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The role of tenants in the transition towards more sustainable energy consumption

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Abstract

The split incentive problem leads to under-investment in energy improvements of rental buildings. This prevents the large CO_2 savings potential from being achieved and leads to disadvantages for tenants. New investment opportunities and a willingness of tenants to pay for investments made by the landlord have the potential to solve the problem. Against this background, the aim of this research project is to find out how the situation is perceived by tenants and what preferences and trade-offs affect their decision-making. To answer this, we conduct a discrete choice experiment (DCE) and analyse the choice behaviour of 680 Swiss tenants. Finally, we calculate their respective willingness to pay (WTP).The results show that tenants are really interested in energy investments, especially when it comes to renewable energy. Moreover, the willingness to pay for such improvements indicates that they consider the current situation to be in need of improvement. Interestingly, however, they do not value collective investment opportunities that can circumvent the split incentive problem, but are more willing to pay part of the investment costs if the landlord invests. However, they also value the purchase of renewable electricity to contribute to more sustainable consumption without the landlord's action. Their choice is also affected by net-metering and subsidy treatments, which shows that targeted policies can help to promote the willingness to contribute to such investments and ultimately reach CO_2 reduction goals.

JEL Classification: D12, L94, Q41.

Keywords: Energy efficiency, Renewable energy, Choice experiment, Conditional logit models

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1 Introduction

Residential buildings are responsible for a significant proportion of all emissions (BFE, 2022; Commission, 2020). Due to a lack of investment in energy improvements in rented buildings, CO_2 savings potential is not realised and tenants bear the disadvantages. One of the reasons for this is the split-incentive problem, as tenants are dependent on the landlords' initiative, who themselves do not benefit from such investments (IEA, 2007). The literature often focuses on landlords, as they are the ones who can make investment decisions (see e.g., Melvin, 2018; Hope and Booth, 2014). Energy efficiency measures are usually referred to in the context of split incentives. However, investments in the production of renewable energy can also be profitable. Such technologies and new investment opportunities also allow tenants to take action and benefit from investments in energy-related projects without relying on landlord action (Moret and Pinson, 2018; Bonzanini et al., 2016).

Despite or even because of the focus on the landlord side and the changing investment situation, it is still unclear if and to what extent the problem is perceived by tenants and what their preferences are when it comes to energy investments. This is also the case because renewable energy investments are not really discussed in the split incentive literature. However, both energy efficiency and renewable energy investments can be beneficial for residents and for achieving the climate targets. For homeowners, a prosumer trend is already discussed (see e.g., Kesting et al., 2013) that shows a preference for renewable energy investments, which could apply just as much to tenants. New insights would be of particular interest to policymakers in order to be able to target this group if necessary.

This paper provides insights about tenants' preferences and trade-offs in a changing energy investment[1] environment and what their decisions depend on. It is to be seen whether the split incentives problem is perceived as such and if tenants have a willingness

[1]We use the term energy investment in the remainder of this paper for convenience even though, technically speaking, tenants are usually not investing but rather contributing to investments carried out by the landlord by, for instance, accepting a rent increase.

to pay (WTP) in order so solve it. In particular, it is also of interest to see how their investment decisions are influenced by innovative solutions such as collective investment projects or smart technologies. Another question is to what extent their decisions are influenced by different policies.

To answer these questions, we conduct a discrete choice experiment (DCE) and analyse data from 680 Swiss tenants with a conditional logit model. Results show that tenants are interested in energy investments, especially if it is renewable energy. Their willingness to pay shows that they see a need for action. In this context, the purchase of green electricity is the most appreciated option. And although this does not require any action by the landlord, they do not seem to generally want to take action independently. They show a preference for wanting to contribute to investments in their own building instead of trying to circumvent the split incentive problem through collective investment projects. Furthermore, tenants show no valuation for smart technologies and net-metering for optimising consumption. Net-metering and subsidy appear to be influential policies to promote investment decisions.

The remainder of the paper is structured as follows. Section 2 provides the background and reviews the related literature. Section 3 addresses the methodology and the experiment, followed by the econometric approach in Section 4. Section 5 presents and discusses the results, and Section 6 concludes and provides policy implications.

2 Background and literature

So far, the literature on energy-related investments focuses to a large extent on homeowners and studies generally consider either energy efficiency or renewable energy but often not both (Kastner and Stern, 2015). Yet, tenants make up a large proportion of all inhabitants in many countries (Eurostat, 2022) and are thus also responsible for a significant share of CO_2 emissions (BFE, 2022). As a result, they play an important role for the energy transition (see e.g., BFE, 2020; Commission, 2018). Nevertheless, it is still uncertain how the savings potential can be achieved, as their situation regarding investment possibilities is radically different from that of owners (Ryan and Campbell, 2012; Black et al., 1985).

Tenants may be less willing to invest in the building because they are less attached and can think about moving (Matschoss et al., 2013). On the other hand, their possibilities to invest in energy upgrades to the residential building are also limited, as this is usually the responsibility of the landlord who has the right to decide. This gives rise to the "split incentives" problem, which occurs because investor and beneficiary are different actors, which affects incentives to invest. This can result in under-investment in energy improvements in rented buildings (Melvin, 2018; Ástmarsson et al., 2013; Bird and Hernández, 2012). There is evidence that rental buildings are less efficient than owner-occupied buildings, especially if tenants cannot observe retrofit choices (Petrov and Ryan, 2021; Gillingham et al., 2012). This not only has an impact on the environment, but also leads to higher energy bills for tenants.

For homeowners, a prosumer tendency has been discussed in previous years (see e.g., Kesting et al., 2013). Yet, the literature on the split incentive problem focuses largely on energy efficiency investments (see e.g., Melvin, 2018; Gillingham et al., 2012). This neglects the potential trend towards renewable energy. However, such investments can also lead to more sustainable consumption and are more relevant than ever, especially in light of current concerns about rising energy prices and the threat of shortages.

New possibilities to invest collectively make it easier for tenants to enter this market and may fundamentally affect the energy investment situation (Moret and Pinson, 2018; Bonzanini et al., 2016). Also, tenants can decide to consume renewable electricity instead of the default product offered by the utility and therewith promote production of sustainable energy (Tabi et al., 2014). Purchasing renewable electricity from the provider is an uncomplicated way to render one's energy consumption more sustainable. Hansla et al. (2008); Yoo and Kwak (2009), for instance, find a positive WTP for renewable electricity, which depends on factors like environmental attitude. Load management provides another possibility for optimising electricity consumption (Kostková et al., 2013). Yet, acceptance of such optimisation depends on the exact design (Soland et al., 2018).

Next to a number of studies on owners' behaviour regarding energy investments, some studies focus on tenants. However, these are usually focused exclusively on energy efficiency. Farsi (2010) and Banfi et al. (2008) conduct choice experiments and examine the tenants' WTP for energy investments. Farsi (2010) uses a choice experiment and finds that Swiss tenants are indeed willing to pay a rent premium in order to benefit from energy efficiency investments. Banfi et al. (2008) also find a positive WTP for energy efficiency investments. Phillips (2012) uses a choice experiment to investigate the split incentive problem. She finds that there is a problem with asymmetric information and misconception between landlords and tenants. Her analysis shows that tenants have preferences for energy efficiency improvements and that their willingness to pay would be sufficiently large to make such investments worthwhile.

