Preferences for retrofit investments among low income renters

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PRELIMINARY VERSION

Abstract

We analyze the preferences of low-income renters for different retrofitting options, using a discrete choice. Using data collected from a Discrete Choice Experiment, we elicit renters' preferences for different retrofitting options, based on four attributes. We find that households are willing to foregone significant future savings in order to avoid investment costs in the present.

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1 Introduction

Improving energy efficiency through retrofits is widely considered one of the most effective ways to reduce energy consumption and achieve the ambitious climate goals set by many countries and communities worldwide. Furthermore, it is often seen as an essential tool to mitigate energy poverty. Low income households can be a fruitful focus area for policymakers for at least two reasons: Firstly, they usually live in less energy efficient buildings compared to higher income households. Therefore, these accommodations offer high potential for energy savings. Secondly, subsidizing low income households in particular may reduce inequality and energy poverty, both of which are stated policy goals in many countries (Seebauer et al., 2019).

Given that they present social benefits which homeowners and landlords may not take into account properly, we can expect home retrofits to be conducted less often than would be socially optimal. However, the adoption of retrofits in residential homes has long been at a level that is suboptimal not only socially, but also privately. Several possible explanations for this energy-efficiency gap exist, including inefficient pricing of energy consumption or information asymmetries between energy providers and consumers (Gerarden et al., 2017).

In rented accommodations, an additional layer of complexity emerges due to the risk of split incentives; usually, the landlord has to bear the cost of efficiency improvements, while the tenant is reaping the benefits through lower energy costs. This may lead to low efficiency investments by landladies, if the investment costs cannot be recouped through higher rents. This landlord-tenant problem is well researched in the literature (see e.g. Gillingham et al. 2012).

Regarding retrofit decisions, the preferences of renters in particular are not well researched so far. Given that renters profit from efficiency investments through lower energy bills, they may be willing to share some of the financial burden of the initial investment. Due to the high shares of renters in many countries, unlocking the retrofit potential of rented dwellings appears like a worthwhile endeavour for policy makers. This, however, requires us to learn more about renters´ preferences regarding retrofits.

Some related work exists regarding retrofits. Achtnicht (2011) estimate the Willingness to Pay for efficiency improvements of homeowners using a Discrete Choice Experiment. Collins and Curtis (2018) estimates the WTP of renters for energy efficiency in the form of a rent premium based on administrative data from Ireland. Schleich et al. (2021) find that poor access to capital can reduce the adoption of retrofit measures, in particular in combination of debt aversion. Melvin (2018) confirms that landlords underinvest in energy efficiency if they do not pay the utility bill. Trotta (2018) finds that renters invest less often in energy efficiency measures than those living in owner-occupied dwellings.

We focus on the following research questions:

1) Under which circumstances are tenants willing to invest in retrofits in their own accommodations? 1b) What is the implied rate of return needed for these investments? 2) Is there a preference for fairness, meaning that renters are willing to pay more for a retrofit if landladies are also investing more? 3) Is the motivation of renters to invest mainly based on cost savings, or do CO2 savings also play a role? 4) How do demographic characteristics influence these preferences? 5) What are the implications of these findings for retrofitting subsidies in the residential sector?

Using a discrete choice experiment (DCE), we shed light on the preferences of renters for different hypothetical retrofitting options. DCEs are a relatively straightforward and flexible way to assess consumers´ preferences and valuations on a range of hypothetical products and outcomes. There is a wide field of potential applications for DCEs, such as marketing, public economics, and environmental economics.

To our knowledge, this is the first study to investigate the preferences of renters to invest in their rented accommodations despite not being the owners.

The rest of this article has the following structure: Section 2 describes the dataset obtained in the experiment and presents descriptive statistics. Section 3 discusses the methodology used in the analysis. The main results are presented in Section 4. Section 5 concludes.

2 Data

2.1 Experimental Design

The participants were recruited from an online sample, based on participants of a mail-in survey (Seebauer and Eisfeld, 2021). The experiment was conducted between November 2020 and January 2021. Two reminders were sent in December of 2020 and January of 2021, respectively. Participation was incentivized via the chance to win an online gift card. Participants were asked to choose the option that they liked the most. At the start of the survey, participants received an explanation that their choice was hypothetical and that no actual renovation would be made based on their choices.

