Working Paper Sustainability and Innovation
No. S 05/2020

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Household preferences for new heating systems: Insights from a multi-country discrete choice experiment

Fraunhofer ISI

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 723716.
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Abstract

This paper employs identical demographically representative discrete choice experiments (DCEs) on new heating systems with owner-occupier households in Poland, Sweden, and the United Kingdom (UK) to estimate respondent willingness-to-pay (WTP) for rebates, heating cost savings, installation time (reflecting "hassle costs") and warranty length. The results from estimating country-specific mixed logit models suggest that participants generally value rebates for new heating systems, but valuation differs substantially across countries and was found to be highest for Poland. For Sweden (but not for Poland or the UK), rebates appeared more effective if offered by a public rather than a private funding source. Because higher income households in the UK value rebates more than lower income households, rebates may be regressive. The results for heating cost savings in the three countries imply static payback times of ten to fifteen years for more energy-efficient heating systems. We further find that respondents have a strong dislike for longer installation time and a high WTP for longer warranty times.

Key words: energy efficiency, energy efficiency obligations, heating systems, hassle costs, energy efficiency paradox, choice experiment.

Highlights:

- Effectiveness of rebates for new heating systems differs across countries.
- For Sweden, publicly-funded rebates are more effective than privately-funded ones.
- In the UK, rebates are regressive - unless targeted at low-income households.
- Static payback times for energy-efficient systems range between 10 and 15 years.

Participants strongly dislike longer installation times for new heating systems.

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1 Introduction

Lowering residential energy use for heating is key to achieving energy efficiency and greenhouse gas emissions targets in the European Union (EU) (IEA, 2018, p. 276), particularly in countries with high heating demand. In this context, both policymakers and energy providers are interested in understanding success factors for the deployment of energy-efficient heating systems among households. More specifically, the Energy Efficiency Directive (EED) (Directive 2012/27/EU) required the EU to lower energy consumption by at least 20% by 2020 compared to baseline consumption. The revised EED (Directive 2018/2002/EU) sets this target to 32.5% by 2030. To help achieve these energy efficiency targets, the EED (Article 3) requires EU Member States (MS) to set indicative national energy efficiency targets and take legally binding measures. Article 7 of the EED mandates the national targets for 2014-2020 to be achieved by energy efficiency obligation schemes (EEOS) for energy distributors and/or retail energy sales companies. The EEOS must deliver a reduction of at least 1.5% in annual energy sales to final customers. MS may also introduce alternative measures to EEOS as long as they produce the same energy savings. Currently, 18 of 28 EU MS have implemented EEOS for energy companies, which are estimated to have achieved about one third of all energy savings in the EU in the period 2014-2017 (European Commission, 2019). EEOS are expected to evolve and play a pivotal role in achieving EU and national energy efficiency targets in 2030 (Fawcett et al., 2019). A recent evaluation of EEOS found that energy companies primarily employ rebates to promote energy efficiency (ENSPOL, 2015). Thus, from a policy perspective, the question that arises is whether subsidies such as rebates provided by energy companies are more effective than subsidies provided by governments.

In addition, a better understanding of households' criteria when purchasing energy-efficient appliances and modern heating systems also helps technology providers to offer products that meet their customers' needs better.

In this paper, we employ a stated preferences discrete choice experiment (DCE) on heating system replacements in owner-occupier households in three EU countries with high heating demand: Poland, Sweden and the United Kingdom (UK). The DCEs simulate a hypothetical market environment by asking participants to choose among multiple heating systems which differ in terms of their attributes. In our case, the attributes considered include purchase price, capacity to reduce participants’ heating costs, time needed for installation, warranty period, amount of available subsidies, and whether the subsidy is offered by a public agency or a private energy company.

Previous studies have employed DCEs for new heating systems in the residential sector, typically in countries with high heating demand such as the United Kingdom (Scarpa and Willis, 2010; Willis et al., 2011), Finland (Rouvinen and Matero, 2012; Ruokamo, 2016) and Germany (Achtnicht, 2011; Achtnicht and Madlener, 2014). The studies by Scarpa and Willis (2010), Willis et al. (2011) and Ruokamo (2016) focus on hybrid heating systems where main and supplementary heating systems (e.g. solar thermal) are combined. In all these studies, higher purchasing costs of the heating system and higher operating costs (including energy costs) decrease the likelihood of choosing a particular system. Similarly, private or public funding support, longer warrantee periods (Achtnicht, 2011; Achtnicht and Madlener, 2014), recommendations by friends or plumbers (Scarpa and Willis, 2010); Willis et al., 2011) or environmental benefits such as lower CO_2-emissions (Achtnicht, 2011; Rouvinen and Matero, 2012; Achtnicht and Madlener, 2014) or environmental friendliness in general (Ruakomo, 2016) were found to increase the likelihood of a particular heating system being selected.