The literature on the split incentive problem and tenants' WTP is usually concerned with energy efficiency renovations or upgrades. These allow to use less energy and, as a result, can help to save costs. However, a prosumer preference is often discussed and evident in the literature on homeowners' energy investments (see e.g., Kesting et al., 2013). This prosumer preference means that homeowners are more interested in renewable energy investments, like PV installations, compared to energy efficiency improvements like insulation. Yet, such investments are not really examined for tenants. Still, they may also be rather interested in such investments to benefit from more sustainable energy consumption. Such a prosumer preference would also make collective investment opportunities more relevant and possibly more attractive, as these are usually about renewable energy generation.

Supportive policies can lower financial hurdles for energy-related investments (IEA, 2010). There is evidence that policy support, for instance in the form of subsidies, positively affect investment behaviour of homeowner. However, there is little evidence on how such policies affect tenants, probably because they are not the ones making the investment decisions and deal with the subsidies as part of it. Yet, they may value such policies and this may also affect their willingness to contribute.

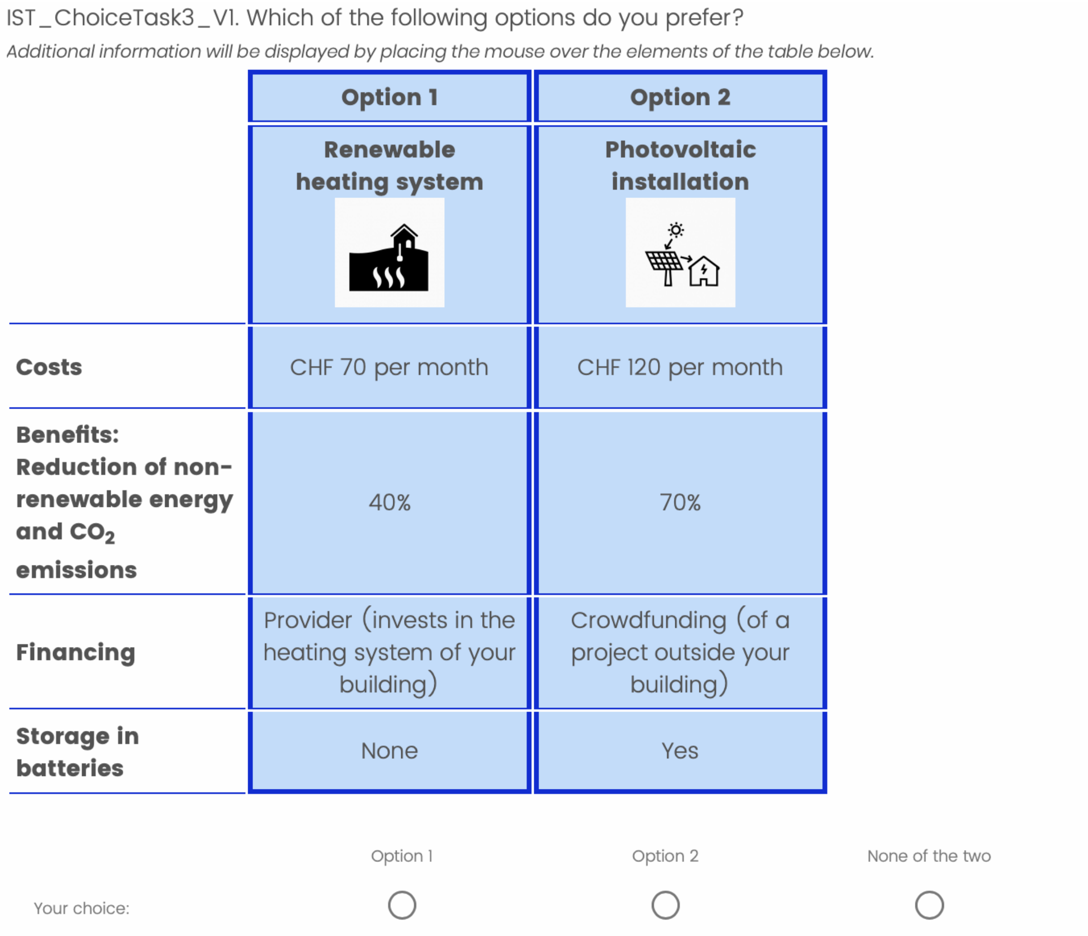
So far, the literature has not clarified which preferences tenants have when all possible energy investments are considered. Furthermore, it has not yet been investigated to what extent tenants perceive the split incentive problem and whether their willingness to pay and new investment opportunities can help solve it. This would be particularly relevant if tenants have a prosumer preference. These questions will be addressed in the coming parts.

3 Experiment

In order to investigate tenants' preferences for energy-related investments, we implement a discrete choice experiment. An example of the choice task design can be seen in Figure 1.

Respondents are asked to answer to six choice tasks. Therein, they could choose between two energy investment options and one non-energy-related option (considered as a status quo (SQ) option). When the latter is selected, a follow-up question is displayed and the respondents are required to indicate an alternative way of spending, investing or saving the money not spent in an energy-related investment. The follow-up question is displayed at most once to each respondent, right after the choice task in which the status quo option is selected. The energy investment options are tailored to the respondent situation considering building age, technological standard and operated system, so that only relevant options are offered.

Figure 1: Example of a choice task



IST_ChoiceTask3_V1. Which of the following options do you prefer?

Additional information will be displayed by placing the mouse over the elements of the table below.

	Option 1	Option 2
	Renewable heating system	Photovoltaic installation
Costs	CHF 70 per month	CHF 120 per month
Benefits: Reduction of non-renewable energy and CO_2 emissions	40%	70%
Financing	Provider (invests in the heating system of your building)	Crowdfunding (of a project outside your building)
Storage in batteries	None	Yes

Your choice: Option 1 / Option 2 / None of the two

3.1 Set-up

All energy investment or purchasing options that respondents could choose from are displayed in Table 1. We are interested in finding out more about the preferences, but also trade-offs tenants face. Because it is of interest to see whether we can find a similar prosumer tendency that has been discussed for owners, for instance, by Kesting et al. (2013), we categorise the offered energy options as either energy-efficiency (EE) or renewable energy (RE) investments. Non energy options will be labelled NE and contain the alternative spending and saving options. Table 1 contains these groups and abbreviations, which will be used in the remainder of the paper.

