 (12.19) | 0 (12.54) | -37.50*** (9.071) | 37.50* (22.56) |
| Constant | 37.51*** (2.107) | 0 (1.124) | 5*** (1.442) | 15*** (4.180) | 25*** (1.272) | 25*** (1.252) | 35*** (1.302) | 45*** (6.657) | 62.50*** (2.447) | 87.50*** (10.44) |
| Observations | 812 | 812 | 812 | 812 | 812 | 812 | 812 | 812 | 812 | 812 |
| (Pseudo) R ² | 0.038 | 0.0149 | 0.0509 | 0.0499 | 0.0472 | 0.0528 | 0.0545 | 0.0423 | 0.0254 | 0.0268 |

Notes: Dependent variable is baseline WTP u_i^0 and endline WTP u_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.

in the upper tail increase their WTP substantially.

Taken together, quantile regression results suggest that the average treatment effect of information is not driven by one tail of the WTP distribution, but affects the WTP distribution for 80% of our sample. Moreover, the treatment effect on median WTP is very close to the treatment effect on average WTP. 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 tenants in order to estimate their acceptance of increased rents in exchange for improved energy efficiency of their space heating system. We find that average WTP associated with an efficiency upgrade from B to A⁺ is economically and statistically significant. Quantitatively, WTP is CHF 37.51 per month (about CHF 450 or USD 470 per year). Moreover, our results suggest that providing tenants with information about expected energy savings significantly affects valuation of energy efficiency, significantly more so when financial information is salient in the MPL tasks. In addition, a considerable fraction of tenants seem to hold more than purely financial motives. Nonetheless, providing information on CO₂ tax payments has virtually no impact on tenants' decisions.

From a policy perspective, our results have important implications. In principle, the fact that tenants are willing to support part of the additional investment cost imposed on landlords through rent increases can be used to incentivize energy efficiency investments in rented properties. In practice, however, this requires coordination between landlords and tenants, and associated transaction costs are likely to form an additional hurdle reducing perceived returns to investing in energy efficiency. Therefore, facilitating and standardizing pre-renovation contracts between landlords and tenants provides a potential avenue to settle ex-ante implications of energy efficiency investments.

Our results also confirm the more conventional view that informational interventions can substantially improve attitudes towards energy efficiency. In particular, our results show that salience of financial gains is important, which suggest that the current design of mandatory energy efficiency labels (Council of European Union, 2013) might not be sufficient to fully inform consumers. The critical information for consumers is financial savings associated with energy

efficiency (see also Newell and Siikamäki, 2014), an area where empirical research is only burgeoning (see Fowlie et al., 2017). This suggest that interventions by a third party could be instrumental in reaching ex-ante agreements, so as to share the financial risk across multiple parties (Sorrell, 2007).

Appendix A Experimental script

Figure A1: Introductory screen 1

tmp_l1. In this part of the survey, we now focus on the use of energy to heat and produce warm water for your dwelling, also called central heating system. We will focus on the dwelling you currently rent and live in.

We want to understand your perceptions about alternative central heating choices. The information that we collect will be used to inform Swiss energy policy, and it is therefore important that your answers reflect your specific situation and your personal tastes.

In particular, 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.

Figure A2: Introductory screen 2

tmp_l2. For the next set of questions, please imagine that your landlord plans to replace your building's current heating system. Note that this choice could influence your rent, and we will imagine different scenarios about such a choice and seek to understand which alternative would be best for your household.

We will consider a choice between two alternative replacement options, and these options are described by a standard label grading how efficient the appliance is at converting the energy in its fuel to heat. Energy efficiency is graded from G (very low) to A++ (very high), and the label for grade A looks like this:



Imagine that your landlord may choose a standard heating appliance, graded B, or alternatively a more energy efficient option, graded A+. Selecting the appliance graded B is considered standard maintenance, so as a tenant your rents would not change. However, if your landlord decides to install a more costly and highly energy efficient (A+) appliance, she/he may ask for an increase in rents to cover some of the additional costs.

Figure A5: First baseline MPL choice task

tmp_bc1. Please make your choice below.

