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Abstract

In May 2010, we surveyed 473 Swiss homeowners about their preferences for energy efficiency renovations in their homes. We used conjoint choice experiments that asked respondents to choose among hypothetical energy efficiency renovation projects. We find that homeowners *are* responsive to the upfront costs of the renovation projects, the savings in energy expenses, the time horizon over which such savings would be realized, and the thermal comfort improvement afforded by such renovations. Even more important, the likelihood of undertaking energy-efficiency renovations increases with the size of the subsidy offered by the Swiss federal government. At least for an average-sized project, we find that the impact of a rebate is comparable to that of an improvement in the thermal comfort of the home. The savings in the annual energy bills and the duration of the investment are less important.

The discount rate implicit in the responses to the conjoint choice experiments is low. Depending on the specification of the random utility model, the discount rate ranges from 1.5 to about 3%. This is consistent with the point in Hassett and Metcalf (1993) and Metcalf and Rosenthal (1995), and with the fact that our scenarios contain no uncertainty.

Respondents who feel completely uncertain about future energy prices are more likely to select the status quo (no renovations) in any given choice task and weight the cost of the investments more heavily than those respondents who expect energy prices to increase in the future. The hypothetical renovations are more likely to take place when respondents believe that climate change considerations should be an important determinant of home renovations.

JEL Classification: Q40, Q48, D91.

Keywords: Energy efficiency, Energy savings, choice experiments, discount rates, residential energy use.

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1. Introduction

In most developed countries, buildings account for some 30-40% of total energy use, and improved energy efficiency in buildings is a potentially large (and untapped) source of CO_2 emissions reductions available at low cost, at least from the social point of view (Levine et al. 2007; Choi Granade et al., 2009). In Switzerland, some 80% of the total energy used in buildings is for space heating. Technical assessments suggest that this could be reduced by 33-50% in existing buildings and by 80% or more in new buildings by enhancing energy efficiency (Jakob and Madlener, 2004).

Despite such an appealing potential, in Switzerland only 1 to 2% of the existing building envelopes undergo maintenance or renovation each year, and thermal insulation[1] is implemented in only 30 to 50% of them (Jochem and Jakob, 2003). Such measures reduce the energy consumption of the building, and hence the energy bills, and improve thermal comfort. Why, then, are these measures undertaken so infrequently?

Jakob (2007) concludes that several factors hinder energy efficiency renovations in homes in Switzerland. Such investments are usually undertaken at the end of the building element's lifetime—which tends to be quite long in Switzerland—and during general renovation projects. Institutional disincentives and the diverging interests of landlords and tenants are also likely to play a role, since two-thirds of the Swiss rent their homes. Market forces only offer limited incentives, since energy efficiency is not yet adequately capitalized into housing values and rents.[2]

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[1] Thermal insulation is here defined as the insulation of the building envelope, including doors and windows, plus a ventilation system. The ventilation system provides the indoor space of the building with fresh and filtered air (pre-heated by a heat exchange system) without the typical energy loss of windows and traditional aeration systems.

[2] An economic analysis conducted by Zurich Cantonal Bank using hedonic pricing techniques suggests that energy-efficient windows raised the sale price of single-family homes by about 2-3.5%, while new single-family owners certified with the Minergie label sold for about 9% more than comparable homes without such

Other market failures and barriers frequently cited as possible causes of this "energy efficiency gap" (Golove and Eto, 1996) include high discount rates, information gaps, transaction costs, the riskiness of technologies, and access to credit, since substantial investments may be required to retrofit the existing housing stock (Clinch and Healy, 2000). Hassett and Metcalf (1993) and Metcalf and Rosenthal (1995) show that uncertainty about future energy prices and the irreversibility of investments play an important role in explaining sluggish energy efficiency investment rates.

Numerous policy measures were introduced in Switzerland starting in 2000 to overcome these market barriers and failures. These include subsidies at the federal, cantonal and municipal levels, often framed as tax credits or deductions. Moreover, cantonal banks offer reduced interest rates on loans for energy efficiency investments in buildings. At the end of 2009, a new incentive program ("Gebäudeprogramm") supported by the cantons and the Swiss federal government was established, providing CHF 133 million a year for energy efficiency investments.[3] This program is expected to continue until 2020.

In this paper, we are concerned with energy efficiency with respect to heating,[4] which depends mainly on the insulation characteristics of the building. We use stated preference methods to investigate the preferences of Swiss homeowners for home energy-efficiency (henceforth denoted as EE) renovations and their responsiveness to government policies.

We ask four research questions. First, when homeowners make EE renovations and investment decisions, do they regard disbursements (the initial cost of the investment) and gains (government incentives and savings on the energy bills) as symmetric? Second, are government incentives effective in encouraging EE investments? Third, at what rate do

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certification. However, this result was not statistically significant at the conventional levels (Borsani and Salvi, 2003).

[3] At the time of this writing 1 CHF is equivalent to 1.03 USD.

[4] Cooling is not common in Swiss homes.

homeowners discount future savings on the energy bills? Fourth, what is the role of expectations about future energy prices?

We administered a survey based on conjoint choice experiments to homeowners in five cantons in Switzerland in May 2010. We focus on owners of single-family and semi-detached homes, and row houses because they account for 60% of the Swiss housing stock (Swiss Federal Population Census, 2000). A majority of these buildings (over 85%) were built before 1990 (Banfi et al., 2010). Attention in this paper is restricted to the homes that serve as the primary residence for the homeowner, because these persons incur both the costs and the benefits of retrofits. We further restrict attention to the owners of homes that haven't been renovated since 1996, and are thus most likely to be renovated within the next few years. The alternatives in our conjoint choice experiments are hypothetical renovations defined by five attributes: i) upfront costs, ii) rebate offered by the government, iii) savings on the energy bills per year, iv) thermal comfort, and v) lifetime of the investment.

Briefly, we find that, as predicted by economic theory, homeowners *are* responsive to the upfront costs of the renovation projects and *do* pay attention to the savings in energy expenses, the time horizon over which such savings would be realized, and the thermal comfort improvement afforded by such renovations. Even more important, the likelihood of undertaking energy-efficiency renovations increases with the size of the subsidy offered by the Swiss federal government. The effect of the subsidy, for a project of average size, is comparable to that of a thermal comfort improvement. The discount rate implicit in the responses to the choice questions is low (1.5-2.9%).

Costs and savings tend to be treated asymmetrically, but the direction of this asymmetry is somewhat surprising: A subsidy of CHF 7,786 is sufficient to offset completely a CHF 10,000 increase in up-front costs. Importantly, persons who believe that climate change should be an important determinant of home energy efficiency renovations are less likely to pass up opportunities for renovations and weight the savings more heavily than the other respondents. The survey responses are consistent with the notion that uncertainty about future energy prices hinders energy efficiency investments (Hassett and Metcalf, 1993; Metcalf and Rosenthal, 1995; D.L. Greene, 2011). Individuals who simply don't know what the price of energy will be in 20 years are more likely to decline renovation projects and weight the upfront costs more heavily, whereas individuals who expect large price increases are more likely to undertake energy efficiency investments. These findings suggest that incentive policies should be accompanied by the provision of clear information about the savings in energy bills and greenhouse gas emissions delivered by EE retrofits in the home.

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 presents the study design and the structure of the questionnaire. Section 4 presents the random utility approach and econometric model. We describe the characteristics of the respondents, their homes and responses in Section 5. Section 6 presents the estimation results. Section 7 concludes.