Our analysis contributes to the literature in various ways. First, while previous DCEs looked at the effectiveness of rebates, our DCE explicitly distinguishes between public and private funding sources. Thus, our findings provide insights whether rebates are more effective if offered by the government or by energy companies, e.g., via EEOS. Second, our study considers "hassle costs", i.e., the time needed for installing the new heating system. If substantial, these costs help explain the so-called energy efficiency paradox, i.e., the gap between the investments that households make in efficiency improvements and the investments that are cost-effective under prevailing economic conditions (Gerarden et al., 2015; Gillingham and Palmer, 2014; Jaffe and Stavins, 1994; Sorrell et al. 2004). Third, while previous DCEs on residential heating systems were carried out in one country (Finland, Germany, or UK), our DCE was simultaneously implemented in three countries (Poland, Sweden, and UK). Heating demand is high in these countries, but there are substantial differences in experiences with EEOS. The UK employs EEOS since 1994; Poland originally introduced EEOS in 2011, but the system has undergone substantial revisions in 2016. Sweden has never implemented EEOS. Our DCEs explicitly allow for heterogeneity of participants' preferences for particular attributes related to income and age, which have been found in empirical studies to be related with household adoption of heating-related investments in retrofit measures or low-carbon heating systems (e.g., Michelsen and Madlener, 2012, 2016; Schleich et al., 2019; Schleich, 2019; Trotta, 2018).

We organize the remainder of the paper as follows. Section 2 describes the methodology including the survey, the DCE for heating systems, and the econometric model. Section 3 presents the results. Section 4 discusses the main findings. Finally, Section 5 concludes the article and offers policy implications.

2 Methodology

2.1 Survey

Our survey was fielded simultaneously in Poland, Sweden, and the UK in July and August 2018 using an existing online household panel provided by NORSTAT. In each country, participants were selected via quota sampling to obtain representative samples in terms of age, gender, income, and regional population distribution. The main part of the survey comprised of a DCE for heating systems. Because tenants typically do not purchase heating systems, only owner-occupiers were qualified to participate in this DCE.

In addition, the survey included items on building characteristics, energy costs, household socio-economic characteristics, and on participants' perceptions of their electricity provider and their sources of information regarding energy efficiency. Professional translators translated the survey from English into Polish and Swedish. Translations were then proofread by native speakers with knowledge of energy efficiency in the residential sector and in survey design. Prior to implementation (and translation), 50 pre-tests were conducted with participants from the access panel Prolific Academic in the UK, resulting in slight adjustments of wording.

2.2 Discrete choice experiment

At the beginning of the DCE, participants were asked to imagine that their heating system had broken down and thus needed to be replaced. The following framing was used to introduce the choice experiment (see also Appendix Figure A1):

“Imagine your heating system has broken down and you need to buy a new one. On the following pages, different options for a new heating system will be

offered to you. We would like to know which heating system you would choose, if these were your only options[1]

Please assume that all heating systems can be installed in your home and that their fuel type is the one you would like to have (for example oil, gas, coal, wood, other biomass, solar, air, water or geothermal heat).

Participants then had to make a series of choices between different heating system purchase options[2]. These options differed by purchase price, capacity to reduce participants' heating costs, time needed for installation, warranty period, amount of available subsidies, and whether the subsidy is offered by a public agency or a private energy company (attributes and levels are summarized in Table 1)[3]. All attributes were chosen to represent relevant information for customers choosing a heating system, and the attributes were independent of one another. The purpose of this choice experiment was to study household preferences and preference heterogeneity with regard to subsidies from public or private providers. Similar to Achtnicht and Madlener (2014), but unlike Rouvinen and Matero (2012), features such as different heating technologies or fuel type were thus not considered. Previous DCEs on heating systems included similar price levels as well as attributes for energy savings, warranty period and subsidies.

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1 Adapted from similar framing for a DCE for refrigerators in Ward et al. (2011) and Li et al. (2016).

2 Because in this DCE, respondents are "forced" to choose one amongst the proposed alternatives, a status quo (current choice) or «do nothing » situation is not included.

3 We adjusted the monetary amounts shown to the participants by country. To ensure comparable purchasing power across countries, we used the following exchange rates to the Euro (used as reference currency): Poland 1€ = 3 PLN; Sweden 1€ = 10 SEK, and UK 1€ = £1.

Table 1: Levels of different attributes considered in the choice experiment

Attribute	Levels
Heating bill	25% less, 50% less, 75% less
Installation	Half a day, three days, one week
Warranty	2 years, 5 years, 10 years
Purchase price	€3 000, €5 000, €8 000, €12 000, €15 000, €20 000
Subsidy	0%, 5%, 15%, 25% (of the purchase price)
Subsidy provider	Public agency, energy provider, no subsidy provider [if subsidy = 0%]

Heating systems in the hypothetical choice experiment allowed participants to reduce their heating costs by 25, 50 or 75 percent, reflecting that new heating systems are more energy efficient than the old systems. In the analysis, we used participants' reported heating costs. In cases where these were missing or took on unreasonable levels, they were estimated based on stated dwelling characteristics. That is, for participants who failed to report their heating costs or provided unreasonable figures, we estimated those costs using information on the type and age of the building, the total living area, geographical location, the heating system and thermal insulation measures implemented in the past. Note that similar to Achtnicht and Madlener (2014), but unlike Rouvinen and Matero (2012), our DCE does not distinguish different heating technologies or fuel types.

