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The Role of Information on the Adoption of Heat Pumps: Experimental Evidence from Germany

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The Role of Information on the Adoption of Heat Pumps: Experimental Evidence for Germany

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Abstract

As the heating sector typically accounts for a sizable share of carbon emissions in many countries, a better understanding of the determinants of households' investment decisions on their heating systems is key for supporting the sector's decarbonisation. To this end, we conducted a survey experiment among about 3,000 German households in 2023, utilising a Multiple Price List framework with repeated choices between two alternatives: a heat pump and a fossil-based heating system. The results indicate that the provision of information on operating and investment cost may increase the willingness to pay for a heat pump, compared to a fossil-based system. Providing additional information on the uncertainty associated with cost projections has a similar effect. In contrast, risk aversion, time preferences and financial literacy are not significantly related to the choice. Our findings suggest that the provision of transparent information on cost can foster the transition to renewable heating solutions if these exhibit a cost advantage.

Keywords: energy policy; heating; information provision; survey experiment

JEL classification: D12, D81, H23

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1 Introduction

In contrast to many other European countries, most notably Denmark and Norway, Germany is yet to start the decarbonisation of its heating sector, although the heating of buildings and water accounts for some 20 % of Germany's carbon emissions (BDEW, 2021). To this end, Germany recently stipulated the aim of establishing a stock of six million heat pumps by 2030, which is a multiple of the stock of about 1.7 million heat pumps in 2023 (BWP, 2024). To facilitate achieving this, the German government revised the Building Energy Act (GEG) to prescribe the installation of heating systems, such as heat pumps, that are operated with at least 65 % of renewable energy in new buildings as of 2024. In addition, this legislation strongly promotes the implementation of heat pumps in existing buildings (Gebäudeenergiegesetz, 2023).

Upfront, enacting this legislation sparked a 'heated' debate on the right way to reduce carbon emissions in the heating sector. Heating systems are often used for two or more decades (Elsland et al., 2014). Hence, when homeowners decide to install a fossil-fuel-based system today, they are 'locked-in' for a long time period, with significant consequences for the heating sector's emissions balance if fossil systems continue to be installed on a large scale. Yet, contrary to the spirit of the legislation, the installation of heating systems based on natural gas reached a new maximum of nearly 800,000 units in Germany in 2023 (NTV, 2024). Simultaneously, heat pump installations also saw a record level of about 350,000 (BWP, 2024).[1]

Against this background, it is pivotal to understand how households decide on their heating systems. As with any investment, the cost is likely to play a key role for this decision, an assumption that is supported by recent research by Davis (2024), who finds that heat pump adoption is correlated with energy prices, i.e., cost of operation. Heating systems come with two types of cost: the upfront investment cost and the continuous cost of operation (Nesbakken, 2001). While the investment cost is relatively certain, the future operating cost depends on the development of fuel or electricity prices and, in Germany, on carbon prices and is, therefore, uncertain. As the cost structures of fossil systems and

[1] In fact, 2023 has seen a record level for the total number of heating systems, with more than 1.3 million systems being installed, a level not seen since German reunification (BDH, 2024).

heat pumps differ, with heat pumps being more capital-intensive (IEA, 2022), it is unclear ex ante which system is most cost-efficient over the life cycle.

Moreover, it is conceivable that uncertainty regarding future price development and the relative novelty of heat pumps, compared to fossil systems, are factors hampering heat pump adoption: Adopting a heat pump might be considered a riskier option, and, due to risk aversion, households may be hesitant to adopt a heat pump. If households had a more complete set of information on the cost associated with different heating solutions, as well as a uncertainty regarding this cost, this would enable them to make more informed choices.

Contributing to the growing literature on heating choices, specifically on the adoption of electric heating appliances (see, e.g., Borenstein and Bushnell, 2022; Davis, 2023, 2024), this paper investigates the impact of information on the choice between a fossil-fuel-based heating system and a heat pump, thereby adding to the literature on the impact of information provision on household decision making in the energy context (e.g. Jessoe and Rapson (2014); Aydin et al. (2018); Allcott (2011)). To investigate the influence of cost information and of transparency about the uncertainty associated with future cost projections, we conducted a large-scale survey experiment among approximately 1,400 German households.[2] Using a Multiple Price List (MPL), we asked respondents to make ten repeated choices between (i) a replacement of their current (natural gas or heating oil) heating system, and (ii) an air-to-water heat pump. The investment costs for (i) were kept constant, while the costs for (ii) were gradually lowered. This design allowed us to infer the price premium that respondents were willing to pay (or, if negative, the price advantage needed) for a heat pump compared to a fossil fuel system. This information can also be used to infer the necessary level of subsidies for heat pumps. Our experiment included three experimental groups, which allowed us to single out the effects of cost information provision (the Information treatment) and information on cost uncertainty (the Uncertainty treatment).

The results of our empirical analysis suggest that information has a significant impact

[2]Our experiment was pre-registered online at the American Economic Association's registry for randomized controlled trials before receiving the data to analyse results (RCT ID: AEARCTR-0012323). The trial information registered included information on the experimental design, our hypotheses and analyses. We will refer to the hypotheses outlined in the pre-registration throughout this paper.

on the price premium households are willing to pay for a heat pump. The positive effect of the information treatment, which informs that, over the life cycle of the heating system, a heat pump would be the more economical solution, could indicate that households are otherwise unaware of the heat pump's (purported) cost advantage. The effect of the Uncertainty treatment on the price premium is of a similar magnitude as the effect of the Information treatment, which is likely due to the fact that this treatment, too, concluded that heat pumps were likely to be the more economical choice.

Irrespective of the treatment, we do not find indications that risk aversion, time preferences or financial literacy are related to the willingness to pay for a heat pump. Not least, our analysis reveals a significant difference in the heating choices of owners and tenants. Households owning their accommodation exhibit, on average, a lower willingness-to-pay for heat pumps, which might partly be attributable to the choice situation being less realistic for tenants. Although tenants were informed that the cost of replacement could increase their future rent, this information may not have been fully taken into account for the decision.

The main policy implication of our results is that, should heat pumps or, more generally, sustainable heating solutions have a cost advantage compared to fossil fuel solutions, transparency about the cost associated with different heating solutions needs to be improved. Should the cost advantage not be given (yet), politics should enact measures to create such a cost advantage for sustainable solutions, for instance via effective carbon pricing.

The following Section 2 describes the data and the sample composition. Section 3 explains the experiment in detail. Subsequently, Section 4 provides the pre-registered hypotheses and 5 details the empirical approach chosen to analyse the experiment, followed by the presentation and discussion of the results in Section 6. Section 7 summarises and concludes.

2 Data

Our experiment was embedded in a larger survey on different sustainability topics that was conducted from mid-September to early October 2023. This survey was the third wave of a multi-year panel that comprises data on several socio-ecological aspects of German households. The survey was conducted by *forsa*, a survey institute that maintains a panel of more than 100,000 individuals representative of the German-speaking internet users aged 14 and above. *forsa* collected the data online using a state-of-the-art survey tool. Participants were able to interrupt and resume the survey at any time.

From a total of 4,501 respondents in the survey, 3,057 took part in the experiment because only individuals using either natural gas or heating oil for heating were assigned to the experiment. Starting from the remaining 3,057 respondents, we excluded further subgroups for the actual estimation. 217 individuals did not indicate responses in the experiment. A further 842 respondents indicated that they did not know which heating system they preferred. This reply was more common among tenants (377 of 1,027) than among owners (465 of 2,030), suggesting that the choice situation is less realistic for tenants. Lastly, the inclusion of certain socio-economic characteristics or other attributes of the individuals and/or their households as control variables necessitated the exclusion of a further 624 individuals who did not provide information on all necessary characteristics. The final sample for the estimation comprised 1,374 individuals. Table A2 in Appendix A.3 illustrates the adjustment of the final sample.

Table 1 shows summary statistics for the socio-economic characteristics of the respondents in our final estimation sample. To some extent, the final estimation sample differs from the overall German population: respondents in our experiment tend to have a higher income, tend to be older and more educated, and own their accommodation more often than the German average (see Table A3 in the Appendix). Therefore, the results of this paper cannot be assumed to hold for the entire German population. This lack of external validity does not, however, impair the internal validity of results. Within the experiment itself, the treatment effects can be estimated reliably due to the random allocation of treatments.