The choice sets were generated using a balanced overlap design via the Sawtooth Lighthouse Studio Software, which was also used to host the experiment. All respondents are renters with low income. As a compromise between high retention and achieving a larger sample size, each respondent was asked to complete 7 choice cards. The sample size is 76 participants for a total of 495 choice situations. This includes all participants who answered at least one choice situation, with 68 respondents answering all 7 of their choice cards.

Demographic data on the respondents was obtained previously in the survey outlined in Seebauer and Eisfeld (2021). Demographic and experiment data were then matched based on the Email addresses of the participants who were interested in participating in a second survey.

Naturally, the actual process of retrofits in rented accommodations may differ in real life situations depending on the jurisdiction. Not all participants could be matched to the demographic survey. For the dataset including demographics, our sample size reduces to 65 participants, answering a total of 422 choice situations. For the estimations shown in Section 4, we use both the matched and unmatched datasets.

Based on previous literature and theoretical considerations, we choose the following four attributes for the DCE: 1) the yearly energy cost savings in Euros, which was included dynamically as a percentage of the household's energy cost; 2) the total investment cost for the renter in Euros; 3) the total investment cost for the landlady in Euros; and 4) the CO_2 savings from the retrofit.

2.2 Descriptive Statistics

This section presents the demographic attributes of the participants, which will be used for our estimations in Section 4.2. Table 1 shows the descriptive statistics of the sample.

As mentioned previously, the sample consists of low income households. This is shown in the income variable EINKOMMEN, which has a mean of 1,120 Euros per month. Monthly net household income was assessed categorically, with a total of six categories, ranging from 'up to 800 Euros' to 'more than 3,000 Euros'. In Table 1 and in our further analysis, the categories are converted to numerical values by taking the midpoint of each category.

Only 30.6% of households report that they are able to save some amount of money at the end of a typical month. The mean of these monthly savings is 33.28 Euros, which is significantly lower than for a typical Austrian household. In 2018, the mean savings amount across all private households in Austria was 338.41 Euros. More than 44% of households report that they have 'problems' or 'severe problems' handling their finances given their income situation.

The average living space is 53.78 square meters with an average household size of 1.8 inhabitants. 8.7% of households do not possess a written rental contract (VERTRAGSCHRIFT = 0). 29.4% of households have a fixed-term rental contract (VERTRAGFRIST), with an average duration of 3.79 years remaining (VERTRAGFRIST_other.

Table 1: Descriptive Statistics

Statistic	Mean	St. Dev.	Min	Max
KostenMonat	107.019	90.322	25	750
WOHNFORM	2.564	0.616	1	3
BAUJAHR	3.128	1.048	1	5
WOHNFLAECHE	53.775	16.394	28	96
EFFBAUWEISE	0.439	0.497	0	1
WOHNDAUERVERG	2,009.353	12.189	1,965	2,020
WOHNDAUERZUK	1.677	0.468	1	2
SILCANGEM	0.713	0.453	0	1
SILCFEUCHT	0.258	0.438	0	1
kostenmietervermiete	1.723	0.971	1	5
EINKOMMEN	1,120.405	380.739	400	2,450
SPAREN	0.306	0.461	0	1
SPARENGENAU	33.284	70.057	0	400
ZURECHT	2.718	1.208	1	6
KOSTEN_heiz	68.640	60.046	2	400
KOSTEN_strom	52.953	22.961	20	110
KOSTEN_miete	480.019	200.976	138	1,196
KOSTEN_heizstrom	119.071	75.768	42	510
KOSTEN_heizmiete	549.706	201.484	193	1,296
KOSTEN_strommiete	546.950	206.256	225	1,296
KOSTEN_heizstrommiete	597.115	218.945	227	1,396
RUECKSTAND_heiz	0.308	0.678	0	3
RUECKSTAND_miete	0.187	0.597	0	3
SOZIALLEISTG_ams	0.316	0.465	0	1
SOZIALLEISTG_kurz	0.037	0.188	0	1
SOZIALLEISTG_sozhilf	0.130	0.336	0	1
SOZIALLEISTG_mindsich	0.257	0.437	0	1
SOZIALLEISTG_wohn	0.534	0.499	0	1
SOZIALLEISTG_energ	0.294	0.456	0	1
SOZIALLEISTG_pflege	0.120	0.325	0	1
SOZIALLEISTG_keine	0.172	0.377	0	1
HAUSHALT_1	0.446	0.979	0	4
HAUSHALT_2	0.034	0.182	0	1
HAUSHALT_3	1.147	0.747	0	3
HAUSHALT_4	0.174	0.422	0	2
hhgroesse	1.801	1.175	1	5
ZUHAUSE	3.302	0.743	2	4
GESCHLECHT	1.434	0.496	1	2
MIETE	1.252	0.632	1	3
VERTRAGFRIST	1.740	0.941	1	3
VERTRAGFRIST_other	3.790	2.320	1	10
VERTRAGSCHRIFT	0.913	0.281	0	1

