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# Consumer Inattention, Heuristic Thinking and the Role of Energy Labels

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Energy labels have been introduced in many countries to increase consumers' attention to energy use in purchase decisions of durables. In a discrete-choice experiment among about 5,000 households, we implement randomized information treatments to explore the effects of various kinds of energy labels on purchasing decisions. Our results show that adding annual operating cost information to the EU energy label promotes the choice of energy-efficient durables. In addition, we find that a majority of participants value efficiency classes beyond the economic value of the underlying energy use differences. Our results further indicate that displaying operating cost affects choices through two distinct channels: it increases the attention to operating cost and reduces the valuation of efficiency class differences.

*Keywords*: Environmental certification, discrete choice experiment, energy efficiency, energy-using durables.

*JEL codes*: D03, D12, D83, Q48, Q50.

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# 1. Introduction

Research from behavioral economics has demonstrated that consumers are attentive to salient attributes of products, while neglecting those that are opaque, such as sales taxes (Chetty et al., 2009) or shipping cost (Hossain and Morgan, 2006). With respect to the purchase of energy-using durables, consumers tend to pay less attention to opaque lifetime energy cost than to salient purchasing prices (e.g. Allcott and Taubinsky, 2015). By decreasing the perceived value of energy efficiency, inattention to energy cost may explain the low tendency of consumers to invest in cost-effective efficiency technologies (e.g. Allcott, 2011) – a phenomenon that is commonly referred to as the "energy efficiency gap" (Jaffe and Stavins, 1994).

To bridge this gap, energy labels on electric appliances have been introduced all around the world. Some of them, such as the EU energy label, categorize appliances into grade-like efficiency classes. As these classes summarize energy information in an intuitive way, consumers may use them to evaluate the energy efficiency of an appliance, while neglecting more precise information on annual energy use. Evidence from both the laboratory (e.g. Gilovich et al., 2002) and from market settings (e.g. Lacetera et al., 2012) has demonstrated that consumers tend to employ such decision heuristics, i.e. simplifying decision rules, in the end making choices that deviate from the benchmark of rational decision making. For example, Pope (2009) finds that hospital ranking positions affect patient choices, even though more precise information on hospital quality is observable.

This paper analyzes the potential of energy labels with efficiency classes – such as the EU label – to influence consumer choices. We propose a conceptual model of energy efficiency investment decisions that explicitly takes into account that consumers may be inattentive to operating cost and apply decision heuristics based on energy efficiency classes. In our empirical analysis, we first investigate whether households have a willingness-to-pay for efficiency class differences *per se*, i.e. irrespective of energy use differences, as one would expect if consumers used efficiency classes for heuristic thinking. Second, we analyze how appliance choices are affected by an increase in the salience of annual operating cost, as well as the number of stimuli that compete for attention. Third, we investigate the channels through which changes in the salience of operating cost and the number of competing stimuli operate.

We conduct a discrete-choice experiment among 5,000 households that is framed as a purchasing decision on refrigerators and assign participants randomly into three groups. Participants in a control condition receive information on the appliances based on a simplified EU label that only displays the annual energy use and efficiency classes. In the first treatment condition, the label additionally presents estimated annual operating cost, thereby increasing the salience of this cost component. In the second treatment condition, participants see further non-energy related appliance characteristics that act as additional stimuli competing for attention. All participants make decisions on four choice sets. Two of them reflect typical choice situations in the market for refrigerators, encompassing common trade-offs between investment cost and operating cost. The remaining two choice sets serve to isolate the valuation of efficiency classes and to investigate the channels through which the information treatments work.

Previous research has focused on energy labels that do not include efficiency classes, such as the US EnergyGuide. Newell and Siikamäki (2014), for instance, find evidence that consumers undervalue energy efficiency in the absence of label information. Furthermore, they show that the provision of annual electricity costs on the EnergyGuide label is particularly effective in increasing the willingness-to-pay for energy efficiency. Analyzing the voluntary Energy Star label in the US, Houde (2014a) concludes that some consumers rely predominantly on the Energy Star certification and some rely on electricity cost information, while the majority does not consider energy information at all. Furthermore, Houde (2014b) shows that firms respond strategically to the Energy Star by designing products that barely meet the certification requirement.

Our results demonstrate that additional cost information on the EU energy label guides consumers to more energy-efficient appliances in choice situations that involve typical market trade-offs between purchasing prices and energy efficiency, while an increase in the number of stimuli competing for attention can have the opposite effect. Furthermore, we observe that consumers value efficiency class differences *per se*: even in a setting where energy use differences are marginal, two thirds of consumers are willing to pay at least 30 EUR for a better efficiency class. Moreover, we find that adding information on operating cost to the EU energy label works through two distinct channels: it increases attention to operating cost and decreases the valuation of efficiency class differences.

Hypothetical rather than market choices are commonly analyzed to investigate alternative label schemes (see e.g. Newell and Siikamäki, 2014). A potential shortcoming of this approach is that its stylized decision environment may induce participants to focus more strongly on the energy label, compared to real-world settings. However, while the hypothetical nature of choices may increase the overall rate of opting for a more energy-efficient appliance, it is less clear why the size of treatment effects should be affected. Ebeling and Lotz (2015), for instance, find that even though individuals choose "green" electricity tariffs more often in hypothetical than in market settings, the treatment effects of tariff defaults are indistinguishable for both approaches. What is more, hypothetical choices are central to our research design as they enable us to construct stylized choice sets and to modify energy labels. By allowing for a proper identification strategy that would be infeasible in real-world settings, they are a precondition for disentangling the behavioral mechanisms that underlie consumers' choices.

The paper proceeds as follows. In the following section, we introduce the EU energy label and the market for refrigerators. In Section 3, we present the conceptual model and our hypotheses. Section 4 describes the experimental design and Section 5 presents the data. In Section 6, we discuss the results. Section 7 concludes.

## 2. EU Energy Label and the Market for Refrigerators

Retailers have to display the EU energy label whenever household appliances are offered for sale in the EU. Our analysis focuses on refrigerators, as their penetration rate reaches nearly 100% in almost all EU member states (Bertoldi et al., 2012) and their energy use is largely independent of usage patterns. As visualized in Figure 1, the label for refrigerators depicts the annual electricity use, an energy efficiency class ranging from D (least efficient) to A+++ (most efficient), and information on the capacity of fresh food and frozen food compartments, as well as the noise level. Due to the imposition of minimum standards (EU Directive 2009/125/EC), refrigerators that are less efficient than class A+ are banned from the EU market since July 2012.

To assign efficiency classes to refrigerators, EU legislation prescribes the calculation of an energy efficiency index (EEI) that accounts for the energy use of the appliance, its product class, and its size.[1] By construction, lower EEI values are associated with higher energy efficiency. The efficiency class of an appliance is determined based on whether its EEI falls below predefined cutoff values and is not a source of genuinely new information to buyers.

To investigate the distribution of energy efficiency in the market for refrigerators, we cal-

[1]Details on the calculation rule are given in EU Directive 2010/30/EU.