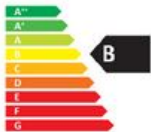

| | |
|---|---|
| <p>OFFER I:</p> <p>STANDARD HEATING SYSTEM</p>  <p>NO change in rents</p> <p>SELECT I</p> <p><input type="radio"/></p> | <p>OFFER II:</p> <p>ENERGY EFFICIENT HEATING SYSTEM</p>  <p>NO change in rents</p> <p>SELECT II</p> <p><input type="radio"/></p> |
|---|---|

Figure A6: Instructions for information screens (T_{iA})

tmp_ta1. For the next part of the study, you will have the opportunity to learn more about Swiss residential buildings and energy. We will show you information about:

- The construction year of residential buildings
- Heating technologies and energy sources

The discussion of each issue will be followed by a one-question quiz. Please pay close attention to the discussion so that you can correctly answer the quiz question.

Figure A7: Instructions for information screens (T_{iB} and T_{iC})

tmp_tb1. For the next part of the study, you will have the opportunity to learn more about Swiss residential buildings and energy. We will show you information about:

- Energy efficiency and heating costs
- The construction year of residential buildings

The discussion of each issue will be followed by a one-question quiz. Please pay close attention to the discussion so that you can correctly answer the quiz question.

Figure A8: Instructions for information screens (T_{iD})

tmp_td1. For the next part of the study, you will have the opportunity to learn more about Swiss residential buildings and energy. We will show you information about:

- Energy efficiency and heating costs
- How heating costs can vary from year to year

The discussion of each issue will be followed by a one-question quiz. Please pay close attention to the discussion so that you can correctly answer the quiz question.

Figure A9: Instructions for information screens (T_{iE} , T_{iF} and T_{iG})

tmp_tg1. For the next part of the study, you will have the opportunity to learn more about Swiss residential buildings and energy. We will show you information about:

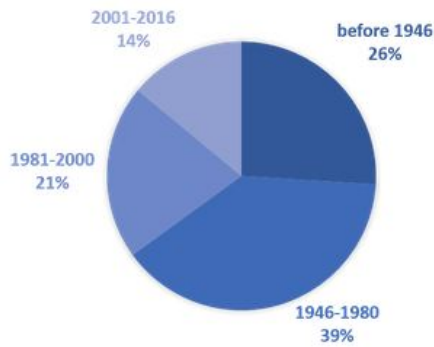
- Energy efficiency and heating costs
- The CO₂ tax on heating oil and natural gas

The discussion of each issue will be followed by a one-question quiz. Please pay close attention to the discussion so that you can correctly answer the quiz question.

Figure A10: Information screen - Neutral I (T_{iA} , T_{iB} and T_{iC})

tmp_ta2. Compared to other countries, Switzerland has a relatively old building stock. According to official estimates, two thirds of the dwellings in Switzerland were built before 1980 (65%), and 14% of today's apartments were built within the last 15 years.

AGE OF DWELLINGS IN SWITZERLAND BY CONSTRUCTION PERIOD



Switzerland's settlement and urban areas have grown rapidly in recent years. The reasons for this are fast population growth and increased demands for housing, leisure and mobility. The transformation of the built environment is a reflection of social change.

tmp_ta3. How many % of Swiss apartments were built between 2001 and 2016?

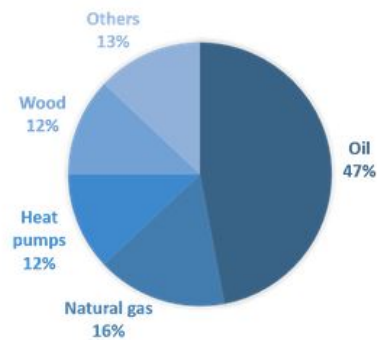
To answer this question, you can only enter integers between 0 and 100. Type your answer below:

 %

Figure A11: Information screen - Neutral II (T_{iA})

tmp_ta4. Swiss households use a variety of different heating technologies and energy sources to enjoy temperate dwellings and warm water. Official records show that heating oil is the most prevalent source of energy to produce residential heat (47%), followed by natural gas (16%).

HEATING SYSTEMS AND ENERGY SOURCES IN SWISS RESIDENTIAL BUILDINGS



Compared to 2009, there has been a 5% decline in the use of oil-based heating, and a 4% increase in the number of heat pumps installed.