As discussed in the paper’s introduction, EEOS are being implemented throughout the EU. From an end customer viewpoint, the complex EEOS mechanisms that are often implemented (e.g., auctions) are not visible since these are dealt with at the level of the intermediaries. In this DCE, we therefore focus on the characteristics of EEOS that are visible to end customers, that is, rebate amount and who finances the rebate (public funding or private funding in the case of an EEOS).

2.3 Econometric models

To estimate the DCE, we employ a mixed logit model for each country sample. In contrast to standard conditional logit models, mixed logit models do not depend on the so-called Independence of Irrelevant Alternatives (IIA) assumption. In addition, mixed logit models allow parameters to vary across individuals (Revelt & Train, 1998).

In our choice experiment, *N* participants take part in a series of *T = 12* choice sets with 2 alternatives each. N differs across the three countries. The 12 choice sets are divided into two blocks. Each participant is randomly assigned to one of the blocks. Hence, each participant sees six choice sets. The latent utility of participant n choosing alternative j in the choice set t can then be expressed as:

$$U_{njt} = \beta_n X_{njt} + \varepsilon_{njt}, n = 1, \dots, N, \quad j = 1,2, \quad t = 1, \dots, T \tag{1}$$

where X_{njt} is a vector of the heating system attributes, ε_{njt} is an error term assumed to follow an extreme-value Gumbel distribution. Finally, β_n is a vector of random parameters that varies across participants, characterized by a density function $f(\beta|\theta)$ with a vector of parameters θ (Train, 2003). As is standard in the literature, we assume β_n to be normally distributed.

These assumptions imply the following conditional probability of the observed sequence of choices for a known β_n:

$$\mathrm{P}_n(\beta_n) = \prod_{t=1}^{T} \frac{\exp(\beta_n X_{nit})}{\sum_{j=1}^{J} \exp(\beta_n X_{njt})} \tag{2}$$

Because β_n is unknown, to obtain the unconditional probability $\mathrm{S}_n(\theta)$, the conditional probability in equation (2) needs to be computed, using the density function of β:

$$\mathrm{S}_n(\theta) = \int P_n(\beta_n) f(\beta|\theta) d\beta \tag{3}$$

The log likelihood function can then be written as:

$$LL(\theta) = \sum_{n=1}^{N} \ln \mathrm{S}_n(\theta) \tag{4}$$

Because a closed-form solution does not exist for equation (4), the parameters are estimated through simulations. The simulated log likelihood is obtained by running a simulation with *R* Halton draws (Train, 2003):

$$SLL(\theta) = \sum_{n=1}^{N} \ln \left\{ \frac{1}{R} \sum_{1}^{R} \mathrm{P}_n(\beta^r) \right\} \tag{5}$$

where β^r is the r^{th} draw from $f(\beta|\theta)$. We used *R* = 250.

The marginal WTP for an attribute x may then be estimated as.

$$\widehat{WTP}_x = -\frac{\hat{\beta}_x}{\hat{\beta}_p} \tag{6}$$

where $\hat{\beta}_x$ is the estimated random parameter associated with attribute x, and $\hat{\beta}_p$ is the estimated price parameter.

For each country, we estimate two specifications of the mixed logit model. The first model (*base model*) includes only attributes from the stated choice experiment. The utility function corresponding to the *base model* is then:

$$U_{njt} = \beta_1 priceb + \beta_2 subsidy\_pub + \beta_3 subsidy\_priv + \beta_4 saving + \beta_5 install + \beta_6 warranty + \varepsilon_{njt}. \tag{7}$$

In constructing *priceb* the rebate was directly subtracted from the purchasing price (in Euros) (see for instance Achtnicht and Madlener, 2014; Train and Atherton, 1995). The variable *subsidy_pub* took on the value of the subsidy in each option (in Euros) if the subsidy was provided by the government and zero otherwise. Similarly, the variable *subsidy_priv* took on the value of the subsidy (in Euros) if the subsidy was offered by the energy provider and zero otherwise. For estimation of the model, *priceb*, *subsidy_pub* and *subsidy_priv* were scaled by dividing the respective values in each option by 1000. The variables *install* and *warranty* are continuous and refer to installation time (in days) and warranty period (in years), respectively. The variable *savings* refers to households' heating cost savings (in Euros). *Savings* was constructed by multiplying participants' reported or estimated heating costs with the percentage heating costs savings in each option in the choice experiment[4].