Table 1: Socio-economic statistics of the final estimation sample

Variable		**Mean**	**Std. Dev.**
Household size	Number of people living in the household	2.18	0.94
Female	Dummy = 1 if respondent is female	0.39	-
Age	Age of respondent	56.81	14.64
Income	Monthly net household income in euros	3,876	1,469
Academic	Dummy = 1 if respondent has university / college degree	0.45	-
Ownership	Dummy = 1 if respondent owns his/her accommodation	0.68	-
No. of observations	1,374		

Note: In our measure of household size, households with 4 or more members are counted as a 4-person household. Hence, our measure of household size is likely to be slightly downward biased. Income is measured in intervals. For calculating the income measure shown, we convert each observation to the midpoint of its respective interval.

3 Experimental Design and Covariates

Only respondents using natural gas or heating oil as their current heating fuel took part in the experiment, and only those respondents who either own or rent their accommodation.[3]

3.1 The Experiment

At the outset of the experiment, respondents were asked to imagine that the current heating system of their building was damaged and needed to be replaced on short notice. They were presented with two options for replacement:

(i) An equivalent of their current, fossil heating system.

(i) An air-to-water heat pump.

The introductory information to the experiment differed between tenants and homeowners (see Appendix A.2). While, in reality, owners usually make the decision and investment themselves, this is generally not the case for tenants. Therefore, we asked tenants to imagine that they can advise the owner on the decision instead of taking the decision themselves. This setup should be more realistic for tenants. We also reminded tenants that, as a result of the replacement of their heating system, their annual rent may be increased by up to 8 % of investment costs according to German law. This aspect implies that tenants in the experiment should have generally been aware that higher investment

[3] A small minority of 1.71 % lived in their accommodation free of charge.

costs for the owner could result in higher rent for themselves, i.e., that their advice to the owner could also have financial impact on themselves. In addition, we reminded tenants that they would have to bear the operating costs of the new heating system.

Before receiving any further information, and before making a choice between options (i) and (ii), respondents were asked to provide an estimate of the anticipated expenses for purchasing and installing the two solutions presented to them. They were also asked to indicate the expected annual (owners) and monthly (tenants) heating costs of both options. We differentiated between owners and tenants because owners usually receive their bill of heating cost once per year, while tenants often pay their heating costs monthly as part of their rent. Subsequently, the study participants were randomly split into three experimental groups: the treatment group Information, the treatment group Uncertainty and the control group.

Next, participants in both the Information and the Uncertainty group received information about the average cost associated with the installation and operation of the two heating alternatives. The information was taken from a study commissioned by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) (BMWK, 2023). Respondents further received the information that, according to the aforementioned study, an air-to-water heat pump would be the cheaper of the two alternatives over the whole life cycle of the heating system. Respondents were presented with the assumptions about investment and operating costs, useful life, and the annual development of electricity and fossil fuel prices underlying this assessment (see Appendix A.2).

In addition, the Uncertainty group was informed that the future development of electricity and fossil fuel prices presented in the study was based on projections, such that the numbers stated in the study were subject to uncertainty. In other words, the actual prices could turn out to be lower or higher than presented, such that the presented savings when investing into a heat pump were not guaranteed. For electricity prices, respondents were informed that, until 2045, they may decrease by up to 25 % or increase by up to 15 %, while natural gas prices were presented as increasing by between 3 % and about 50 % (see Appendix A.2).[4] Participants in the control group, by contrast, did not receive

[4]The information on potential price development was based on a study by Fraunhofer ISE and Fraunhofer IEE (Thomsen et al., 2022) (tables 19 and 24 therein).

any information on the cost of the two options or the uncertainty associated with it.

Participants in the Information group spent, on average, about 50 seconds on the screen that provided their treatment. In the Uncertainty group, the mean time spent on the screen was about 57 seconds, indicating that the additional information provided to the Uncertainty group, as compared to the Information group, has, at least to some extent, been picked up by respondents.[5]

Afterwards, respondents were shown a multiple price list (MPL) (Table 2), which comprised ten choices between two options: an oil or gas heating system and a heat pump. We asked respondents to assume that all characteristics of the two heating options (apart from the costs), such as comfort, were practically the same. Each option was associated with a price corresponding to the investment costs, but not including the future cost of operation. While the investment costs for the fossil fuel system were held constant at the actual average investment costs as provided by the BMWK study, the investment costs for the heat pump were lowered by 10 percentage points in each step, thereby coming closer to, and eventually being lower than, the price of the fossil fuel solution. For each of the ten purchase price pairs, we asked respondents to indicate their choice between the fossil fuel system and the heat pump. After making their choices, respondents also indicated what aspects they had considered when making their decisions, how reliable they deemed the cost information provided, and whether they had taken the previously provided information about the heating systems and their costs into account.

3.2 Risk and Time Preferences, Financial Literacy, and Environmental Attitudes

In a later part of the survey, we also elicited the respondents' risk and time preferences, their financial literacy as well as their environmental attitudes (see Appendix A.2.1 for details). To obtain incentive-compatible answers, respondents could win vouchers, the value of which was based on their answers in the risk and time preferences exercises. We based the elicitation of time preferences on Meier and Sprenger (2010): respondents made several choices between a voucher that they would receive one month after the survey

[5]To prevent bias from outliers, the numbers stated were calculated excluding the top 1 % of time counts.

Table 2: Multiple Price List used in the experiment

(i) **Fossil fuel heating system (oil or gas)**	(ii) **Heat pump**
10.980 Euro	28.620 Euro
10.980 Euro	25.758 Euro
10.980 Euro	22.896 Euro
10.980 Euro	20.034 Euro
10.980 Euro	17.172 Euro
10.980 Euro	14.310 Euro
10.980 Euro	11.448 Euro
10.980 Euro	8.586 Euro
10.980 Euro	5.724 Euro
10.980 Euro	2.862 Euro

and a voucher they would receive six months after the survey. The latter voucher always had a value of 30 euros, while the value of the former voucher varied between 29 and 9 euros. As in Meier and Sprenger (2010), we calculate the monthly discount rate based on the last choice situation in which respondents choose the smaller, earlier payment over the larger, later payment. We also include respondents who show inconsistent choice behaviour, i.e., who switch multiple times, by using the first switching point observed to calculate their discount factor (as Meier and Sprenger (2010) do in a robustness check). Excluding individuals with inconsistent time preferences does not notably impact the estimation results in the remainder of this paper (see Table B7 in Appendix B.3).

We based the assessment of risk preferences on Holt and Laury (2002). Respondents made repeated choices between two lotteries that determined the value of a voucher they could potentially receive. Each lottery had two potential outcomes, which were assigned varying probabilities. The difference between the two outcomes of one lottery was smaller than the respective difference in the other lottery (see Appendix A.2). As in Holt and Laury (2002), we use the number of times a respondent chooses the less extreme (i.e., safer) lottery as an indicator of risk aversion. The 'Risk aversion' variable we will use throughout the paper is, thus, a count variable between 0 and 10, with a higher number corresponding to a higher degree of risk aversion. Respondents that exhibit inconsistent choice behaviour in the lottery, i.e., that switch back and forth multiple times, are included in the analysis, following Holt and Laury (2002). Excluding them from the

Table 3: Further statistics of the final estimation sample

Variable	Mean	Std. Dev.
Risk aversion	5.35	2.71
Monthly discount rate (time)	0.02	0.03
Financial literacy	0.79	-
Env. attitudes	11.06	3.09
No. of observations 1,374		

Note: The monthly discount rate is measured in percentage terms, i.e., it averages at c. 1.7 % in the sample.

regressions does not notably impact results (see Table B7 in Appendix B.3).

To assess financial literacy, following Lusardi and Mitchell (2011), we asked respondents to solve an arithmetical problem associated with interest rates and compound interest. Our dummy indicator for financial literacy indicates whether respondents solved this exercise correctly or not. Lastly, to assess respondents' environmental attitudes, we used a shorter variant of the original Diekmann and Preisendörfer scale (2003), which covers all its three spheres – affective, cognitive, and conative. The measure is calculated based on three questions on respondents' environmental attitudes (see Appendix A.2.1). Each answer is assigned a score from 1 to 5, which are then added up to an overall score ranging from 3 to 15 points, where a higher score indicates a higher pro-environmental attitude.