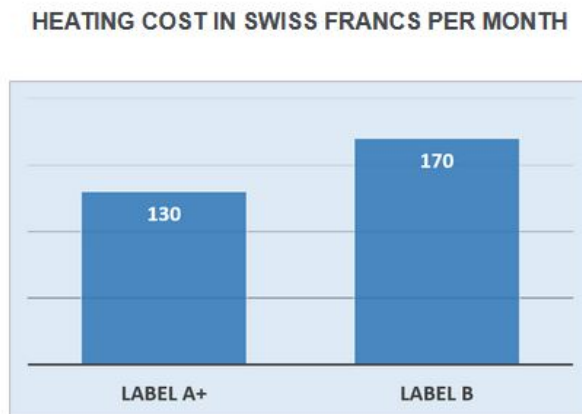
tmp_ta5. How many % of Swiss residential buildings are heated with natural gas today?

To answer this question, you can only enter integers between 0 and 100. Type your answer below:

 %

Figure A12: Information screen - Heating costs ($T_{iB}-T_{iG}$)

tmp_te2. Choosing an energy efficient heating appliance can lower your household's heating costs significantly: keeping everything else equal, switching from an appliance graded B to one graded A+ would decrease energy use by 25 percent on average. This implies that heating costs for a household who pays Fr. 170 per month with an appliance graded B could decline to Fr. 130 per month with an A+ appliance.



Therefore, while more energy efficient appliances are typically more expensive to purchase (the investment cost), over a 15-year lifetime the additional cost may be more than compensated by lower heating costs.

tmp_te3. Typically, if heating expenditures with an appliance graded A+ amount to Fr. 130 per month, how much would heating cost be with an appliance graded B?

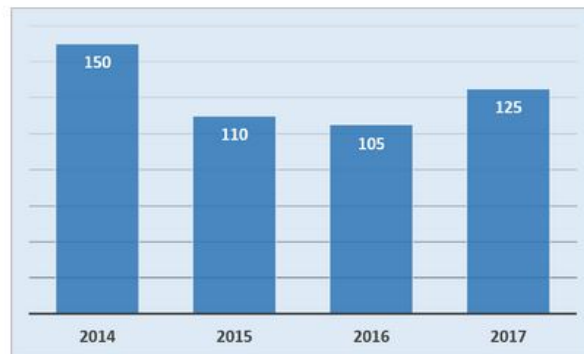
To answer this question, you can only enter integers. Type your answer below:

Fr.

Figure A13: Information screen - Heating cost variability (T_{iD})

tmp_td4. Heating costs depend in great part on the cost of fuel. Yearly energy costs for a boiler operated with heating oil, for instance, vary from year to year with the price of oil: while average monthly heating costs were at Fr. 150 per household in 2014, they only amounted to Fr. 105 per household in 2016.

HEATING COST IN SWISS FRANCS PER MONTH



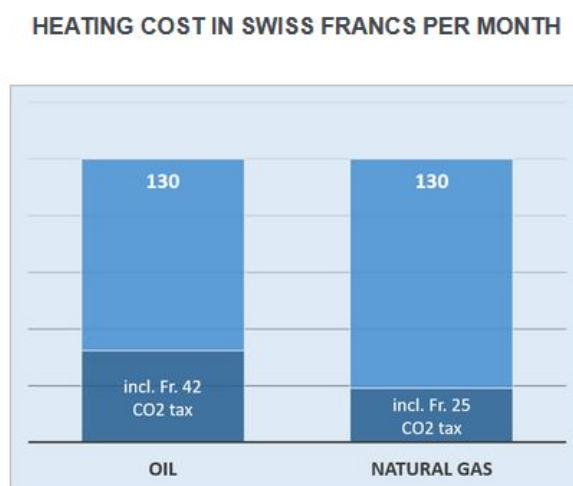
Therefore, because of varying energy prices, heating costs of households who select an energy efficient heating system may not necessarily decline as much as expected.

tmp_td5. Does the purchase of energy efficient heating appliances always result in lower heating costs?