2. Background and Literature Review

A. Hurdles to Energy Efficiency Investments

Buildings account for some 30-40% of total energy use, and engineering and policy circles alike hold that it should be possible to attain significant reductions in energy use (and in the emissions associated with power generation) if the energy efficiency of buildings was improved, especially residential buildings (Levine et al., 2007; Choi Granade et al., 2009). Much research has been concerned with the so-called "energy efficiency paradox," whereby individuals pass up opportunities to purchase highly efficient, but somewhat more expensive, equipment (or energy efficiency investments) that result in energy savings in the future. Possible explanations for this behavior include (i) impatience (i.e., high discount rates for money), (ii) information failures, and (iii) uncertainty about the savings in energy expenditures (Hassett and Metcalf, 1993; Metcalf and Hassett, 1999). Attention has also been paid to (iv) institutional disincentives, which may occur when the party making the investment is not the one that reaps the benefits of that investment (e.g., landlords and renters; see Levinson and Niemann (2004) and Houser et al. (2009), and (v) liquidity constraints (see Golove and Eto, 1996, for a review).

In this paper, we are especially concerned about (i), (iii) and (v). As mentioned, one possible explanation for the low rate of adoption of EE technologies holds that people have high rates of intertemporal preference (i.e., they discount the future heavily). An early review of the literature that empirically estimated the discount rates implicit in homeowners' EE retrofit decisions or appliance purchases (Train, 1985) suggests discount rates in the 2-36% range for thermal integrity, space heating systems and fuel type, and even higher discount rates for specific appliances, such as refrigerators.

Some observers believe that energy efficiency investments are undermined by the uncertainty surrounding the available technologies under real-life operating conditions. Metcalf and Hassett (1999) suggest that people do not believe the energy savings predicted by engineering estimates, and estimate a model that shows that people make investments in energy efficiency in homes at an internal rate of return comparable to market interest rates.

Even in the absence of uncertainty about the energy savings measured in physical units (e.g., kWhs), monetized savings may remain uncertain because of fluctuations in energy prices. Hassett and Metcalf (1993) argue that the energy efficiency paradox is a rational response to uncertainty about the price of energy. They model the price of energy as a random walk—a stochastic representation that describes well actual energy prices—and show that, because EE investments are irreversible, it is rational for the consumer to wait one more period before making an investment to confirm information about energy price trends.

Based on plausible assumptions about discount rates, their model predicts the investment rate to be low and EE investments to occur in a lumpy fashion, with extended periods of inactivity. Hassett and Metcalf also argue that the "high" discount rates estimated in the literature are an artifact due to the failure to account for an "option price," and derive the relationship between true and "apparent" discount rates.

We use stated preference methods and test this model empirically by examining whether—under well-specified conditions and in the absence of uncertainty in the choice scenarios—those individuals who state that they are completely uncertain about future energy prices and those individuals who expect price increases are, respectively, less and more likely to do EE renovations. We infer the discount rate from the responses to choice investment questions, finding that it is much lower than the estimates obtained in earlier literature.

We also investigate the effectiveness of (financial) incentives offered by the government in encouraging energy-efficiency investments in the home. Incentives that lower the up-front cost of EE retrofits and investments, such as rebates, tax credits and low-cost loans (Choi Granade et al., 2009) should increase the rate at which EE investments and may offer relief to liquidity-restricted homeowners. Indeed, government incentives to EE are currently offered to homeowners and renters in many countries, including the US, where they have been standard practice since the 1970s and were included in president Obama's 2009 stimulus package, and Switzerland. Little is known, however, about their effectiveness, and concerns have been raised that they may carry the risk of "free riding," i.e., people take the subsidies but many of the observed investments would be made even in their absence.[5]

[5] Grösche and Vance (2008) study four types of energy efficiency retrofits (attic insulation, façade insulation, window replacement, heating equipment replacement) as reported by 2530 single-family homeowner in the 2005 German Residential Energy Consumption Survey. They match each type of investment with engineering estimates of the cost of the investment and the energy savings (in KWh), and fit conditional and mixed logit models to obtain the marginal willingness to pay for each KWh saved. They define free riding to occur when the WTP for the investment is greater than its cost to the consumer, and calculate that it affects some 50% of the homeowners in their sample. They conclude that a recent policy in Germany that issues grants to homeowners for EE investments is highly cost-ineffective. Their conclusions, therefore, sound common themes with the

B. Use of Conjoint Choice Experiments to Study EE Investments

Conjoint choice experiments are a stated-preference method where survey respondents are asked to choose the most preferred out of K (K≥2) alternative variants of a good (or K policy packages), where each variant (or policy package) is defined by a vector of attributes. In each choice task, respondents are assumed to trade off the attributes of the alternatives being compared and select the alternative that gives them the highest utility.

Conjoint choice experiments lend themselves to studying people's response to technical, financial and policy aspects of residential EE renovation projects because their hypothetical nature allows analysts to observe what people would do under a much broader range of conditions than are experienced in real life.

In the majority of the earlier studies based on conjoint choice experiments and involving residential projects, the alternatives being compared were either renovation projects or variants of one's dwelling, and the attributes were physical interventions (e.g., new windows with double glazing, as in Banfi et al., 2008), energy efficiency outcomes (e.g., reduction in energy use by a specified percentage, as in Chau et al., 2010), and, in some cases, environmental quality improvements associated with the EE renovations (e.g., better indoor air quality and noise reduction, as in Chau et al., 2010). The monetary attribute (which is necessary to compute the marginal willingness to pay for an attribute) was, depending on the study, the cost of the project, the change in the monthly maintenance fee, or a housing price differential.

To our knowledge, the earlier studies that have examined EE retrofits and investment decisions using conjoint choice experiments have found that people *are* willing to pay for such investments. For example, Banfi et al. (2008) estimate that respondents are willing to

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views in Metcalf and Hassett (1993), who recommend instead approaches based on regulations (e.g., prescribed energy efficiency standards for appliances and homes).

pay 13% more than the current home price for new windows and 6-7% more for façade insulation. Jakob (2007) concludes that the marginal WTP for these improvements is greater than their market price, and hypothesizes that one reason why the actual rate of EE renovations and investments in homes is very low might be that energy efficiency is not yet capitalized into the prices of homes in Switzerland. This has potentially important implications for government policies that seek to encourage energy-efficient homes. In Chau et al. the attributes (2010) are a dwelling's water and energy efficiency, indoor air quality, noise reduction, landscaping, and the monthly fee. These authors find that energy efficiency is judged more important than water efficiency, and that residents of conventional and "green" buildings in Hong Kong have similar valuations of all attributes, except for landscaping/recreational facilities.[6]

3. Study Design and Implementation

A. Research Questions and Study Design

In this paper, we deploy conjoint choice experiments to investigate four research questions. First, when homeowners make EE renovations and investment decisions, do they regard disbursements (the initial cost of the investment) and gains (government incentives and savings on the energy bills) as symmetric? Second, are government incentives effective in encouraging EE investments? Third, at what rate do homeowners discount future savings on the energy bills? Fourth, what is the role of uncertainty about future energy prices?

Attention is restricted to home renovations that enhance the thermal integrity of a home. Such projects include insulation, replacing windows with energy-efficient ones,

[6] The story might be somewhat different at other locales or when respondents must examine other types of technologies. Scarpa and Willis (2009) find that the WTP for so-called "micro-generation" technologies (e.g., solar and PV) in the UK is well below the actual cost of such equipment on the market, and conclude that subsidies and incentives will be important if non-fossil, renewable energy sources are to become more widespread.

replacing old and outdated furnaces and boilers, etc. The lifetime of such investments can be expected to be in the 20-40 years range.