Table 3 provides summary statistics on the characteristics discussed. The mean number of safe choices in the risk aversion elicitation exercise (5.35) is broadly in line with the numbers Holt and Laury (2002) report in their experiment, for which they use lotteries with different payoff levels. The monthly discount rate of about 2 % is significantly lower than the rate reported in the sample of Meier and Sprenger (2010), but still relatively large when viewed relative to annual discount rates.[6] The mean of 0.79 for the financial literacy variable indicates that nearly 80 % of the final estimation sample solved the arithmetical problem correctly and can, thus, be considered financially literate in the context of this paper.

[6]The difference between the average discount rates of our experiment and that of Meier and Sprenger (2010) might partly be due to a different setup of the experiment as Meier and Sprenger (2010) compare choices that are one month apart, while we compare choices that are five months apart.

4 Pre-Registered Hypotheses

We have pre-registered our experiment with the AEA's registry for randomized controlled trials. Our pre-registration listed several hypotheses that we planned to test with the experiment.

Firstly, we expected that individuals in the Information group would be willing to pay a higher price premium for the heat pump than individuals in the control group. The reason for this is that respondents in the Information group were informed that, over the whole lifespan, the heat pump is associated with lower costs than a fossil fuel heating system.

Hypothesis 1: Study participants in the Information group will prefer the heat pump to the fossil fuel system at higher investment costs for the heat pump than participants in the control group.

Moreover, we expected participants in the Uncertainty group to show a lower willingness to pay for a heat pump than participants in the Information group because the information about the uncertainty of future fuel and electricity prices might lead the Uncertainty group to stick to the more familiar choice of fossil fuel heating due to risk aversion. We hypothesised that the effect of general uncertainty induced by this treatment would outweigh the effect that the Uncertainty group is informed that the potential corridor of price developments looks more negative (i.e., prices rising more) for natural gas prices than for electricity prices.

Hypothesis 2: Study participants in the Uncertainty group will prefer the heat pump to the fossil fuel system at lower investment costs for the heat pump than participants in the Information group.

We further expected differences in the choices between the control group and the Uncertainty group. The direction of the difference was unclear ex ante. While the provision of additional information could positively influence the incidence of choosing the heat pump, the reminder of the uncertainty associated with future prices might have a negative impact, ceteris paribus.

Hypothesis 3: There is a statistically significant difference between the WTP for a the heat pump between the Uncertainty group and the control group.[7]

Regarding the impact of risk preferences on the choice between the heat pump and the fossil fuel system, it was conceivable that respondents with a high degree of risk aversion would show a lower willingness to pay for the heat pump than those who are less risk-averse.

Hypothesis 4: Study participants with a high degree of risk aversion will prefer the heat pump to the fossil fuel system at lower investment costs for the heat pump than participants with a low degree of risk aversion.

Lastly, we expected the degree of risk aversion to also have an impact on the effect of the Uncertainty treatment because uncertainty influences the decisions of risk-averse individuals more strongly.

Hypothesis 5: The effect of the Uncertainty treatment on the willingness to pay, relative to the Information treatment, is stronger for those individuals with a high degree of risk aversion than for those with a low degree of risk aversion.

5 Empirical Strategy

5.1 Multiple Price List

In our experiment, we employ a multiple price list (MPL) approach. This approach comprises repeated choices between two alternatives, with (in our case) the price of one of the alternatives being constantly lowered. The MPL is used to elicit a willingness-to-pay (WTP) for a heat pump, as compared to a fossil fuel heating system. More precisely, we interpret our WTP as a price premium that individuals are willing to pay for a heat pump compared to a fossil fuel heating system. In case respondents switch to the heat pump at a price lower than the fixed price for the fossil alternative, we interpret the difference as the price advantage of a heat pump required to induce the switch. From the price pre-

[7] In the pre-registration, we instead referred to the frequency of choosing a heat pump being different between the two groups. However, we deem the WTP more appropriate in hindsight.

mium and price advantage information, one can then infer information on the subsidy level required to make individuals prefer a heat pump for their homes.

The application of an MPL is associated with certain advantages and disadvantages, which we briefly summarise in the following. This summary largely builds on the overview presented by Andersen et al. (2007, 2006). One main advantage of the MPL is that it is easy to explain and understand. In addition, an MPL is easy to implement, both in an online as well as in an offline setting.

However, the application of an MPL induces several potential difficulties. Firstly, the fact that respondents choose between pre-stated price pairs instead of indicating precise values implies that researchers using an MPL only elicit interval responses. Secondly, respondents can potentially show inconsistent choice behaviour: if they switch multiple times between the two options in the table, instead of switching once at most, this impedes the elicitation of their preferences. Thirdly, respondents' choices may be influenced by the values shown in the MPL. Irrespective of the limits of the (price) scale presented, respondents may be drawn towards switching in the middle of the ordered table. We briefly address each of the three potential drawbacks presented and how they relate to our experiment.

With regard to potentially being drawn towards the middle of the table, we cannot fully rule out an impact of this type of framing effect on our results. Figure 1 indeed shows some clustering at the midpoint of the MPL. One option would have been to employ different price ranges in the price list to assess whether the switching depends on the prices shown or more on the position within the price list. However, including a second MPL for a subgroup of the experiment would have reduced the sample size for the actual MPL experiment. The potential negative effects on the validity of our estimates outweighed, in our view, the potential benefits from having a subgroup with a different MPL range. Moreover, note that potential framing effects would not compromise the internal validity of our experiment as all subjects, regardless of the treatment group, were shown the same MPL. Hence, (qualitative) observations on the direction and statistical significance of effects remain valid. Framing effects could, however, affect the external validity of our results, such that implications for the absolute WTP should be interpreted

with caution.

The degree of inconsistent choice behaviour we observe in our experiment is limited. Of the 1,998 respondents who indicate useful responses in the experiment (i.e., those who choose one of the two alternatives instead of the options 'I don't know' or 'No answer'), only 63 respondents, or about 3 %, show an inconsistent choice pattern. This low share may partially be attributed to the inclusion of the options 'I don't know' and 'No answer'. In the absence of such options, respondents may have signalled their inability to answer through erratic choice behaviour, resulting in a higher share of inconsistent responses. Compared with other experiments using repeated choices, the share of inconsistent responses in our experiment is, consequently, low. For instance, Andersen et al. (2006) report a share of 5.8 % (while their experiment also included an indifference option), Callen et al. (2014) report a share of roughly 9.7 %, and Meier and Sprenger (2010) report a share of approximately 11 %. We exclude respondents who answered inconsistently from our estimations in the remainder of this paper, as is frequently done in the literature (see Callen et al., 2014, for example).

5.2 Estimation Strategy

Several methods exist to handle response data that is measured in intervals instead of precise values. The main approach that we follow in this paper is the interval regression method, developed by Stewart (1983). He proposes a maximum likelihood estimation method for interval responses as the dependent variable that is both asymptotically efficient and yields consistent estimates. Interval regression takes into account that the outcome variable, in this case the price premium, is only observed to fall into a certain category, without the precise value within this category being known. Moreover, it accounts for the left- and right-censored intervals at the respective ends of the MPL: if respondents choose to never switch to the heat pump, not even at the lowest presented price for the heat pump of 2,862 euros, i.e., at a price advantage of 8,118 euros, their price premium falls into the left-censored interval $(-\infty; -8,118)$. In other words, they would only switch if the price advantage of the heat pump was larger than 8,118 euros. How much larger it would need to be cannot be inferred from the MPL. Likewise,

if respondents always choose the heat pump, even at the maximum price of 28,620 euros presented in the MPL, i.e., at a price premium of 17,640 euros, their price premium falls into the right-censored interval $[17,640; \infty)$. It can only be inferred that they are willing to pay a price premium of at least 17,640 euros. We use Stata's `intreg` command (Stata, 2024), which estimates the coefficients, β, and the variance of the error terms, σ, via maximum likelihood estimation. The coefficients of the interval regression can be interpreted as marginal effects (Stata, 2024).