- Yes
- No

Figure A14: Information screen - CO₂ tax (T_{iE} , T_{iF} and T_{iG})

tmp_l_te4. Switzerland participates in international efforts to reduce the risk of climate change, and the government has enacted laws that require a reduction in CO₂ emissions by 20 percent from 1990 to 2020. Fossil fuels are important contributors to CO₂ emissions and, since 2008, in Switzerland heating oil and natural gas are taxed in proportion to the CO₂ emitted when they are used in heating systems.



This CO₂ tax has increased from Fr. 12 per ton of CO₂ emitted in 2008 to Fr. 84 per ton of CO₂ in 2016. At the current rate, this corresponds to a tax on heating oil of around Fr. 42 for a monthly heating bill of Fr. 130, while the tax on natural gas amounts to Fr. 25 for a monthly heating bill of Fr. 130. For other fuels, including wood and electricity, the CO₂ tax is nil.

tmp_l_te5. If your heating system is operating on heating oil and your monthly heating bill amounts to CHF 130, how high is the associated CO₂ tax payment?

To answer this question, you can only enter integers. Type your answer below:

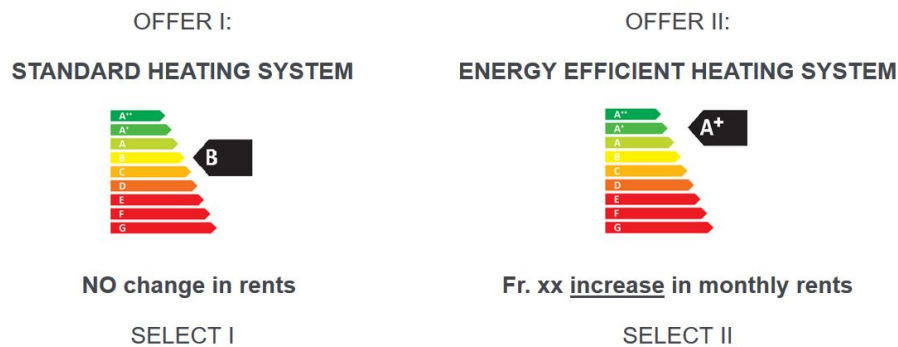
Fr.

Figure A15: Introductory screen 4 - Endline MPL

tmp_ta_ec_i1. Now please consider again the possibility that the current primary heating appliance of your dwelling needs replacement. Imagine once again that your landlord may choose a standard heating appliance, graded B, or alternatively a more energy efficient option, graded A+.

Figure A16: Instructions for endline MPL with rent increase (i.e. T_{iA} , T_{iB} and T_{iE})

tmp_tb_ec_i2. You will now be asked to make further choices between pairs of offers. Here is an example of the choice we want you to consider:

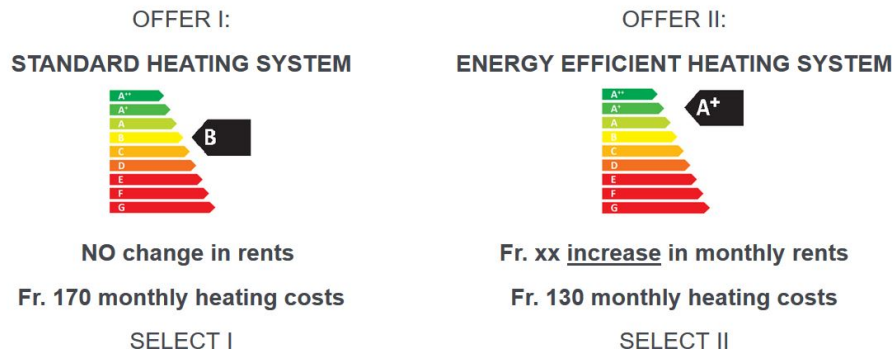


Besides the the attributes described, these two appliances are again exactly similar and the change of appliance will again take place in 2017. All decisions have the same format.

Please consider your choices carefully, and remember that expenses for your dwelling will not be available for other things. It is important that your choices reflect your preferred situation, as this research will contribute to inform energy policy in Switzerland. The only right answer is what you would choose in reality.