We created choice experiments where the alternatives are renovation projects defined by five attributes: (i) the total up-front cost of the project, (ii) the rebate on the cost of the project (provided by the Swiss federal government), (iii) the savings on the energy bills per year, (iv) the lifetime of the investment, which is also number of years over which the savings would be experienced, and (v) thermal comfort. Three of our attributes are amounts of money, implying that—as we discuss in section 4 below—their coefficients in our discrete choice models are (rescaled) marginal utilities of income. This allows us to test whether individuals view disbursements and gains symmetrically, namely our first research question. We emphasize that our interest in asymmetric treatment of disbursements and savings should not be confused with the theory of prospects (Kahnemann and Tversky, 1979), because there is no uncertainty in our scenario, and because the cost of a renovation project is likely to capture other costs of the project, such as the disruption at someone's home during project completion and the cost of acquiring the funds for doing the project itself, that are difficult to measure.

Since the rebate from the federal government is varied across renovation project, and ranges from zero (no rebate) to 30% of the cost of the renovation project, we are able to estimate its effect on the willingness to undertake home EE projects. By letting the horizon over which the savings are realized vary between 20 and 40, we can estimate the discount rate implicit in the individual's response—or more precisely the discount rate that is applied for such relatively long investment lifetimes.

Our scenarios are cast in completely certain terms. Taken at face value, they allow us to investigate how homeowners would make decisions if they are completely informed about the economic aspects of the EE projects and there is no uncertainty about the costs and benefits of the projects. To make sure that people accept the "no uncertainty" of the energy savings associated with each alternative EE project, we assign respondents at random to one of two groups. Those in the first group are reminded that the annual savings in energy expenditures delivered by a particular project are computed as if the energy prices of today were to continue in the future. Those in the other group are not given this reminder.

It is important to us to investigate whether our EE projects have a different appeal to persons who believe that energy prices will increase in the future. For this purpose, at the end of the questionnaire we remind respondents that in the 12 months prior to the survey the price of heating oil was on average CHF 66.50 per 100 liters, and then ask them to tell us what they expect it to be in 20 years. Will it be lower? Increase by less than 10%? Increase by 10-50% percent? Increase by even higher percentages? We also offered a "don't know" response option to capture complete uncertainty about future energy prices.

B. Design of the Conjoint Choice Experiments

In our choice experiments we asked respondents to consider hypothetical home renovation projects characterized by five attributes. Attribute and attribute levels are summarized in table 1.

Briefly, attribute "Investment Costs" captures the upfront costs and is expressed in CHF. The initial investment cost amounts were selected from a range that varied with the size of the respondent's home.[7] Attribute "Subsidy" represents the subsidies provided by the government and is expressed in Swiss Francs (CHF). Government-financed rebates on energy efficiency home renovations are well established in Switzerland, and so we expect most people to be familiar with them, even though they may have never received them before.

[7] For the purposes of our survey and this paper, a home is small if it is less than $130m^2$, medium if it is between 130 and $190m^2$, and large if it is more than $190m^2$. The average size of a single-family home in Switzerland is 160 m^2.

Attribute “Comfort” captures the thermal comfort in the building after the renovation. Comfort can take two possible levels—remain the same or improve to attain an “an agreeable and seasonally balanced room temperature.” We present the savings on the energy bills by reminding the respondents about their current heating expenditure in CHF and stating the percent savings made possible by the renovation. Finally, attribute “Horizon” is the lifetime of the retrofit and hence number of years over which the proposed savings will be realized. In sum, in contrast to earlier studies, 1) three out of five attributes were amounts of money, and 2) we did not specify the type of construction, device or technology corresponding to each hypothetical alternative.

In the questionnaire, the conjoint choice questions were preceded by a screen that set up the choice experiments. We asked the respondent to imagine that he is about to start a renovation project, that he will be shown several potential such projects, and will be asked to tell us which one he would select. Only on that screen, for concreteness, did we provide examples of investments corresponding to specified investment amounts. For example, a respondent with a medium-sized home might expect new windows to cost CHF 20,000 and insulating the building envelope to cost CHF 100,000.

The hypothetical projects were presented in pairs: Each respondent was shown a total of 6 pairs of hypothetical renovation alternatives. For each pair, the respondent was to indicate which he preferred between alternative A, alternative B, and neither one (the status quo). Clearly, the choice set for this question is 3. The “neither” option is broadly consistent with the notion discussed in Hassett and Metcalf (1993) that individuals may want to wait before making an investment if future prices are uncertain. A sample choice card is shown in Figure 1.

The design of the choice experiment is a Fold-over design. To generate this design, first an orthogonal design for alternative A was constructed resulting in $5 \times 3^3 \times 2 = 270$

combinations of the five attributes and their levels. Second, a fold-over design was used to generate a subsequent alternative B (Rose and Bliemer, 2009). We checked for choice tasks that contained a dominant alternative, i.e., one where all five attributes are better than in the other, or one where four attributes are better than and one is equal to the other alternative. If a pair of projects contained a dominant alternative, we reassigned one to another pair within this block until no choice task contained a dominated alternative. These 270 combinations were divided at random into 45 blocks each containing 6 choice tasks.

C. Structure of the Questionnaire

The questionnaire is comprised of 6 sections. The first (questions 1-6) is a series of questions about the respondent's home and recent renovations, and serves as a screener. Specifically, the respondent is asked whether he owns or rents his home, the type of dwelling (single-family home or other), the year the home was built and when the respondent acquired it, and whether selected types of renovations were done in the last 15 years (since 1996).

In this study, attention is restricted to owners of single-family homes, duplexes or row houses, and so the interview is terminated if the respondent is a renter or owns a home that is not of the above described types. The interview is also terminated if the respondent indicates that he or she has had the façade renovated since 1996, but continues if only the basement ceiling or the attic were insulated, or windows were replaced, in the last 15 years.

In Section 2 of the questionnaire (questions 7-14), the respondent describes the size of the home (e.g., number of floors and square footage), its general condition and value. We also ask several questions about the heating system, the fuel used, typical annual heating expenditure, and the level of thermal comfort in the home.

Section 3 (questions 15-20) is dedicated to renovations. The respondent is asked to indicate the reasons why he hasn't done the structural or energy efficiency renovations listed in the first section of the questionnaire. Was this because he felt there was no need for renovations, for financial reasons, to avoid the disruption associated with extensive renovations, because of an imminent move or because demolition and rebuilding are planned?

We also ask the respondent if other renovation and maintenance work was done in the last 15 years, such as painting the interior of the home, renovating the bathroom(s) or kitchen, adding another room or converting unfinished space into finished space. Next, we ask the respondent which of selected energy efficiency investments (insulation of the attic, roof, façade or basement ceiling, new windows, or a new heating system) he is most likely to do in the next 5 years, and for what reasons. Is this to keep up or increase the value of the home, improve comfort or aesthetics, improve the energy efficiency of the home, for climate change considerations, to reduce noise or reduce the heating bills?

Respondents who indicate that they were planning at least one such investment over the next 5 years are also asked to estimate the likely savings in the heating bills. Finally, we ask all respondents to tell us how important it is to them to have a home that is (i) in good condition, (ii) aesthetically pleasing, (iii) equipped with modern comforts, and (iv) energy efficient.

Section 4 of the questionnaire contains the conjoint choice questions (see above). In section 5 of the questionnaire (questions 25-27), we inquire about energy conservation practices, the respondent's opinions about energy efficiency policies (including incentives, low-cost loans, aggressive pricing, audits and regulation), and his familiarity with current Federal and Canton energy efficiency programs for homeowners in Switzerland. Section 6 (questions 28-35) contains the usual socio-demographic questions.