Using a simple OLS regression on the midpoints of the intervals is an evident alternative to interval regression. However, this OLS approach can result in inconsistent estimates (see, for example, Cameron and Huppert, 1989; Stewart, 1983). A further potential problem with using OLS methods on interval data is the necessary, arbitrary choice of 'midpoints' for the left- and right-censored intervals (Cameron and Huppert, 1989). A second alternative is the application of an ordered logit model to the data, which treats the outcome variable (i.e., the intervals) as categories.

We compare the results from interval regression, which we will discuss in Section 6.1, with results for two types of OLS regressions, differing in the definition of the left- and right-censored intervals. We also compare our results to an ordered logit regression model. Qualitatively, the results are very similar across the different methods, as we show in Tables B5 and B6 in Appendix B.2.

6 Empirical Results and Discussion

6.1 The Price Premium Required for Purchasing a Heat Pump

Figure 1 plots the intervals of price premiums for heat pumps at which respondents first choose the heat pump by treatment group. In the control group, about 18 % always choose the heat pump and this share increases to almost 25 % with the Uncertainty treatment. By contrast, the share of respondents who never choose the heat pump is highest in the control group with about 9 % and lowest in the Information treatment group (6 %). This already suggests that the price premium respondents are willing to pay for the heat pump is higher in the treatment groups than in the control group. Across all groups,

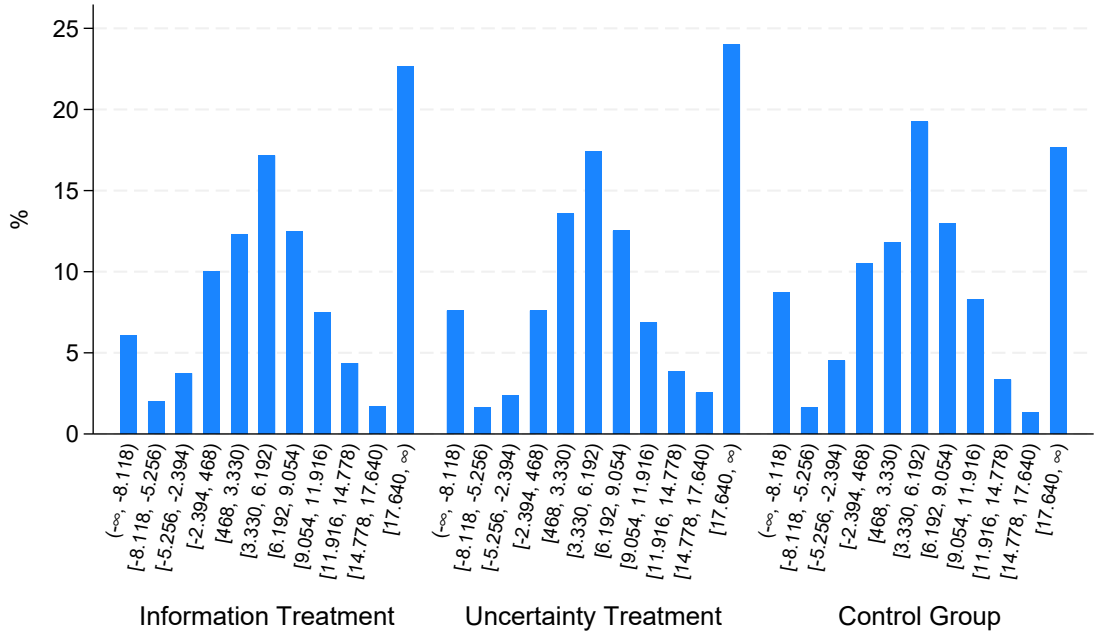

Figure 1: Price premium for the heat pump at which respondents switch from the fossil fuel heating system to the heat pump

there is some clustering around the midpoint with a price premium between 3.330 and 6.192 euros.

Table 4 presents the results of several interval regressions. The price premium households are willing to pay (or, if negative, the price advantage required) to switch from a fossil fuel heating system to a heat pump constitutes the outcome variable in the regressions. The first column presents the results of a specification without covariates, regressing the price premium only on the two treatment indicators for being assigned to the Information or Uncertainty treatment. The effect is assessed relative to being in the control group that did not receive any treatment. The constant in column (1) shows that, on average, respondents in the control group are willing to pay a price premium of 6,472 euros for the heat pump. Column (2) shows the results of a regression that controls for certain socio-economic covariates. Lastly, column (3) shows results of a regression that includes both socio-economic covariates as well as variables indicating the degree of risk-aversion, time preferences and the financial literacy. We consider this regression (3) as our main specification.

Across the three specifications, the effects of receiving the Information treatment as

Table 4: Results of interval regression with price premium as outcome variable

	(1)		(2)		(3)	
Information	1655.4*	(710.5)	1667.4**	(599.5)	1638.7**	(598.3)
Uncertainty	2183.8**	(713.9)	2171.4***	(610.9)	2130.7***	(609.3)
Household size			-694.1*	(317.6)	-699.3*	(316.3)
Ownership			-4464.0***	(631.8)	-4525.2***	(632.3)
Female			-1732.8**	(530.8)	-1574.4**	(538.4)
Age			-17.43	(19.41)	-13.85	(19.70)
Medium income			1880.5	(1647.9)	1648.4	(1656.9)
High income			3714.8*	(1643.3)	3432.3*	(1652.7)
Very high income			5666.8***	(1677.2)	5335.4**	(1687.9)
Academic			1881.9***	(522.0)	1811.9***	(522.8)
Env. attitudes			1466.6***	(86.93)	1458.8***	(86.77)
Risk aversion					-50.60	(98.10)
Discount rate (time)					-1784.5	(8019.5)
Financial literacy					1198.4	(646.1)
Constant	6472.2***	(491.8)	-8461.6***	(2244.2)	-8894.5***	(2331.2)
$ln(\sigma)$	9.260***	(0.0281)	9.081***	(0.0290)	9.079***	(0.0290)
Observations	1374		1374		1374	
log $\mathcal{L}$	-3091.7		-2876.1		-2874.0	

Robust standard errors in parentheses. *, ** and *** indicate statistical significance at the 5 %, 1% and 0.1 % level, respectively. The outcome variable in each regression is the price premium households are willing to pay to switch from a fossil fuel heating system to a heat pump.

well as of receiving the Uncertainty treatment on the price premium households are willing to pay for the heat pump are positive. Individuals that receive information about the cost associated with both alternatives (a fossil fuel system and a heat pump) are, on average, willing to pay around 1,650 euros more for a heat pump than individuals in the control group, who do not receive this information. The effect of the Information treatment, thus, increases the willingness to pay by around 25 %, compared to the control group. The regression results, therefore, support our hypothesis 1. The general direction of the effect of the Information treatment is unsurprising, given that the information presented concludes that a heat pump would be the cheaper of the two alternatives over the whole life cycle. The effect suggests that the information of transparent cost provision can foster the adoption of heat pumps, at least if the information provided actually concludes that heat pumps are the more economical heating solution.

If individuals receive additional information about the uncertainty associated with the future prices of electricity and fossil fuels, represented by the Uncertainty treatment, this also increases their willingness to pay for a heat pump relative to the control group. On average, individuals in the Uncertainty group are willing to pay about 2,100 euros, or one third, more for a heat pump than individuals in the control group, ceteris paribus.

Hence, our hypothesis 3 – that there is a statistically significant difference between the Uncertainty group and the control group – is also supported.

Our regression results do not support hypothesis 2. While we hypothesised that the effect of the Uncertainty treatment on the price premium would be lower than that of the Information treatment, the coefficient for the Uncertainty treatment is actually larger, but not significantly different from the Information treatment.[8] The message delivered by both the Information and the Uncertainty treatment is similar: they both explain that a heat pump is likely to be the more economical choice. In addition, the information on uncertainty contains external projections that electricity prices might decrease by up to 25 % or increase by up to 15 % until 2045, depending on the scenario, while the same external projections show a range of possible price increases for natural gas between 3 % and 50 % by 2045 (see Appendix A.2). Hence, respondents might have gathered the impression that the risk of a rise in gas prices is higher than the respective risk for electricity prices, explaining the slightly higher coefficient for the Uncertainty treatment.