Figure A17: Instructions for endline MPL with heating costs (T_{iC} and T_{iD})

tmp_tc_ec_i2. You will now be asked to make further choices between pairs of offers. In addition, for each offer we now report approximate total heating and warm water cost for an average Swiss household:





Besides the the attributes described, these two appliances are again exactly similar and the change of appliance will again take place in 2017. All decisions have the same format.

Please consider your choices carefully, and remember that expenses for your dwelling will not be available for other things. It is important that your choices reflect your preferred situation, as this research will contribute to inform energy policy in Switzerland. The only right answer is what you would choose in reality.

Figure A18: Instructions for endline MPL with heating costs and CO₂ tax, A⁺ lower tax (T_{iF})

tmpl_tf_ec_i2. You will now be asked to make further choices between pairs of offers. In addition, for each offer we now report approximate total heating and warm water cost, as well as the associated CO₂ tax for an average Swiss household:

| | |
|---|---|
| <p>OFFER I:</p> <p>STANDARD HEATING SYSTEM</p>  <p>NO change in rents</p> <p>Fr. 170 monthly heating costs (incl. Fr. 55 CO₂ tax)</p> <p>SELECT I</p> | <p>OFFER II:</p> <p>ENERGY EFFICIENT HEATING SYSTEM</p>  <p>Fr. xx <u>increase</u> in monthly rents</p> <p>Fr. 130 monthly heating costs (incl. Fr. 42 CO₂ tax)</p> <p>SELECT II</p> |
|---|---|

Besides the the attributes described, these two appliances are again exactly similar and the change of appliance will again take place in 2017. All decisions have the same format.


Please consider your choices carefully, and remember that expenses for your dwelling will not be available for other things. It is important that your choices reflect your preferred situation, as this research will contribute to inform energy policy in Switzerland. The only right answer is what you would choose in reality.

Figure A19: Instructions for endline MPL with heating cost and CO₂ tax, A⁺ no tax (T_{iG})

tmpl_tg_ec_i2. You will now be asked to make further choices between pairs of offers. In addition, for each offer we now report approximate total heating and warm water cost, as well as the associated CO₂ tax for an average Swiss household:

OFFER I:

STANDARD HEATING SYSTEM




NO change in rents
Fr. 170 monthly heating costs
(incl. Fr. 55 CO₂ tax)

SELECT I

OFFER II:

ENERGY EFFICIENT HEATING SYSTEM



Fr. xx increase in monthly rents
Fr. 130 monthly heating costs
(no CO₂ tax)

SELECT II

Besides the the attributes described, these two appliances are again exactly similar and the change of appliance will again take place in 2017. All decisions have the same format.


Please consider your choices carefully, and remember that expenses for your dwelling will not be available for other things. It is important that your choices reflect your preferred situation, as this research will contribute to inform energy policy in Switzerland. The only right answer is what you would choose in reality.

Figure A20: First endline MPL choice task - Heating cost (T_{iC} and T_{iD})

tmpl_tc_ec1. Please make your choice below.

OFFER I:

STANDARD HEATING SYSTEM




NO change in rents
Fr. 170 monthly heating costs

SELECT I

OFFER II:

ENERGY EFFICIENT HEATING SYSTEM



NO change in rents
Fr. 130 monthly heating costs

SELECT II

Figure A21: First endline MPL choice task - Heating cost and CO₂ tax (A⁺ lower tax, T_{iF})

tmp1_tf_ec1. Please make your choice below.





| | |
|--|--|
| <p>OFFER I:</p> <p>STANDARD HEATING SYSTEM</p>  <p>NO change in rents Fr. 170 monthly heating costs (incl. Fr. 55 CO₂ tax)</p> <p>SELECT I</p> <input type="radio"/> | <p>OFFER II:</p> <p>ENERGY EFFICIENT HEATING SYSTEM</p>  <p>NO change in rents Fr. 130 monthly heating costs (incl. Fr. 42 CO₂ tax)</p> <p>SELECT II</p> <input type="radio"/> |
|--|--|

Figure A22: First endline MPL choice task - Heating cost and CO₂ tax (A⁺ no tax, T_{iG})

tmp1_tg_ec1. Please make your choice below.