D. Sampling Frame and Survey Administration

The survey was administered on-line by Link, Inc. (a professional survey firm) in May 2010. Our universe was comprised of owners of single-family homes, semi-detached homes and row houses that were built in 1990 or earlier, and had not received any major energy efficiency retrofits in the last 15 years. Attention was restricted to homeowners because renters do not usually undertake expensive renovation projects.[8] We ruled out owners of condominium apartments because they typically cannot make independent decisions involving the building envelope or the heating/cooling systems of the building.

The survey was self-administered on-line by residents of five Swiss cantons (Aargau, Bern, Basel-Land, Thurgau and Zurich) that account for the majority of the German-speaking population. Data from the 2000 Census indicate that there are a total of 354,791 single-family homes in that region, and that the owner lives in 281,037 of them. Of these, 83% were built before 1990.

Link, Inc. has assembled a panel whose members are representative of the Swiss Population and use the internet at least once a week for private purposes. A total of 3499 persons were selected from the Link panel and asked to participate in the survey. This group of potential respondents was supplemented with 305 persons recruited directly from ETH's Centre for Energy Policy and Economics, for a total of 3804. Survey participants were assigned at random to two orthogonal treatments: 1) the version of the conjoint choice experiments (45 variants), and 2) the "reminder" about the calculation of energy savings at the current energy prices (present or absent).

4. The Model

We posit that the responses to the conjoint choice questions are driven by the random utility model:

[8] Renters account for 60% of the homes in Switzerland, and conflicting incentives between landlords and tenants are one possible reason why many dwellings are energy-inefficient (Levison and Neimann, 2004).

(1) $$V = \alpha_{SQ} + \beta_1 \cdot INVEST + \beta_2 \cdot REDUCT + \beta_3 \cdot S \cdot \frac{1-\exp(-\delta \cdot T)}{\delta} + \beta_4 \cdot C + \varepsilon$$

where INVEST is the outlay (in CHF) for the hypothetical renovation project, REDUCT is the subsidy from the Swiss federal government (also expressed in CHF), S is the annual savings (in CHF) on energy and heating expenses made possible by the renovation project, T is the lifetime of the project, and C is a dummy denoting whether the retrofit improves the thermal comfort level of the home. In equation (1), coefficient β_1-β_3 are marginal utilities of income, β_4 is the marginal utility of improved comfort, δ is the discount rate, and α_{SQ} is a status-quo alternative-specific intercept.

Equation (1) assumes that individuals look at the net present value of the EE project. By design, the cost of the investment and the rebate (if any) is incurred immediately. The fourth term in equation (1) is the present value of the flow of savings in energy costs over the lifetime of the investment T. This is one of the two benefits of the renovation project, the other being the improvement in the thermal comfort of the home (the fifth term in equation (1)).

Assuming that error term ε is an i.i.d. draw from the type I extreme value distribution, the probability that the respondents selects alternative k in any given choice task is

(2) $$\Pr(k) = \exp(\bar{V}_k) \Big/ \sum_{j=1}^{J} \exp(\bar{V}_j),$$

where $\bar{V} = \alpha_{SQ} + \beta_1 \cdot INVEST + \beta_2 \cdot REDUCT + \beta_3 \cdot S \cdot \frac{1-\exp(-\delta \cdot T)}{\delta} + \beta_4 \cdot C$. This is the contribution to the likelihood of a conditional logit model (Greene, 2011) that is non-linear in variables and coefficients.

We expect β_1 to be negative, and the other βs to be positive. The model is not estimable unless an additional restriction is imposed on the coefficients for identification. We experiment with three alternate restrictions. In our first round of estimation runs, we assume that credit is costless and individuals treat disbursements and financial gains symmetrically, so that $\beta_1 = -\beta_2 = -\beta_3$. If this restriction is imposed, all coefficients (including the discount rate, δ) are identified and equation (1) is simplified to

$$(2) \qquad V = \alpha_{SQ} + \beta_1 \cdot \left[NETCOST - S \cdot \frac{1-\exp(-\delta \cdot T)}{\delta} \right] + \beta_4 \cdot C + \varepsilon$$

with NETCOST=INVEST-REDUCT.

However, there is reason to presume that individuals do not treat the up-front cost of the project symmetrically with respect to its financial gains. If credit is not free, then equation (1) must be amended to include the cost of a loan. Suppose for simplicity that the present value of the cost of a loan is proportional to the cost of the project, with the proportionality factor being α. Further suppose that individuals experience disutility when the renovation project is underway and that the disruption caused by construction is proportional to the size of the investment. Let the disutility of disruption be $\theta \cdot INVEST$. This would be sufficient to make $\beta_1 = -\beta_2 + \alpha + \theta$ (with α and θ both negative) in equation (1) different from $-\beta_2$. In our second round of estimation, we force $\beta_2 = \beta_3$ and let β_1 be different from them. In other words, all financial gains are treated alike but are potentially different from disbursements.[9] The restriction that $\beta_2 = \beta_3$ allows us to estimate the discount rate directly from the responses to the conjoint choice questions.

Finally, if the discount rate δ is assumed to be zero, then the discounted flow of savings in equation (1) is simplified to the total undiscounted savings:

$$(4) \qquad \lim_{\delta \to 0} S \cdot \frac{1-\exp(-\delta \cdot T)}{\delta} = S \cdot T,$$

which makes the model a standard, linear-in-the-parameters conditional logit where the regressors are INVEST, REDUCT and total undiscounted savings, S·T.

[9] We note here that while we allow potentially asymmetric treatment of disbursements and gains, our model is well within conventional utility theory and is not related to Kahneman and Tversky's prospect theory.

We test several hypotheses based on the models described above. First, we suspect that investments costs and benefits may be treated asymmetrically, and so we test (and expect to reject) the null hypothesis that $\beta_1 = -\beta_2$. Second, the three models can be amended to allow for the alternative-specific intercept, the marginal utility of savings and the marginal disutilities of disbursements to vary across respondents, depending on their sociodemographics and other variables, such as the respondents' assessment of the importance of climate change consideration in motivating home retrofits.

Third, following Hassett and Metcalf, we expect that the greater the uncertainty about future prices, the more likely is the respondent to choose the "neither project" alternative in any given choice task. To test this hypothesis we include in the model an interaction between the status quo and a measure of uncertainty, and test the null that the coefficient on that interaction is zero. If the Hassett and Metcalf model is borne out in our data, we expect to reject this null.

5. The Data

A. Characteristics of the Respondents

In total, 3804 persons were invited to participate in the survey and 2129 persons began the questionnaire (2007 from the Link panel and 122 from the ETH group). A total of 1383 were screened out because they did not meet our sampling requirements.[10] An additional 201 (169 from the Link panel and 62 from the ETH sample) exceeded the time

[10] We remind the reader that our requirements are that 1) the respondent owns his or her home, 2) this home is a single-family home, duplex, row house, or farmhouse built before 1990, and the respondent has lived there since 2005 or earlier, 3) the respondent lives in one of five Swiss cantons (Aargau, Bern, Basel-Land, Thurgau and Zurich), and 4) no major renovations of the façade, or more than one renovation of the remaining elements of the building envelope (i.e. roof, basement ceiling or windows), have been done since 1996. Major reasons for eliminating observations were that i) the building was constructed after 1990 (N=586), ii) the façade of the house was insulated after 1996 (N=205) or iii) the respondent acquired the house after 2005 (N=99).

limits for completing the questionnaire (N=201). Finally, 70 questionnaires were discarded because the canton quotas we specified for this study had already been met.[11]

In total, 475 persons completed the survey (411 from the Link panel and 62 from the ETH sample). For the analysis, however, we excluded two underage respondents. The final dataset thus contains 473 valid observations.