All attributes and levels, which represent realistic values, are displayed in Table 2. All energy-related options come with five different attributes: (I) type of investment or pur-

Table 1: Energy investment alternatives

Investment	Abbr.	Category	Description
Status quo	SQ	NE	Non-energy-related option, for which respondents could choose an alternative usage of the money, for instance saving it or spending it for other purposes
Envelope reinstatement	ER	NE	Reinstatement of the facade without energy efficiency gains (e.g. painting)
Heating system reinstatement	HS	EE	Reinstatement of the existing fossil fuel powered heating system
Renewable heating	RH	RE	Switch from a fossil fuel powered to a renewable heating system, such as a heat pump, a wood heating system
Photovoltaic installation	PV	RE	Photovoltaic installation that converts solar power into electricity
Insulation	EI	EE	Renovation of the building's envelope with energy-efficiency gains (e.g. replacement of windows and/or insulation of façade, attic or roof)
Purchasing renewable heat	BH	RE	Purchase of renewable heat from the provider (e.g. district heating)
Purchasing renewable electricity	BE	RE	Purchase of renewable electricity from the utility

PV and insulation come in some cases in combination with heating-related investments

chasing option; (II) corresponding costs for contributing to the investment or purchasing renewable energy; (III) the benefits expressed as a reduction of non-renewable energy and CO_2 emissions; (IV) financing arrangement, i.e. who is covering investment upfront costs; and (V) whether there is any form of storage in batteries and load management involved.

Table 2: Investment attributes and levels used in the experimental design

Attributes	Description	Levels
Costs	Contribution or purchasing costs	Depending on the specific energy option between 3 - 330 CHF per month
Benefits	Reduction of non-renewable energy and CO2 emissions	Depending on the specific investment option between 0 and 100% energy saved / energy produced or consumed from renewable energy sources
Financing	Contributing to investments made by the landlord or collective investment projects	(1) contributing to investments for the residential building made by the landlord (2) self-consumption community with others, (3) crowd-investment (4) purchasing renewable heat from the utility and (5) purchasing renewable electricity from the provider
Storage and load management	Renewable energy investments can come with batteries for storing the produced energy or the investment can be accompanied by load management by the utility to consume energy most efficiently	For the first 4 choice tasks, only storage (yes/no) was available. For the last two choice tasks, different combinations of storage and load management were available

Varying the levels of costs and benefits across choice tasks and across respondents makes it possible to identify trade-offs, their impact on the decisions and is the basis for the WTP estimations. All levels are presented in Table 3.

Table 3: Cost and benefit levels

	Costs in CHF/month	Benefits in %
Energy investment options		
ER	40; 60 ; 70; 80	0
HS	10; 20	5; 10; 15; 25
RH	70; 90; 110; 130	20; 40; 60; 100
PV	30; 40; 70; 90	15; 25; 40; 60
- with storage	40; 60; 90; 120	20; 30; 50; 70
- with load management	60; 90; 110	20; 30; 70
- with storage and load management	60; 80; 110; 130	20; 40; 60; 80
- with RH	100; 130; 180; 220	20; 70; 100
- with RH and storage	110; 150; 200; 260	40; 70; 100
- with RH and load-management	110; 150; 200; 240	20; 40; 70; 100
- with RH and storage and load-management	130; 170; 220; 270	20; 40; 70; 100
EI	90; 130; 180; 220	15; 25; 40; 60
- with HS	40; 110; 170; 220	15; 25; 40; 60
- with RH	170; 220; 270; 330	20; 40; 60; 100
Purchasing options		
BH	70; 90; 110; 130	20; 40; 60; 100
BE	3; 7; 11; 15	15; 25; 40; 60

Costs in CHF, benefits in form of reduction of non-renewable energy and CO2 emissions

3.2 Informational interventions: Treatments

Another objective of our analysis is to identify whether energy-related choice behaviour is affected by information about policy changes or peer behaviour. Even though certain policies such as subsidies rather target the investor, they may also affect tenants. Thus, it is of interest whether information about changing policies and peer behaviour affects tenants' choices.

We therefore introduce different treatments and divide respondents into different treatment groups for this purpose.[2] We use four different treatments, which may all be of relevance for tenants. They are introduced after the first two choice tasks. As a result, our experiment comes with both between group variation and variation within the exper-

[2]For more detailed information about the different treatments, see also Appendix A.1.

iment. It is of interest to see how the treatments affect choice behaviour after they have been introduced.

The first treatment contains information about further increasing CO_2 taxes and the consequences as higher energy costs if fossil fuels are used. A first increase in CO_2 taxes already took place in Switzerland in 2022 and the population is aware of the possibility of further increases (BAFU, 2021). Thus, they are familiar with such measures and can assess the consequences. Such an increase has direct effects on tenants as they have to pay for their energy consumption, and it also plays a role in the context of the split incentive problem. As CO_2 emissions can be lowered by means of energy-related upgrades, tenants may be more interested in such improvements in order to save money if taxes are expected to rise. Thus, such treatment can lead to higher selection rates of both energy efficiency improvements such as insulation, but also renewable energy investments in renewable heating. Investment related benefits may be more appreciated due to such a treatment. Usually, price elasticity in the context of energy demand is rather low, and energy costs often do not play an important role (Labandeira et al., 2017; Ürge-Vorsatz et al., 2007), which can limit the effect of such a treatment.

Feed-in tariffs (FITs) constitute the second treatment. Considering that FITs have been in place in Switzerland from 2008 to 2022 (BFE, 2019), respondents can be expected to be familiar with this policy instrument, which have been identified to affect energy choices, see e.g. Castaneda et al. (2020). FITs were recently replaced by subsidies in Switzerland, and we therefore include a subsidy treatment, to see whether tenants show stronger reactions to one of these instruments. FITs can be relevant in the context of the split incentives problem because a lack of investment can deter tenants from benefiting from such investments. Thus, information about re-introduction of FITs can motivate tenants to choose investments in renewable energy in order to benefit thereof.

Substantial costs can deter landlords from investing (see e.g., Heiskanen et al., 2012), especially if the investments do not benefit them personally or recouping the costs is uncertain (Ástmarsson et al., 2013; Mitchell et al., 2011). On the other hand, subsidies have been identified to promote investment decisions of homeowners (see e.g., Mundaca and Samahita, 2020). Even though if it is rather the owner for whom reduced upfront costs play a major role in the first place and the tenants are not directly affected by these policies, they can appreciate the associated benefits. For example, such policies can lead to lower costs passed on to tenants in the form of a rent increase. Thus, benefiting from energy investments can be cheaper and thus more worthwhile and attractive.

Furthermore, a "peer pressure" treatment is introduced to investigate how information about high adoption rates in the neighbourhood affects investment decisions. More precisely, respondents are informed that PV adoption rates are above average in their neighbourhood. This should give them a sense of a social norm. Thus, people may want to comply with what they consider to be normal. This kind of peer pressure can induce them to choose PV options more often in the choice experiment. For owners, such peer pressure effects have been analysed before. Researchers find mixed results of peer pressure on others. Müller and Rode (2013) find that visibility of PV installations on adjacent buildings can affect investment behaviour, whereas others like Mundaca and Samahita (2020) do not find any effect of visible technologies on investment decisions for Swedish house owners. For tenants, however, there is a lack of detailed knowledge about the effect of visible technologies such as PV systems on energy investment decisions.