| | |
|--|--|
| <p>OFFER I:</p> <p>STANDARD HEATING SYSTEM</p>  <p>NO change in rents Fr. 170 monthly heating costs (incl. Fr. 55 CO₂ tax)</p> <p>SELECT I</p> <input type="radio"/> | <p>OFFER II:</p> <p>ENERGY EFFICIENT HEATING SYSTEM</p>  <p>NO change in rents Fr. 130 monthly heating costs (no CO₂ tax)</p> <p>SELECT II</p> <input type="radio"/> |
|--|--|

Appendix B Sample Composition

Table B1: Summary statistics for selected variables

| | N | Mean | Std.-dev. | Min | Max |
|-----------------------------------|-----|-------|-----------|-------|------|
| <i>Respondent characteristics</i> | | | | | |
| Female indicator | 406 | 0.53 | 0.50 | 0 | 1 |
| Age (in years) | 406 | 43.38 | 15.01 | 20 | 85 |
| University indicator | 406 | 0.47 | 0.50 | 0 | 1 |
| Risk aversion ^a | 405 | 0.93 | 0.74 | -1.84 | 1.51 |
| Discount rate (in %) ^b | 404 | 7.76 | 20.16 | .5 | 100 |
| <i>Household characteristics</i> | | | | | |
| Household income ^c | 340 | 3.74 | 1.41 | 1 | 6 |
| Multifamily house indicator | 406 | 0.84 | 0.37 | 0 | 1 |
| Oil heating indicator | 406 | 0.37 | 0.48 | 0 | 1 |
| Individual meter for heating | 406 | 0.40 | 0.49 | 0 | 1 |

Notes: ^aRisk aversion is based on the results of a MPL experiment and it is coded as a range from -1.84 (highly risk loving) to +1.51 (extremely risk averse). ^bThe discount rate corresponds to the actual rate measured in the results of a MPL experiment and ranges from 0.5% (very patient) to 100% (very impatient). ^cMonthly gross household income is coded as: 1 – CHF 3,000 or less; 2 – CHF 3,000-4,459; 3 – CHF 4,500-5,999; 4 – CHF 6,000-8,999; 5 – CHF 9,000-12,000; 6 – CHF 12,000 or more.

Appendix C Treatment randomization

Table C1: Characteristics across treatment groups

| | A | B | C | D | E | F | G |
|--|-------|-------|-------|-------|-------|-------|-------|
| <i>Mean respondent characteristics</i> | | | | | | | |
| Baseline WTP (u_i^0) ^a | 31.55 | 38.33 | 42.37 | 36.23 | 38.42 | 38.89 | 36.98 |
| Female indicator | 0.50 | 0.41 | 0.51 | 0.51 | 0.60 | 0.65 | 0.55 |
| Age (in years) | 43.76 | 42.79 | 43.42 | 44.57 | 44.39 | 43.62 | 41.14 |
| University indicator | 0.48 | 0.56 | 0.51 | 0.44 | 0.49 | 0.42 | 0.38 |
| Risk aversion ^b | 1.03 | 0.96 | 0.83 | 0.93 | 1.04 | 0.87 | 0.86 |
| Discount rate (in %) ^c | 6.96 | 4.97 | 10.35 | 6.75 | 6.82 | 5.74 | 12.75 |
| <i>Mean household characteristics</i> | | | | | | | |
| Household income ^d | 3.48 | 3.63 | 3.92 | 4.08 | 3.85 | 3.70 | 3.50 |
| Household size (in m ²) | 81.71 | 89.90 | 88.79 | 96.54 | 96.91 | 96.19 | 94.36 |
| Multifamily house indicator | 0.90 | 0.83 | 0.91 | 0.77 | 0.88 | 0.87 | 0.74 |
| Oil heating indicator | 0.34 | 0.38 | 0.33 | 0.44 | 0.33 | 0.44 | 0.33 |
| Consumption-based heating bill indicator | 0.38 | 0.38 | 0.37 | 0.39 | 0.42 | 0.37 | 0.48 |
| Observations | 58 | 63 | 57 | 61 | 57 | 52 | 58 |