It seems that individuals' risk aversion has no significant impact on the price they are willing to pay for a heat pump, relative to a fossil fuel heating system. The coefficient on risk aversion is negative, but not statistically significantly different from zero. One potential explanation could be that individuals do not see differences in terms of technical reliability between the two heating solutions and, therefore, do not associate, for instance, a higher risk with installing a heat pump as compared to a fossil fuel solution, or vice versa. Hypothesis 4 is, thus, not confirmed.

Lastly, hypothesis 5 is not confirmed either, as we show in Table B4 in Appendix B.1. The degree of risk aversion does not seem to have a noticeable effect on the impact of the Uncertainty treatment, since the coefficient on the interaction term is insignificant.

Looking at the other covariates, one interesting aspect is that owners are willing to pay a lower price premium for heat pumps than tenants, on average by roughly 4,500 euros. A potential reason could be that homeowners immediately carry the (financial) burden of a new heating system. Tenants, instead, will likely pay for a new heating sys-

[8] It can be readily observed from Table 4 that the coefficient on Information and Uncertainty are not significantly different from one another, based on their standard deviations. Additionally, we show this in Table B4 in Appendix B.1, where we perform the same regression as in (3), but with the Information group as the baseline.

tem via their rent, but the cost will accumulate over time, rather than being paid upfront, as in the case of homeowners. In other words, there is no intertemporal choice for tenants, while there is one for owners. It should be noted that we reminded tenants prior to their choice that the owner may increase their annual rent by up to 8 % of investment costs after installing a new heating system. Hence, during the experiment, tenants should have been aware that their choices would have an impact not just on the owner's financial situation, but also on their own. Still, the difference between upfront payments for owners and staggered repayment via their rent for tenants may explain the divergence in the price premium between these two groups.

Higher income also positively affects the willingness to pay for a heat pump, as reflected in the highly significant effect of the 'very high income' variable. This adds to the literature, which has so far found mixed evidence on the importance of income. While Özcan et al. (2013) identify income as an important factor for the heating system choice in Turkey, Braun (2010) finds only little influence in Germany. Specifically looking at heat pumps, Davis (2024) finds very little correlation between household income and heat pump adoption in the US.

Moreover, a tertiary degree and pro-environmental attitudes both positively influence the price premium for a heat pump. The latter is unsurprising, given that a heat pump is usually associated with being the more environmentally-friendly heating solution (compared to a fossil fuel system).

On the other hand, individuals' financial literacy, their risk preferences as well as their time preferences do not seem to play a decisive role in determining the price premium they are willing to pay for a heat pump.

6.2 Policy Implications

The main finding of our paper is that transparent information on the total cost of the two heating alternatives has a positive impact on the WTP for the heat pump, which is identified to likely be the more economical solution over the equipment's life cycle in both the Information and the Uncertainty treatment. The main implication for governments that want to foster the adoption of sustainable heating solutions, such as heat pumps, is, thus,

that the cost advantage of sustainable heating solutions needs to be explained transparently. Sustainable heating solutions, such as heat pumps, are often more capital-intensive than conventional fossil heating systems. This means that their purchase price is often higher, while they are less costly to operate. Hence, their cost is more front-loaded than in the case of fossil heating systems. If households only consider the investment cost when making their decision on heating systems, they will consequently lean towards purchasing fossil heating systems. To tackle this potential short-sighted decision making, households' awareness for the likely advantages of sustainable heating solutions in future operating costs needs to be increased.

Achieving this is certainly not straightforward. As heating systems are usually purchased via and installed by specialised craftsmen, who also advise their clients, these craftsmen constitute an evident transmitter for the cost information.

Another option, of course, is the regular publishing of information in public databases, on official websites or in news outlets. Such information campaigns come at a certain cost, which would have to be traded-off against the potential (carbon emissions) savings.

Importantly, all of the above relies on the notion that sustainable heating is, indeed, the more economical solution over the life cycle of a heating system, as suggested by our treatments. This arguably differs across regions as it is very dependent on the development of fuel, electricity and carbon prices. In addition, such cost estimations necessarily rely on projections, which are never certain. Therefore, the more fundamental step to be taken before taking the price advantage of sustainable heating for granted is to rigorously assess whether the advantage exists after all. If this is not the case, the first step for any government wanting to support the decarbonisation of the heating sector should be to enact policies that create and / or strengthen a cost advantage of sustainable heating solutions, relative to fossil fuel solutions. An evident instrument to achieve this would be effective carbon prices to internalise the externalities resulting from burning fossil fuels for heating. Such carbon prices work via the operating costs of heating. In Germany, a carbon price for heating has been introduced in 2021 to promote decarbonisation. In 2023, the price was 30 euros per ton and it was increased to 45 euros in 2024 (Deutschlandfunk, 2024). Another potential instrument is subsidising sustainable heating systems, which

reduces the disadvantage of high upfront investment costs of sustainable heating solutions. This would make the cost advantage more visible and the initial investment for a sustainable heating solution would become more affordable for households with liquidity constraints. The more general merit of targeted subsidies, compared to the more widely applicable carbon pricing, is a topic of debate to which we do not intend to add further in this paper.

In theory, both carbon prices and subsidies could help to solve the underlying cost disadvantage that sustainable heating suffers in many contexts. This would, ideally, yield a situation where sustainable heating exhibits cost advantages that can then, in turn, be communicated transparently to households to foster environmentally sustainable decision-making.

7 Summary and Conclusions

With a share of about three quarters, fossil-fuel heating systems are still dominant in Germany. Consequently, decarbonisation of the heating sector has recently become a very 'hot topic', leading to legislative changes that particularly benefit the installation of heat pumps. As heating investments are very long-term in nature, such that households are 'locked-in' into a technology for many years, understanding how households decide on their heating systems today is paramount to fostering future decarbonisation.

This paper has provided insights for a better understanding of these decisions, adding to recent literature such as Borenstein and Bushnell (2022) and Davis (2023, 2024). We set up a survey experiment among about 1,400 German households that utilises a Multiple Price List where respondents had to make repeated choices between a fossil heating system and a heat pump, with the price of the latter continuously being reduced. This framework allowed us to infer information on the price premium that respondents are willing to pay for a heat pump compared to a fossil system, which can in turn inform subsidy policies.

The sample was randomly divided into three experimental groups. Respondents in one group were presented with information on a cost comparison of the two available op-

tions over the system's life cycle (Information treatment). In a second group, respondents were provided the same information as the Information group as well as information on the uncertainty associated with the cost comparison (Uncertainty treatment).

Our results show that both the Information and the Uncertainty treatment have a positive effect on the WTP for a heat pump. As both treatments provide information that a heat pump would be the more economical solution, the effects' directions are in line with expectations. The findings suggest that, in the absence of any of the two treatments, some households may be unaware of the purported cost advantage of the heat pump and, on average, favour a fossil system at higher prices than would be financially beneficial. Hence, our results underline the importance of cost transparency for consumer decisions. The main policy implication that can be drawn from this is that, should governments want to promote the transition towards more sustainable heating, they need to clearly convey the message that sustainable heating is cheaper (as long as that is actually the case). If there is no such cost advantage of sustainable heating, politics first needs to enact policies that strengthen the cost advantage of sustainable heating solutions, e.g. via effective carbon pricing. Moreover, we find that, regardless of the treatment, neither a respondent's risk aversion nor time preferences nor financial literacy have an impact on WTP.

In summary, our paper confirms that information provision has an impact on consumer choices, as previous research in similar contexts has shown. However, we do recognise that consumer decisions in the heating sector are very dependent on individual, regional or national circumstances. Therefore, we encourage replication of our analysis in other contexts, e.g. in other countries and under different legislative regimes. With regard to the information provided, it is essential to assess whether other, less contentious types of (non-cost) information, such as information on the environmental impact associated with different heating solutions, have the potential to nudge households towards more ecological heating solutions. Looking ahead, we see the area of the economics of heating and, more specifically, the factors impacting personal heating choices as a fruitful avenue for further research.