**Figure 1:** EU Energy Label for Refrigerators

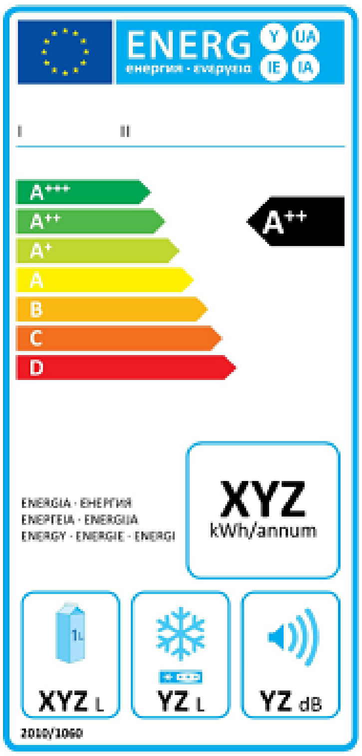
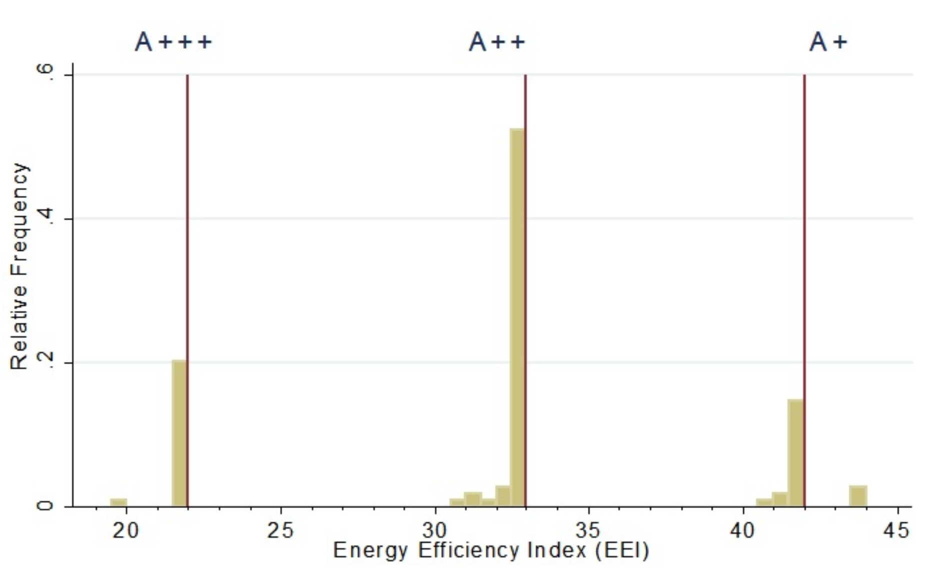



**Figure 2:** Energy Efficiency of Refrigerators on the Market




*Note: Three appliances exceed the current EEI cutoff value for A+ appliances. Since they were already on the market prior to July 2014, when the respective cutoff value was reduced from 44 to 42, they benefit from an exceptional rule.*

culate the EEI for appliances offered in online stores of two large German retailers.[2] Figure 2 visualizes that the relative frequencies of the EEI bunch strongly below the values of 42, 33 and 22, which are the cutoff values that determine the respective efficiency classes. Apparently, the energy efficiency of refrigerators does not vary continuously, but in increments that allow to reach a better efficiency class.

The evidence of bunching below the cutoff values indicates that producers of refrigerators respond strategically to the existence of efficiency classes. This finding is in line with evidence from the voluntary US Energy Star label (see Houde, 2014b) and strongly suggests that producers consider efficiency classes to be an important driver of consumers' purchasing decisions. Since investigating the valuation of efficiency classes from the consumers' point of view is central to our paper, we explicitly consider efficiency classes when developing a conceptual model of energy efficiency investments in the following section.

## 3. Conceptual Model and Hypotheses

In this section, we develop a conceptual model that is based on Gerarden et al.'s (2015) framework on technology adoption decisions. Consider the choice between two energy-consuming durables A and B that are equal in any quality dimension, but differ in their purchasing price and energy use. Cost-minimizing consumers calculate the present value of cost (PVC) for each alternative $j \in \{A, B\}$:

$$PVC_j = K_j + O(E_j, P) \times D(r, T) + C,$$

where $K_j$ represents the purchasing price of alternative $j$, $O(E_j, P)$ denotes annual operating costs that depend on the energy use $E_j$ and the energy price $P$, both assumed to be constant over time for the sake of simplicity. $D(r, T)$ stands for a discount factor that depends on the consumer's discount rate $r$ and the expected lifetime $T$ of the appliance, while $C$ denotes any further costs that are assumed to be invariant across alternatives.

To fix ideas, let A denote the more energy efficient alternative with a higher purchasing price but lower annual operating cost. Given cost-minimizing behavior, consumers choose the

[2]The underlying data for this analysis stems from product data sheets of the retailers Media Markt (www.mediamarkt.de) and Saturn (www.saturn.de). Because refrigerators with small to medium cooling and freezer compartment sizes form a particularly homogeneous appliance class and represent a considerable market share of 20%, we focus on this product class. We consider all 109 refrigerator models that were offered in at least one of the online stores in July 2015.

energy efficient alternative A if its PVC is smaller than the PVC of alternative B:

$$PVC_A - PVC_B \quad = \Delta K + \Delta PVO < 0, \tag{1}$$

where $\Delta K$ corresponds to the difference in purchasing prices and $\Delta PVO$ denotes the difference in the present values of operating cost between alternative A and B: $\Delta PVO := \Delta O(E_A, E_B, P) \times D(r, T)$. Empirical investigations of the energy efficiency gap (e.g. Allcott and Wozny, 2014, and Hausman, 1979) typically use such a cost-minimizing decision rule as a benchmark and find that consumers tend to underinvest in energy efficiency. In our case, this would imply that alternative B is chosen even though Inequality (1) suggests otherwise.

Investments into energy-using durables involve a trade-off between easily observable purchasing prices and the present values of operating cost, which are based on beliefs over energy prices, the lifespan of the appliance and individual time preferences and, hence, can be classified as an "opaque value component" (DellaVigna, 2009). Research in behavioral economics has demonstrated that consumers tend to be inattentive to such opaque value components (Chetty et al., 2009, Hossain and Morgan, 2006), deciding based on the difference between perceived present values of cost (PPVC):

$$\Delta PPVC = \Delta K + \theta(S, N)\Delta PVO,$$

where $\Delta PPVC$ corresponds to the difference between the PPVCs of both alternatives, $PPVC_A - PPVC_B$, and $\theta(S, N)$ is an attention parameter that captures the degree to which the opaque component, $\Delta PVO$, is considered in the decision making process. We follow DellaVigna (2009) by assuming $\theta$ to be a function of the salience $S$ of the present value of operating cost and the number $N$ of stimuli that compete for attention. Under some degree of inattention, i.e. $0 \leq \theta(S, N) < 1$, operating cost are only partly considered, which offers an explanation for why a cost-effective investment into the energy-efficient alternative A may not be realized.

Some labels, such as the EU energy label, present grade-like efficiency classes. Although such classes only summarize readily available information on annual energy use, they may influence decision making. Most notably, the display of efficiency classes may induce consumers to adopt simplifying decision rules that treat efficiency classes as the only source of energy information, neglecting the more detailed information on energy use. An implication of decision making based on such heuristics is that consumers express a willingness-to-pay for energy class differences *per se*, irrespective of energy use differences between appliances.

Taking heuristic thinking into account, consumers' evaluation of the alternatives is based on:

$$\Delta PPVC = \Delta K + \theta(S,N)\Delta PVO + \tau(S,N)\Delta EC, \tag{2}$$

where $\Delta EC$ denotes the difference in efficiency classes between alternative A and B and $\tau(S,N)$ reflects the valuation of this difference. As participants may substitute operating cost for efficiency class information in the decision-making process (and vice versa), variables that influence the attention to operating cost may simultaneously affect the valuation of efficiency class differences. Accordingly, we specify $\tau(S,N)$ as a function of the salience of the present value of operating cost $S$ and the number of stimuli $N$ that compete for attention.