Tables 2 and 3 present summary statistics of the characteristics of the respondents. The average age is 56, the average respondent attended school for 14 years, and the average household size is 3.

We elicited information about income using categories based on the quintiles of the distribution of gross household income in Switzerland. In total, 399 respondents report information on income. Median household income is about CHF 9100 per month. In our regressions, we summarize income information into a dummy that takes on a value of one if the respondent has income greater than 9,100 CHF (in other words, if he or she is above the median).

The sample is well balanced in terms of gender, with slightly more men than women (55.8%). The sample is also well balanced with respect to the cantons, with shares between 18.4 and 21% each. A majority (63.2%) of the respondents lives in urban areas, where an urban area is a city or a metro area (not reported).

B. Characteristics of the Homes

We report descriptive statistics about the respondents' homes in table 4. On average the living area of the house is 193 m^2 (median 180 m^2). Most respondents (55%) live in a single-family home, 23% in a semi-detached home, 17% in a townhome or rowhouse, and 5% own a farmhouse.

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[11] The survey firm was instructed to collect an even number of completed questionnaire in each canton. The final sample is comprised of 99 persons from Aargau, 87 from Bern Canton, 89 from Basel-Land, 99 from Thurgau and 99 from Zürich.

On average, respondents report annual heating expenses of about CHF 2010 per year. In terms of heating, about two-thirds of the sample use fossil fuels to heat the home (oil 40%, gas 24%), and only 9% heat with electricity. About 58.1% of the sample reports using renewable energy sources such as wood, pellets, a heat pump, solar, and district heating.[12] Wood and heat pumps are often used in combination with another heating system: Wood, for example, is commonly combined with heating oil (N=50). Finally, 30% of the respondents state that they have changed the heating system since 1996 (not reported in the table).

C. Representativeness

In order to check the representativeness of the sample, we compared the sample with data from the 2000 Census[13] and the 2008 National Register of Buildings and Dwellings (RBD) for the five cantons in our study. The Census reports the number of single-family dwellings used as a primary residence by their owners and built before 1990. Comparison with our sample (see table A1 in the Appendix) shows that our sample overrepresents newer homes and underrepresents older homes. For example, 46% of the buildings in the sample were built between 1981 and 1990 versus 20% in the Census.

Comparison with the RBD is more difficult, because the RBD lumps together single-family and semi-detached homes and does not distinguish between owners and renters. With these limitations in mind, the distribution of homes by vintage category in the RBD is similar to the Census (see table A1 in the Appendix), and our sample is comprised of generally newer homes than the stock of housing as documented in the RBD. It is also possible to compare the size of the homes in our sample with the distribution in the population as per the

[12] Heat pumps are mostly geothermal heat pumps, but there might also be some air-to-air heat pumps in the sample. District heating is considered as renewable energy source since the heat is mostly generated as byproduct of industrial processes such as waste incineration.
[13] Data from the 2010 are not available yet.

2000 Census, which we display in table A2 in the Appendix. Again, our sample overrepresents the larger homes.

Because our survey was self-administered by the respondents on-line, we wondered whether our sample tended to be younger than the population at large. This is indeed the case. Based on comparison with Census data, young persons are overrepresented in our sample, whereas people aged 70 or older are clearly underrepresented (sample: 9%; population: 34%).

D. Responses to the Choice Experiment Questions

The frequencies of alternative A, alternative B and the status quo from the six choice tasks are displayed in Table 5. Alternative A was selected in 37.5% of the cases, alternative B in 37.8%, and the status quo in 24.8%.

We do not find any obvious patterns in the choices from choice task one to six. There is no obvious pattern in the frequency of the status quo either, and based on these considerations we conclude that the respondents were not especially influenced by the order of the choice task. We find this result encouraging, in that it suggests that people were paying attention to the attributes of the alternatives, as we posit in section 4 of this paper and empirically test in section 6.

We also checked our data for other possible anomalies. A closer look at the responses reveals that only 6 respondents (1.3% of the sample) chose alternative A in all six choice tasks, only 11 (2.3%) always chose alternative B, and 48 (10.1%) always chose the status quo. We wish to emphasize that these may well be plausible responses; at any rate they occur in extremely few cases.

E. Are the Attributes of the Alternatives and the Treatment Appropriate?

Sample size limitations and the need to limit the cognitive burden imposed on the respondents suggested that we should restrict attention to one type of policy in the conjoint choice experiments, i.e. the subsidy offered by the government. Was this a good decision? We believe it was.

Table 6 displays the responses to a question where we ask the respondents to indicate the three most important policies for making EE investments attractive. Clearly, “subsidies” and “deductions from taxes” (which is one way in which subsidies can be provided) are important to two-thirds or more of the respondents. Reduced interest rates on loans are a distant second at 38%, and only about 21% of the respondents judge information important. It is interesting that regulations are selected as an important option only by 8.63% of the sample.

We also checked for whether the respondents’ familiarity with possible and existing policies. The responses to this question are shown in table 7. They show that 15% of the respondents have previously evaluated or considered programs that offer tax deductions (a form of subsidy) for EE renovations, and over 65% were at least familiar with them. Over 9% of the respondents had actually looked into two programs (“Gebäudeprogramm,” which started in 2009, and its predecessor, “Klimarappen”), and a total of 68% indicated that he had heard of them. By contrast, fewer than 6% had evaluated or considered a reduced interest on loans, and about a quarter of the respondents had at least heard of this option. Taken together, these statistics suggest that the subsidy was a good choice for the policy attribute in our conjoint choice experiments, and that respondents were comfortable and familiar with it.

Reasons for doing renovations (shown in table 8) include repair or keeping up the value of the home (67%), but also improve the comfort in the home (44%), reducing the energy bills (76%) and improving energy efficiency (53%), all of which are attributes of the hypothetical renovation projects. Importantly, climate change and environmental considerations were selected by 55% of the respondents, and reducing dependence on fossil fuels by 26% of them. This suggests that "private" motives are somewhat more important than "public" motives in driving the responses to the conjoint choice questions, but also that concern about climate change may well be a driver of EE decisions.

Table 9 displays the respondents' estimates of future energy prices. Almost 12% of the respondents were completely unsure about the price of heating oil in 20 years. Out of those who were willing to make predictions, virtually all expect increases in the price of heating oil. Fully 40% indicates an increase between 10% and 50% over the current price. Nineteen percent of the sample is comprised of persons who expect large increases (13% chooses 100-200% increases, and 6% an increase by 200% or more).

6. Results

A. Basic Models

We present the estimation results for models without individual characteristics of the respondents in columns (A)-(C) of table 10. All models were estimated with costs and financial gains expressed in thousand CHF.

Column (A) displays the conditional logit that restricts δ to be zero. For simplicity, in this model we ignore the alternative-specific intercept. All coefficients are strongly statistically significant and have the expected signs. They suggest that the disutility of a dollar spent on investments is more than offset than the utility from a dollar's worth of rebates, which is turn is slightly lower than a dollar saved on energy bills (regardless of when those savings are incurred).

In column (B), we display the estimation results for the model that does not restrict δ to be zero but does impose that all marginal utilities of money be the same. All coefficients have the expected signs. This model includes an alternative-specific intercept for the status quo, which is negative and quite large (in absolute value), implying that respondents are even *less* likely to choose the status quo than is predicted by setting all attributes to zero.