3 Methodology

We are using a discrete choice framework, based on the random utility model (Train, 2009; McFadden, 1974). We work in characteristic space, which assumes that the utility of a choice or product is derived from its attributes and attribute levels. The utility of individual n for alternative i in choice situation t can be described as

$$U_{nit} = V_{nit} + \epsilon_{nit} \tag{1}$$

where V_{nit} denotes the deterministic component and ϵ_{nit} is the unobserved stochastic component, which is assumed to be independently and identically distributed (I.I.d.) following a Gumbel distribution. In each choice situation t, households choose the option which has the highest utility, which means that

$$U_{nit} > U_{njt}(\forall i \neq j). \tag{2}$$

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

$$\begin{aligned} P_{ni} &= Prob(V_{ni} + \epsilon_{ni} > V_{nj} + \epsilon_{nj} \forall j \neq i) \\ &= Prob(\epsilon_{nj} < \epsilon_{ni} + V_{ni} V_{nj} \forall j \neq i). \end{aligned}$$

This type of distribution leads to a S-shaped relationship between the representative utility V_{nit} and the choice probability P_{ni} (Train, 2009).

4 Results

4.1 Main Results

Table 2 shows the coefficients of our preferred specification. These estimations are conducted purely based on the results from the Discrete Choice Experiment; the results from the estimations in conjunction with the demographic characteristics of the participants will be discussed in Section 4.2. The first estimations contain only the alternative-specific variables monetary savings, renter cost, owner cost, and CO_2 savings.

Table 2: Two main models, without demographics

	Dependent variable:	
	choice	
	(1)	(2)
(Intercept):2	-0.205^{**}	
	(0.096)	
monetary_savings	0.001^{*}	0.001^{*}
	(0.001)	(0.001)
renter_cost	-0.001^{***}	-0.001^{***}
	(0.0001)	(0.0001)
owner_cost	-0.0001^{**}	-0.0001^{**}
	(0.0001)	(0.0001)
co2_savings	0.005^{*}	0.005^{**}
	(0.002)	(0.002)
Observations	495	495
R^2	0.077	
Log Likelihood	−312.814	−315.115
LR Test	52.549^{***} (df = 5)	

Notes:***,**, and * indicate significance at the 0.01, 0.05, and 0.10 levels, respectively. Clustered robust standard errors in parentheses.

All of the estimates are statistically significant at least at the 10% level, with most of them also being significant at the 5% level. The coefficient estimates have the expected signs. Higher savings both in terms of energy cost and CO_2 increase the likelihood of choosing a certain option, while the two investment cost variables have negative signs. As expected, the effect size of renter_cost is larger than that of owner_cost. While households have a preference for a lower investment cost for their landlord, their own investment costs are a much stronger factor in the decision for or a against a certain choice card. For the owner cost variable, different interpretations would be possible. From a purely economic point of view, the cost for the owner should not matter for the participants' decision, which would require the coefficient estimates to be not statistically significant. However, other factors may be involved here: renters may have a preference for lower owner cost as a form of altruism, potentially due to having a personal relationship with their landlord. The opposite effect is also feasible: Renters may be willing to invest more if their landlord also invests due to a preference for sharing the investment cost in a way that they would perceive as fair. Either way, the small negative coefficient we find shows that renters have a slight preference for a lower investment cost of owners.