Building on Equation (2), we hypothesize that an increase in the salience of operating cost raises the difference in perceived present values of cost ($\Delta PPVC$) and thus the probability to choose the more energy-efficient appliance ($P_A$), so that $\partial P_A/\partial S > 0$ (*cost hypothesis*).[3] Second, we anticipate that an increase in the number of competing stimuli $N$ in the form of further product characteristics that are unrelated to energy use decreases $\Delta PPVC$ and leads to less frequent choices of the energy-efficient appliance, so that $\partial P_A/\partial N < 0$ (*stimuli hypothesis*).

Third, we expect consumers to express a willingness-to-pay for better efficiency classes, that is, $\tau(S,N) > 0$. As this hypothesis is consistent with the idea that consumers employ simplifying decision rules based on efficiency classes, we refer to it as the *heuristics hypothesis*.

Fourth, the salience of operating cost $S$ and the number of competing stimuli $N$ can work through two channels: they can influence both the attention to operating cost $\theta$ and the valuation of efficiency class differences $\tau$. We expect that the two channels work in opposite directions (*ambiguity hypothesis*). Following DellaVigna (2009), we presume that the attention to operating cost $\theta$ increases in its salience, $\partial\theta/\partial S > 0$, and decreases in the number of competing stimuli, $\partial\theta/\partial N < 0$. In contrast, we expect the valuation of efficiency class differences $\tau$ to decrease in the salience of operating cost, $\partial\tau/\partial S < 0$, which corresponds to a substitution effect between coarse information from efficiency classes and energy cost information, as suggested by Houde (2014a). Finally, we anticipate that consumers rely more strongly on simplifying decision heuristics based on efficiency classes in a cognitively demanding environment with

[3] In the presence of unobserved idiosyncratic preferences for either alternative, captured by the random error terms $\epsilon_A$ and $\epsilon_B$, the probability to choose alternative A is defined as $P_A = P(\Delta PPVC + \Delta\epsilon > 0)$, where $\Delta\epsilon = \epsilon_A - \epsilon_B$.

more competing stimuli, so that $\partial\tau/\partial N > 0$.

## 4. Experimental Design

To test our hypotheses, we conducted a discrete-choice experiment with randomized information treatments. Participants repeatedly chose between two refrigerators that differ in their purchasing price and energy use. Households were randomly assigned into one of three groups. In the Control Condition (*C*), participants received information on the appliances based on a simplified EU label that displays annual electricity use and the EU energy efficiency class (bottom panel of Table 1).

In the Operating Cost Condition (*OC*), the label additionally displays annual operating energy cost, calculated based on the average electricity price in Germany. In the Competing Stimuli Condition (*CS*), participants face the simplified version of the label, complemented by all remaining non-energy related attributes of the original EU label (information on the capacity of the fresh food and the frozen food compartment, as well as the noise level) and a picture of the refrigerator. As the only purpose of this treatment is to increase the number of competing stimuli, the levels of the additional attributes vary only by minimal increments (upper panel of Table 1).[4] For example, compartment sizes differ only by about 1 liter and the pictures depict the same refrigerator model with different food contents (Appendix A.2). We assign the attribute levels randomly to alternatives A and B in all choice sets.

We implement four binary choice sets that allow to estimate the causal effects of the information treatments with a minimum of distributional assumptions (Angrist and Pischke, 2009). The first two choice sets (*M1* and *M2*) correspond to typical market choice situations between refrigerators. In line with market prices and refrigerator characteristics that we collected from product data sheets of two large German retailers, we let participants trade off annual energy savings of either 40 or 60 kWh against appliance price increases of 70 EUR (Table 1).[5] Both choice sets reflect that more energy-efficient appliances typically fall into a better efficiency class.

[4] The rationale of introducing some variation in the additional attributes is to induce the cognitive effort of considering them as additional stimuli. Because we do not intend to influence consumers' appliance valuations, the differences we introduce are particularly small.

[5] To construct realistic choice sets, we used the product data sheets that we collected from the two large German retailers Media Markt and Saturn. Comparing appliances of a given brand, the median electricity use difference is 45 kWh per year and the interquartile range is from 35 to 53 kWh. The median purchasing price difference amounts to 60 EUR with an interquartile range from 20 to 200 EUR.

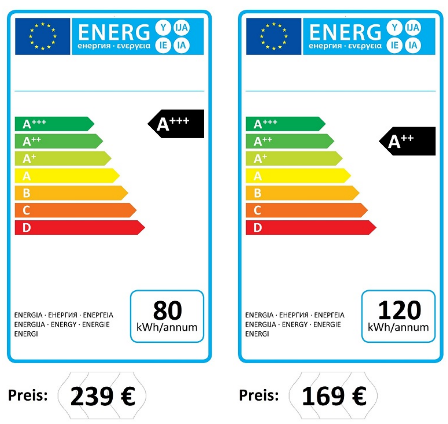
**Table 1:** Overview of Choice Sets and Experimental Conditions

| **Attributes in the four Choice Sets** | | | | | | | | | | **Share of Participants: Choosing Alternative A** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Choice Set | Alter-native | Purchas-ing Price, in € | Electricity Consumption, in kWh | Efficiency Class | Annual Operating Cost, in € | Size of Cool-ing Compart-ment, in Liter | Size of Freez-ing Compart-ment, in Liter | Noise Level, in Decibel | Picture | Control Condition | Operating Cost Condition | Competing Stimuli Condition |
| *M1* | A | 239 | 80 | A+++ | 22 | 105 | 14 | 37 | P1 | 0.853 | 0.880 | 0.850 |
| | B | 169 | 120 | A++ | 34 | 106 | 15 | 39 | P2 | | (2.30*) | (-0.20) |
| *M2* | A | 449 | 120 | A++ | 34 | 104 | 14 | 39 | P2 | 0.872 | 0.903 | 0.830 |
| | B | 379 | 180 | A+ | 50 | 105 | 13 | 38 | P1 | | (2.78**) | (-3.34**) |
| *S1* | A | 289 | 153 | A++ | 43 | 106 | 15 | 38 | P2 | 0.656 | 0.614 | 0.682 |
| | B | 259 | 154 | A+ | 43 | 104 | 14 | 39 | P3 | | (-2.49*) | (1.52) |
| *S2* | A | 309 | 160 | A+ | 45 | 104 | 15 | 37 | P4 | 0.714 | 0.784 | 0.714 |
| | B | 239 | 200 | A+ | 56 | 106 | 14 | 38 | P3 | | (4.54**) | (0.01) |

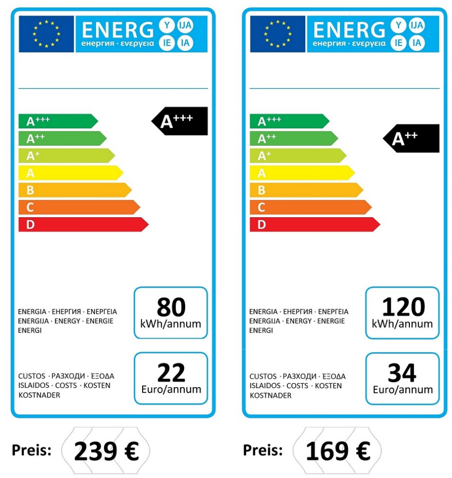
*Note: P1-P4 in the column "Picture" refer to the pictures for the refrigerators as given in Appendix A.2. Values in parentheses give the t-test statistic for equality in means between the treatment conditions and the control condition. **,* denote statistical significance at the 1% and 5% level, respectively.*