Notes: ^aAcceptable rent increases as measured in the MPL experiment *before* treatment, in CHF per month. ^bRisk aversion is based on the results of a MPL experiment and it is coded as a range from -1.84 (highly risk loving) to +1.51 (extremely risk averse). ^cThe discount rate corresponds to the actual rate measured in the results of a MPL experiment and ranges from 0.5% (very patient) to 100% (very impatient). ^dMonthly gross household income is coded as: 1 – CHF 3,000 or less; 2 – CHF 3,000-4,459; 3 – CHF 4,500-5,999; 4 – CHF 6,000-8,999; 5 – CHF 9,000-12,000; 6 – CHF 12,000 or more.

Appendix D Additional regression results

Table D1: Regressions with control variables and interaction terms

| | (1) Endline WTP u_i^1 | (2) Endline WTP (control set a) | (3) Endline WTP (control set b) | (4) Endline WTP interactions |
|--|-------------------------------|---------------------------------------|---------------------------------------|------------------------------------|
| Heating cost screen | 1.189 (5.019) | 1.354 (4.999) | 1.036 (5.015) | 2.106 (5.180) |
| Cost MPL task | 16.89** (6.657) | 15.61** (6.618) | 15.53** (6.722) | 33.86** (13.69) |
| Cost variability screen | -6.964 (6.757) | -5.836 (6.611) | -5.653 (6.735) | -5.680 (6.852) |
| CO ₂ tax screen | -1.078 (5.246) | -1.787 (5.226) | -1.361 (5.239) | -3.591 (5.363) |
| CO ₂ tax MPL task | -1.352 (8.193) | -1.271 (8.165) | -0.950 (8.302) | 0.394 (8.515) |
| Baseline WTP (u_i^0) | 0.747*** (0.0565) | 0.748*** (0.0546) | 0.745*** (0.0547) | 0.715*** (0.0557) |
| Female indicator | - | 6.588** (3.268) | 6.934** (3.274) | 4.714 (3.958) |
| Age (in years) ^a | - | -0.187 (0.118) | -0.186 (0.118) | 0.0433 (0.146) |
| University indicator | - | 4.686 (3.148) | 4.250 (3.101) | 10.53** (4.259) |
| Discount rate (in %) ^b | - | 0.0835 (0.0840) | 0.0869 (0.0844) | 0.208 (0.159) |
| Risk aversion ^c | - | -2.810 (2.853) | -2.712 (2.926) | 1.901 (1.988) |
| High income indicator ^d | - | - | -0.0555 (0.0474) | 13.89** (6.647) |
| Household size (in m ²) ^a | - | - | - | 0.0485 (0.0440) |
| Multifamily house indicator | - | - | - | 1.130 (5.071) |
| Cost MPL task X female indicator | - | - | - | 2.901 (6.299) |
| Cost MPL task X age (in years) ^a | - | - | - | -0.321 (0.223) |
| Cost MPL task X university indicator | - | - | - | -11.13* (6.295) |
| Cost MPL task X discount rate (in %) ^b | - | - | - | -0.184 (0.180) |
| Cost MPL task X risk aversion ^c | - | - | - | -7.736 (5.057) |
| Cost MPL task X high income indicator ^d | - | - | - | -8.183 (9.167) |
| Cost MPL task X household size (in m ²) ^a | - | - | - | -0.0934 (0.0634) |
| Cost MPL task X multifamily house indicator | - | - | - | -5.668 (9.363) |
| Constant | 15.14*** (3.408) | 11.93*** (4.384) | 12.90*** (4.234) | 1.407 (6.340) |
| Observations | 406 | 403 | 403 | 403 |
| Adjusted R ² | 0.502 | 0.512 | 0.513 | 0.519 |

Notes: ^aNormalized to mean zero for ease of interpretation. ^bThe discount rate corresponds to the actual rate measured in the results of a MPL experiment and ranges from 0.5% (very patient) to 100% (very impatient). ^cRisk aversion is based on the results of a MPL experiment and it is coded as a range from -1.84 (highly risk loving) to +1.51 (extremely risk averse). ^dMonthly gross household income of CHF 9,000 or more (above sample median). Robust standard errors are reported in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively.

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