4 Econometric analysis

Discrete choice experiments present hypothetical choices tasks which are answered by a relevant sample in order to analyse their stated preferences. Our sample consists of $N = 680$ individuals who choose from $J = 3$ alternatives in $T = 6$ choice tasks. Alternatives vary with respect to their attributes and respective levels. U_{njt} represent the individual n's utility from choice j. It consists of a known part V_{njt} and a random component ε_{njt}, which is assumed to be independently and identically distributed (IID) and follows a type I extreme value distribution. It can be formally expressed as follows:

$$U_{njt} = V_{njt} + \varepsilon_{njt} \quad \forall \quad j \quad \text{with} \quad n = 1, ..., N, \quad j = 1, 2, 3, \quad t = 1, ..., 6 \tag{1}$$

Following McFadden (1974), the probability that individual n chooses alternative i can be expressed as:

$$P_{ni} = Prob(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}) \quad \forall \quad j \neq i \tag{2}$$

The representative utility V_{njt} is specified as a linear function with x_{njt} being the vector of observable explanatory variables of alternative j:

$$V_{njt} = \beta' x_{njt} \tag{3}$$

The ratio of the coefficients can be used to calculate the WTP. Therefore, the benefit coefficient β_{ben} has to be divided by the cost coefficient β_{cost} as it is expressed in Equation 4

$$WTP_{ben} = \frac{-\beta_{ben}}{\beta_{cost}} \tag{4}$$

It states how much respondents would be willing to pay in order to obtain a marginal increase in benefits that results from energy investments.

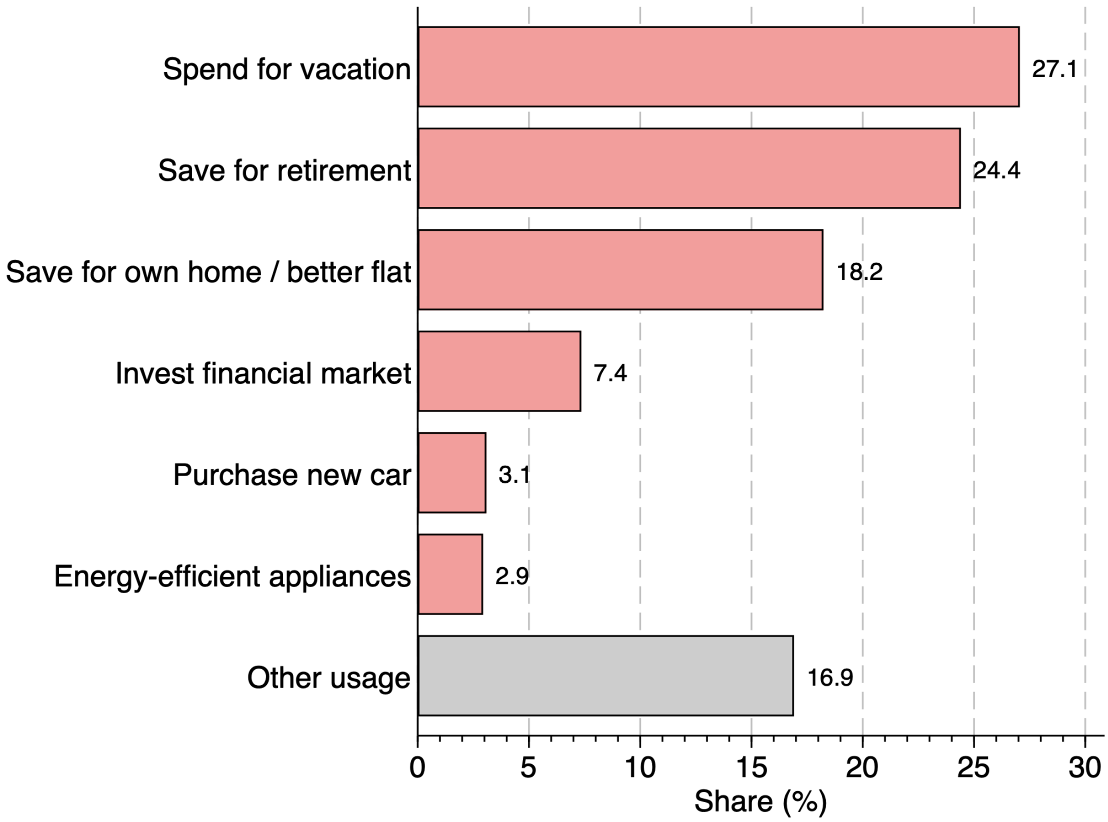
5 Results

The result section features both descriptive statistics and the results of the econometric analysis. All of them are used to answer the research questions and shed light on tenants' interest in energy investments, their perception of the split incentive problem and whether collective investment options are valued as means to circumvent under-investment by landlords.

5.1 Descriptive statistics

Before the actual choice experiment starts, respondents are asked to indicate how they would like to spend an unexpected tax refund of CHF 2,500. This is intended to provide preliminary insights into tenants' preferences and trade-offs between energy and other spending options. As Figure 2 illustrates, most respondents indicate they would use the money for a holiday. Many also answer that they would like to save it, either for their retirement, for their home or other purposes. Rather few state that they would invest it either in the financial market or for a new car. Upgrading appliances in their accommodation is the least favoured option. This already shows that energy consumption of their current appliances is not considered to be a major issue. Thus, if split incentives are a problem, it is rather the lack of larger energy investments and not so many appliances in the flat.

Figure 2: Preferred usage of unexpected tax refund



To get a first indication about their preferences when it comes to the energy investments, descriptive statistics based on the choices are presented. Figure 3 displays selection probabilities of the different energy investments by monthly contribution costs. Renewable electricity stands out as frequently being chosen. This applies to both consumption and production of renewable energy, with purchasing renewable electricity being particularly often chosen, followed by PV. Envelope reinstatement, insulation and simple overhaul of fossil fuel-operated heating system are less frequently selected, even when the building age and condition probably makes such investments feasible from an energy efficiency perspective.