**Visualization of Choice Set M1 in the three Experimental Conditions** (see Appendix A.1 for the other choice sets.)

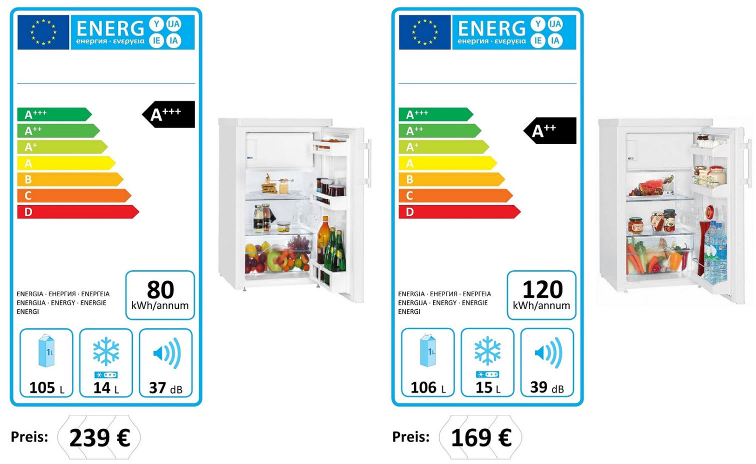
Control Condition




Operating Cost Condition




Competing Stimuli Condition



To investigate the channels through which the information treatments operate, we construct two stylized choice sets (*S1* and *S2*) that cannot be observed in practice. Choice set *S1* aims at identifying the value of efficiency class differences by taking advantage of the EEI cutoff values that determine efficiency classes. We set the annual electricity use of the alternatives A and B closely around the cutoff value that separates the efficiency classes A+ and A++, differing only by one kWh, so that the difference of the present value of operating cost is negligible ($\Delta PVO \approx 0$). Fixing the difference in purchasing prices at 30 Euro, this choice set allows us to investigate whether individuals have a non-negligible willingness-to-pay for efficiency class differences. [6] In choice set *S2*, participants trade off a 70 EUR difference in purchasing prices against a reduction in annual electricity use of 40 kWh. While these differences are identical to choice set *M1*, we determine the levels of electricity use such that there is no difference in efficiency classes ($\Delta EC = 0$).

We test our hypotheses described in the previous section using combinations of the choice sets and experimental conditions, as illustrated in Table 2. Using choice sets *M1* and *M2* that mimic typical market trade-offs between purchasing prices and energy efficiency, we test whether the Operating Cost Condition increases the probability of choosing the more energy-efficient appliance (*cost hypothesis*) and whether the Competing Stimuli Condition decreases this probability (*stimuli hypotheses*).

To investigate whether consumers value better efficiency classes *per se* (*heuristics hypothesis*), we employ choice set *S1* that allows to identify the percentage of consumers who are willing to pay at least 30 EUR for an appliance with a better efficiency class, even though the energy use difference is negligible.

The combination of choice sets *S1* and *S2* with the information treatments serves to investigate the *ambiguity hypothesis*. Because this hypothesis is formulated in terms of unobservables, such as the attention to operating cost $\theta(S, N)$ and the valuation of efficiency class differences $\tau(S, N)$, it is not directly testable. However, when the difference in the present value of operating cost is negligible (choice set *S1*), changes in the probability to choose alternative A in response to the information treatments are directly linked to changes in the valuation of efficiency class differences. Similarly, in the absence of efficiency class differences (choice set *S2*), any impact of the information treatments on choice probabilities reflects changes in the

[6] Even when assuming a discount rate of 0%, the present value of saving one kWh per year corresponds to only 4.1 EUR (given a constant electricity price of 29 cent/kWh and an appliance lifetime of 14 years).

**Table 2:** Overview of Experimental Variation Used to Test Hypotheses

| Hypothesis | Choice Sets | Source of Variation |
|---|---|---|
| *Cost* | *M1* and *M2* | Operating Cost Condition (increases salience $S$ of operating cost) |
| *Stimuli* | *M1* and *M2* | Competing Stimuli Condition (increases number of stimuli $N$) |
| *Heuristics* | *S1* | Choice set where the efficiency class differs, but energy use is almost the same |
| *Ambiguity* | *S1* and *S2* | Operating Cost and Competing Stimuli Condition in choice sets where: |
| | | • Efficiency classes differ, but energy use is almost the same (*S1*) |
| | | • Energy use differs, but the efficiency class is the same (*S2*) |

attention to operating cost. Thus, the analysis of the choice sets *S1* and *S2* allows to infer the effect of the information treatments on both $\theta(S, N)$ and $\tau(S, N)$ by investigating their effect on observable choice probabilities.

## 5. Data

We conducted the discrete-choice experiment using the household panel of the survey institute *forsa*. Participants are household heads, defined as the individuals responsible for financial decisions at the household level. We randomly assigned participants into one of the three experimental conditions and exposed them to all four choice sets. To avoid ordering effects (Carlsson et al., 2012; Day et al., 2012), the sequence of choice sets and the presentation of an appliance as alternative A or B is randomly determined.

Data was collected by *forsa* via a survey tool that allows participants to complete the questionnaire at home via the internet or television. Respondents can interrupt and continue the survey at any time. At the outset of the survey, we introduced the experiment (details are given in Appendix A.3) and informed households about the meaning of the label attributes in their experimental group. The survey took place between March 3 and April 28, 2015, and comprised 5,069 household heads. In total, 270 of them did not complete it, which corresponds to a dropout rate of 5.3%. As illustrated by Table A1 in Appendix A.4, the socio-economic characteristics of our sample closely match the characteristics of the population of German household heads.

The descriptive statistics provided in Table 3 illustrate that the percentage of women in our sample amounts to 33%, which can be traced back to our decision to ask household heads to participate in the survey. About one fifth of our respondents graduated from college. Pro-environmental attitudes, proxied by the statement to be in favor of voting for Germany's green party, are reported for about 8% of the respondents. Furthermore, we create a high income

**Table 3:** Descriptive Statistics

| Variable | Explanation | All | Control | OC | CS |
|---|---|---|---|---|---|
| *Age* | Age of respondent | 55.25 | 54.87 | 55.49 | 55.39 |
| | | | | (1.77) | (1.31) |
| *Female* | Dummy: 1 if respondent is female | 0.333 | 0.322 | 0.325 | 0.352 |
| | | | | (0.04) | (3.50) |
| *College degree* | Dummy: 1 if respondent graduated from college | 0.212 | 0.217 | 0.202 | 0.217 |
| | | | | (1.03) | (0.00) |
| *High income* | Dummy: 1 if monthly net household income is above € 4,700 | 0.118 | 0.104 | 0.128 | 0.121 |
| | | | | (3.71) | (1.90) |
| *Pro-environmental attitudes* | Dummy: 1 if respondent tends to vote for the green party | 0.083 | 0.074 | 0.082 | 0.092 |
| | | | | (0.70) | (3.40) |
| *Uninformed* | Dummy: 1 if respondent states to have no idea of the average electricity price in Germany | 0.296 | 0.297 | 0.289 | 0.302 |
| | | | | (0.22) | (0.11) |
| | Percentage of respondents that did not finalize the survey | 0.053 | 0.056 | 0.053 | 0.050 |
| | | | | (0.14) | (0.58) |

*Note: $\chi^2$-statistics for mean differences between participants in the Control and the Operating Cost (OC) or the Competing Stimuli (CS) Condition are in parentheses. There are no statistically significant differences in means at the 5% level.*

dummy variable that equals unity for some 12% of participants with monthly net household incomes above 4,700 €. The dummy variable $uninformed$ captures whether consumers report not knowing the average electricity price in Germany, which is the case for about 30% of participants.