In comparison, the second model (*socio-demographics interaction model)* includes interaction terms for individual characteristics (age and income) with all attributes except *priceb*. The utility function corresponding to the *socio-demographics interaction* is:

$$U_{njt} = \beta_1 priceb + (\beta_2 + \beta_3 elder + \beta_4 lowinc) \times subsidy\_pub + (\beta_5 + \beta_6 elder + \beta_7 lowinc) \times subsidy\_priv + (\beta_8 + \beta_9 elder + \beta_{10} lowinc) \times saving + (\beta_{11} + \beta_{12} elder + \beta_{13} lowinc) \times install + (\beta_{14} + \beta_{15} elder + \beta_{16} lowinc) \times warranty + \varepsilon_{njt}. \tag{8}$$

4 We used estimated heating costs when no reported heating costs were available or when the difference between reported and estimated annual heating costs was larger than 750€.

Household income was measured in three categories in the screening questions (low, medium, and high income), using income levels provided by the market research institute for each country. The dummy variable *lowinc* took on the value 1 if reported household income was in the lowest income quartile of a country. Similarly, the dummy variable *elder* was set equal to 1 if the participant was at least 55 years old (based on the survey questionnaire).

3 Results

We first present the results for the *base model*, which only includes the attributes. Then we show the findings for the *socio-demographics interaction model*, in which the attributes were interacted with dummies for low income and high age.

3.1 Results for base model

Looking at the bottom part of Table 2, we observe that for all three countries, some standard deviations of the coefficient estimates are statistically significant, suggesting heterogeneity across participants. N reflects the number of observations used in the econometric analysis after cleaning the data (i.e. excluding incomplete responses). The number of participants can be calculated as N/12 (dividing for number of options displayed to each participant).

Turning to the top part of Table 2, we note that most coefficients associated with main effects are statistically significant. In particular, the coefficient associated with price is, as expected, negative. Hence, an increase in the price (net of any subsidy) lowers the latent utility and hence the propensity to purchase a particular heating system. For Sweden and the United Kingdom, the coefficient associated with *subsidy_pub* fails to be significant at conventional levels. This implies that an additional Euro of subsidies provided by a public agency has the same effect as a price decrease of one Euro. In comparison, for all three countries, the coefficient associated with *subsidy_priv* is statistically significant but differs in sign across countries. For Poland, the coefficient is positive, suggesting that an additional Euro offered by an energy provider as a rebate is equivalent to a price decrease of more than one Euro. In contrast, respondents from Sweden and the UK value an additional Euro of subsidies offered by an energy provider by less than one Euro.

Table 2: Results for *base model* in preference space†

	Poland	**Sweden**	**United Kingdom**
Mean			
priceb	-0.181***	-0.167***	-0.133***
	(0.000)	(0.000)	(0.000)
subsidy_pub	0.114***	-0.010	-0.049
	(0.000)	(0.777)	(0.148)
subsidy_priv	0.106***	-0.118***	-0.065**
	(0.005)	(0.001)	(0.045)
savings	0.003***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)
install	-0.080***	-0.027	-0.013
	(0.000)	(0.285)	(0.549)
warranty	0.123***	0.156***	0.080***
	(0.000)	(0.000)	(0.000)
Standard Deviation			
subsidy_pub	0.002	-0.092	0.014
	(0.981)	(0.628)	(0.935)
subsidy_priv	0.243***	0.021	0.010
	(0.000)	(0.864)	(0.909)
savings	-0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)
install	-0.009	-0.025	-0.107
	(0.915)	(0.852)	(0.221)
warranty	0.085***	0.109***	0.029
	(0.000)	(0.000)	(0.290)
Log likelihood	-2577.307	-2076.831	-2029.715
N	9276	7668	6612

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; †p-values are in parentheses;

In all three countries, respondents dislike longer installation time, but the coefficient associated with *install* is statistically significant in Poland only. Finally, respondents from all three countries prefer longer warranty periods to shorter warranty periods at statistically significant levels.

The reported coefficients in Table 2 denote the coefficients in the latent utility function (scaled by 1000 in case of *priceb*, *subsidy_pub* and *subsidy_priv*). Hence, their magnitude is not very explicative in itself. Therefore, for a more substantive interpretation of the findings, we used equation (6) to calculate the estimated WTP. Table 3 presents the estimated WTP for those attribute-country pairs for which the coefficients in Table 2 turned out to be statistically significant (statistically significant values in bold). These figures reflect the point estimates for participants' average WTP for a one-unit change in the attribute level. Accordingly, in Poland participants are willing to pay around 64 Euro-cents to receive a one Euro rebate by a public agency and 59 Euro-cents for a one Euro rebate from an energy provider. While the point estimates for the rebates differ slightly across funding sources, findings from a Wald test suggest that this difference is not statistically significant. In comparison, in Sweden and the UK, participants' WTP for a subsidy offered by an energy provider is negative. For example, in Sweden, respondents are only willing to pay 29 Euro-cents (= 1€ - 0.71€) to receive a rebate of one Euro by an energy provider. On average, participants from Sweden and the UK are willing to pay one Euro to receive one additional Euro as a rebate from a public agency. Finally, the difference between funding sources is statistically significant in Sweden, but not in the UK.