A striking result of the model in column (B) is that the discount rate is only 1.47%. This is in sharp contrast with much of the literature on the energy efficiency paradox, which ascribes this phenomenon to high discount rates, and with much empirical literature that has inferred discount rate by observing people's investment decisions in durables. This finding is, however, broadly consistent with Hassett and Metcalf (1993), who show that the discount rates "apparent" in observed investment decisions overstate true discount rates. We removed any uncertainty from the scenarios we presented to the respondents, and that in itself may be the reason for the low discount rate (D. L. Greene, 2011). It is also possible that this result is due to the relatively abstract nature of our hypothetical projects (see Train, 1985), to the fact that our renovation projects do not entail assessment of EE technologies, and/or to our use of relatively long time horizons for the renovations.

Thermal comfort is important to our respondents. The monetized value of thermal comfort is CHF 22,576. At the discount rate we infer from the survey responses (1.47%), and assuming an investment lifetime of 20 years, this is equivalent to CHF 1292 per year.

Model (C) relaxes the restriction that all marginal utilities of money be the same. In this model, we simply impose that the marginal utilities of the gains (the rebate and the discounted savings on the energy bills) be the same. The estimated coefficients are close their counterparts in model (B), which is a restricted variant of (C). A likelihood ratio test, however, rejects soundly the null that the coefficient on the upfront cost of the project is equal to the negative of the coefficient on the rebates and the savings (likelihood ratio statistic 7.094, p value 0.0077). We therefore regard (C) as our preferred model.

It is interesting that in (C) the discount rate (2.9%) is almost twice as large as that in (B). Even this discount rate is, however, low. Even more important, there is evidence that costs and gains savings are treated asymmetrically, but—much like in model (A)—this asymmetry is the opposite of what we expected: It takes a rebate of only CHF 7,786 to offset completely an increase in investment costs of CHF 10,000!

We re-estimated models (A)-(C) after including interactions between the attributes of the alternatives and a dummy for the “reminder” treatment, but we found that the coefficients on such interactions were jointly insignificant. We find this result comforting, because we had expected and wanted people to accept the project descriptions without trying to second-guess where such savings would be coming from.

One concern is that the conditional logit impose stringent substitution patterns that might be violated in the data. We attempted mixed logit (Train, 2003), but find no evidence that the coefficients are random. We believe this is due to the modest size of the sample, the small choice set used in our choice experiments (K=3), and few choice occasions per respondents (only 6; see van Haefen, 2011). When we run a variant on model (C) that accounts for the panel nature of the sample, there is evidence of within-respondent correlation. This key estimates from this run are $\hat{\beta}_1$=-0.0224 (t statistic -21.06), $\hat{\beta}_2 = \hat{\beta}_3$ =0.0293 (t stat 10.42), $\hat{\beta}_4$=0.498 and the discount rate is 0.0238 (t stat 3.43). The point estimates are thus very similar to those in table 8, column (C), and the predicted shares of projects predicted by this model are likewise similar.

B. The Effect of Incentives and Other Attributes

We use model (C) of table 10 to compare a renovation project that costs CHF 70,000, has a lifetime of 20 years and brings savings of CHF 600/yr for 20 years (but delivers no thermal comfort improvements) with a similar project that further offers a 30% rebate and with the status quo (no renovation project). The probability of selecting the first project is 26%, that of selecting the same project with the government incentive is 39%, and the probability that the status quo (i.e., no project) is selected is 35%. If the rebate is removed and replaced with an improvement in the thermal comfort, the probabilities are 26%, 40% and 34%, respectively, suggesting that (at least for a project of this size) a large rebate and thermal comfort serve as substitutes for one another.

If the annual savings are doubled, and the thermal comfort removed, from the second project, the probabilities become 28%, 34% and 37%, respectively, and if the lifetime of the investment in the second project is doubled (to 40 years, holding the annual savings at CHF 600), they become 28%, 33%, and 38%. Clearly, it takes large increases in savings and the horizon over which such savings are realized for the effect on the probability of doing the project to be roughly comparable to that of the rebate and the improvement in thermal comfort.

Model (C) further predicts that when larger renovations are considered, most people would pass up the project. For example, a CHF 150,000 project that delivers no thermal comfort benefits, produces 30% savings on annual energy expenditures of CHF 5000, and lasts for 20 years has a 12% probability, versus 30% if a 30% rebate is offered and 58% for the status quo. These probabilities become 10%, 40% and 50% the second project further offers thermal comfort.

Our conditional logit doesn't allow us to predict exactly the share of the population that would undertake a project with specific costs and benefits. It does, however, allow us to compute odds ratios between not undertaking any renovations at all and doing a project with the specific costs and benefits. For example, a homeowner would be 4.77 times more likely to pass up the CHF 150,000 project (with no rebate and no thermal comfort benefits) than to do it. If a thermal comfort improvement was present, the homeowner would be 3 times more likely to do nothing than to do the project.[14]

C. Individual Characteristics and Climate Change

We experimented with interactions between the status quo specific intercept, upfront costs, rebates and savings and sociodemographic characteristics of the respondents, but the coefficients on these interactions were generally insignificant. For the sake of brevity, in table 10, column (D) we report the estimation results for a specification that includes interactions between sociodemographics and the present value of the savings. The coefficients on the interaction terms are statistically insignificant at the conventional levels when individually considered. Moreover, a likelihood ratio test fails to reject the null that the coefficients on all interactions are jointly equal to zero (likelihood ratio statistics 5.814, p value 0.21). We observed similar results—in that the coefficients on the interactions were jointly insignificant—when we included interactions with the investment cost and with thermal comfort.

In column (E) of table 10 we drop the interactions with the individual characteristics of the respondents and include interactions between savings and dummies for the type of heating fuel used. Fuel type does not matter. In column (F), we create an interaction between the discounted flow of savings on the energy bills and a dummy variable, CLIMCHANGE, indicating that the respondent believes that climate change considerations are an important reason for doing EE renovations. These persons attach a heavier weight on the savings on the energy bills than the rest of the sample: The coefficient on this interaction is large and statistically significant at the 1% level or better.

[14] These calculations rely on the independence of irrelevant alternatives (IIA) assumption implicit in conditional logit models.

To get a sense for the magnitude of this effect, consider the first example of section 6.A, where a project that costs CHF 70,000, brings savings of CHF 600/yr for 20 years but no thermal comfort improvements was compared with a similar project that further offers a 30% rebate and with the status quo. For the average respondent, the probabilities were 26%, 39%, and 35%, respectively. For a person who believes climate change considerations are important, the probability of selecting the first project is 30%, that of the second project 48%, and the probability of declining either project is only 22%. Clearly, climate-change motivated individuals are much more likely to undertake a project and much less likely to select the status quo.

This finding is consistent with the notion that individuals derive utility from reducing their household's carbon emissions, which in turn slows down climate change, regardless of savings in heating expenses and improved thermal comfort. An alternate specification consistent with this interpretation is one that includes only one another interaction—between the climate change consideration dummy and the status quo. This model imposes the same restrictions on the coefficients as in (C). The status quo intercept is -0.475 (t stat. -6.06) and the coefficient on status quo × Climate change is -0.971 (t stat. -9.92), confirming that those respondents who feel that climate change considerations are an important determinant of home renovations are indeed less likely to decline the renovation project in any given choice task.