Columns 4 to 6 of Table 3 show that covariate means are very similar across experimental conditions, as expected from randomization. When conducting $\chi^2$-tests for mean differences, we cannot reject the null hypothesis of no difference for any of the covariates at the 5% level. As the last row of Table 3 illustrates, dropout rates do not vary by experimental condition so that selection bias due to sample attrition does not seem to be of importance.

## 6. Results

The upper right panel of Table 1 summarizes the percentage of respondents who choose the more energy-efficient appliance for all choice sets and experimental conditions. In the following, we discuss the implications of participants' responses for our hypotheses.

### 6.1. Heuristics Hypothesis

We start by investigating the role of efficiency classes, which constitute the defining element of the EU energy label. To test the *heuristics hypothesis*, we analyze choice set *S1* and determine the percentage of individuals that opt for the better efficiency class by regressing our dependent variable of choosing alternative A on a constant. As the left panel in Table 4 illustrates, 65% of the individuals are willing to pay at least 30 Euro for the better efficiency class of alternative A, even though its electricity use is only marginally lower. This percentage is statistically different from zero at all conventional significance levels and demonstrates that a majority of individuals value efficiency classes *per se*, as claimed in the *heuristics hypothesis*.

**Table 4:** Analysis of the *Heuristics Hypothesis*

| **Dependent variable**: Choice of alternative A in choice set *S1* | | | | |
|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. |
| Constant | 0.651** | (0.007) | 0.371** | (0.034) |
| College degree | – | – | -0.045* | (0.019) |
| Uninformed | – | – | 0.050** | (0.017) |
| Pro-environmental attitudes | – | – | 0.026 | (0.026) |
| High income | – | – | -0.003 | (0.024) |
| Female | – | – | 0.089** | (0.016) |
| Age | – | – | 0.004** | (0.001) |
| Number of observations | 4,808 | | 4,063 | |

*Note: Standard errors are in parentheses. **,* denote statistical significance at the 1% and 5% level, respectively.*

Besides indicating the use of decision heuristics, the valuation of efficiency class differences may also reflect consumers' desire to signal pro-environmental behavior (Sexton and Sexton, 2014). Furthermore, consumers may succumb to a "halo effect" (Boatwright et al., 2008), having the false perception that refrigerators with better efficiency classes have higher non-energy related product quality.

To shed light on the role of decision heuristics, we investigate response heterogeneity by estimating the following linear probability model:

$$Y_i = \alpha + \boldsymbol{\beta}^T \mathbf{x}_i + \epsilon_i, \tag{3}$$

where $Y_i$ is a dummy variable that equals unity if individual $i$ chooses the alternative A and zero otherwise, $\mathbf{x}_i$ denotes a vector of socio-economic characteristics and $\epsilon$ designates an idiosyncratic error term.[7]

If decision heuristics played a role, we would expect that participants with large information or decision cost are particularly prone to valuing the efficiency class difference by at least 30 EUR. The results from the right panel of Table 4 tend to support this expectation. For example, the average probability to choose alternative A increases by some 5 percentage points for par-

[7] When the data generating process is unknown, Angrist and Pischke (2009) advocate for using linear probability models instead of nonlinear models that require distributional assumptions (such as probit or logit). Appendix A.5 illustrates that our results are robust to estimating probit or logit models.

ticipants that are uninformed about electricity prices. In addition, college graduates have a 4.5 percentage points lower probability to choose alternative A.

Pro-environmental attitudes appear to be unimportant for the valuation of efficiency class differences, which may undermine the explanation that individuals value efficiency classes to signal pro-environmental behavior. Furthermore, the parameter estimates on gender and age indicate that significantly more women and older individuals value efficiency class differences by at least 30 EUR.

## 6.2. Cost and Stimuli Hypotheses

Next, we analyze the effect of the Operating Cost and Competing Stimuli Condition using participants' responses on the choice sets *M1* and *M2* that reflect typical market trade-offs between purchasing prices and energy efficiency. Because of randomization, the difference between sample averages is a consistent estimator for the average treatment effect and can be estimated by a linear probability model (Angrist and Pischke, 2009). Thus, pooling responses for the choice sets *M1* and *M2*, we estimate the following model:

$$Y_{ij} = \alpha + \sum_{c} \omega_c T_i^c + \epsilon_{ij}, \tag{4}$$

where $Y_{ij}$ is a dummy variable that equals unity if individual $i$ chooses the more energy-efficient alternative A in choice set $j \in \{M1, M2\}$ and $T_i^c$ denotes a treatment group dummy that equals one if individual $i$ is in experimental condition $c \in \{OC, CS\}$ and zero otherwise. The parameters $\omega_c$ denote the average treatment effect of treatment $c$. To account for serial correlation of the error terms in subsequent choices of participants, standard errors are clustered at the individual level.

As reported in panel (*M1* and *M2*) of Table 5, participants in the Operating Cost Condition choose the more energy-efficient appliance significantly more often by about 3 percentage points on average, which confirms the *cost hypothesis*. Furthermore, our estimates are consistent with the *stimuli hypothesis*, since participants in the Competing Stimuli Condition choose the more energy-efficient appliance significantly less often, by 2.2 percentage points on average. Comparing participants' responses in the Control and Competing Stimuli Condition separately for both choice sets $M1$ and $M2$ illustrates that the effect of the Competing Stimuli Condition is mostly driven by the choice set $M2$ (upper right panel of Table 1). In contrast, the

**Table 5:** Analysis of the *Cost*, *Stimuli* and *Ambiguity Hypothesis*

**Dependent variable**: Choice of alternative A in the choice sets *M1* and *M2*, *S1*, or *S2*

| Choice Sets | (*M1* and *M2*) | | (*S1*) | | (*S2*) | |
|---|---|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| Constant | 0.863** | (0.007) | 0.656** | (0.012) | 0.714** | (0.011) |
| Operating Cost Condition ($T_{OC}$) | 0.029** | (0.010) | -0.042* | (0.017) | 0.070** | (0.015) |
| Competing Stimuli Condition ($T_{CS}$) | -0.022* | (0.011) | 0.025 | (0.017) | 0.000 | (0.016) |
| Number of observations | 9,641 | | 4,804 | | 4,717 | |

*Note: Standard errors are in parentheses (for M1 and M2 clustered at the individual level). **,* denote statistical significance at the 1% and 5% level, respectively.*

effect of the Operating Cost Condition is very similar in both choice sets $M1$ and $M2$.

### 6.3. Ambiguity Hypothesis

To investigate the *ambiguity hypothesis*, we estimate the linear probability model from Equation (4) separately for the choice sets *S1* and *S2*. First, we analyze responses in choice set *S1*, in which alternative A has a better efficiency class, but consumes only marginally less electricity than alternative B. The results reported in panel (*S1*) of Table 5 illustrate that the probability to choose alternative A decreases by some 4 percentage points in the Operating Cost Condition. This implies that information on operating cost acts as a substitute for the coarse information incorporated in efficiency classes: some participants change the basis for their decision making as soon as easily understandable information is additionally provided in the form of operating cost. As a result, the percentage of participants with a substantial willingness-to-pay for efficiency class differences decreases. In contrast, we cannot reject the null hypothesis that the Competing Stimuli Condition has no effect.