The intercept, which captures the alternative specific component, may appear inherently meaningless in an unlabeled experiment such as ours. However, we include it to account for a potential left-right bias, i.e. the possibility that participants have a preference for choosing the first option they see, which is the left option when reading from left to right (Yonnie Chyung et al., 2018). We find that the intercept coefficient is statistically significant, which indicates the presence of left-side bias. However, the effect appears to be small, as the other coefficient estimates are virtually identical between the two specifications. For the rest of this section, we continue with the results from Model 1.

Unlike in a regular OLS regression, the coefficient estimates depicted in Table 2 can not be directly interpreted as percentages due to the non-linear relationship between choice probability and representative utility. However, the marginal effects can be derived, as shown in Table 3.

These marginal effects denote the change in selection probability if the accompanying attribute is increased by one unit, i.e. one Euro for the investment cost and monetary savings variables and one percent for the CO_2 savings. For example, a retrofit that is 100 Euros less expensive for the

Table 3: Marginal Effects, Model 1

Variable	Marginal effect, in %
Yearly savings in Euros	0.0238
Cost renter in Euros	-0.0173
Cost owner in Euros	-0.0029
CO_2 savings in %	0.1120

renter would, ceteris paribus, have a 1.73% higher chance of being selected. While the relationship between coefficient estimates and marginal effects is not linear, larger coefficients are still correlated with larger marginal effects, as the table shows.

Based on the coefficients depicted in Table 2, we can calculate the Willingness to Pay (WTP) for the attributes used in the experiment. We can obtain the ratio for which the utility of households is unchanged by dividing one coefficient estimate by another. This ratio signifies the amount of one attribute (e.g. investment cost in Euros) that consumers are willing to give up in order to increase or decrease another attribute by one unit (e.g. CO_2 savings in %). In principle, this relationship can be calculated between any two attributes.

Usually, however, a variable that is expressed in monetary terms is used as the denominator, such as renter cost in this case. Table 4 shows the mean WTP for the different attributes in Euros, obtained by dividing the coefficient estimates for the different variables by the renter cost coefficient.

Table 4: Willingness to Pay, Model 1

Variable	WTP, in Euros
Yearly savings in Euros	1.38
Cost renter in Euros	1.00
Cost owner in Euros	-0.17
CO_2 savings in %	6.47

As the table shows, households are willing to pay 1.38 Euros in additional investment costs today to save 1 Euro in energy costs every year. Additionally, they are willing to invest 6.47 Euros to save one additional percent of CO_2 in their home. The WTP to lower the investment cost for the homeowner by 1 Euro is 0.17 Euros. The WTP for the variable Renter Cost is, by definition, 1 Euro.

Based on these WTP values, we can calculate the implied Internal Rate of Return (IRR) of the retrofitting investment. The IRR is defined as the discount rate for which someone is indifferent between investing and not investing. This can be done using the formula

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0 \tag{3}$$

with NPV as the Net Present Value and C_t as the net cash flow in time period t. Setting NPV to 0 and solving numerically yields the IRR.

Table 5: Internal Rate of Return, Model 1

Timeframe in years	1	2	3	4	5
IRR in %	-27.42	28.90	51.86	62.06	67.00

The IRR depends on the assumed time horizon of the investment, which may vary between individuals. Table 5 shows the implied yearly IRR for different investment horizons. The values show that for an investment period of 2 or more years, the rate of return that participants implicitly expect grows excessively large. There could be three explanations for this, namely: 1) households have a very short time horizon when considering this investment; The WTP values imply an expected payback period of 16.5 months. This may be appropriate if renters expect to move out within the foreseeable future. 2) households strongly discount future savings, i.e. they have high discount rates. 3) households have low access to liquidity and would not be able to invest any substantial amount of money in the first place, which results in foregoing potential future savings in order to reduce the invested amount today.

4.2 Demographic Interactions: Income

Combining the data obtained in the DCE with the demographic data from the first survey, as described in Seebauer and Eisfeld (2021), yields additional insights into renters' preferences. To this end, we first match the two datasets. This reduces the sample size from 495 choice situations of

76 individuals to 422 choice situations of 65 participants. In an unlabeled experiment, individual characteristics can only be meaningfully included if they are interacted with product attributes.