Figure 3: Selection probability of energy investments by costs

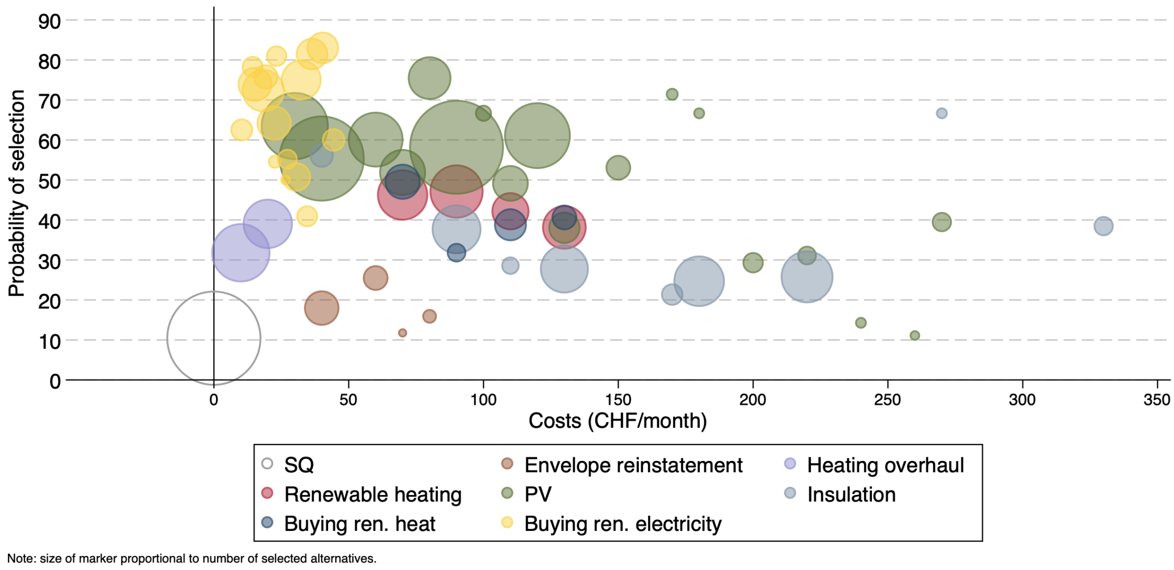


Table 4 shows the numbers and shares of respondents who always, sometimes or never chose certain options. This analysis provides a better understanding of their preferences. It becomes apparent that some respondents have clear preferences, as they always or never chose some specific options. So is SQ always chosen by 3.4% of the respondents, who show no interest in the offered energy investments. Contrarily, the majority of respondents (74%) never chose SQ and, thus, they seem to be interested in energy investments. Some respondents have certain likes or dislikes when it comes to the available energy investments. 22.7& of all respondents chose at least once the SQ option. So, not all offered energy investment options seem to be appealing to them. Reinstatement of the envelope was often (77.5%) not selected when offered. On the other hand, those who never chose the PV option (15.2%) are outnumbered by those who did. Among all energy-related options, buying renewable electricity has always been selected most often when it was available. This may be partly due to the fact that this option is comparatively cheap and flexible compared to the other energy investments.

In general, a heterogeneity of preferences can be observed. Efficiency and non-energy related options were never chosen by a larger share compared to renewable energy options. This can be seen as an indication for a prosumer preference. Yet, a share of respondents only sometimes selected the same option, which shows that they are interested in different options and that respective attributes can affect their choice behaviour.

Table 4: Choice patterns

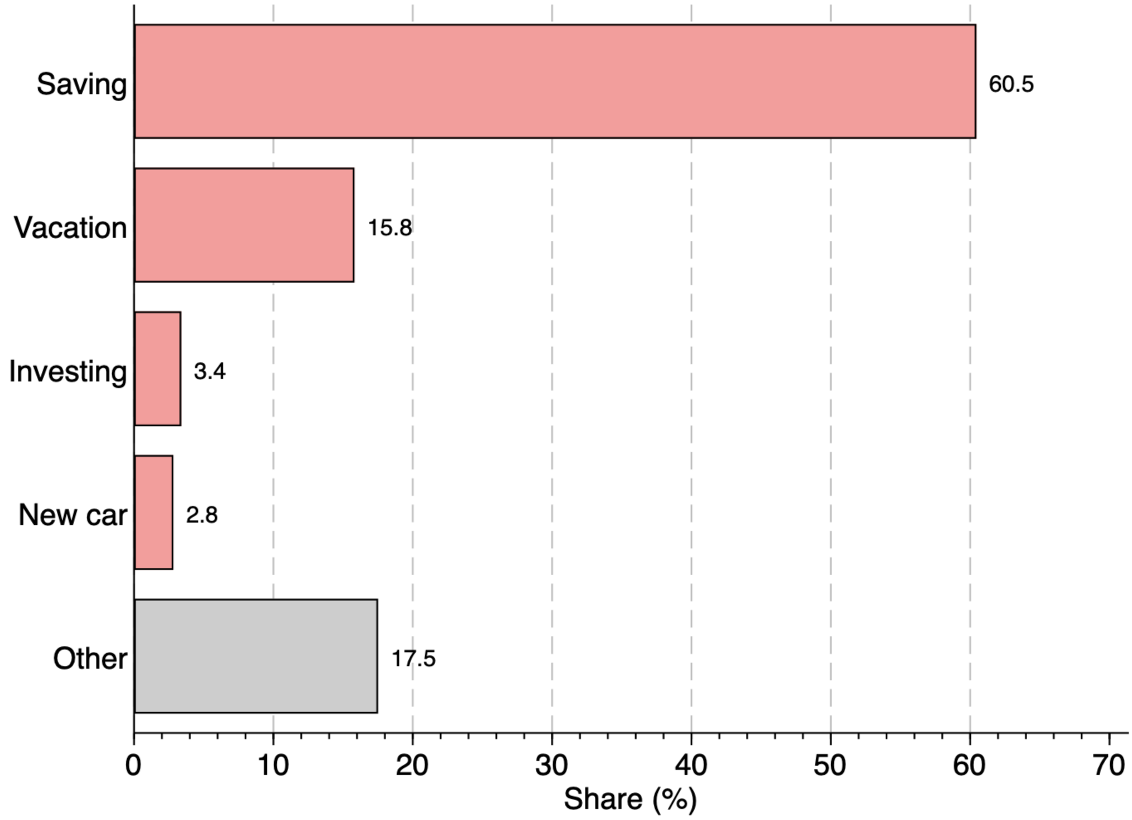
	SQ	Envelope reinstatement	Heating overhaul	Ren. heating	PV	Insulation	Buying ren. heat	Buying ren. electricity
Always	3.38	13.93	13.58	25.26	23.24	9.51	32.52	61.44
Sometimes	22.65	8.57	51.85	47.1	61.62	46.02	21.84	14.16
Never	73.97	77.50	34.57	27.65	15.15	44.47	45.63	24.40
Total	680	280	162	293	680	452	206	459

Shares in %

Answers to the follow-up question, which was displayed after SQ was selected for the first time by a respondent, provide further information about their preferences. By far, the main reason for not choosing an energy-related investment is the preference to save money, as can be seen in Figure 4. Other usage and spend it on holiday are also frequently selected. Only few tenants indicate that they want to invest the money in financial markets or use it to get a new car. So, in contrast to an unexpected tax repayment, tenants have a preference for saving rather than simply spending it when it is their own capital.

These descriptive statistics already provide an initial insight into their choice behaviour. However, in order to determine preferences and influential factors more precisely, the econometric analysis is applied.

Figure 4: How would you spend the money not invested in energy-related projects?



5.2 Estimation results

We use three different specifications for our econometric analysis, which contain all the same options and attributes, but differ with respect to the way the benefits are included. Model 1 is the base model, which has a general benefit and squared benefit term. In Model 2, we introduce investment specific benefits but without squared terms. Model 3 contains the whole set of investment specific benefit and benefit squared, which allows calculating the WTP for different levels of benefits. It can indeed be expected that WTP varies with the amount of benefits.[3] Estimation results of all three models are presented in Table 5 and 6.[4]

[3]Investment specific benefit interactions are not considered for overhaul, as such an investment only yields minor energy savings, if any at all, and the decision to implement an overhaul is usually not motivated by energy savings.