We then consider choice set *S2* that allows isolating the impact of the information treatments on the attention to operating cost. The estimates from panel (*S2*) of Table 5 demonstrate that the Operating Cost Condition significantly fosters the uptake of the more energy-efficient appliance by about 7 percentage points. Since differences in efficiency classes are absent in this choice set, we can attribute this effect to an increase in consumers' attention to operating cost information. Furthermore, the effect of the Competing Stimuli Condition is again not significantly different from zero.

To summarize, we find that an increase in the salience of operating cost has two channels of operation: it increases the attention to operating cost, while reducing the valuation of efficiency class differences, as claimed in the *ambiguity hypothesis*. Reflecting these behavioral channels, the estimates from the second row of Table 5 illustrate why displaying operating cost on the label induces more energy-efficient choices in our market choice sets (Panel *M1 and M2*): the associated decrease in the valuation of efficiency classes (Panel *S1*) is more than outweighed by an increase in the attention to operating cost (Panel *S2*).

## 7. Summary and Conclusions

This paper has investigated the impact of energy labels on the choice of energy-using durables. Drawing on a survey of about 5,000 participants, we conducted a discrete-choice experiment that is framed as a purchasing decision between refrigerators of different prices and energy uses. Participants were randomly assigned into three experimental conditions and exposed to different energy labels. In the control condition, we presented appliances using a simplified version of the EU energy label that displays the yearly energy use and the energy efficiency class of the appliance. In the first treatment condition, we increased the salience of operating cost by adding estimated annual energy cost of the appliance to the label. In the second treatment condition, we presented further non energy-related appliance characteristics that act as additional stimuli that compete for attention.

Our results show that adding information on operating cost to the label fosters the choice of energy-efficient appliances, while exposing consumers to additional non energy-related characteristics can impede it. Furthermore, we find that two out of three participants value a better efficiency class by at least 30 EUR, even when it is only associated with marginal improvements in energy efficiency. Moreover, we demonstrate that the provision of operating cost information works through two opposing channels when efficiency classes are present: it decreases the valuation of efficiency class differences, while increasing attention to operating cost.

Based on our results, we expect positive total welfare effects from adding information on operating cost to the current EU energy label. With some 15 million refrigerators and millions of other appliances being sold annually in the EU, fostering the choice of energy-efficient appliances by modifying the energy label accordingly promises significant reductions in negative externalities associated with energy consumption. Moreover, as the provision of operating cost can be considered a "pure nudge" (Allcott and Taubinsky, 2015), i.e. a behavioral intervention that informs previously uninformed consumers, but has no further effects, we do not expect private welfare of consumers to decrease after being better informed.

Finally, our findings call for particular caution when transferring results on optimal label design between energy labels with and without efficiency classes. Efficiency classes not only influence decision making directly, but also interact with other label elements, such as the provision of operating cost. Therefore, the effects of modifying energy labels can differ depending on whether efficiency classes are present.

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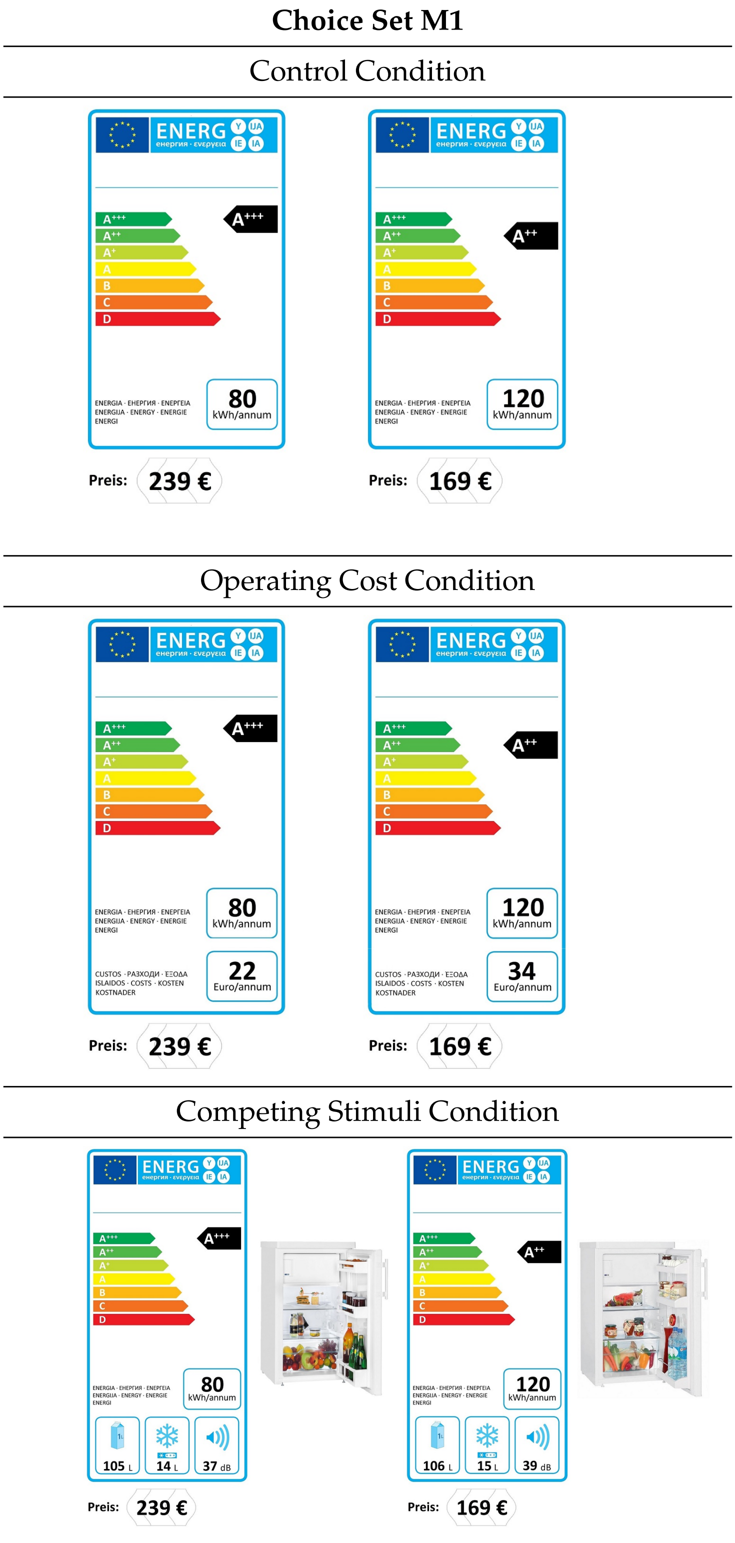
# A. Appendix