A Appendix A: Details on Sample and Experiment

A.1 Details on the Experiment

In this section, we show (translated from German) the exact wording of those sections in our questionnaire that are relevant for the experiment presented in this paper.

A.1.1 Introduction to the Experiment

Owners only:

Now imagine that your current heating system sustains damage today and has to be replaced on short notice. There are two available options:

- An equivalent replacement of your previous heating system
- A heat pump

A decisive factor may probably be financial aspects.
In the following, we would like to ask you for your assessment of the investment and operating costs. This is not about right or wrong answers, but only about your assessment.

Tenants only:

Now imagine that the current heating system in your flat / house sustains damage today and has to be replaced on short notice. Assume that you are allowed to advise your landlord/landlady for the decision about the type of new heating system. Your landlord/landlady has two available options:

- An equivalent replacement of your previous heating system
- A heat pump

A decisive factor may probably be financial aspects. Your annual rent may be increased by up to 8 % of investment costs (Modernisierungsumlage). The cost of operating the heating system is also borne by you.
In the following, we would like to ask you for your assessment of the investment and operating costs. This is not about right or wrong answers, but only about your assessment.

A.1.2 Treatment Information

Group Information and group Uncertainty only:

To facilitate your decision, we would like to provide you with further information. According to the Federal Ministry for Economic Affairs, the average costs of acquisition and installation are...

- approx. 11,000 euros for an equivalent replacement of your previous heating system.
- approx. 28,600 euros for a heat pump.

These costs concern installation in a single-family house.

Group Information only:

According to a study commissioned by the Federal Ministry for Economic Affairs and Climate Action, the **installation of an air-to-water heat pump is the cheapest alternative**. Compared to the installation of a fossil fuel heating system, you can **save approx. 320 euros annually over the heating system's whole lifespan of approx. 20 years**. The following table shows the investment costs as well as the operating costs (e.g., cost for energy consumption).

For the calculation of these values a lifespan of 20 years was assumed, as well as an increase in electricity prices of 0.5 % per year and an increase in natural gas prices (incl. CO2-price) of 1 % per year.

Cost overview for a single-family house

	Fossil heating system	**Air-to-water heat pump**	**Difference (Heat pump - fossil system)**
Investment (one-time)	10,980 euros	28,620 euros	+ 17,640 euros
Consumption + operating costs (p.a.)	4,918 euros	3,689 euros	- 1,229 euros

Group Uncertainty only:

According to a study commissioned by the Federal Ministry for Economic Affairs and Climate Action, the **installation of an air-to-water heat pump is the cheapest alternative**. Compared to the installation of a fossil fuel heating system, you can **save approx. 320 euros annually over the heating system's whole lifespan of approx. 20 years**. The following table shows the investment costs as well as the operating costs (e.g., cost for energy consumption).

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Cost overview for a single-family house

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Investment (one-time)	10,980 euros	28,620 euros	+ 17,640 euros
Consumption + operating costs (p.a.)	4,918 euros	3,689 euros	- 1,229 euros

The **evolution of electricity and (natural gas prices / oil prices)**, on which these calculations are based, is based on **projections**. It is **not guaranteed that prices actually develop** as assumed by the ministry. Thus, the switch to renewable energy could lead to a much stronger increase in electricity prices in the short term, while prices could decrease in the long term. The Fraunhofer Institutes ISE and IEE assume for example that **electricity prices could, depending on the scenario, decrease by approx. 25 percent or increase by approx. 15 percent by 2045.**

The evolution of natural gas prices, in turn, depends, inter alia, on the evolution of the CO2-price. If it increases stronger than assumed, the (natural gas price / oil price) increases stronger, too. According to an analysis by the Fraunhofer Institutes ISE and IEE, the **prices for natural gas could, depending on the scenario, increase by only 3 percent or by approx. 50 percent by 2045.**

Accordingly, the **savings** assumed through the installation of a heat pump, as compared to the installation of a new (natural gas heating system / oil heating system) **cannot be guaranteed**. They **may turn out higher or lower.**

A.1.3 Choice Situation

Owners only:

Now imagine that **your heating system sustains damage today and has to be replaced**. You can either **replace** your previous heating system **by an equivalent system or purchase a heat pump**. Please assume that all other characteristics of the two alternatives (e.g., maintenance costs, comfort, etc.) are identical. The lifespan of the heating system shall also be identical with 20 years.

We will present to you multiple options in the following. The costs for the installation of a purely fossil heating system will be held constant. The costs for the installation of a heat pump are reduced successively. You can imagine this as though the state pays a subsidy for the installation of heat pumps.

Tenants only:

Now imagine that the **heating system in your rented flat / rented house sustains damage today and has to be replaced**. Your landlord/landlady can either **replace** the previous heating system **by an equivalent system or purchase a heat pump**. Please assume that all other characteristics of the two alternatives (e.g., maintenance costs, comfort, etc.) are identical. The lifespan of the heating system shall also be identical with 20 years.
We will present to you multiple options in the following. The costs for the installation of a purely fossil heating system will be held constant. The costs for the installation of a heat pump are reduced successively. You can imagine this as though the state pays a subsidy for the installation of heat pumps.

Owners only:

Please choose for every price pair which option you would decide for.

Tenants only:

Please choose for every price pair, which option you would propose to your landlord/landlady.

Table A1: Multiple Price List used in the experiment

(i) **Fossil fuel heating system (oil or gas)**	(ii) **Heat pump**
10.980 Euro	28.620 Euro
10.980 Euro	25.758 Euro
10.980 Euro	22.896 Euro
10.980 Euro	20.034 Euro
10.980 Euro	17.172 Euro
10.980 Euro	14.310 Euro
10.980 Euro	11.448 Euro
10.980 Euro	8.586 Euro
10.980 Euro	5.724 Euro
10.980 Euro	2.862 Euro

A.2 Details on the Elicitation of other Variables

A.2.1 Pro-environmental attitude

To what extent to you agree with the following statements?

Scale:

- do not agree at all
- do rather not agree
- neither nor
- rather agree
- totally agree

Items:

- It worries me when I think about the environmental conditions that our children and grandchildren will probably have to live in.
- There are natural limits to growth, which our industrialised world has long reached or exceeded.
- Environmental protection should have priority for Germany, even if this affects economic growth.

A.2.2 Financial Literacy

Imagine you have 200 euros on your savings account. The interest on this balance is 10 % per year. What do you think, what will your balance be after 2 years?

Items (randomised):

- 220 euros
- 240 euros

- 242 euros
- 204 euros
- I don't know *(fixed at this position)*
- No statement *(fixed at this position)*

A.2.3 Time and Risk Preferences

In the following we would like you to work on **two exercises**. In each of these exercises you will have to make **several decisions between two options**. As a gesture for your participation, we will raffle **150 vouchers** from `https://www.wunschgutschein.de/` worth up to 30 euros each among all participants.
For every person that wins, one choice situation is randomly drawn. **The amount of the voucher depends on the choice situation chosen and your choice made for option A or option B**. The winners will be informed about their prize shortly after the survey's conclusion, i.e., approx. at the end of September. If appropriate, the voucher may be sent out only at a later point in time. Further information on this will be found in the explanation of the exercise.

Time Preferences:

Should you win a voucher for participation in this exercise, the amount of the voucher is determined as follows:
In the following table, you can decide whether you want to receive the voucher approx. one month or approx. six months after the survey's conclusion. The value of the voucher which you will receive six months after the survey's conclusion is always 30 euros. The value of the voucher which you will receive one month after the survey's conclusion differs depending on the decision.

Example:
If you choose for the first decision...

- Option A, you will receive a voucher worth 30 euros approx. six months after the survey's conclusion.

- Option B, you will receive a voucher worth 29 euros approx. one month after the survey's conclusion.

Your decisions between options A and B determine, thus, the value and timing of mailing of the voucher. If you win a voucher for this exercise, one decision is randomly drawn. The respective voucher will be sent to you via email.

Therefore, always remember: your decisions can determine the value and the timing of mailing of the voucher.

Which option do you choose in the 9 decisions?