Table 3: WTP for heating systems attributes in the *base model*

	Poland	**Sweden**	**United Kingdom**
subsidy_pub	**0.63**	-0.06	-0.37
subsidy_priv	**0.59**	**-0.71**	**-0.49**
savings	**15.18**	**14.55**	**9.66**
install	**-441.17**	-162.57	-101.32
warranty	**681.72**	**938.22**	**605.45**

Participants in Poland and Sweden are willing to pay around 15 Euros for an annual energy cost saving of one Euro. In the UK, this amount is about five Euros lower. On average, participants in Poland are willing to pay about 441 Euros more if the time it takes to install the heating system is shortened by one day. For Sweden and the UK, the corresponding amounts are 162 Euros and 96 Euros, but the coefficients used to calculate the WTP are not statistically significant. Finally, participants in Poland are willing to pay 681 Euros more if the heating system comes with an additional year of warranty. In Sweden, the WTP for an additional year of warranty is 938 Euros, in the United Kingdom it is 604 Euros.

3.2 Results for socio-demographic characteristics model

The findings for the socio-demographic characteristics model in preference space appear in Table 4. Only few of the socio-demographic interaction terms in Table 4 turn out to be statistically significant, mostly in the UK. The coefficient for *subsidy_pub*, *subsidy_priv*, *savings*, *install* and *warranty* provide information on how the attributes in the choice experiment are valued by those participants where all interaction terms are set to zero, i.e. by younger participants (<55 years of age) which live in households having a higher income than the lowest quartile. In Poland, participants from lower income households value energy savings less than the "baseline" participants. In Sweden, older participants value rebates from a public agency higher than the "baseline participants. Finally, In the UK, older or higher income households value rebates more than the "baseline" participants.

Table 4: Results for *socio-demographic characteristics model* in preference space†

	Poland	Sweden	United Kingdom
Mean			
priceb	-0.182***	-0.167***	-0.132***
	(0.000)	(0.000)	(0.000)
subsidy_pub	0.080**	-0.116**	-0.022
	(0.044)	(0.015)	(0.621)
subsidy_priv	0.113**	-0.143***	-0.037
	(0.018)	(0.003)	(0.398)
savings	0.003***	0.003***	0.001***
	(0.000)	(0.000)	(0.000)
install	-0.060**	-0.039	0.011
	(0.035)	(0.270)	(0.726)
warranty	0.119***	0.164***	0.085***
	(0.000)	(0.000)	(0.000)
elder_subsidy_pub	0.108	0.254***	0.153**
	(0.109)	(0.001)	(0.037)
elder_subsidy_priv	0.010	0.105	0.188***
	(0.896)	(0.163)	(0.006)
elder_savings	-0.000	0.000	0.000
	(0.153)	(0.885)	(0.363)
elder_install	-0.043	0.008	-0.052
	(0.370)	(0.883)	(0.308)
elder_warranty	0.009	-0.015	-0.029*
	(0.574)	(0.420)	(0.062)
lowinc_subsidy_pub	0.025	0.106	-0.170**
	(0.694)	(0.143)	(0.011)
lowinc_subsidy_priv	-0.024	-0.011	-0.187***
	(0.728)	(0.870)	(0.002)
lowinc_savings	-0.001**	-0.000	-0.000
	(0.042)	(0.150)	(0.294)

	Poland	Sweden	United Kingdom
lowinc_install	-0.025	0.029	-0.019
	(0.568)	(0.583)	(0.681)
lowinc_warranty	0.008	-0.008	0.009
	(0.563)	(0.657)	(0.520)
Standard Deviation			
subsidy_pub	-0.010	-0.076	-0.006
	(0.922)	(0.681)	(0.975)
subsidy_priv	-0.256***	0.016	0.005
	(0.000)	(0.896)	(0.951)
savings	0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)
install	-0.006	-0.007	0.113
	(0.946)	(0.965)	(0.157)
warranty	0.084***	0.109***	0.028
	(0.000)	(0.000)	(0.315)
N	9276	7668	6612

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; † p-values are in parentheses;

4 Discussion

The findings presented in the previous section suggest that rebates for modern heating systems are effective, independent of the funding source for the rebate. Such rebates are particularly effective in Poland, where participants are willing to pay more than one Euro to receive an additional Euro as a rebate. This result is in line with Achtnicht (2011) and Achtnicht and Madlener (2014), who find that the average participant in their sample of homeowners in Germany is willing to pay about 3.3 Euros (Achtnicht, 2011) and 2.5 Euros (Achtnicht and Madlener, 2011) per additional Euro received through a rebate[5]. Thus, on average, participants in Poland appear to enjoy additional, non-monetary benefits from the fact