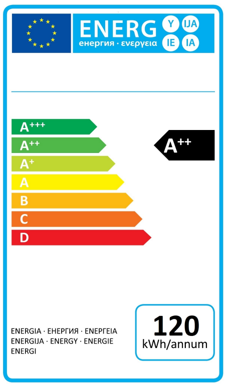
## A.1. Visualization of Choice Sets

**Figure A1:** All four Choice Sets in the three Experimental Groups

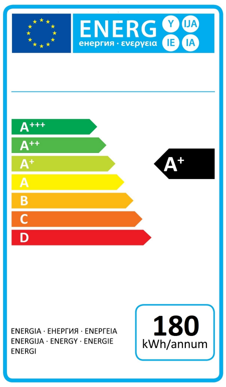


## Choice Set M2

### Control Condition

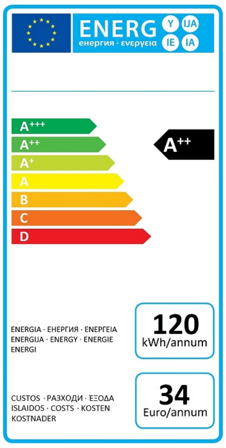



Preis: 449 €

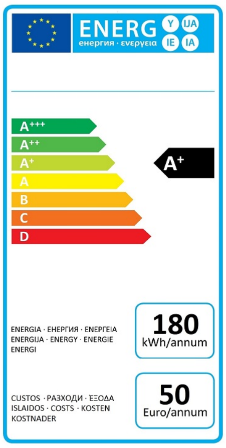



Preis: 379 €

### Operating Cost Condition

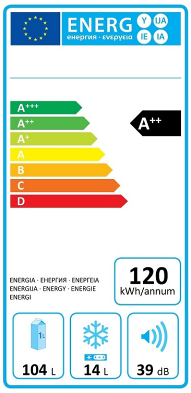



Preis: 449 €

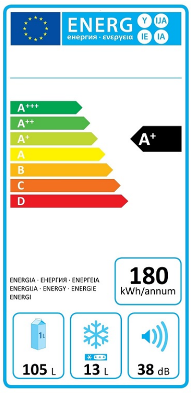



Preis: 379 €

### Competing Stimuli Condition



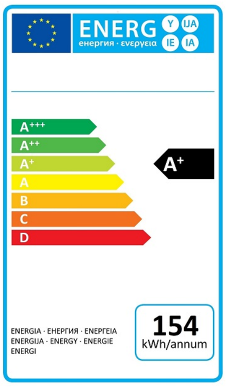

Preis: 449 €



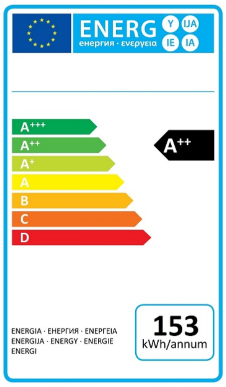

Preis: 379 €

## Choice Set S1

### Control Condition

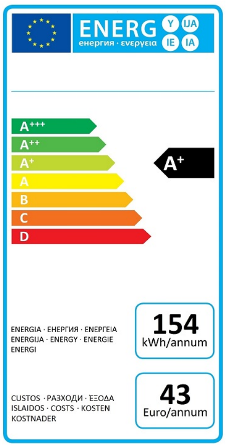



Preis: 259 €

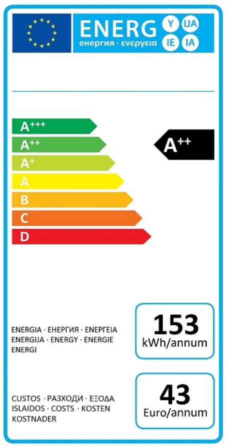



Preis: 289 €

### Operating Cost Condition

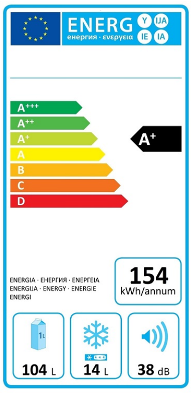



Preis: 259 €

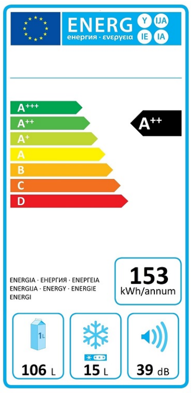



Preis: 289 €

### Competing Stimuli Condition



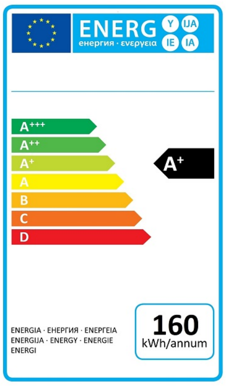

Preis: 259 €



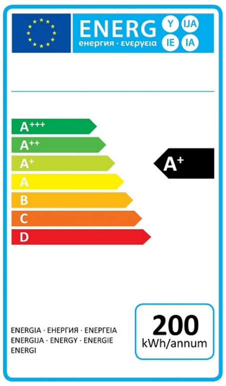

Preis: 289 €

## Choice Set S2

### Control Condition

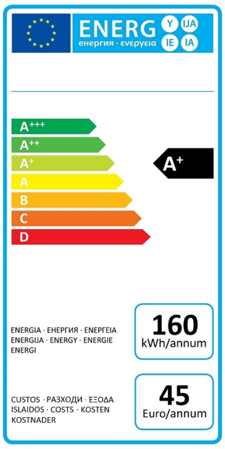



Preis: 309 €

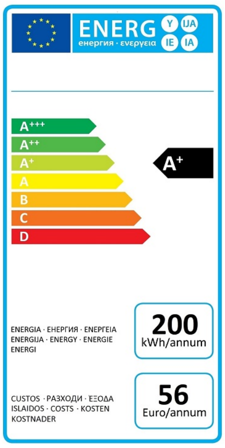



Preis: 239 €

### Operating Cost Condition

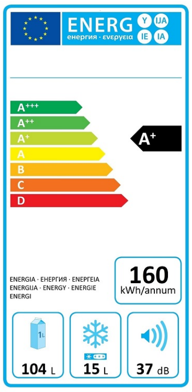



Preis: 309 €

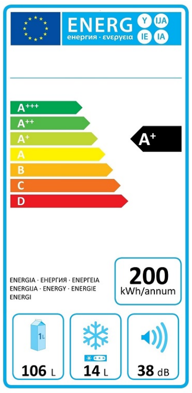



Preis: 239 €

### Competing Stimuli Condition




Preis: 309 €




Preis: 239 €

## A.2. Pictures of Refrigerators

**Figure A2:** Visualization of the Refrigerators P1-P4 used in the Competing Stimuli Condition

(a) Refrigerator P1

(b) Refrigerator P2

(c) Refrigerator P3

(d) Refrigerator P4

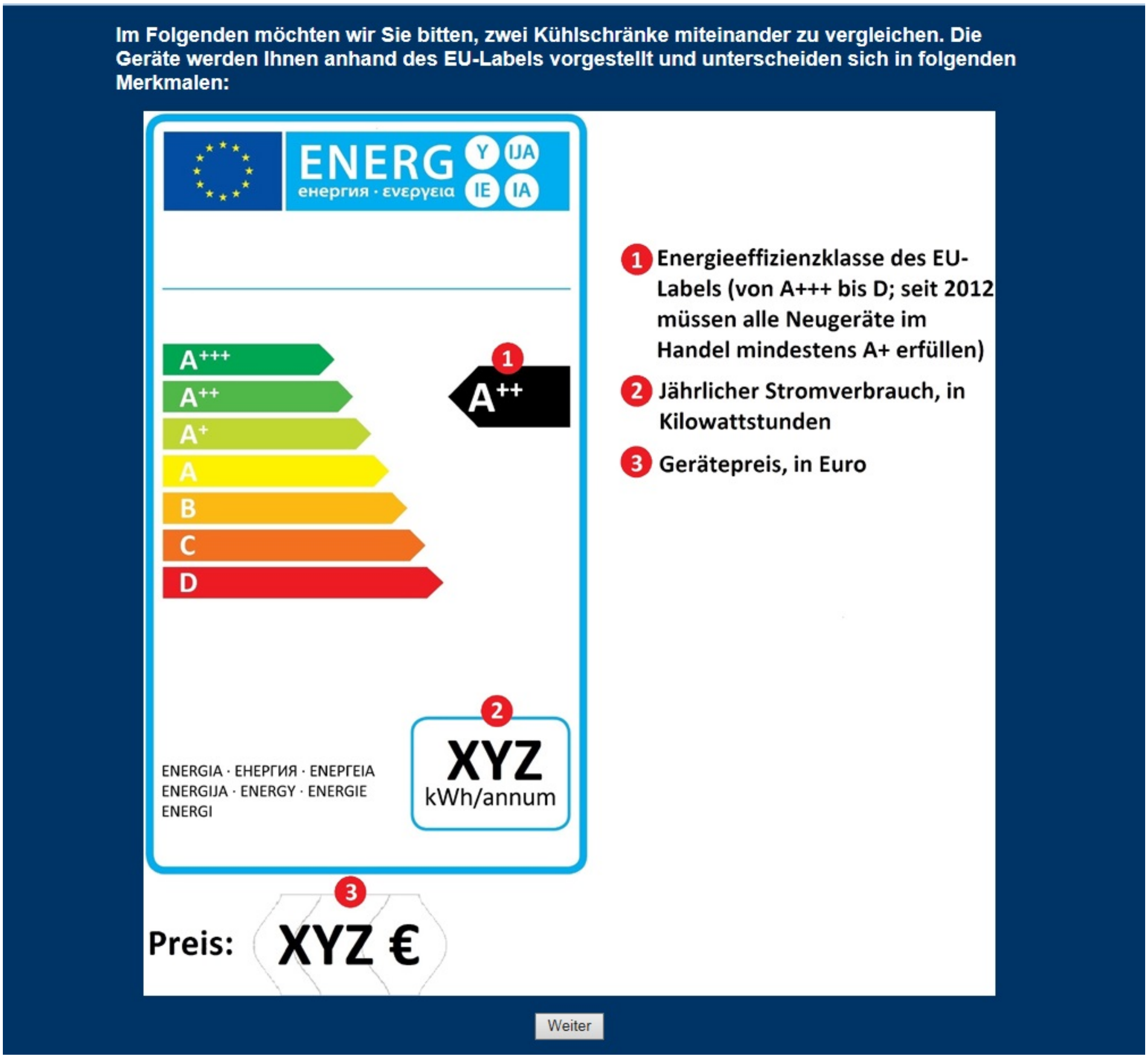
## A.3. Visualization of Screens used in the Experiment

### Screen 1: Introduction to the Discrete-Choice Experiment

Text: "Please imagine that you are about to purchase a refrigerator (similar to the one illustrated in the picture). To your information: the average lifespan of a refrigerator in Germany is about 14 years".

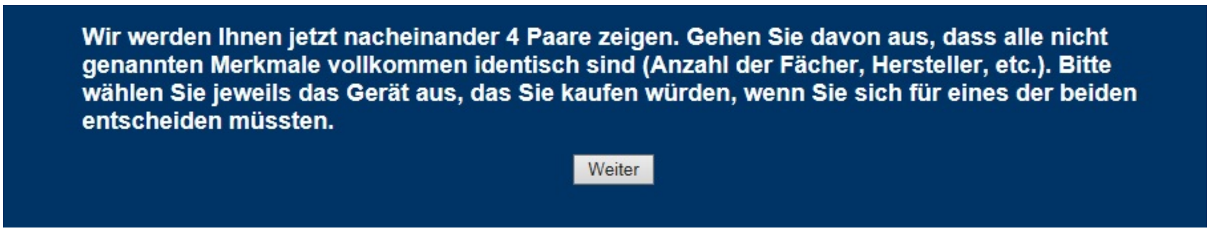

### Screen 2: Description of the Label Shown to the Respondents

Text: "In the following, we would like to ask you to compare two refrigerators. The appliances are presented on the basis of the EU energy label and differ in the following features:"




**Screen 3: Further Instructions**

Text: "We will show you four pairs of refrigerators. Please assume that all appliance characteristics not mentioned are identical (such as the number of compartments, the brand, etc.). For every pair of refrigerators, please select the alternative that you would purchase if you had to choose one of the two."