[4]We moreover add a trend variable (i.e., a count variable going from 1 to 6 indicating the order of the choice tasks) in the regression to determine whether the tendency to select the status quo option is

The coefficients for all energy investment types are positive and significant, thereby showing an overall positive consideration of such energy investments. Among the coefficients associated with the various energy investments, the one for buying renewable electricity stands out. PV and renewable heating come also with strong effects. The strong likelihood for respondents in our discrete choice experiment to select the purchase of renewable electricity may be partly due to the relatively low price and flexibility of this alternative compared to other ones. The lack of a significant effect for buying renewable heat can be due to the fact that it makes hardly any difference for tenants whether the renewable energy is produced by means of a heat pump or comes from district heating. Insulation and overhaul are less favoured. Buying renewable heat from the utility is not significant in Model 1 but shows a relatively strong and significant effect in the other two specifications.

Costs come as expected with negative coefficients, showing that cheaper investments are preferred, everything else being equal. This is especially true for mark-ups paid to consume renewable (green) electricity because the corresponding cost coefficient is larger than the cost coefficient for the other investment types. This shows that even though buying renewable electricity is the most valued option for tenants, the premium has to be rather small for such a purchasing option to be attractive. The effect of benefits is globally positive, but the coefficient of squared benefits is negative, indicating that the marginal appreciation of benefits is decreasing.

When it comes to financing, contributing to investments made by the landlord for the residential building appears to be preferred to collective investment options developed by the dwellers themselves, as all collective investment options are disliked compared to contributing. There may be several reasons for this. For instance, respondents are probably not familiar with collective investment options and uncertain about how they work

influenced by the length of the experiment as a sign of fatigue or learning. Anyhow, the results suggests the contrary, with respondents being less likely to select the status quo as the number of choice tasks increase, even though the effect is only significant for the first model, which can be an indication of a learning effect. Also, we included an indicator variable for the last two choice tasks, because storage and load-management were only offered for those last two choice tasks.

out, because it can be assumed that very few of their peers already have experience with such projects. Furthermore, collective investment projects in our choice experiment are neighbourhood projects, which require collective decision-making and action. Resulting transaction costs and risks can reduce interest in such projects and make implementation difficult (Matschoss et al., 2013; Heiskanen et al., 2012). These factors may have made tenants in the choice experiment less willing to select such projects. Still, these non-building-related projects actually open up more opportunities for them, as it is no longer the landlord but the tenants themselves who can make the investment decision. This can therefore correct the lack of energy investments due to the split incentives problem, especially in the case of investments in prosumer projects. Tenants may be more willing to invest in projects supported by institutions such as utilities, as this would reduce the associated risk and transaction costs. Deeper investigations in this field could be the object of further research, because such collective energy investment projects certainly expand tenants' opportunities and can play an important role in more sustainable energy consumption.

Another important part of our analysis is dedicated to evaluate the effect of policy and information treatments on the energy investment decision-making. In order to investigate treatment effects, we interact treatment status with benefits. Because tenants show a clear preference for saving money, as reported in the follow-up question, it might be crucial to keep costs low in order to secure their participation in energy-related projects. Towards this end, subsidies are of course one prominent instrument. Such policies also seem promising because we find that the net-metering and subsidy treatments significantly and positively affect the tenants' choices and may therefore provide strong incentives for implementing such investments, not only because it is easier for the investor to recoup the costs, but also because it appears to foster interest of tenants who may be more willing to contribute. Thus, policies that decrease costs bear potential to help overcome the split incentive problem. The lack of significant effects of potential CO_2 tax increase may be explained by the lack of importance of energy expenditures or low price elasticity when it comes to energy prices (Labandeira et al., 2017; Ürge-Vorsatz et al., 2007). Peer pressure and neighbours' behaviour may be less influential for tenants because their relationship to the building is not the same as for owners (Black et al., 1985).

Storage and load management do not seem to exert any significant impact. The availability of a battery is only associated with positive but small (and weakly significant in Model 2) coefficients. The fact that batteries do not have a significant or only a weakly significant effect may be due to the fact that such investments have not really been profitable in Switzerland (Swissolar, 2019). Furthermore, it can be difficult for tenants to coordinate utilisation of storage devices as their consumption possibilities depend also on the actions of fellow tenants in the residential building.

Table 5: Estimation results - part 1

	Model 1	Model 2	Model 3
Investments (base category: non-energy*:			
Heating overhaul	0.3223*	0.3805*	0.3680*
	(0.1680)	(0.2131)	(0.2135)
Ren. Heating	0.4887***	0.8444***	0.5852
	(0.1869)	(0.2047)	(0.4160)
PV	0.7409***	1.2466***	0.8096***
	(0.1693)	(0.1554)	(0.2231)
Insulation	0.4443**	0.4476**	0.3328
	(0.1963)	(0.1943)	(0.2765)
Buying ren. heat	0.1808	0.7972***	0.9630*
	(0.1972)	(0.2798)	(0.5424)
Buying ren. electricity	1.3344***	1.5324***	2.4964***
	(0.2748)	(0.3068)	(0.5182)
Costs (CHF per month)			:
Contribution	−0.0057***	−0.0063***	−0.0057***
	(0.0008)	(0.0008)	(0.0008)
Costs for buying ren. electricity	−0.0239***	−0.0377*	−0.0355*
	(0.0093)	(0.0203)	(0.0203)
Benefits (in %):			
Benefits	0.0318***	0.0279***	0.0286***
	(0.0049)	(0.0092)	(0.0092)
Benefits × Benefits	−0.0001***		
	(0.0000)		
Investment specific benefit effects of: (in %):			
Ren. Heating		−0.0101	−0.0031
		(0.0095)	(0.0178)
PV		−0.0143	0.0046
		(0.0093)	(0.0121)
Insulation		−0.0006	0.0013
		(0.0096)	(0.0146)
Buying ren. heat		−0.0154	−0.0256
		(0.0094)	(0.0232)
Buying ren. electricity		0.0031	−0.0670**
		(0.0127)	(0.0329)
Investment specific squared benefit effects of: (in %):			
Ren. Heating			−0.0001
			(0.0001)
PV			−0.0002***
			(0.0001)
Insulation			−0.0000
			(0.0001)
Buying ren. heat			0.0001
			(0.0002)
Buying ren. electricity			0.0009**
			(0.0004)

Table 6: Estimation results - part 2

	Model 1	Model 2	Model 3
Treatment effects (interacted with benefits):			
Tax treatment	0.0066	0.0061	0.0058
	(0.0040)	(0.0040)	(0.0040)
Net-metering	0.0091**	0.0087**	0.0083**
	(0.0042)	(0.0041)	(0.0041)
Subsidies	0.0113***	0.0109**	0.0105**
	(0.0043)	(0.0043)	(0.0043)
Peer pressure	0.0024	0.0016	0.0014
	(0.0037)	(0.0036)	(0.0037)
Financing options (base: contributing to investments made by the landlord):			
SCC	−0.2324***	−0.2447***	−0.2440***
	(0.0856)	(0.0856)	(0.0870)
Crowd	−0.5272***	−0.5268***	−0.5331***
	(0.0862)	(0.0859)	(0.0880)
Storage (base: no battery or load management):			
Battery	0.1160	0.1879*	0.1536
	(0.0976)	(0.0987)	(0.0997)
Load management	−0.1759	−0.1229	−0.1436
	(0.1666)	(0.1659)	(0.1675)
Battery and load management	0.0854	0.2089	0.1706
	(0.1491)	(0.1520)	(0.1527)

12,240 observations in total; Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
We controlled for choice task specific fixed effects, even though they are not reported in this table. We also tested the effect of personal characteristics but there is no significant effect

* Non-energy in this context includes the status quo and envelope reinstatement options

5.3 Willingness to pay

Using the estimation results, we calculate the marginal willingness to pay (in CHF per month)[5] for energy savings and renewable energy, as well as smart technologies like batteries for storing produced renewable energy and load-management for more efficient consumption. The estimated WTPs are displayed in Tables 7-9 and Figure 5. WTP estimates for smart technologies based on Model 1 are reported in Table 8. In general, there is a positive but marginally decreasing WTP. This indicates their willingness to contribute a certain amount in order to save energy and/or consume renewable energy, but they show no willingness to spend a lot to exhaust all potential benefits.