Option A: Approx. 6 months after survey conclusion		**Option B: Approx. 1 month after survey conclusion**	
30	O	29	O
30	O	27	O
30	O	26	O
30	O	24	O
30	O	21	O
30	O	18	O
30	O	15	O
30	O	12	O
30	O	9	O

- I don´t know / I don't want to participate

Risk Preferences:

In the next exercise, we would like you to make several decisions between different lotteries.

Your decisions between lottery A and lottery B determine the value of the voucher. Should you win a voucher for this exercise, one of your decisions is randomly drawn. The respective voucher will then be sent to you via email.

Therefore, always remember: your decisions can determine the value of the voucher.

Which lottery do you choose?

Lottery A		**Lottery B**	
15,60 euros with a probability of 10% 12,50 euros with a probability of 90%	O	30,00 euros with a probability of 10% 0,78 euros with a probability of 90%	O
15,60 euros with a probability of 20% 12,50 euros with a probability of 80%	O	30,00 euros with a probability of 20% 0,78 euros with a probability of 80%	O
15,60 euros with a probability of 30% 12,50 euros with a probability of 70%	O	30,00 euros with a probability of 30% 0,78 euros with a probability of 70%	O
15,60 euros with a probability of 40% 12,50 euros with a probability of 60%	O	30,00 euros with a probability of 40% 0,78 euros with a probability of 60%	O
15,60 euros with a probability of 50% 12,50 euros with a probability of 50%	O	30,00 euros with a probability of 50% 0,78 euros with a probability of 50%	O
15,60 euros with a probability of 60% 12,50 euros with a probability of 40%	O	30,00 euros with a probability of 60% 0,78 euros with a probability of 40%	O
15,60 euros with a probability of 70% 12,50 euros with a probability of 30%	O	30,00 euros with a probability of 70% 0,78 euros with a probability of 30%	O
15,60 euros with a probability of 80% 12,50 euros with a probability of 20%	O	30,00 euros with a probability of 80% 0,78 euros with a probability of 20%	O
15,60 euros with a probability of 90% 12,50 euros with a probability of 10%	O	30,00 euros with a probability of 90% 0,78 euros with a probability of 10%	O
15,60 euros with a probability of 100% 12,50 euros with a probability of 0%	O	30,00 euros with a probability of 100% 0,78 euros with a probability of 0%	O

- I don´t know / I don‘t want to participate

A.3 Details on the sample

A.3.1 Adjustments towards final estimation sample

Only individuals using either natural gas or heating oil as their heating fuel at the time of survey implementation were assigned to the experiment. Moreover, individuals that indicated that they were living in their current accommodation free of charge, i.e., individuals that were neither renting nor owning their accommodation, were excluded from the experiment. This reduced the sample to 3,057 individuals which used natural gas (2,319) or heating oil (738) and were either owning (2,030) or renting (1,027) their accommodation. Table A2 summarises the steps outlined and provides an overview of the sample composition.

Table A2: Adjustments towards final estimation sample

Total sample	4,501
- those not indicating to rent or own	86
Reduced sample	4,415
- those not using gas or oil	1,358
Reduced sample	3,057
◇ of which tenants	1,027
◇ of which owners	2,030
Tenants in the experiment	1,027
- those giving no useful response	454
Tenants giving useful responses (I)	573
Owners in the experiment	2,030
- those giving no useful response	605
Owners giving useful responses (II)	1,425
Useful responses in total (I + II)	1,998
- those not providing all necessary socio-economic information	624
Final sample	**1,374**

A.3.2 Comparison of the sample and the German population

Table A3 compares the estimation sample with the respective statistics for the German population.

Table A3: Comparison of sample and German population

	Sample	**Population**
Household size:		
1 person	0.230	0.408
2 persons	0.499	0.337
3 persons	0.130	0.120
4 or more persons	0.141	0.134
Female	0.392	0.506
Age:		
$<$ 25 years	0.006	0.244
25 - 35 years	0.068	0.127
35 - 45 years	0.149	0.128
45 - 55 years	0.208	0.132
55 - 65 years	0.250	0.155
$\geq$ 65 years	0.320	0.214
Net household income:		
$<$ 1,200 euros	0.025	0.129
1,200 - 2,700 euros	0.223	0.375
2,700 - 4,200 euros	0.330	0.246
$>$ 4,200 euros	0.421	0.250
Academic	0.453	0.169
Ownership	0.676	0.418

Source: Destatis (2023), Destatis (2024). Destatis reports net household income in different brackets than those used in the experiment. We convert the brackets by assuming the household incomes within each bracket are uniformly distributed.

B Appendix B: Robustness Checks and Alternative Estimations

B.1 Regressions with Different Baseline Category

Regressions (1) and (2) in Table B4 replicate regressions (1) and (2) in Table 4, with the only difference being that the Information group now constitutes the base category, relative to which the effects of other variables are assessed. Regression (3) is complemented by adding further variables on risk-aversion, time preferences and financial literacy, as in regression (3) in Table 4. In addition, an interaction term (Uncertainty $\times$ Risk aversion) is included to investigate hypothesis 5.

The coefficient on Uncertainty provides evidence against hypothesis 2: in contrast to our hypothesis, there is no statistically significant difference between the effect of being

Table B4: Results of alternative interval regressions

	(1)		(2)		(3)	
Control	-1655.4*	(710.5)	-1667.4**	(599.5)	-1631.9**	(598.2)
Uncertainty	528.5	(730.1)	504.0	(611.2)	-269.6	(1249.4)
Household size			-694.1*	(317.6)	-695.1*	(315.8)
Ownership			-4464.0***	(631.8)	-4517.8***	(631.5)
Female			-1732.8**	(530.8)	-1577.4**	(538.5)
Age			-17.43	(19.41)	-14.12	(19.68)
Mid income			1880.5	(1647.9)	1631.8	(1657.3)
High income			3714.8*	(1643.3)	3405.5*	(1653.1)
Very high income			5666.8***	(1677.2)	5293.6**	(1688.2)
Academic			1881.9***	(522.0)	1830.8***	(522.7)
Env. attitudes			1466.6***	(86.93)	1462.2***	(86.86)
Risk aversion					-101.4	(116.5)
Discount rate (time)					-1924.8	(8019.6)
Financial literacy					1212.9	(646.8)
Uncertainty × Risk Aversion					144.1	(212.4)
Constant	8127.5***	(521.1)	-6794.2**	(2273.7)	-7009.3**	(2369.7)
$\ln(\sigma)$	9.260***	(0.0281)	9.081***	(0.0290)	9.079***	(0.0290)
Observations	1374		1374		1374	
$\log \mathcal{L}$	-3091.7		-2876.1		-2873.8	

Robust standard errors in parentheses. *, ** and *** indicate statistical significance at the 5 %, 1% and 0.1 % level, respectively.

in the Information and the Uncertainty group on the price premium. If at all, it seems (in contrast to our hypothesis) that the Uncertainty treatment has a slightly more positive effect on the price premium than the Information treatment.[9]

Regarding hypothesis 5, where we assumed that a high degree of risk aversion increases the effect of the Uncertainty treatment on the price premium, relative to the Information treatment, regression (3) offers no conclusive evidence. The coefficient on the interaction term (Uncertainty × Risk aversion), albeit positive, is not statistically significant.

B.2 Results of OLS and Ordered Logit

Table B5 compares the results of the main interval regression from Table 4, here in column (1), with results for an alternative regression using OLS. To apply OLS, we transform our dependent variable from the interval format to point values, using the midpoints of each interval (as discussed in Section 5.2). The two OLS regressions shown differ in the way

[9]This is clear from regressions (1) and (2). In regression (3), the coefficient on Uncertainty is negative. However, considering the positive coefficient on the interaction term Uncertainty × Risk aversion, the negative coefficient on 'Risk aversion' and the observation that the median risk aversion score (measured as the amount of times the risk-averse lottery is chosen) in the regression sample is 5, one can also derive that, on average, the effect of the Uncertainty treatment is slightly above the effect of the Information treatment.