**Screen 4-7: Choice between Alternative A and B in the Choice Set *M1* in the Control Condition**

Text: “Which of the following alternatives would you choose?”

## A.4. Descriptive Statistics

**Table A1:** Comparison of our Sample with the Population of German Household Heads

| Variable | Sample | German Household Heads |
|---|---|---|
| *Age under 25 years* | 0.007 | 0.047 |
| *Age 25–under 65 years* | 0.714 | 0.671 |
| *Age 65 years and more* | 0.279 | 0.281 |
| *Female* | 0.330 | 0.354 |
| *College degree* | 0.212 | 0.191 |
| *High income* | 0.118 | 0.110 |

*Data for the population of German household heads is drawn from Destatis (2015). This data source asks the main earner to complete the questionnaire, whereas we ask the household member that usually makes financial decisions on the household level. Furthermore, the variable* high income *is top-coded at 4,500 EUR, while in our sample the upper threshold is at 4,700 EUR.*

## A.5. Logit and Probit Models

**Table A2:** Analysis of the *Heuristics Hypothesis* (Average Marginal Effects)

**Dependent variable**: Choice of alternative A in choice set *S1*

| | Logit | | Probit | |
|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. |
| College degree | -0.044* | (0.019) | -0.044* | (0.019) |
| Uninformed | 0.051** | (0.017) | 0.050** | (0.017) |
| Pro-environmental attitudes attitude | 0.026 | (0.026) | 0.026 | (0.026) |
| High income | -0.004 | (0.023) | -0.003 | (0.023) |
| Female | 0.088** | (0.016) | 0.088** | (0.016) |
| Age | 0.004** | (0.001) | 0.004** | (0.001) |
| Number of observations | 4,063 | | 4,063 | |

*Note: Standard errors are in parentheses. **,* denote statistical significance at the 1% and 5%level, respectively.*

**Table A3:** Analysis of the *Cost*, *Stimuli*, and *Ambiguity Hypothesis* (Average Marginal Effects)

**Dependent variable**: Choice of alternative A in the choice sets *M1* and *M2*, *S1*, or *S2*

| | Logit | | | | | |
|---|---|---|---|---|---|---|
| Choice Sets | (*M1* and *M2*) | | (*S1*) | | (*S2*) | |
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| Operating Cost Condition ($T_{OC}$) | 0.029** | (0.010) | -0.042* | (0.017) | 0.070** | (0.015) |
| Competing Stimuli Condition ($T_{CS}$) | -0.022* | (0.011) | 0.025 | (0.017) | 0.000 | (0.016) |
| | Probit | | | | | |
| Operating Cost Condition ($T_{OC}$) | 0.029** | (0.010) | -0.042* | (0.017) | 0.070** | (0.015) |
| Competing Stimuli Condition ($T_{CS}$) | -0.022* | (0.011) | 0.025 | (0.017) | 0.000 | (0.016) |
| Number of observations | 9,641 | | 4,804 | | 4,717 | |

*Note: Standard errors are in parentheses. **,* denote statistical significance at the 1% and 5%level, respectively.*