5 To calculate the WTP in these studies, we used equation (6) and the results for the coefficients in latent utility functions reported in Table 4 in Achtnicht (2011) and Table 6 in Achtnicht and Madlener (2014).

that they receive a subsidy. Alternatively, this outcome may be explained by loss aversion (Kahnemann and Tversky, 1979) presuming that participants in Poland perceive foregoing a rebate as a loss. For Sweden and the UK, rebates appear substantially less effective than for Poland. On average, participants from the UK value one additional Euro of a subsidy by less than one Euro with no statistically significant difference between funding sources for the subsidy. This is similar to the findings by Li et al. (2016) and could indicate that consumers in the UK perceive rebates as signaling low quality. For Sweden, our results suggest that participants would dislike rebates offered by their energy provider (e.g., via EEOS) rather than by a public agency. We can only speculate why this may be the case. Possibly, Swedish participants are less familiar with rebates offered by their energy provider, as Sweden never implemented EEOS (in contrast to Poland and the UK).

On average, participants in the three countries included in our sample were willing to pay between about 10 and 15 Euros for each additional Euro of annual heating costs saved. Put differently, these figures correspond to static payback times of about 10 to 15 years. Thus, our findings on the WTP for energy cost savings appear quite reasonable. Our results on the costs of installations suggest that "hassle costs" are substantial in Poland (441 Euro per day), but may be less of a concern in Sweden and the UK. If hassle costs are higher for more energy-efficient technologies (because they take longer to be installed, e.g., natural gas boiler compared to electric heating), this finding contributes to explaining the energy efficiency paradox (e.g., Jaffe and Stavins, 1994). If transaction costs such as "hassle costs" were accounted for, the magnitude of the energy efficiency paradox would be smaller, and the negative cost potentials documented in the well-known McKinsey reports (e.g., McKinsey, 2013) would shrink. Finally, our estimates for the WTP for an additional year of warranty range between 603 Euros for the United Kingdom and 938 Euros for Sweden. In comparison, for their sample of German homeowners, Achtnicht (2011) and Achtnicht and Madlener (2014) estimate the WTP for an additional year of warranty at 425 Euros and 450 Euros, respectively[6].

In general, we find limited evidence that participants' preferences for heating system attributes vary by socio-demographic factors such as income and age.

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6 Using equation (6) and the results reported in Table 4 in Achtnicht (2011) and in Table 6 in Achtnicht and Madlener (2014), we calculate a WTP of 450 Euros for an additional year of warranty in Achtnicht (2011) and of 425 Euros in Achtnicht and Madlener (2014).

Most notably though, the findings for the United Kingdom suggest that low-income homeowner households and younger households value rebates less than high-income or older households. Thus, offering rebates to homeowner households for modernizing their heating systems may have regressive distributional effects and favor the older relative to the younger generation. In addition, without proper targeting of socio-economic groups, such rebates may entail substantial free-rider effects (e.g., Olsthoorn et al., 2017), that is, subsidies are provided for investments in modern heating systems that would also have been incurred without a subsidy. This result may be explained by high-income households having higher opportunity costs of time. For Poland, our findings suggest that low-income homeowner households value energy cost savings less than high-income households. This outcome may be explained by Newell and Siikamäki's (2015) empirical finding that richer people discount future earnings less than poorer people. Thus, in general, the findings for the income-attribute interaction terms help explain the positive relation between income and household stated investments in retrofit measures or low-carbon heating systems found in the empirical stated adoption literature (e.g., Michelsen and Madlener, 2012, 2016; Schleich et al., 2019; Trotta, 2018). Similar to the UK, older households in Sweden appear to value rebates provided by a public agency more than younger households.

5 Conclusions

A better understanding of the factors driving household investment decisions in energy-efficient heating systems should help governments achieve national and global energy efficiency and greenhouse gas emissions targets. Such an understanding should also help technology providers designing products and services that meet their customers' needs. Employing identical demographically representative DCEs with owner-occupier households in Poland, Sweden, and the UK, we simulate hypothetical choices of a new heating system. The choices differ with respect to purchase price, capacity to reduce participants' heating costs, time needed for installation, warranty period, and amount of available subsidies. In particular, we explore whether rebate effectiveness differs depending on whether it is offered by a public or private funding source. We also allow preferences for these attributes to vary by household income and participant age. More specifically, we distinguish between low-income households (in lowest income quartile of a country) and high-income households, and between older participants (at least 55 years old) and younger participants. Our findings have implications for energy policymakers, manufacturers, retailers and installers of modern heating systems.