The willingness to make an investment may be heavily influenced by the financial situation of a household. In particular, higher income households can be expected to be more willing and able to invest into retrofits. To test this hypothesis, we divide the investment cost and monetary savings by the yearly household income in the following estimations [1]. This means that a value of 0.1 in renter cost divided by yearly income would represent investment costs of 10% of the yearly household income. In this estimation, the values for the monetary savings and renter cost variables are not directly comparable between models due to the different units. For example, while renter costs range from 500 to 2000 Euros, renter cost divided by income ranges from 0.02 to 0.42. Table 6 shows the results of this estimation. Column 2 reproduces Column 1 of Table 2 for reference.

Table 7 shows the estimation result when differentiating by income. The estimation results for households with a net monthly income of less than

[1]Note that because household income is denoted in categories, we take the midpoint between two category limits as the mean income for each participant

Table 6: Two main models, with demographics

	Dependent variable:	
	choice	
	(1)	(2)
(Intercept):2	−0.131	−0.205**
	(0.114)	(0.096)
monetary_savings_by_income	32.678***	
	(12.041)	
renter_cost_by_income	−9.548***	
	(1.563)	
monetary_savings		0.001*
		(0.001)
renter_cost		−0.001***
		(0.0001)
owner_cost	−0.0001**	−0.0001**
	(0.0001)	(0.0001)
co2_savings	0.007**	0.005*
	(0.003)	(0.002)
Observations	370	495
R^2	0.122	0.077
Log Likelihood	−223.887	−312.814
LR Test (df = 5)	62.026***	52.549***
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 7: Estimations including income

	Dependent variable:		
	choice		
	(1)	(2)	(3)
(Intercept):2	−0.208	−0.088	−0.124
	(0.162)	(0.161)	(0.114)
monetary_savings	0.001	0.006***	0.004
	(0.001)	(0.002)	(0.003)
renter_cost	−0.001***	−0.001***	−0.002***
	(0.0002)	(0.0002)	(0.0004)
owner_cost	−0.0002**	−0.0001	−0.0001**
	(0.0001)	(0.0001)	(0.0001)
co2_savings	0.006*	0.008*	0.007**
	(0.004)	(0.004)	(0.003)
monetary_savings:EINKOMMEN			−0.00000
			(0.00000)
renter_cost:EINKOMMEN			0.00000**
			(0.00000)
Observations	171	199	370
R^2	0.070	0.172	0.116
Log Likelihood	−109.000	−113.836	−225.393
LR Test	16.471*** (df = 5)	47.351*** (df = 5)	59.015*** (df = 7)
Note:			*p<0.1; **p<0.05; ***p<0.01

5 Conclusions

In this article, we assess the preferences of households regarding their willingness to invest in energy efficiency in their non-owned accommodations. We find that the initial investment cost is the biggest deterrent of supporting such measures. The implied rate of return that tenants demand for their potential investment in retrofits is excessively large when assuming a time horizon of two or more years.

It should be noted that the choices made by the participants were purely hypothetical. Making choices that have no consequences in an experiment like this may lead to hypothetical bias (Hensher, 2010). Furthermore, the small sample size is a limitation, which is why we refrain from estimating interaction effects. Still, we find results of statistical significance that have economic meaning.

Naturally, the decision to undertake a home retrofit is more complex than can be simulated in an online experiment such as this. Additionally, retrofitting is not necessarily a binary choice; actual retrofitting outcomes may differ greatly based on the characteristics of the individual home and the preferences of both landladies and tenants. In addition, rules and regulations may have a strong influence on the specific outcomes and may limit the options of both parties regarding efficiency investments.

Several main implications of this research remain: 1) The main obstacle to renters' willingness to invest in their non-owned dwellings is the initial investment cost. 2) the desired return on investment is prohibitively large, or the time horizon considered is short, i.e. less than 2 years.

Based on the research conducted in this paper, the main ways to promote stronger inclusion of renters in retrofitting would be to: 1) lower investment costs for low-income households, e.g. through investment subsidies; 2) promote long term or permanent rental contracts so that renters have a longer time horizon for investments; and 3) advertise the potential for CO_2 savings through retrofitting.

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