D. The Effect of Expectations About Future Prices

Based on Hassett and Metcalf (1993), we would expect that the greater the uncertainty about future energy prices, the more likely is an individual to choose the status quo in any given choice task. By contrast, we would expect respondents to be less likely to opt for the status quo when they expect energy prices to increase in the future. (Energy prices are here measured as the price of heating oil, which is an important fuel for heating purposes in our sample as well as the rest of Switzerland.)

We test this conjecture by running a model similar to specification (C) of table 11, but where we enter interactions between the status quo specific intercept and dummies denoting that the respondent expects a moderate price increase in the next 20 years (10-50%), a sizable increase (50% and higher) and is completely uncertain, respectively. The results from this run are displayed in table 11, panel (A). Clearly, the larger the expected price increase, the less likely is the respondent to select the status quo, but there is virtually no difference in the likelihood of selecting the status quo between those respondents who indicated a 10-50% increase and those who indicated a 50% or higher increase. Those respondents who are completely uncertain about future prices are not statistically distinguishable from those who expect a small decrease or a small increase in prices.

We attempted to run models that include interactions between the price expectations dummies and all of the other attributes, but they were badly behaved and failed to converge. For this reason, in this paper we only report the results of a specification where the price expectation dummies are interacted only with investment costs (table 11, panel (B)). Briefly, the up-front cost of the investment is less unappealing to individuals who expect increases in the price of heating oil. This effect is statistically significant at the 1% level or better. Respondents who are completely uncertain about the future price of energy get more discouraged by the up-front costs than the baseline group (people who expect no change, modest decreases or modest increases in the price of heating oil), but this effect is not statistically significant at the conventional levels.

We conclude that our data are broadly consistent with Hassett and Metcalf's prediction that the greater the uncertainty about price, the more likely is an individual to wait before committing to an irreversible energy efficiency investment. They also provide support for the notion that the larger the expected price increases, the more appealing the energy-savings retrofits.

7. Conclusions

We have studied the preferences for energy-efficiency home renovations among Swiss homeowners using a survey-based approach and conjoint choice experiments.

Attention was restricted to those homeowners who incur both the costs and the benefits of EE retrofits and who are most likely to undergo home renovations soon. Our final sample was comprised of 473 such individuals in five major German-speaking cantons in Switzerland.

In our conjoint choice experiments, the alternatives are home renovation projects described by five attributes. Three of these five attributes are expressed in CHF, and any uncertainty about lifetime, costs and benefits, etc. is ruled out (see D. L. Greene, 2011). The attributes are couched in a fashion that allows us to estimate the rate at which future savings are discounted.

The responses to the conjoint choice questions are well-behaved and consistent with utility optimization. Individuals prefer investment profiles that are less expensive, deliver larger savings, and entail improvements in thermal comfort. The discount rate implicit in the responses to the choice questions is very low (1.5-2.9%, depending on the specification), a result that is contrast with earlier literature and claims about the reasons for the so-called "energy efficiency gap" (Golove and Eto, 1996). Such a low discount rate may result from our no-uncertainty scenarios (D.L. Greene, 2011), from expressing most key attributes in monetary terms rather than technologies, from this study's long time horizon (20-40 years), and from its abstract nature (Train, 1985).

Importantly, the rebate offered by the government has a strong effect on the likelihood of choosing a given renovation project, and, at least for a medium-sized renovation project, the magnitude of this effect is roughly comparable to that of improving thermal comfort in the home. Changing the savings or the lifetime of the investment—both such changes get folded into the discounted flow of savings over the project's lifetime—is less important, even if our sample's discount rate is extremely low. We conclude that the types of incentives that people seem to respond best to are those that lower the upfront cost of the investment and/or increase other co-benefits of energy-efficiency investments, such as comfort in one's home.

Failure to make energy-efficiency investments that, at least on paper, make economic sense has been attributed to a variety of reasons, including uncertainty about various aspects of energy-efficiency investments (Hassett and Metcalf, 1993; Metcalf and Rosenthal, 1995; D. L. Greene, 2011). In this paper, we study the importance of uncertainty about future energy prices and empirically test the prediction in Hassett and Metcalf (1993) and Metcalf and Rosenthal (1995) that when prices are uncertain and investments irreversible, it may be optimal for individuals to wait before making the investment to confirm if prices are truly increasing or decreasing. Indeed, we find that the respondents with the greatest uncertainty about future prices—those who said that they don't know what the prices will be—are more likely to choose the status quo in any given choice experiment, and weight the upfront cost more heavily, than those respondents who expect meaningful increases in energy prices.

Even more important for policy purposes, individuals who believe that climate change considerations are an important driver of decisions to do energy efficiency renovations are potentially more willing to do projects, in part because they weigh the savings in the energy bills more heavily. Based on these results, we conclude that 1) incentives are a potentially promising policy avenue for increasing home energy efficiency, and 2) public campaigns that provide information about the costs and benefits of EE retrofits—including those to the public related to climate change—in the home may help boost EE investment rates.

To further elaborate on the latter point, in the US, policies that rely on individuals modifying their behavior voluntarily in the interest of environmental quality—such as programs where public is asked to limit or forgo driving on high-ozone days (Cutter and Neidell, 2009, and Cummings and Walker, 2000)—have been found to be ineffective. However, Poortinga et al. (2003) report that households are more accepting of measures and changes to individual behaviors at home than in the transportation and mobility context, suggesting that more research—ideally, research that is based on carefully designed pilot programs with experimental treatments—is needed on the effectiveness of EE policies targeted at residential buildings and based on information and exhortations with a view to the public good.

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Appendix.

Table A1: construction period of the homes in the sample compared with the Swiss census 2000 (only houses built until 1990) and the National Register of Buildings and Dwellings 2008 (RBD) (only houses built until 1990).

	Census 2000	Percentages	RBD	Percentages	Survey	Percentages
Before 1919	29'692	12.71%	46‘894	15.73%	56	11.84%
1919 - 1945	31'806	13.62%	44‘595	14.96%	39	8.25%
1946 - 1960	37'872	16.22%	50‘786	17.04%	41	8.67%
1961 - 1970	32'896	14.09%	40‘689	13.65%	32	6.77%
1971 - 1980	49'792	21.32%	56‘688	19.02%	86	18.18%
1981 - 1990	51'492	22.05%	58‘418	19.60%	219	46.30%
Total	**233'550**		**298‘070**		**473**	

Table A2: living area in m2.

	Census 2000 (N=211'624)	Survey (N=433)
below 40	0.13%	0%
40 - 59	1.23%	0.69%
60 - 79	4.46%	1.39%
80 - 99	12.71%	2.54%
100 - 119	15.62%	4.62%
120 - 139	19.31%	14.32%
140 - 159	16.19%	15.01%
160 - 179	9.47%	10.85%
180 and more	20.89%	50.58%
	100%	**100%**

Bitte klicken Sie unten in der Tabelle die Variante an, die Sie vorziehen: Variante A, Variante B oder keine der beiden Varianten.

Bitte geben Sie für jede Frage auf dieser Seite eine Antwort.

Auswahl 3/6	Variante A	Variante B	Keine der beiden Varianten
Investitionskosten	CHF 40'000	CHF 40'000	
Förderbeiträge	CHF 12'000	CHF 6'000	
Wohnkomfort	Wie im heutigen Zustand	Verbessert	
Verringerung Ihrer jährlichen Heizkosten von rund CHF 3'000	60%	60%	
Wirkung auf die Heizkosten während...	20 Jahren	40 Jahren	

Figure 1: Example of a Choice Card.

Table 1: Attributes and attribute levels in the choice experiments.