Main findings

Our results from estimating country-specific mixed logit models suggest that participants in all three countries value rebates for modern heating systems, but the valuation differs substantially across countries. Such rebates were most valued by participants from Poland, which, on average, were willing to pay more than one Euro to receive an additional Euro as a rebate. In Sweden and the UK, rebates were overall less valued, with respondents willing to pay less than one Euro for an additional Euro as rebate. For Poland and the UK, we found no difference in participants' WTP for a rebate offered by a public or private funding source. In Sweden, however, participants appeared to dislike rebates offered by their energy provider rather than by a public agency. We further found higher income households in the UK and older households in the UK and Sweden to be particularly responsive to rebates.

On average, participants in all three countries seemed to account for heating cost savings when choosing among alternative heating systems. More specifically, the observed choices correspond to plausible static payback times between 10 and 15 years. For Poland (but not for Sweden and the UK), we found statistically significant and quantitatively relevant "hassle costs" (such as the time it takes to install a new heating system). Finally, our results suggest that on average, participants in all three countries care substantially about the length of the warranty period of a new heating system.

Implications for policymakers and companies

Our findings of the DCE for heating systems in three EU Member States have implications for policymaking. The results suggest that rebates help spur the implementation of modern heating systems in all three countries included in this study. Effectiveness, however, varied by country, and was found to be particularly high for Poland. In contrast, for Sweden and the UK, effectiveness of rebates may be low, in particular if they are offered by private companies such as energy providers rather than by a public agency. This is particularly important in light of the implementation of EEOS in the European Union, since with such programs, end customers receive rebates from private actors. This dislike may therefore jeopardize the success of such programs in these countries. In Sweden or the UK, where homeowners may perceive rebates as signaling low quality, rebates for heating systems could be complemented by expert advice, or by reports from organizations providing credible product ratings and reviews such as Consumer Reports. The findings for Sweden suggest that rebates offered by public agencies would be more effective than rebates offered by private companies. Further, our results for the UK imply that rebates for heating systems should be geared towards low-income households to avoid undesired distributional effects. Targeting rebates would also help limiting free-rider problems. In any case, policies to promote the implementation of heating systems may be less effective than expected, if implementation involves substantial "hassle costs" such as the time it takes to implement a new heating system. Thus, failing to account for "hassle costs" and other transaction costs would lead to overestimate the effectiveness of policy measures in ex-ante policy assessments.

Our findings also provide insights for companies. For example, the results of the DCE for warranties suggest that manufacturers and retailers of modern heating systems may be able to increase their market shares by offering longer warranty periods. In particular though, the findings for "hassle costs" suggest that installers who are quick at implementing new heating systems should advertise this ability to gain additional customers. Likewise, when designing their products, manufacturers should take into account installation time. In addition, "hassle costs" imply that households may prefer a one-stop solution where all energy-saving measures are implemented at once, rather than a step-by-step approach typically involving larger "hassle" costs. This suggestion is consistent with the business model retained by a new business actor, energiesprong (energysprong.eu). Energiesprong uses prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installation to transform existing houses into net zero energy houses within about one week (and without residents having to leave their homes)[7]. A refurbishment comes with a warranty on energy performance for up to 40 years. Energiesprong started in the Netherlands, but its activities have by now spread to other countries like Belgium, France, Germany, and Italy.

7 A net zero energy house generates the total amount of energy needed for its heating, hot water and electrical appliances.

References

Achtnicht, M. (2011): Do environmental benefits matter? Evidence from a choice experiment among house owners. Ecological Economics 70, 2191–2200.

Achtnicht, M.; Madlener, R. (2014): Factors influencing German houseowners' preferences on energy retrofits. Energy Policy 68, 254–263.

Carlsson-Kanyama, A.; Lindén, A.-L.; Eriksson, B. (2005): Residential energy behaviour: does generation matter? International Journal of Consumer Studies 29, 239–253. doi:10.1111/j.1470-6431.2005.00409.x.

ChoiceMetrics (2014): Ngene 1.1.2.: User manual and reference guide. The cutting edge in experimental design. Choice Metrics Pty Ltd.

Curtis, J.; McCoy, D.; Aravena, C. (2018): Heating system upgrades: The role of knowledge, socio-demographics, building attributes and energy infrastructure. Energy Policy 120, 183-196.

ENSPOL (Energy Saving Policies) (2015): Energy Saving Policies and Energy Efficiency Obligation Scheme. D2.1.1: Report on existing and planned EEOs in the EU – Part I: Evaluation of existing schemes, March 2015.

European Commission (2019): Report from the Commission to the European Parliament and the Council. 2018 assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive as required by Article 24(3) of the Energy Efficiency Directive 2012/27/EU. Brussels, COM (2019) 224 final.

Fawcett, T.; Rosenow, J.; Bertolid, P. (2019): Energy efficiency obligation schemes: their future in the EU. Energy Efficiency 12, 57–71.