Table 7 compares the WTP for contributing to investments and the WTP for purchasing a share of renewable electricity. The willingness to contribute to investments made by the landlord is comparably larger than for purchasing renewable electricity. It should however be noticed that purchasing renewable electricity is much cheaper, and usually costs a fairly small premium on top of the regular electricity bill.

Table 7: Model 1: WTP for 15pp. of benefits (in CHF/month)

	0-15%	15-30%	30-45%	45-60%
WTP	85^{***}	74^{***}	63^{***}	52^{***}
(Contribution to investment)	(17)	(13)	(10)	(8)
WTP	21^{***}	18^{***}	15^{***}	13^{***}
(Price for renewable electricity)	(8)	(7)	(6)	(5)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In Table 8 monthly WTP for batteries and load-management are reported. As it can be seen, the results are positive whenever batteries are part of the investment and negative for load-management. Yet, none of the WTP estimates for these smart technologies are significant.

The average monthly WTP for a 15 percentage point increase of benefits are estimated for each investment type based on Model 2. As it can be seen in Table 9, the WTP for

[5] In 2020, when our choice experiment was implemented, 1 CHF ≈ EUR 0.93 ≈ USD 1.07

Table 8: WTP for smart technologies (in CHF/month)

	Storage (battery)	Load-management	Storage and load-management
WTP	20	-34	14
	(17)	(31)	(26)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

insulation is the highest, which also depends on the relatively high investment costs. On the other hand, the low WTP for buying renewable electricity can be explained by the moderate mark-up that has to be paid therefore.

Table 9: Model 2: WTP for 15pp. of benefits (in CHF/month)

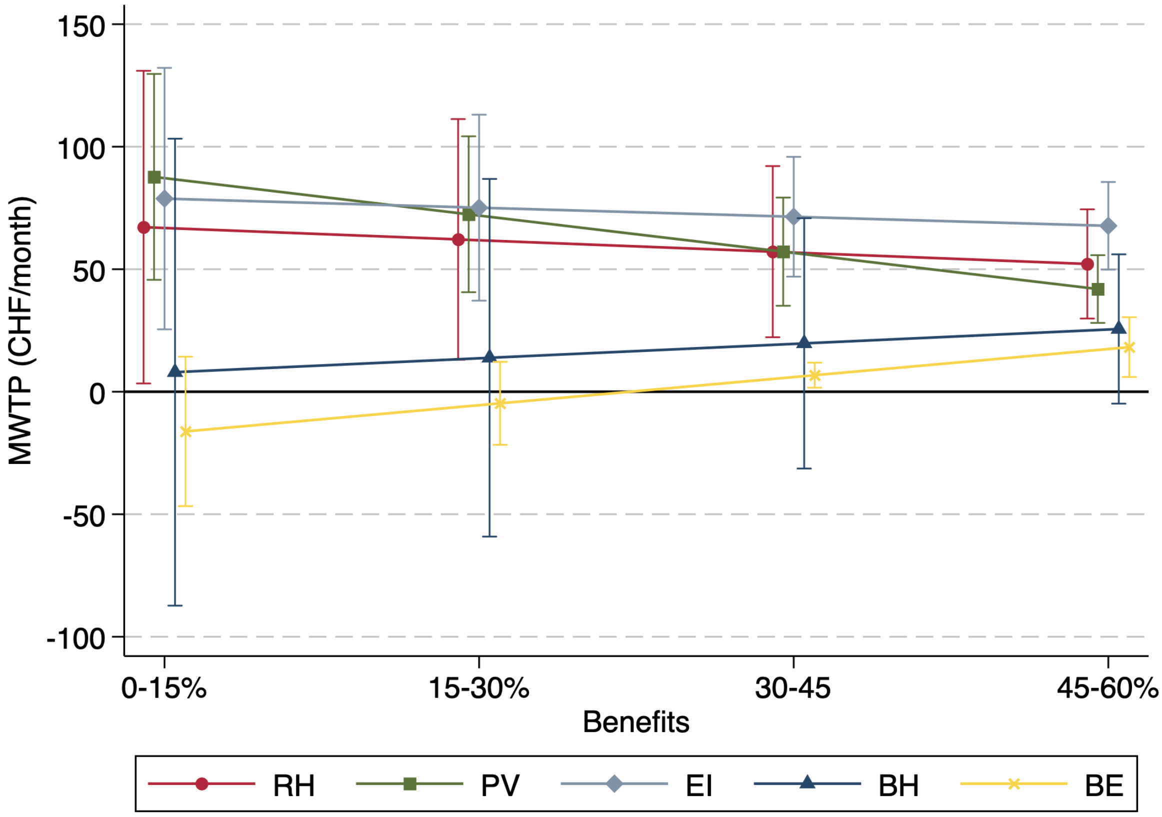
	Renewable heating	PV	Insulation	Buying ren. heat	Buying ren. electricity
WTP	42***	32***	65***	30***	12***
	(8)	(6)	(9)	(9)	(4)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Finally, Model 3 is used to calculate the WTP for 15 additional percentage points of benefits at different levels and for each investment type. The results, presented in Table 5, show that WTP for PV is the highest at small levels of benefits, but it decreases rapidly. WTP for renewable heating and insulation decrease slower. WTP estimates for purchasing renewable heat are not significant. Contrary to the contribution options, the WTP for buying renewable electricity is increasing with the amount of corresponding benefits. Tenants may consider that making changes for a small proportion of renewable electricity is not worth the effort. In the case of renewable electricity, products that entail 100% renewable energy therefore appear much more attractive than products with only a share of renewable energy.

The estimated WTP for energy savings and renewable energy consumption show that tenants are indeed willing to contribute to energy investments, which could also be leveraged to find solutions to the split incentive problems. The WTP is sufficiently large to enable investments. In that sense, our results are comparable to those of Phillips (2012). Yet, the decreasing WTP indicates that their willingness to contribute is limited.

Figure 5: WTP for 15pp. of benefits



Therefore, they are willing to contribute a certain amount to an investment made by the landlord. However, the WTP is not necessarily sufficient to make a large investment worthwhile for the landlord. This is also the case because often the costs of the measures needed to achieve the maximum benefits are comparatively high. This in combination with the decreasing willingness to pay can lead to only smaller investments being worthwhile. The low or even lacking significant WTP for both buying options despite the strong effects in the Regression (Table 5 and 6) indicate that tenants are interested in these options, but the prices may have to be low. Scale economies and policy support can promote the purchase of renewable energy by facilitating attractive conditions.