Attributes	**Levels**
Investment costs [CHF] (adjusted to the respondent's house size)	100'000 CHF 90'000 CHF 60'000 CHF 40'000 CHF 20'000 CHF
Subsidy [CHF]	0% 15% 30 % of the total investment costs
Comfort	Same as now Improved
Savings on the energy bill per year [%] (with respect to the respondent's annual heating expenses)	10% 30% 60 % of the annual heating expenses
Time horizon for savings on the energy bill	20 years 30 years 40 years

Table 2: Characteristics of the respondents.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Description
respondentage	473	56.51586	10.01314	31	93	Respondent age
Over65	473	0.218	0.49983	0	1	Homeowner is 65 years or older
yearsschool	472	14.36864	2.713439	9	18	Years of schooling
children	141	1.978723	1.098493	1	10	Number of children 18 and younger
hhsize	473	2.868922	1.298527	1	11	Size of the household (including adults and children)

Table 3: Characteristics of the respondents. N=473.

Variable	Obs.	Percentages	
Income I			Gross income classes according Switzerland's quintiles of gross income (Bundesamt für Statistik 2009)
Up to 4'600 CHF	20	4.23	
4'601 – 6'900 CHF	86	18.18	
6'901 – 9'100 CHF	122	25.79	
9'101 – 12'100 CHF	99	20.93	
more than 12'100 CHF	72	15.22	
Missing	74	15.64	
Income II			
IncomeH	171	36.15	Income larger than 9'101 CHF
IncomeNO	74	15.64	No information about income available
Male	264	55.81	
Employed	331	69.98	At least one adult in the household is employed
Retired	126	26.64	Respondent is retired
Resident of			
Aargau	99	20.93	
Bern	87	18.39	
Basel-Land	89	18.82	
Thurgau	99	20.93	
Zürich	99	20.93	

Table 4: Characteristics of the Homes.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Description
Livingarea	433	192.7252	90.59595	50	900	Living area in m^2
Single-family home	423	0.55		0	1	Single-family home dummy
Semi-detached home	433	0.23		0	1	Semi-detached home dummy
Row house	433	0.17		0	1	Row house
Farm house	433	0.05		0	1	Farm house
Heating costs	423	2009.456	997.4341	750	5500	Annual heating costs
Heating oil	433	0.40		0	1	House is heated with heating oil
Gas	433	0.24		0	1	House is heated with gas
Wood	433	0.29		0	1	House is heated with wood
Electricity	433	0.09		0	1	House is heated with electricity
Heat pump	433	0.19		0	1	House is heated with a heat pump
District heating	433	0.03		0	1	House is heated with district heating
Solar	433	0.05		0	1	House is heated with solar energy
Other heating	433	0.04		0	1	House has other type of heat

Table 5. Frequencies of choosing alternative A, alternative B and “neither one” (status quo).

Choice task	**Alternative A (%)**	**Alternative B (%)**	**Status quo (%)**
1	39.96	38.69	21.35
2	39.11	35.31	25.58
3	35.73	40.38	23.89
4	36.15	39.53	24.31
5	33.62	39.11	27.27
6	39.53	34.25	26.22
Overall	37.53	37.88	24.77

Table 6. What are the three most important items that make energy efficiency investment attractive?

Description	Percent of the Sample
Discount on interest rates on mortgages	38.11
Better availability of technical information	21.26
Deducting the cost of renovations from taxes for several years	65.26
More subsidies	62.32
Higher energy prices	17.26
Laws and regulations	8.63
Simplify/relax requirements on buildings	30.11
No VAT on EE investments	26.53

Table 7. Familiarity with Policies.

Description	Respondent considered such an option before	Respondent is aware of such a policy	Respondent is not aware of such a policy
Reduced interest rates on loans (offered by certain banks)	5.68	25.68	68.63
promotion through the canton/community	14.74	56.84	28.42
tax deductions	15.37	65.68	18.95
subsidy through 'Klimarappen'	4.84	50.74	44.42
subsidy through 'Das Gebäudeprogramm'	4.63	17.89	77.47

Table 8. Reasons for Doing Renovations.

Description	Percent of the Sample
repair/keep up the value	66.58
increase the value	10.70
increase comfort in the home	44.12
Aesthetics	3.48
climate and environment considerations (ClimChange)	54.55
noise protection	7.22
savings on the energy bills	76.20
improve energy efficiency	53.48
reduce dependence on fossil fuels	25.67
Other	1.34

Table 9. Future prices of oil.

Description	Percent of the Sample
Decrease	0.42
increase by 0-10%	3.37
increase by 10-50%	40.21
increase by 50-100%	25.26
increase by 100-200%	12.63
increase by over 200%	6.32
don’t know/no idea	11.79

Table 10. Estimation Results. Basic Models. N=2838.

Regressor	(A)*	(B)	(C)	(D)	(E)	(F)
Status quo intercept		-0.892 (-13.27)	-0.832 (-11.61)	-0.821 (-11.41)	-0.805 (-11.1)	-0.819 (-11.4)
Investment costs	-0.0147 (-17.4)	-0.0198 (-21.81)	-0.0204 (-21.4)	-0.0203 (-21.21)	-0.0198 (-20.26)	-0.0201 (-20.85)
Reduction on investment costs	0.0191 (6.29)	0.0198 (21.81)	0.0262 (9.9)	0.0258 (9.55)	0.023 (7.67)	0.0228 (8.13)
Savings		0.0198 (21.81)	0.0262 (9.9)	0.0258 (9.55)	0.023 (7.67)	0.0228 (8.13)
Savings × gender				0.0087 (1.57)		
Savings × college				-0.00062 (-0.12)		
Savings × incH (income higher than the average)				0.0042 (0.79)		
Savings × incNO (no information on income)				-0.0032 (-0.56)		
Savings × renewables					0.0147 (1.3)	
Savings × heating with oil					0.0343 (2.01)	
Savings × heating with gas					0.0324 (1.85)	
Savings × ClimChange						0.074 (4.27)
Comfort	0.6635 (13.9)	0.447 (8.85)	0.45 (8.9)	0.448 (8.85)	0.445 (8.78)	0.460 (8.99)
Horizon × Savings	0.0244 (17.36)					
Discount Rate		0.0147 (2.69)	0.029 (3.77)	0.0399 (3.23)	0.085 (2.74)	0.0851 (4.42)
Log L	-2772.636	-2704.651	-2701.104	-2698.197	-2634.457	-2649.705

* Specification (A) imposes the restriction that δ=0.

Note: ClimChange = Reason for motivations might be climate and environmental considerations.

Table 11. The Effect of expectations about future energy prices. N=2838.

	(A) Effect on the choice of the status quo		(B) Effect on the unattractiveness of investment costs	
Regressor	coefficient	t stat	coefficient	t stat
Status quo intercept	-0.216	-1.03	-0.847	-11.76
Status quo × heating oil prices will increase by 10-50%	-0.776	-3.62		
Status quo × heating oil prices will increase by 50% or more	-0.736	-3.46		
Status quo × complete uncertainty about future heating oil prices	0.078	0.34		
Investment costs	-0.0204	-21.37	-0.0253	-9.12
Investment costs × heating oil prices will increase by 10-50%			0.00636	2.29
Investment costs × heating oil prices will increase by 50% or more			0.00575	2.08
Investment costs × complete uncertainty about future heating oil prices			-0.00346	-1.09
Subsidy	0.0265	9.98	0.0263	9.92
Savings	0.0265	9.98	0.0263	9.92
Comfort	0.449	8.87	0.449	8.88
Discount rate	0.0284	3.76	0.0284	3.73
Log L		-2675.74		-2685.255