Gerarden, T.; Newell, R.G.; Stavins, R.N. (2015): Deconstructing the energy-efficiency gap: Conceptual frameworks and evidence. American Economic Review: Papers and Proceedings 105, 183–186. doi:10.1257/aer.p20151012.

Gillingham, K.; Palmer, K. (2014): Bridging the energy efficiency gap: Policy insights from economic theory and empirical analysis. Review of Environmental Economic Policy 81(1), 18–38.

IEA (International Energy Agency) (2018): World Energy Outlook. IEA-OECD. Paris.

Jaffe, A. B; Stavins, R.N. (1994): The energy paradox and the diffusion of conservation technology. Resource and Energy Economics 16, 91–122.

Kahneman, D.; Tversky, A. (1979): Prospect theory: An analysis of decision under risk. Econometrica 66, 497–527.

Li, X.; Clark, C. D.; Jensen, K. L.; Yen, S. T. (2016): The effect of mail-in utility rebates on willingness-to-pay for ENERGY STAR certified refrigerators. Environmental and Resource Economics 63(1), 1–23.

McKinsey (2013): Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve. McKinsey&Company.

Michelsen, C.C.; Madlener, R. (2012): Homeowners' preferences for adopting innovative residential heating systems: a discrete choice analysis for Germany. Energy Economics 34(5), 1274–1283.

Michelsen, C.C.; Madlener, R. (2016): Switching from fossil fuel to renewables in residential heating systems: An empirical study of homeowners' decisions in Germany Energy Policy 89, 95–105.

Newell, R.G.; Siikamäki, J. (2015): Individual time preferences and energy efficiency. American Economic Review: Papers & Proceedings 2015, 105(5), 196–200. http://dx.doi.org/10.1257/aer.p20151010.

Olsthoorn, M.; Schleich, J.; Gassmann, X.; Faure, C. (2017): Free riding and rebates for residential energy efficiency upgrades: A multi-country contingent valuation experiment. Energy Economics 68(S1), 33–44.

Revelt, D.; Train, K. (1998): Mixed logit with repeated choices: households' choices of appliance efficiency level. Review of Economics and Statistics 80 (4), 647–657.

Sándor, Z.; Wedel, M. (2001): Designing conjoint choice experiments using managers' prior beliefs. Journal of Marketing Research 38, 430–444.

Schleich, J. (2019): Energy efficient technology adoption in low-income households in the European Union – What is the evidence? Energy Policy 125, 196–206.

Schleich, J.; Gassmann, X.; Meissner, T.; Faure, C. (2019): A large-scale test of the effects of time discounting, risk aversion, loss aversion, and present bias on household adoption of energy-efficient technologies. Energy Economics 80, 377–393.

Sorrell, S.; O'Malley, E.; Schleich, J.; Scott, S. (2004): The economics of energy efficiency: Barriers to cost-effective investment. Edward Elgar, Cheltenham, UK.

Trotta, G. (2018): Factors affecting energy-saving behaviours and energy efficiency investments in British households. Energy Policy 114, 529–539.

Ward, D. O.; Clark, C. D.; Jensen, K. L.; Yen, S. T.; Russell, C. S. (2011): Factors influencing willingness-to-pay for the ENERGY STAR® label. Energy Policy 39(3), 1450–1458.

Appendix A

Figure A1: Screen shot of framing of discrete choice experiment on heating systems.

Introduction

Imagine **your heating system has broken down and you need to buy a new one.** On the following pages, different options for a new heating system will be offered to you. We would like to know **which heating system you would choose, if these were your only options.**

Please assume that all heating systems can be installed in your home and that their fuel type is the one you would like to have (for example oil, gas, coal, wood, other biomass, solar, air, water or geothermal heat). The options offered to you differ only on the following attributes:

1. Heating bill: Your current **heating costs will be reduced** by 25, 50, or 75 percent.
2. Installation: Installation will take **half a day, three days, or one week.**
3. Warranty: The **warranty** for each heating system is 2, 5, or 10 years.
4. Purchase price: The amount of **money you must pay for the heating system** (including installation). Costs are £3 000, £5 000, £8 000, £12 000, £15 000, or £20 000.
5. Subsidy: The amount of **money you may receive from public or private funding sources when you buy a heating system.** Subsidies are 0, 5, 15, or 25 percent of the purchase price. The purchase price does not include this subsidy.
6. Subsidy provider: The subsidy is provided by **a public agency** (public funding), or by an **energy provider** (private funding).

Figure A2: Example of a scenario shown to participants in the heating system choice experiment in the UK.

Scenario 1

Which heating system would you choose?

	Option A	Option B
Heating bill	25% less	75% less
Installation	3 days	half a day
Warranty	5 years	5 years
Purchase price	£3 000	£5 000
Subsidy	0%	15% (£750)
Subsidy provider	None	Energy provider

	Option A	Option B
I choose:	○	◉

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Karlsruhe 2020