Table B5: Comparison between interval regression and OLS regression outcomes

	(1)		(2)		(3)	
Information	1638.7**	(598.3)	1098.7*	(433.5)	1219.7**	(470.0)
Uncertainty	2130.7***	(609.3)	1542.3***	(439.4)	1664.4***	(476.8)
Household size	-699.3*	(316.3)	-467.4*	(227.1)	-520.8*	(246.2)
Ownership	-4525.2***	(632.3)	-3144.7***	(437.5)	-3441.2***	(476.2)
Female	-1574.4**	(538.4)	-1108.9**	(385.1)	-1207.6**	(418.8)
Age	-13.85	(19.70)	-13.09	(13.79)	-12.68	(15.01)
Mid income	1648.4	(1656.9)	1332.6	(1174.4)	1408.5	(1283.8)
High income	3432.3*	(1652.7)	2697.3*	(1166.6)	2845.4*	(1276.5)
Very high income	5335.4**	(1687.9)	4118.8***	(1191.6)	4382.3***	(1302.6)
Academic	1811.9***	(522.8)	1426.1***	(377.7)	1500.9***	(409.5)
Env. attitudes	1458.8***	(86.77)	1102.5***	(59.95)	1184.2***	(65.16)
Risk aversion	-50.60	(98.10)	-50.49	(70.54)	-53.21	(76.65)
Discount rate (time)	-1784.5	(8019.5)	-309.4	(5722.3)	-635.7	(6245.1)
Financial literacy	1198.4	(646.1)	883.5	(470.3)	957.3	(511.5)
Constant	-8894.5***	(2331.2)	-5941.8***	(1652.7)	-6623.7***	(1800.6)
$\ln(\sigma)$	9.079***	(0.0290)				
Observations	1374		1374		1374	
R^2			0.291		0.288	

Robust standard errors in parentheses. *, ** and *** indicate statistical significance at the 5 %, 1% and 0.1 % level, respectively.

that the left- and right-censored intervals are treated. In regression (2), we assume that the values in these open-ended intervals are equal to the boundary values, i.e., to -8,118 euros in the left-censored interval and 17,640 in the right-censored interval. This approach is in line with Tomberg (2024). In regression (3), we define the values as being equidistant to the other interval midpoints. In other words, as each interval has a width of 2,862 euros, we keep this distance constant to arrive at values of -9,549 euros and 19,071 euros for the open-ended intervals, respectively. We consider this second approach as a sensitivity analysis with respect to the rather arbitrary choice of the 'midpoint' of the open-ended intervals, in line with the suggestion by Cameron and Huppert (1989).

As can be seen in Table B5, the results of regression (2) and (3) are qualitatively very similar, with the size of the treatment effects slightly larger in the latter specification. Additionally, and more importantly, the results of both OLS regressions are also very similar to the results of our main interval regression specification in column (1). The OLS regressions generally seem to detect smaller effect sizes for both treatments as well as most other control variables. Still, they find significant effects of both treatments on the price premium for heat pumps as well as no significant effects for factors such as risk aversion, time preferences and financial literacy.

Table B6: Comparison between interval regression, OLS and Ordered Logit outcomes

	(1)		(2)		(3)	
Information	1638.7**	(598.3)	1098.7*	(433.5)	0.290*	(0.116)
Uncertainty	2130.7***	(609.3)	1542.3***	(439.4)	0.420***	(0.119)
Household size	-699.3*	(316.3)	-467.4*	(227.1)	-0.130*	(0.0615)
Ownership	-4525.2***	(632.3)	-3144.7***	(437.5)	-0.804***	(0.121)
Female	-1574.4**	(538.4)	-1108.9**	(385.1)	-0.289**	(0.104)
Age	-13.85	(19.70)	-13.09	(13.79)	-0.00401	(0.00383)
Medium income	1648.4	(1656.9)	1332.6	(1174.4)	0.254	(0.325)
High income	3432.3*	(1652.7)	2697.3*	(1166.6)	0.709*	(0.321)
Very high income	5335.4**	(1687.9)	4118.8***	(1191.6)	1.089***	(0.330)
Academic	1811.9***	(522.8)	1426.1***	(377.7)	0.400***	(0.102)
Env. attitudes	1458.8***	(86.77)	1102.5***	(59.95)	0.306***	(0.0190)
Risk aversion	-50.60	(98.10)	-50.49	(70.54)	-0.00640	(0.0194)
Discount rate (time)	-1784.5	(8019.5)	-309.4	(5722.3)	-0.540	(1.648)
Financial literacy	1198.4	(646.1)	883.5	(470.3)	0.262*	(0.127)
Constant	-8894.5***	(2331.2)	-5941.8***	(1652.7)		
$\ln(\sigma)$	9.079***	(0.0290)				
cut1					0.386	(0.457)
cut2					0.616	(0.457)
cut3					1.045*	(0.460)
cut4					1.793***	(0.465)
cut5					2.606***	(0.467)
cut6					3.614***	(0.472)
cut7					4.299***	(0.476)
cut8					4.794***	(0.479)
cut9					5.050***	(0.481)
cut10					5.136***	(0.481)
Observations	1374		1374		1374	
R^2			0.291			
$\log \mathcal{L}$	-2874.0		-14022.2		-2683.8	

Robust standard errors in parentheses. *, ** and *** indicate statistical significance at the 5 %, 1% and 0.1 % level, respectively.

The results of the ordered logit regression are qualitatively very similar to the results from the interval and OLS regressions (Table B6). The only notable exception is that the ordered logit model detects a statistically significant (on a 5 % confidence level), positive effect of financial literacy on the price premium for a heat pump. Apart from this observation, the comparison of the interval regression with OLS and ordered logit confirms the general suitability of interval regression for the data at hand. The log likelihood of the ordered logit regression, shown at the bottom of Table B6, is actually larger than that of the interval regression, meaning ordered logit suits the data slightly better. However, due to the less straightforward interpretation of the regression outputs, we refrained from reporting the ordered logit model as our main specification in this paper. In general, the results of our estimation are qualitatively robust to changes in the regression method.

B.3 Regressions with inconsistent time or risk preferences

Table B7: Regressions excluding inconsistent preferences

	(1)		(2)		(3)	
model						
Information	1638.7**	(598.3)	1666.4**	(605.7)	1616.3**	(603.8)
Uncertainty	2130.7***	(609.3)	2180.2***	(614.9)	2208.8***	(627.9)
Household size	-699.3*	(316.3)	-718.4*	(321.4)	-751.4*	(322.2)
Ownership	-4525.2***	(632.3)	-4498.5***	(637.4)	-4321.3***	(633.2)
Female	-1574.4**	(538.4)	-1635.8**	(543.7)	-1667.4**	(552.3)
Age	-13.85	(19.70)	-15.25	(19.94)	-17.34	(19.96)
Medium income	1648.4	(1656.9)	1562.8	(1748.8)	1214.4	(1842.7)
High income	3432.3*	(1652.7)	3269.1	(1741.9)	2908.6	(1837.7)
Very high income	5335.4**	(1687.9)	5218.6**	(1775.9)	4984.2**	(1870.0)
Academic	1811.9***	(522.8)	1773.2***	(528.0)	1701.2**	(535.6)
Env. attitudes	1458.8***	(86.77)	1463.2***	(87.93)	1513.6***	(89.64)
Risk aversion	-50.60	(98.10)	-61.28	(99.57)	-48.66	(100.5)
Discount rate (time)	-1784.5	(8019.5)	-1579.7	(8088.4)	-3879.6	(7693.4)
Financial literacy	1198.4	(646.1)	1170.8	(657.9)	1344.1*	(662.1)
Constant	-8894.5***	(2331.2)	-8617.6***	(2409.4)	-8894.4***	(2507.6)
lnsigma						
Constant	9.079***	(0.0290)	9.084***	(0.0292)	9.069***	(0.0299)
Observations	1374		1352		1279	
$\log \mathcal{L}$	-2874.0		-2826.2		-2660.3	

Robust standard errors in parentheses. *, ** and *** indicate statistical significance at the 5 %, 1% and 0.1 % level, respectively.

Column (2) of Table B7 shows the results of a regression where individuals with inconsistent time preferences are excluded, as compared to the main regression specification in column (1), where individuals with inconsistent time preferences are included. Column (3) shows results for a specification where individuals with inconsistent risk preferences are excluded. The impact of either exclusion on the regression results is negligible.

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