6 Conclusion

By their numbers alone, tenants are influential in terms of climate change. However, what affects their energy investment decision-making is not extensively studied. The interest of our research is enhanced because new forms of investments, such as self-consumption communities and crowdfunding projects, are emerging and offer new opportunities for tenants, and may also help to circumvent the split incentives problem.

We conduct a discrete choice experiment (DCE) and gather data from 680 Swiss tenants, which allows us to investigate energy investment related preferences and issues of this important segment of the population. We estimate how their energy investment decisions are affected by different types of energy measures, corresponding attributes such as costs and benefits, and information treatments. We also calculate the WTP for energy savings obtained with various energy investment types.

Our results show that tenants value energy investments and are willing to contribute to such investments. More precisely, they choose more often renewable energy options compared to energy efficiency improvements. In particular, purchasing renewable electricity stands out as one of the favourite solutions for tenants. Even though collective investment opportunities can help tenants to benefit from energy investments and can help to circumvent the split incentives problem, we find that such opportunities are disliked to contributing to investments made by the landlord for the residential building. Thus, acceptance of these projects as we have been considering may not be sufficient for them to play a role in overcoming the split incentives problem. However, their willingness to contribute to the landlord's investments shows that it can arguably be worthwhile for the landlord to make energy investments, which in turn can contribute to solving the split incentives problem.

Policy-related information treatments about changing net-metering and subsidy frameworks affect choice behaviour positively. Thus, such policies may be effective to increase the amount of energy investments, not only by lowering upfront costs, which are difficult to recoup for the landlord-investor, but by fostering the tenants' willingness to contribute.

Since tenants also otherwise indicate that they would rather save money or spend it on other, non-energy related expenses, the reduced costs due to policies like subsidies can promote the willingness to contribute.

Our estimates indicate that tenants are ready to contribute to energy investments, which shows that there is a potential for involving tenants in energy investments and that solutions to the split incentive problem may exist. Towards this end, designing measures targeting this (large) group of the population appears crucial. This has important implications for policymakers, landlords and utilities. Even though the offered collective investment options are not valued, the situation may be different if such crowd investment projects are launched by utilities. Thereby, coordination hurdles and involved risk can be reduced, which can make such projects an interesting option for tenants and the utilities. On the other hand, even if acceptance of the offered collective investment projects is not sufficiently high yet, the positive willingness to contribute to landlords' investments shows that it can be worthwhile for landlords to invest and let the tenants contribute to the investment, for instance through a rent increase. If policies such as subsidies not only make the investment more favourable for the landlord but also increase the interest of tenants, such measures can be effective in promoting energy investments for rental buildings and, thereby, also reduce the split incentives problem.

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A Appendix

A.1 Treatments

The following treatments were introduced between the second and third choice tasks. A single treatment was randomly displayed to each respondent. Each treatment group contains around 20% of the sample. A control group, also composed the remainder or the sample (also around 20%) was not displayed any treatment and jumped directly from the second to the third choice task. The four treatments were formulated (exactly) as follows:

Treatment 1: Policy – CO_2-tax increase

Today, fossil fuels are taxed at CHF 96 per ton of CO_2. In order to reduce CO_2 emissions, the Swiss government is expected to increase this tax to CHF 200. If your heating runs on heating oil or gas, your energy costs will increase. If the owner invests in your building, your energy costs go down, but your rent will probably increase.

Treatment 2: Policy – Subsidies

The Swiss government is planning to substantially increase subsidies for building retrofits and producing renewable electricity (PV). New federal and cantonal contributions will cover about 30% of homeowners' investment costs. That means, if your owner makes some investments, you benefit from these subsidies.

Treatment 3: Electricity tariff system – Net metering

Net-metering and higher tariffs make investing in PV more attractive for owners. Imagine that these measures are increased by the state and the house owner wants to invest such system. This might lead to a higher rent for you, but you might also benefit from lower costs for energy.

Treatment 4: Policy – Information nudge for diffusion

It turns out that in your neighbourhood, many people invested in photovoltaics (PV). The adoption rate in your neighbourhood is above the Swiss average. It is likely that the majority of your neighbours will invest in PV in the upcoming years.

A.2 Characteristics

Table 10 shows the characteristics of the respondents who always or never chose certain options, even though they were available to see whether they differ from others.

Table 10: Characteristics of specific groups of respondents

	Always SQ	Never SQ	Never renewable heating	Never PV	Never insulation	Never buying heat	Never buying electricity	New building	With renewable heating	No preference	Whole sample
Group:	-	1	2	3	4	5	6	7	8	9	-
Relative group size:	3.4%	74%	11.9%	15.1%	29.6%	13.8%	16.5%	31.8%	40.7%	13.4%	100%
Respondent age < 65	21	438	68	78	173	82	94	184	245	76	586
	(91.30)	(87.08)	(83.95)	(75.73)	(86.07)	(87.23)	(83.93)	(85.19)	(88.45)	(83.52)	(86.18)
Respondent age 65+	2	65	13	25	28	12	18	32	32	15	94
	(8.70)	(12.92)	(16.05)	(24.27)	(13.93)	(12.77)	(16.07)	(14.81)	(11.55)	(16.48)	(13.82)
Total	23	503	81	103	201	94	112	216	277	91	680
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
New building	8	144	24	30	53	27	25	92	110	30	202
	(34.78)	(28.63)	(29.63)	(29.13)	(26.37)	(28.72)	(22.32)	(42.59)	(39.71)	(32.97)	(29.71)
Old building	15	359	57	73	148	67	87	124	167	61	478
	(65.22)	(71.37)	(70.37)	(70.87)	(73.63)	(71.28)	(77.68)	(57.41)	(60.29)	(67.03)	(70.29)
Total	23	503	81	103	201	94	112	216	277	91	680
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Lower education	10	263	43	58	102	55	59	118	138	48	356
	(43.48)	(52.29)	(53.09)	(56.31)	(50.75)	(58.51)	(52.68)	(54.63)	(49.82)	(52.75)	(52.35)
Graduate	13	240	38	45	99	39	53	98	139	43	324
	(56.52)	(47.71)	(46.91)	(43.69)	(49.25)	(41.49)	(47.32)	(45.37)	(50.18)	(47.25)	(47.65)
Total	23	503	81	103	201	94	112	216	277	91	680
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Maximum mean income	16	371	62	82	152	73	89	163	196	71	507
	(69.57)	(73.76)	(76.54)	(79.61)	(75.62)	(77.66)	(79.46)	(75.46)	(70.76)	(78.02)	(74.56)
More than mean income	7	132	19	21	49	21	23	53	81	20	173
	(30.43)	(26.24)	(23.46)	(20.39)	(24.38)	(22.34)	(20.54)	(24.54)	(29.24)	(21.98)	(25.44)
Total	23	503	81	103	201	94	112	216	277	91	680
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Shares of the respective respondent group (in %)